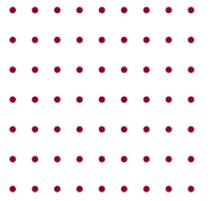


Central Washington University



DECARBONIZATION PLAN

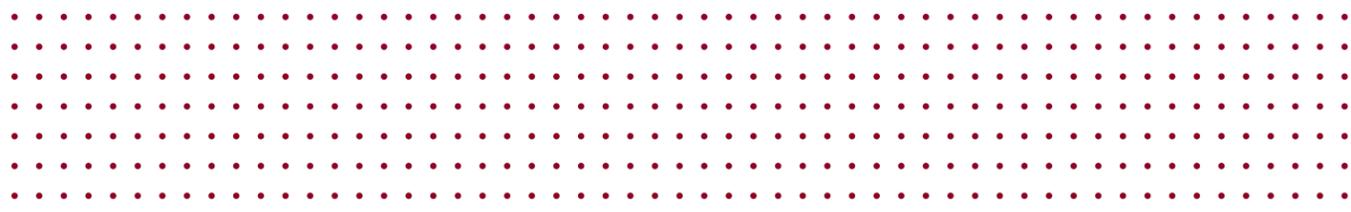
CWU Contract #16374-01

Task 2 Deliverable:
Energy Solutions for Central Washington University Selection
Version 2

Ellensburg, WA
May 24, 2024



ZERO+ PLANNING STUDIO



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VERSION HISTORY

- 4/26/2024 - Draft - Issued for CWU Review
- 5/17/2024 - Version 1 - Issued to CWU
- 5/24/2024 - Version 2 - CWU Comments Incorporated

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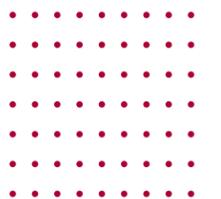
SECTION 1

Executive Summary



Key Takeaways

- CWU must align master planning of its long-term energy solution with Washington State energy and carbon reduction requirements.
- This is a progress report summarizing development of the CWU campus decarbonization plan.
- This milestone report is for CWU to approve further development of the recommended campus heating and cooling plant concept of nodal GeoEco Plants.
- Next steps for the recommended system include refinement of the concept, first cost estimates, incentives evaluation, energy and carbon analysis, lifecycle cost, and capital budget development.



Executive Summary | Introduction & Goals

This report provides a summary of work done to date on the CWU Decarbonization Plan, as well as a decarbonized system recommendation for CWU's consideration.

Intro and Report Purpose

Central Washington University (CWU) strives to create a positive impact that extends beyond campus, inspiring the next generation of leaders to affect meaningful change in the world. To that end, CWU is developing a decarbonization plan with the eventual goal of eliminating fossil fuel use in campus buildings. This goal aligns with the requirements of House Bill 1390, which was passed during the 2023 Washington State Legislative session and requires CWU to submit a decarbonization plan to the Washington State Department of Commerce by June 30, 2025. This document provides a summary of the work done to date on campus decarbonization, as well as a recommended decarbonized system for CWU's consideration. In addition to HB 1390 compliance, CWU is taking a holistic approach to the decarbonization process, including a building energy metering strategy, critical infrastructure assessment, and capital funding requests. This effort will also support attainment of the below goals set by the State of Washington:

45% Greenhouse Gas Emission Reductions by 2030

70% Greenhouse Gas Emission Reductions by 2040, compared to 2005 levels → Washington State Goals Applicable to CWU

Zero-Carbon/Net-zero no later than 2050



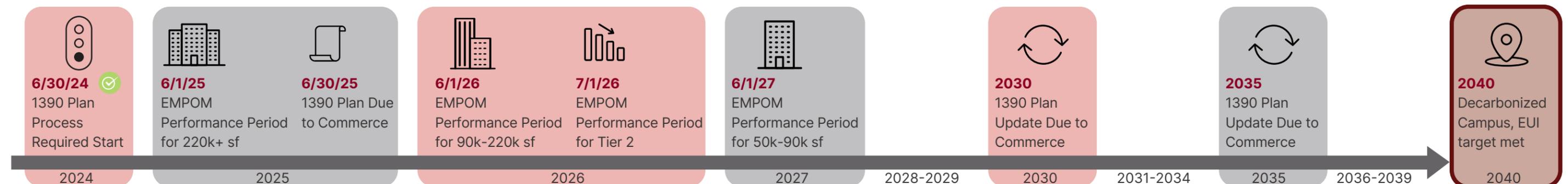
(Image courtesy of Opsis Architecture)

Project Outcomes

- 15 year **plan and roadmap** to decarbonize CWU's campus buildings
- Progress towards overall CWU **sustainability** goals
- HB 1390 **compliance**
- Campus engagement** throughout the process
- Alignment** with campus capital and master plans
- Resiliency** in the face of climate and economic uncertainty

1390 Requirements and Timeline

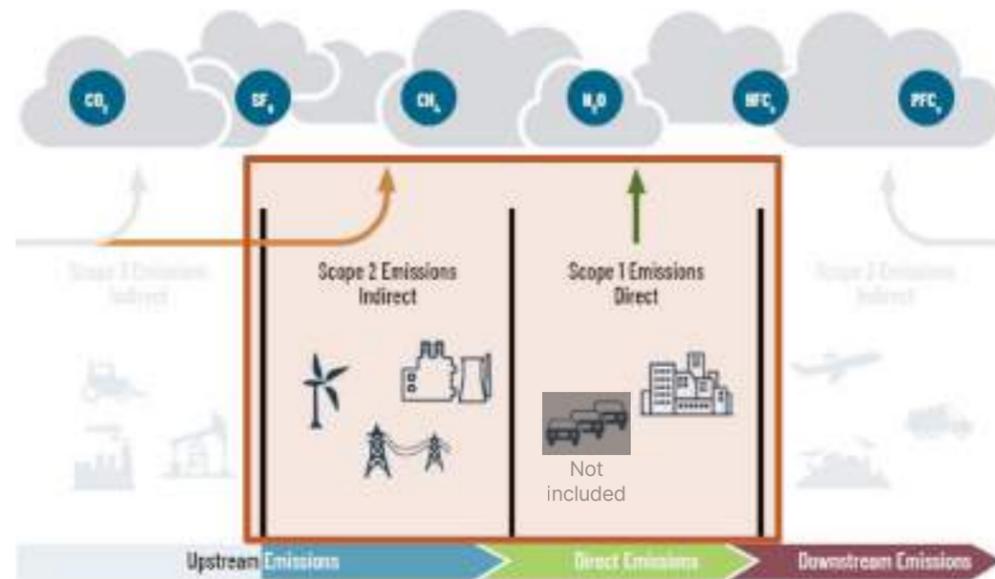
EMPOM - Energy Management Plan and Operations & Maintenance Plan



Executive Summary | Decarbonization Concepts & Scope

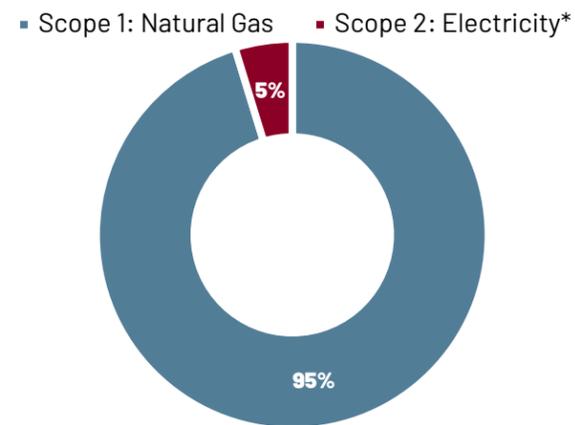
Carbon Emissions

University carbon emissions are classified based on their source and the University's ability to influence them, as shown below. **This project focuses primarily on mitigating Scope 1 emissions by minimizing on-campus burning of fossil fuels.** As noted below, on-campus fleet emissions are not included in this study.



CWU Building Emissions

As shown below, the vast majority of CWU's emissions are from natural gas. These are from burning fossil fuels to generate space and water heating. Most of the space heating is achieved via a large central steam plant.



*Emissions assume the City of Ellensburg fuel mix for electricity production. See appendix for explanation of fuel mixes and electricity carbon intensity factors.

What is Decarbonization?

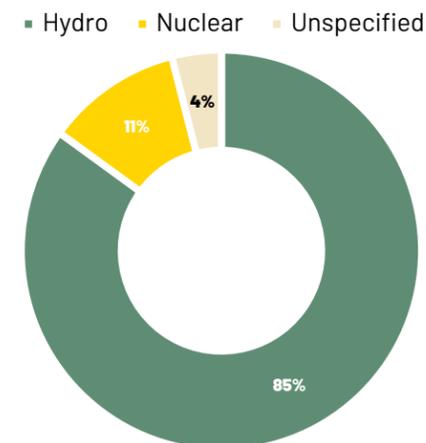
Decarbonization is a move away from burning fossil fuels to reduce carbon emissions and mitigate the worst impacts of climate change. As it pertains to CWU's building infrastructure, this entails transitioning campus fossil fuel-based heating systems to those that don't burn fossil fuels.

What is Electrification?

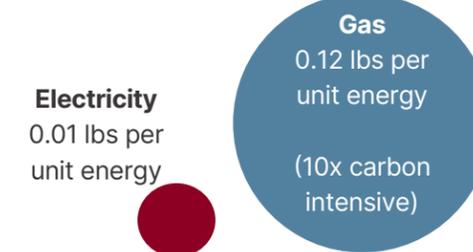
For CWU, and for much of society, the path to decarbonization means replacing those fossil fuel sources with efficient electrified systems. There are a few driving principles behind this movement:

-  Electricity is currently produced using a range of sources:
 - Carbon-emitting fossil fuels - natural gas, coal
 - Zero-carbon sources - hydropower, nuclear, wind, solar, etc.
-  The power grid is shifting away from fossil fuels and towards zero-carbon sources
-  Natural gas inherently emits carbon when burned, distributed, and produced, meaning gas-based heating sources will always emit carbon
-  Electrifying our heating systems means their carbon emissions will drop as the grid continues to add more renewables, eventually dropping to zero

Electricity Fuel Mix



Emissions by Fuel Source



The power provided to CWU via the City of Ellensburg is particularly clean, making electrification an effective decarbonization strategy.

Executive Summary | Decarbonized System Recommendation

Recommended Approach

Based on the analysis done to date, a **nodal open-loop geothermal system with 4-pipe distribution** is recommended to reduce operation of the fossil fuel-based steam central plant. Definitions of this system include:

Open-Loop Geothermal: This system will use the underground aquifer for heating and cooling, building on the approach of the North Academic Complex. This is in contrast to the existing mechanical system, which uses fossil fuel-based steam boilers for heating and chillers for cooling.

Nodal: GeoEco Plant nodes dispersed across the campus will provide heating and cooling. The quantity and location of the new plants will be evaluated in the next phase of this project. This is the approach employed for the first GeoEco Plant (GEP-1), which will begin construction soon. This is in contrast to the existing mechanical system, which centralizes all heating and cooling equipment at the existing central utility plant.

4-Pipe Distribution: Heating and cooling will be distributed to buildings via 2 pipes of heating hot water (one for supply heating water and one for return heating water) and 2 pipes of chilled water (one for supply chilled water and one for return chilled water). This is similar to the existing mechanical system, which uses 2 pipes of steam/condensate, and 2 pipes of chilled water to serve the majority of the campus. The new system will reuse the existing chilled water piping, and will expand the existing low temperature hot water piping to serve most buildings. The steam will be maintained, as described below.

Low Temperature vs. High Temperature Hot Water: This system will most likely employ a mix of low temperature (i.e. 120°F-130°F) and high temperature (160°F-180°F) water. The next phase of this project will evaluate applicability by building group. Low temperature is preferred, but buildings that require high temperature may need either a high temperature heat pump or a second stage heat pump to boost the temperature.

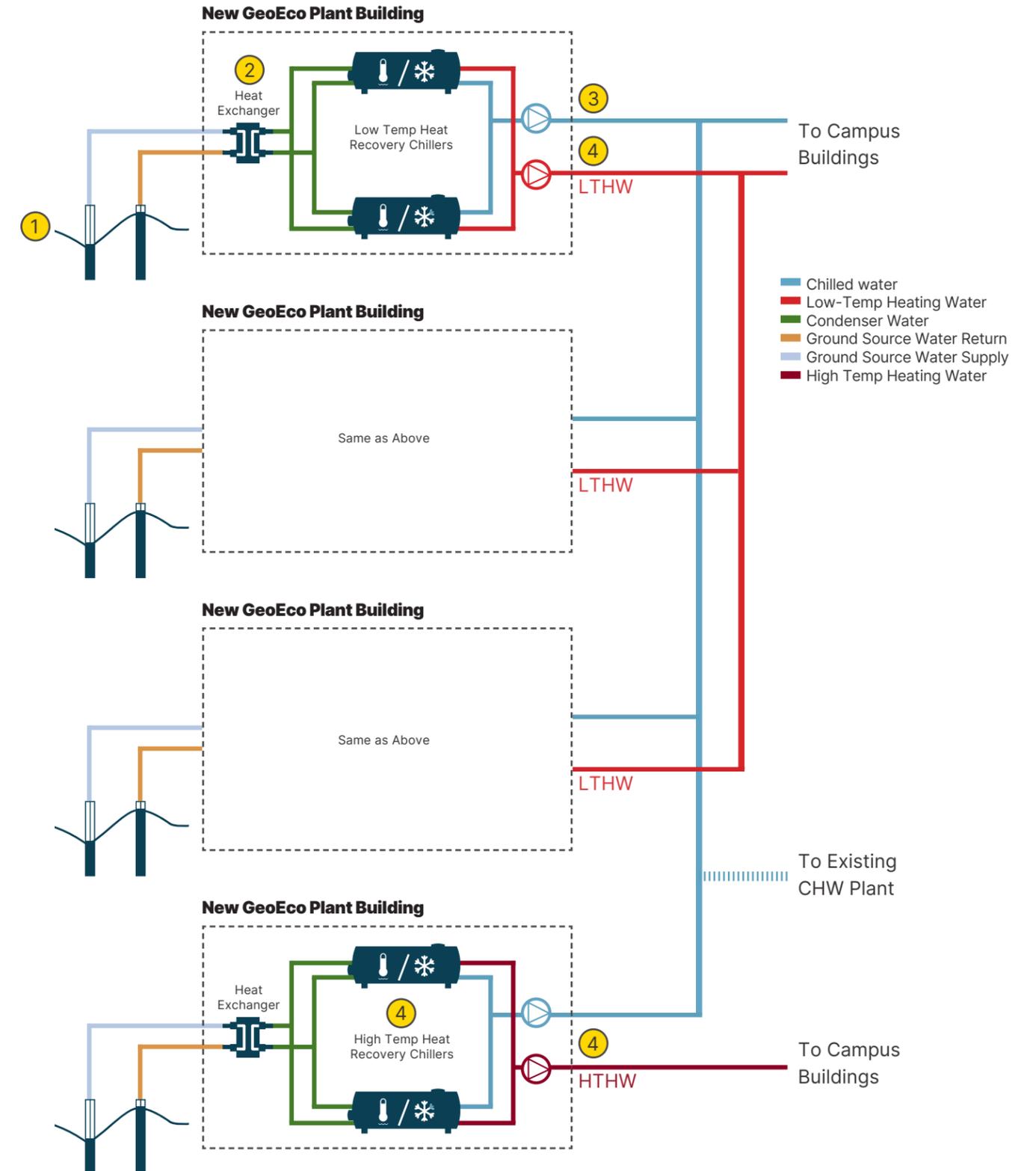
Redundancy and Resiliency: While the recommended system employs electricity for heating instead of gas, the existing steam system and associated piping will remain in place. This system will provide redundancy and resiliency to the campus.

Cost, Incentives, Construction: The nodal aspect of this proposed approach will allow for phased implementation over time to align with planned expenditures for capital projects, major retrofits, and new construction projects. This alignment, as well as taking advantage of IRA incentives for geothermal, will maximize cost-effectiveness and minimize disruption to campus operations.

Carbon Impact: Once fully implemented, this system is estimated to reduce campus Scope 1 emissions by 100% and overall emissions (Scope 1 and 2) by 95%, aligning with CWU and Washington State goals.

Diagram Legend and Notes

- ① Open-loop geothermal - each geothermal node requires at least one extraction well and at least one injection well. The number of wells per node will be determined in the next phase.
- ② Nodal plants - four nodes are shown here for demonstration purposes. The number of nodes will be determined in the next phase.
- ③ 4-pipe distribution
- ④ Low temp vs. High temp - a mix of low temp and high temp water are shown here. A high temp heat recovery chiller plant is shown here for demonstration. Nodal plant heating distribution temperature recommendations will be determined in the next phase.



Executive Summary | Decarbonized System Recommendation

Recommended System Layout

The campus map shows a preliminary concept for the recommended decarbonized system. Note this is a snippet of the campus map. The full campus map is included in the appendix. **The next phase of this project will include detailed cost estimates and lifecycle cost analysis of the recommended system.** Key components of this plan include:

Nodal Plants: Potential GeoEco Plant (GEP) locations are indicated on the map. These are ground-up new construction plant buildings housing the necessary mechanical and electrical equipment. The GEP-1 plant has already been designed as part of the North Academic Complex (NAC) project. The locations of GEP-2/3/4 are preliminary and are based on discussions with the CWU Capital Planning and Facilities groups. They take into account known capital plans and budget requests. This snippet shows the first four potential nodal plants; additional plants may be needed. **The locations and quantities of the GEP's will be further evaluated in the next phase of this project.**

Open-Loop Geothermal: Each of the GEP's will have at least one set of injection and extraction wells. The mechanical systems will extract heat from (providing building heating) and reject heat to (providing building cooling) the aquifer via these wells. Additional considerations for geothermal are included in the "Decarbonized Solutions" portion of this report. A test well for GEP-1 will be evaluated in the coming months. If the test results are available, they will be incorporated into the next phase of this project.

4-Pipe Distribution: The map shows the extent of the new low temperature hot water piping to be installed across a portion of campus. As indicated, part of this piping will be installed as part of the NAC/GEP-1 project. The piping distribution as shown is conceptual, and will be further refined in the next phase of this project. For clarity, the chilled water piping and existing steam piping are not shown on this map and will be maintained.

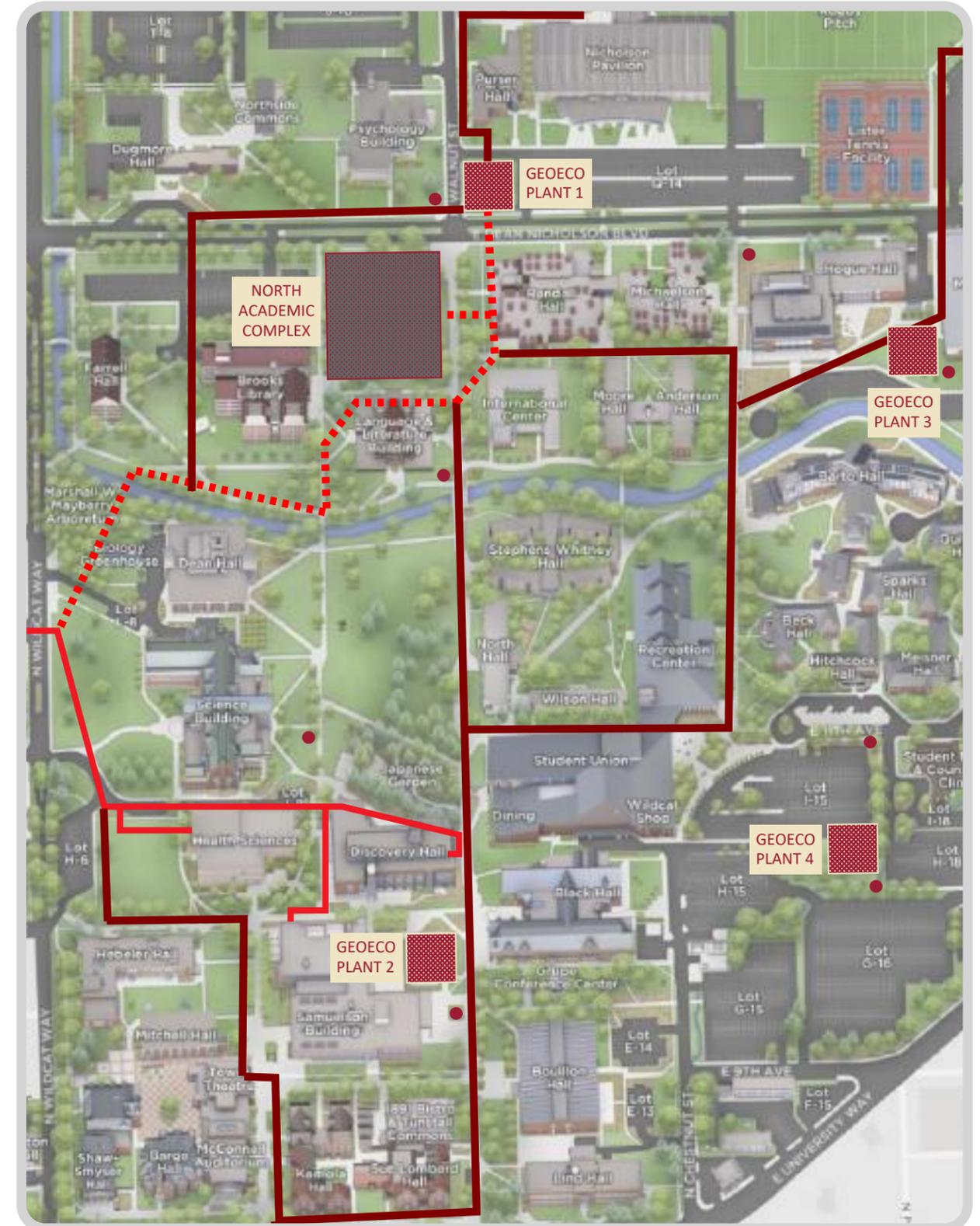
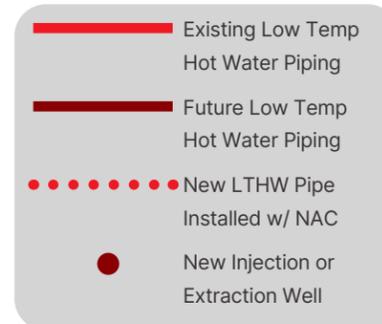
Low Temperature Hot Water: The map shows a system that only employs low temperature hot water. The next phase of the project will determine which buildings require high temperature hot water and how that will be provided.

Electrical Systems

Since the CWU decarbonization plan will rely heavily on electrification, understanding existing campus electrical infrastructure and its capacity for future growth is essential.

Existing Capacity Analysis: The existing campus peak demand (7.2 MVA) is 70% of existing capacity. This will most likely increase to 80% with the addition of GeoEco Plant 1.

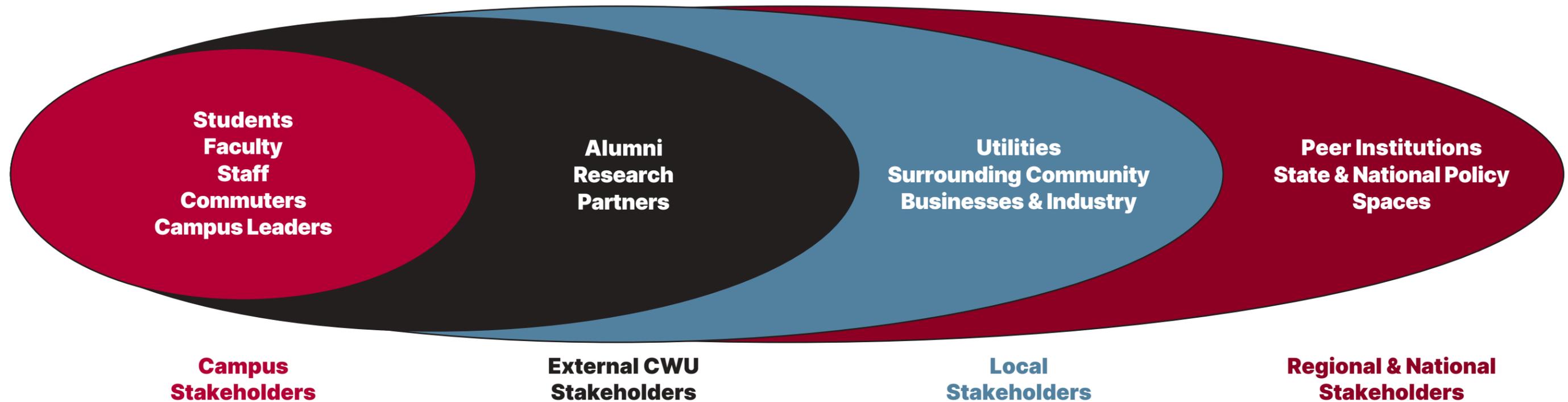
Potential Added Load: This electrification effort represents a significant load addition. Preliminary estimates suggest the load could increase by up to 18 MVA once the 15 year transition to electric heating is complete. This is a preliminary conservative estimate that will be refined in the next phase of this project. The existing electrical system will require new infrastructure to support the added load. Utility coordination is under way to plan for this total future load, as well as the phasing plan over 15 years.



Executive Summary | Equity & Environmental Justice

Environmental Justice & CWU's Decarbonization Efforts

Public universities play an important role in forwarding environmental justice (EJ) outcomes at multiple scales. For example, the university serves a diversity of students, preparing many for careers in the sustainability, energy, and policy administration fields. Additionally, the university is an integral part of the broader Ellensburg community – providing employment opportunities for the community but also affecting land use decisions, energy and utility services, and commerce for Ellensburg and the region. This EJ assessment can provide a blueprint for CWU's peer institutions to learn from and adopt to ensure structural integration of environmental justice into broader campus energy planning efforts.



The current effort for CWU to decarbonize is an important step to reach its energy and climate goals while also complying with state legislation. However, decarbonization processes, if implemented without an equity lens, can reinforce structural challenges for some groups while introducing new disbenefits. CWU is leading an equity and environmental justice assessment to analyze methods for supporting broader environmental justice outcomes, equitable climate action, and a just transition away from carbon-intensive energy systems.

A just transition framework highlights how decarbonization efforts can affect equity and EJ at various scales – from the immediate campus community to the broader landscape of stakeholders across Ellensburg and the region. Key questions include:

- 1 What are the **potential benefits and disbenefits** of this action for campus community members? Particularly those who are underrepresented and historically marginalized, such as low-income students or people of color?
- 2 Are there potential **considerations for implementation** that can mitigate any potential disbenefits?
- 3 What potential **just transition considerations** are there? For example, does an action require workforce retraining?
- 4 What **broader** equity and EJ considerations are there?

Key EJ findings include:

-  **Disruption from construction and installation** to the campus community and the broader Ellensburg community is the most immediate EJ disbenefit. Considering the sequencing and timing of construction and installation can help minimize these disruptions to the broader community.
-  Some systems **may require retraining for campus staff** – such as maintenance staff. There may be some challenges of existing staff to adapt to new technologies. Training programs and additional support (e.g., shadowing opportunities) can help mitigate impacts on existing staff members.
-  There may be **some costs passed onto CWU's students**. While CWU has multiple funding sources that can fund capital costs, some systems may be more expensive to maintain in the long-term. Other institutions have passed similar costs into increased facility fees embedded with student fees and tuition. This may disproportionately affect low-income students. Employing a portfolio of measures that can reduce the cost burden for students – such as energy efficiency measures or financial assistance programs – can alleviate these impacts.

Executive Summary | Next Steps

Next Steps

This report represents the conclusion of the first phase of the decarb plan development. Next steps include:

- CWU approval to further develop recommended decarbonized system
- Detailed scoping of decarbonized mechanical and electrical system, including further coordination with utility
- Analysis of first cost, energy/carbon, incentives, and lifecycle cost of recommended system and business-as-usual system
- Capital request for 2025-2027 biennium
- Development of 15-year decarbonization roadmap
- Development of Energy Management Plan, Operations and Maintenance Plan, and Asset Management Strategy
- Submittal of plans to Commerce for approval

Additional Project Materials

In addition to the Decarbonization plan itself, the below materials have been developed as part of this project to support 1390 compliance, capital requests, and decarbonization implementation.

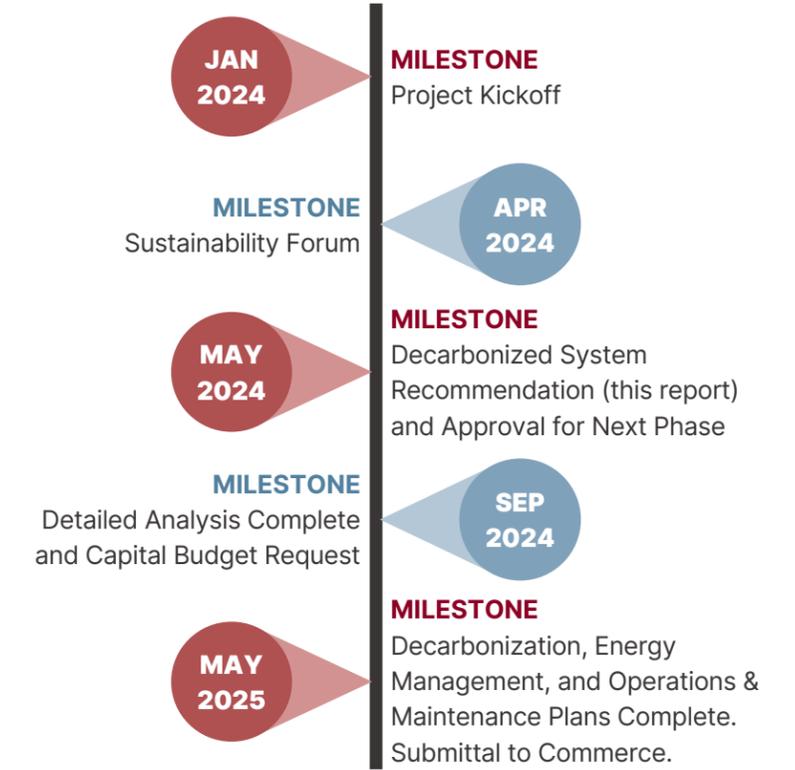
1390 Compliance Strategy Memo: documents the 1390 legislation in its current form, and provides guidance to CWU on compliance. Note, at the time of this report rulemaking was not finalized, so some requirements may still change.

Metering Report: surveys the existing energy metering infrastructure and provides costs and an implementation plan to expand metering on campus.

Infrastructure Memo: surveys the existing condition of major steam, chilled water, and electrical equipment and distribution systems.

Interactive Campus Data Dashboard: aggregates all energy data, as well as campus general info and mechanical system info. Will be updated in the detailed analysis phase.

Decarbonization Plan Development Timeline



Campus Engagement Plan

In addition to the technical and planning aspects of developing the decarbonization plan, a campus engagement effort is underway. This emphasizes two main components: 1) educating the CWU campus community on planned decarbonization efforts and 2) conveying the campus community's important role in the climate planning efforts to ensure an implementable, accessible, and technically defensible plan. Specific engagement objectives include:

- Sharing information to create a general understanding of energy transitions and emissions reductions
- Bringing students along on the planning process to enhance buy-in for planning outcomes
- Setting the campus community up for more effective and equitable implementation post-planning
- Encouraging members of the campus community to share their values and priorities regarding decarbonization strategies

This process builds on the already-successful engagement strategy employed by the CWU Sustainability department, with the main engagement to date being involvement in the recurring sustainability forum. Integrating into the pre-existing connection points with the campus community will help avoid engagement fatigue. Completed engagement activities related to this decarbonization plan development include:

- Presentation on decarbonization and CWU strategies at the April sustainability forum
- A Q&A session and activity with students reinforcing their understanding of the concepts discussed

These are the first steps in the engagement process; the full engagement plan is included in the appendix of this report.



2024 April Sustainability Forum



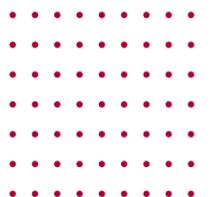
SECTION 2

Campus Existing Conditions



Key Takeaways

- 95% of campus emissions are Scope 1 direct combustion of fossil fuels.
- The campus spends \$4.4M on electric and gas utilities each year.
- The campus is heating-dominated with surplus steam capacity.
- The campus electrical system currently has spare capacity but will need infrastructure upgrades to accommodate longterm electrification.

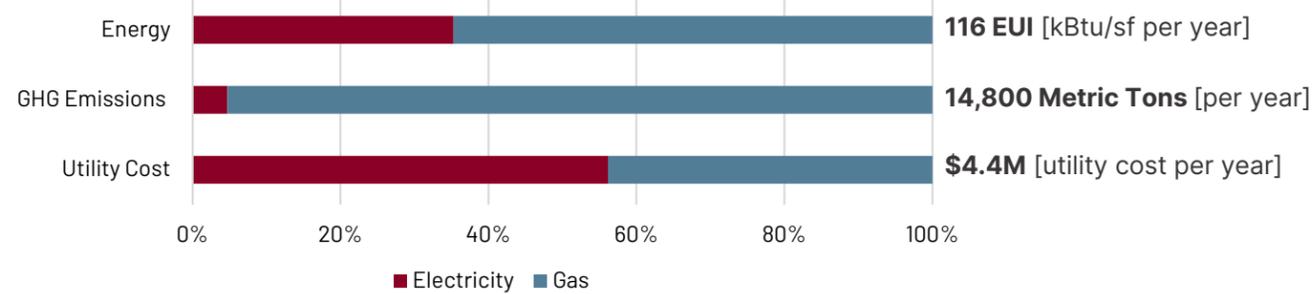


Existing Conditions | Energy Use

Campus Energy Use

The CWU campus is served by electricity and natural gas from the City of Ellensburg. The central plant provides the majority of the heating and cooling on campus. Natural gas is used at the central plant to produce steam that is distributed to most campus buildings. Natural gas is also used in a smaller magnitude throughout campus at several building-level boiler plants, domestic hot water heating systems, and for cooking. Campus energy below is based on City of Ellensburg utility bill data.

Annual Metrics

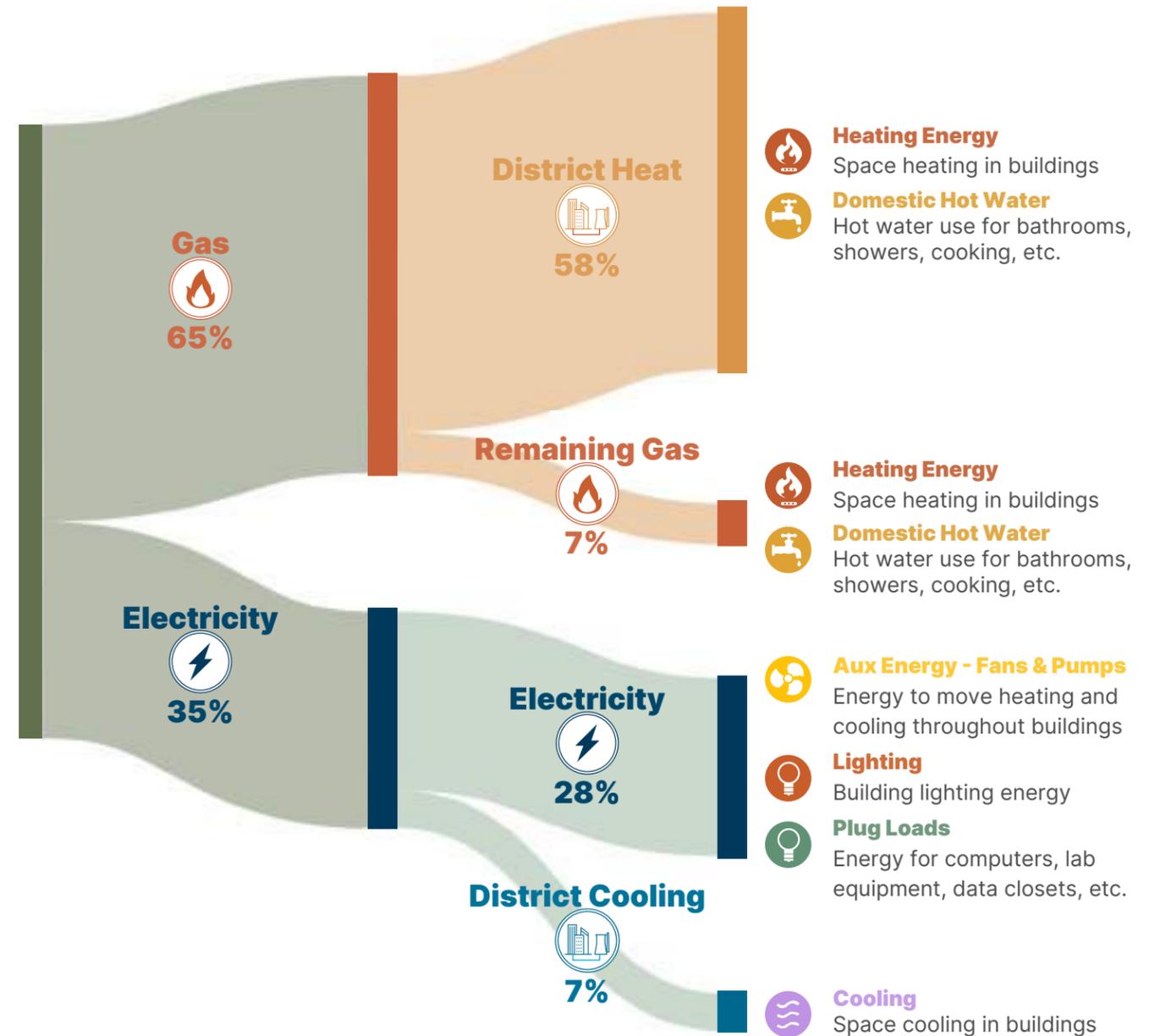


Campus Energy Modeling

A campus level energy model was developed to estimate building-level heating and cooling loads. Inputs for the energy model simulations were based on drawing and control system review, site-walk data, and facility interviews. The energy model was calibrated to overall campus-level energy use. The energy model is used to fill in gaps where energy metering data is missing, and will also be used to estimate campus energy and cost reductions.

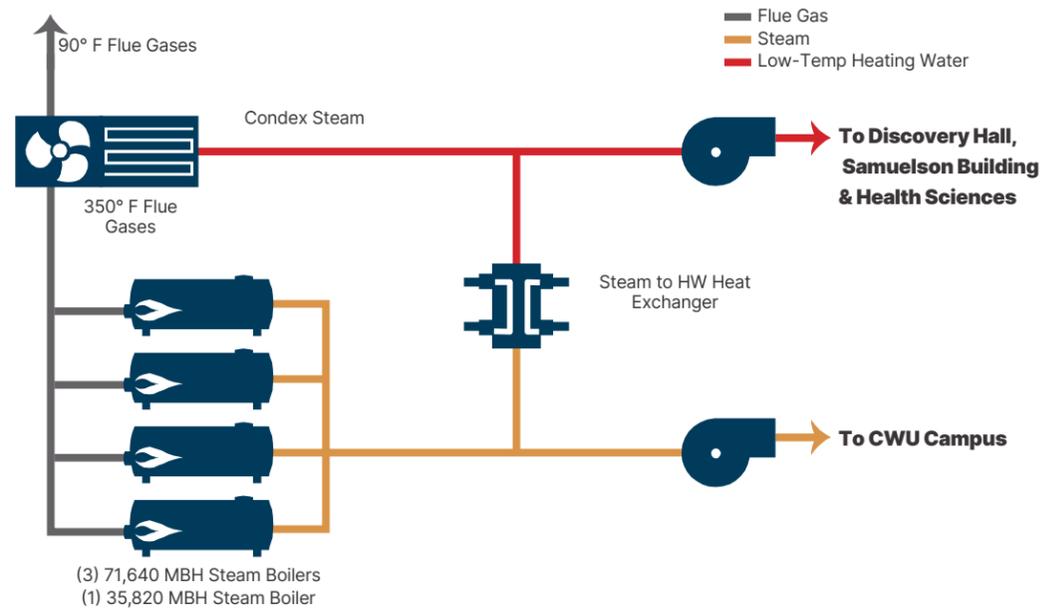
Campus Energy - Energy Source Breakdown

The below sankey diagram shows how energy is used across the CWU campus, and helps assess where decarbonization efforts should be focused. While there are some disparate fossil fuel (natural gas) uses across campus, the majority of fossil fuel use is attributed to the central steam plant loop. Note this diagram does not include campus vehicles using fossil fuels, as those are outside the scope of this project.

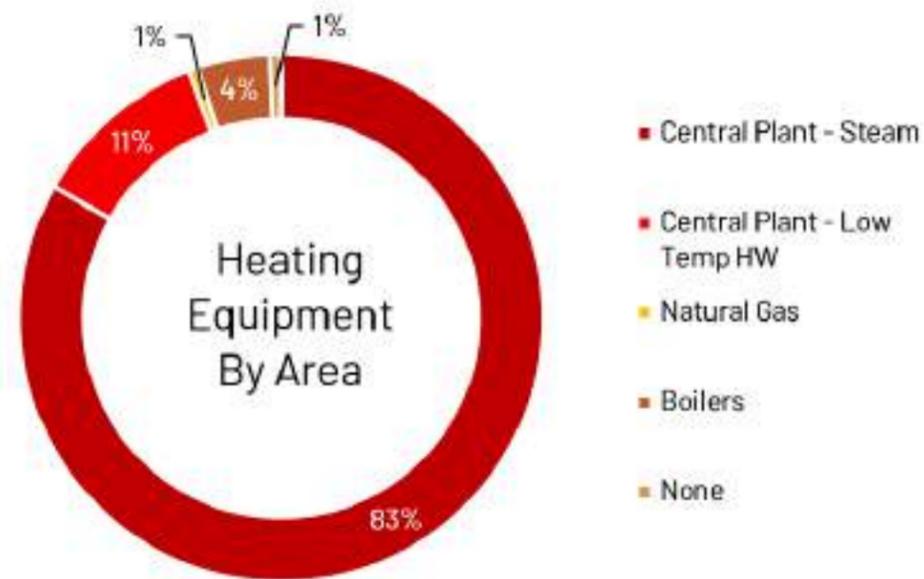


Existing Conditions | Mechanical Plant Systems

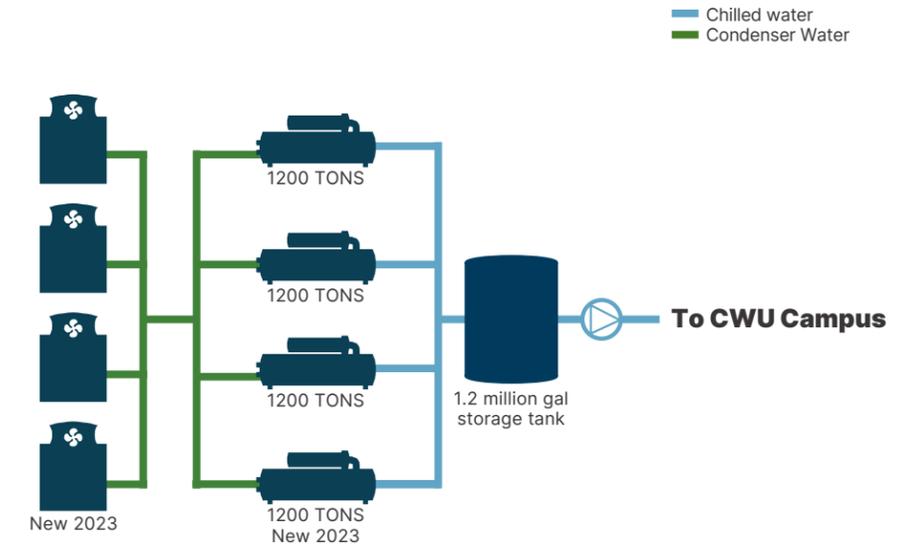
Campus Heating



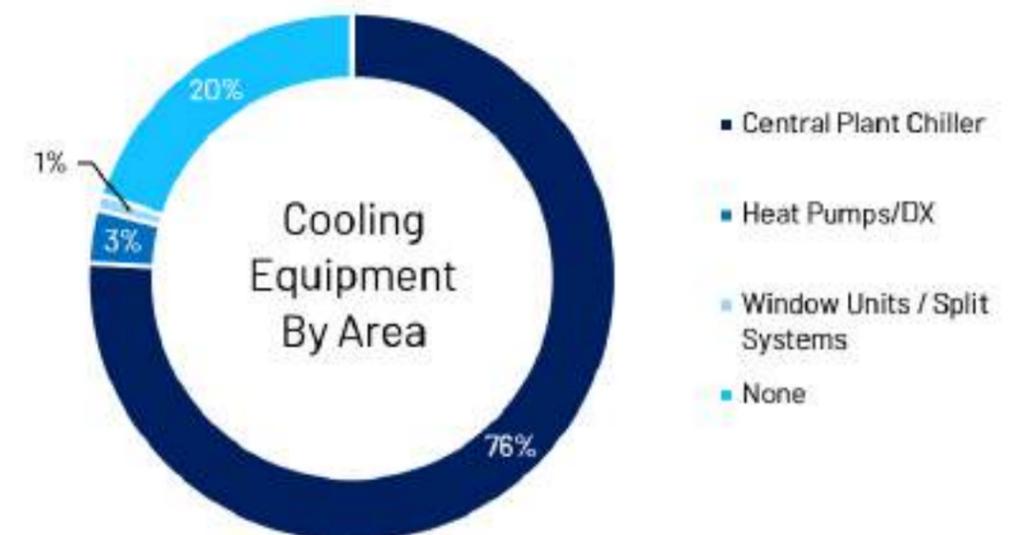
The central steam plant provides heating to over 80% of the campus. It has a total heating capacity of 250,000 MBH and consists of (4) boilers. Three buildings are served by a low temperature hot water loop, with heat generated from recovered boiler stack heat (CONDEX System). The remaining buildings are heated with non-centralized systems (electric resistance, heat pumps, gas boilers).



Campus Cooling



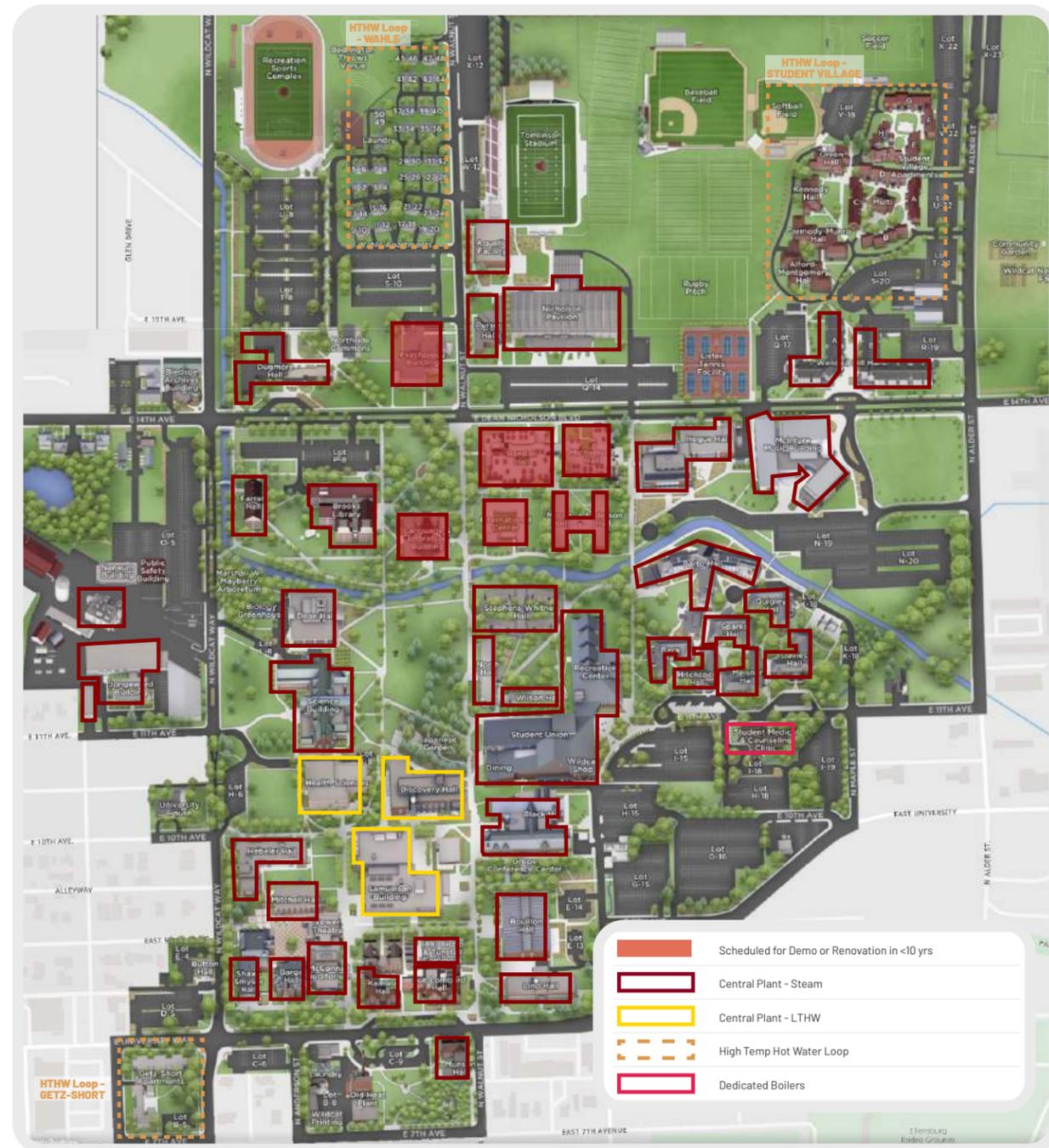
The central chilled water plant provides cooling to about 75% of the campus. It has a total cooling capacity of 4,800 tons and consists of (4) chillers, the most recent of which was installed in 2023. The central plant also has a 1.2 million gallon thermal storage tank to allow for peak shaving and operational efficiency.



Existing Conditions | Mechanical Systems

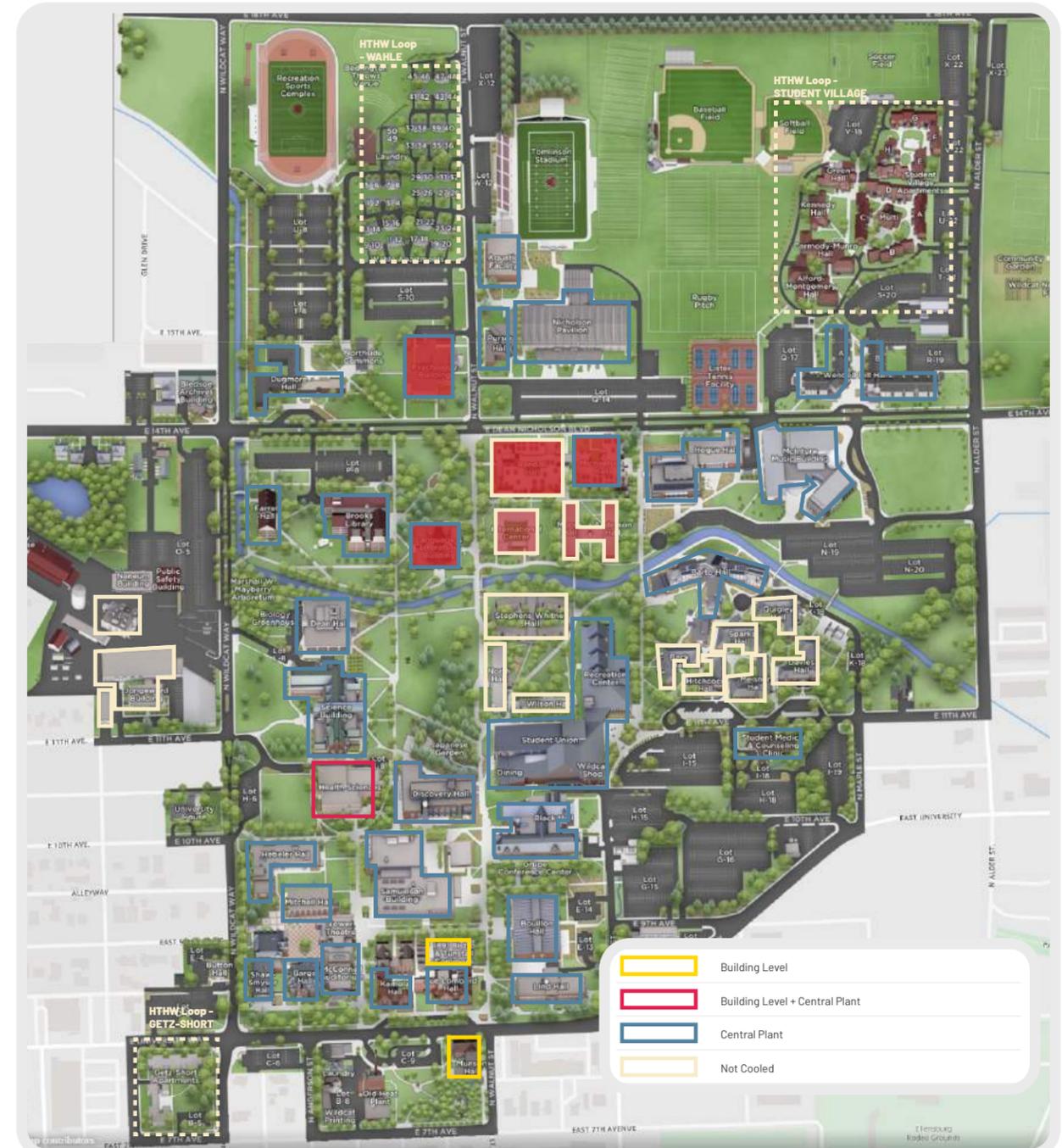
Heating System Types

The campus steam system, which serves most buildings over 20,000 sf, employs steam supply piping and condensate return piping, most of which are in utilidor. Low temperature hot water is provided to Health Sciences, Discovery Hall, and Samuelson. The Student Village and Wahle residential buildings have their own central boilers serving the buildings. High temperature hot water is distributed via direct-buried hot water piping. As shown in the map below, some buildings have additional heating sources.



Cooling System Types

The campus chilled water system, which serves most buildings over 20,000 sf, employs chilled water supply and return piping, most of which are in utilidor. As shown in the map below, a couple buildings have standalone cooling systems. Many of the residence halls do not have cooling.



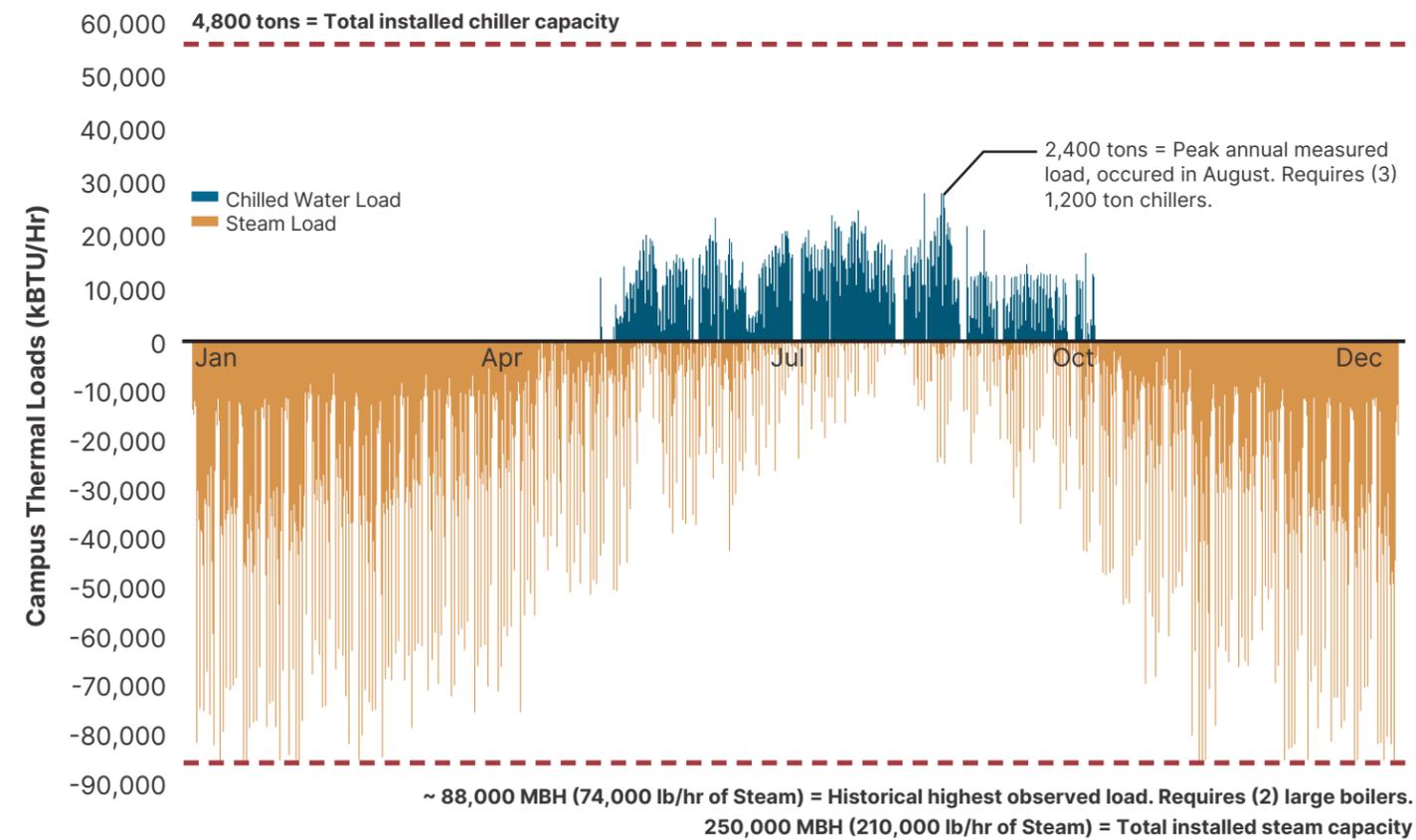
Existing Conditions | Mechanical Loads & Building Systems

Annual Load Profile

The below graph shows the hourly central chilled water and steam loads across the year. Key takeaways from the data include:

- The CWU campus loads are heavily heating-dominated.
- The highest recorded historical steam load is 35% of installed steam capacity. The central plant has plenty of installed steam heating capacity.
- The highest metered chilled water load of the past year is 50% of installed chiller capacity.
- CWU Facilities staff turn off the chillers September to May.
- Simultaneous heating and cooling is limited, limiting the effectiveness of heat recovery solutions.
- Heating loads see significant daily spikes that quickly dissipate.

Note: The chilled water data uses chiller plant metered data. The steam data uses campus energy model outputs. Metered data at the steam plant is not currently available. Weekly steam condensate readings at the building level were provided, and the energy model has been calibrated to the annual steam plant gas bills. However, the hourly profile doesn't match the gas usage exactly, so there are some discrepancies.



Building-Level Mechanical Systems

To develop an implementable decarbonization plan, a full understanding of the existing building mechanical, electrical, and plumbing (MEP) systems is needed. This will be used in the next phase of this project to determine not only the cost of decarbonization, but also the phasing and complexity of each project. The below table is a snippet of a larger building matrix showing a high-level summary of building mechanical systems for buildings over 50,000 sf. The more detailed matrix is in development and will be delivered with the deliverable for the next phase of the project.

Building	Building Area [sf]	Building Type	Hot Water Supply Temp	Heating Capacity per sf (BTU/sf)	Direct Steam Load?	Mech System Type	Centralized/Decentralized
Student Union & Recreation Center	228,261	Dining	HHW - HTHW [>160°F]	77	Yes	AHU (Single Zone)	Both
Health Education Center	156,892	Recreation	HHW - HTHW [>160°F]	89	No	AHU (VAV)	Centralized
Science Building	155,307	Science	HHW - HTHW [>160°F]	113	Yes	AHU (VAV)	Both
Brooks Library	143,324	Academic	Steam-Direct	66	Yes	AHU (Dual Duct)	Both
Samuelson Building	141,706	Academic	HHW - LTHW [<140°F]	89	No	Chilled Beam (w/DOAS)	Decentralized
Barto Hall	121,456	Housing	HHW - MTHW [140-160°F]	37	No	TBD	TBD
Discovery Hall	119,330	Academic	HHW - LTHW [<140°F]	60	No	AHU (VAV)	Both
Black Hall	105,000	Science	HHW - HTHW [>160°F]	74	Yes	AHU (VAV)	Centralized
Dugmore Hall	102,563	Housing	HHW - LTHW [<140°F]	29	No	FCU (DOAS)	Decentralized
Hogue Hall	95,996	Science	HHW - LTHW [<140°F]	83	No	AHU (VAV) w/DOAS	Centralized
Health Science Building	80,748	Science	HHW - LTHW [<140°F]	122	No	Chilled Beam (w/DOAS)	Decentralized
Dean Hall	79,095	Academic	HHW - HTHW [>160°F]	49	Yes	AHU (Dual Duct)	Centralized
Bouillon Hall	72,504	Administrative	HHW - LTHW [<140°F]	68	No	AHU (VAV)	Both
Wendell Hill Hall Building B	71,994	Housing	HHW - MTHW [140-160°F]	68	No	FCU (DOAS)	Decentralized
Mcintyre Music Building	68,920	Academic	HHW - HTHW [>160°F]	65	Yes	AHU (VAV)	Both
Wendell Hill Hall Building A	63,415	Housing	HHW - MTHW [140-160°F]	TBD	No	FCU (DOAS)	Decentralized
Barge Hall	53,441	Administrative	HHW - HTHW [>160°F]	22	No	AHU (VAV)	Both
Shaw-Smyser Hall	52,000	Academic	HHW - HTHW [>160°F]	64	No	AHU (VAV)	Both
Hebeler Hall	51,868	Academic	Steam-Direct	16	Yes	AHU (VAV)	Centralized
Mcconnell Hall	49,723	Academic	Steam-Direct	38	Yes	AHU (Single Zone)	Both
Kamola Hall	49,455	Academic	HHW - HTHW [>160°F]	48	No	FCU	Decentralized

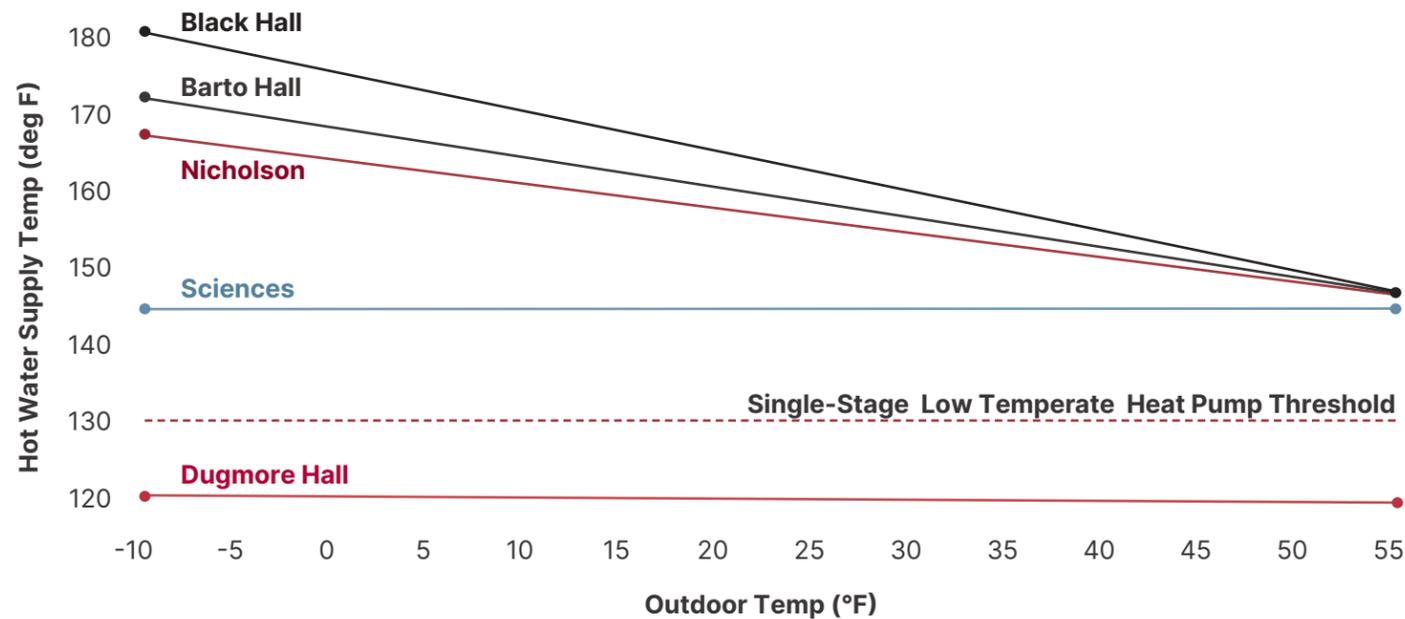
Existing Conditions | Heating System Operation

Heating Hot Water Temperatures

Heating hot water (HHW) supply temperatures are a key consideration when decarbonizing, as the temperatures have a direct impact on the viability of heat pump technologies. Current single-stage heat pump technology is best suited for HHW supply temperatures around 120°F-130°F. Temperatures above this ideal range will most likely require high temperature heat pumps (which are an emerging technology) or dual stage heating. This is explained in greater detail in the “Decarbonized Solutions” section of this report.

Currently many buildings on campus exceed this ideal threshold at low outdoor air temperatures. The graph below shows a sample of HHW temperatures trended on the building automation system from early 2024. At the coldest outside air temperature only one of the buildings sampled falls below the threshold. Three buildings show a reset schedule allowing for lower temperature hot water when outside air temperatures increase. The other two buildings show constant HHW supply temperatures.

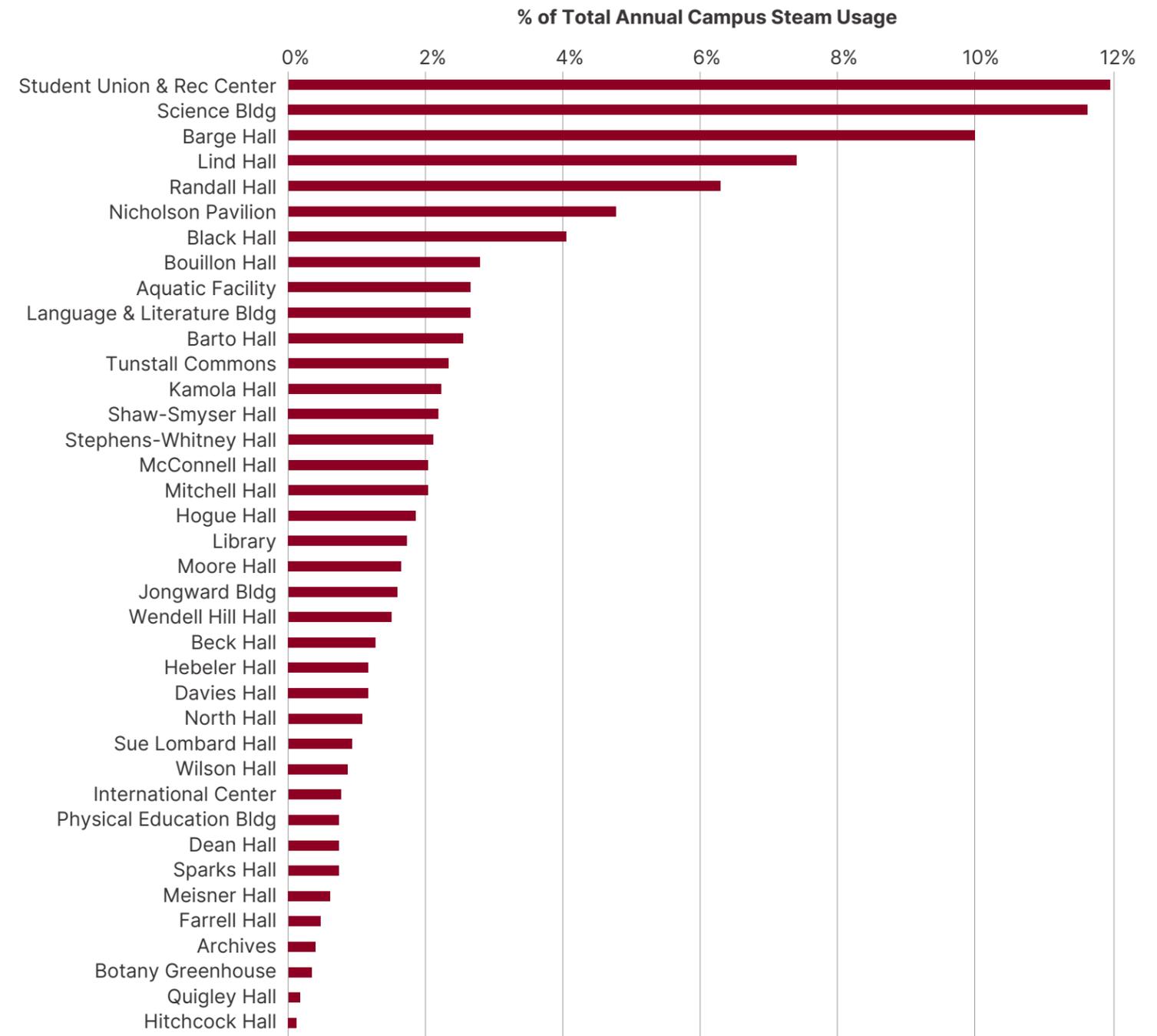
The next phase of this project will more deeply evaluate HHW temperatures to determine decarbonization viability. Buildings that can reduce their peak HHW temperature on the coldest days, and still meet building heating demands, will be the easiest to decarbonize. Based on these findings, buildings will be classified into categories to determine decarbonization priority and extent of mechanical system retrofit needed.



High Steam Users

Buildings with the highest steam use are shown in the graph to the right. In some cases, high steam use is a function of the building use. For example, the Science building has higher steam demands due to process loads and high outside air requirements. In other cases, buildings may have high building loads due to inefficient systems or issues with condensate meters.

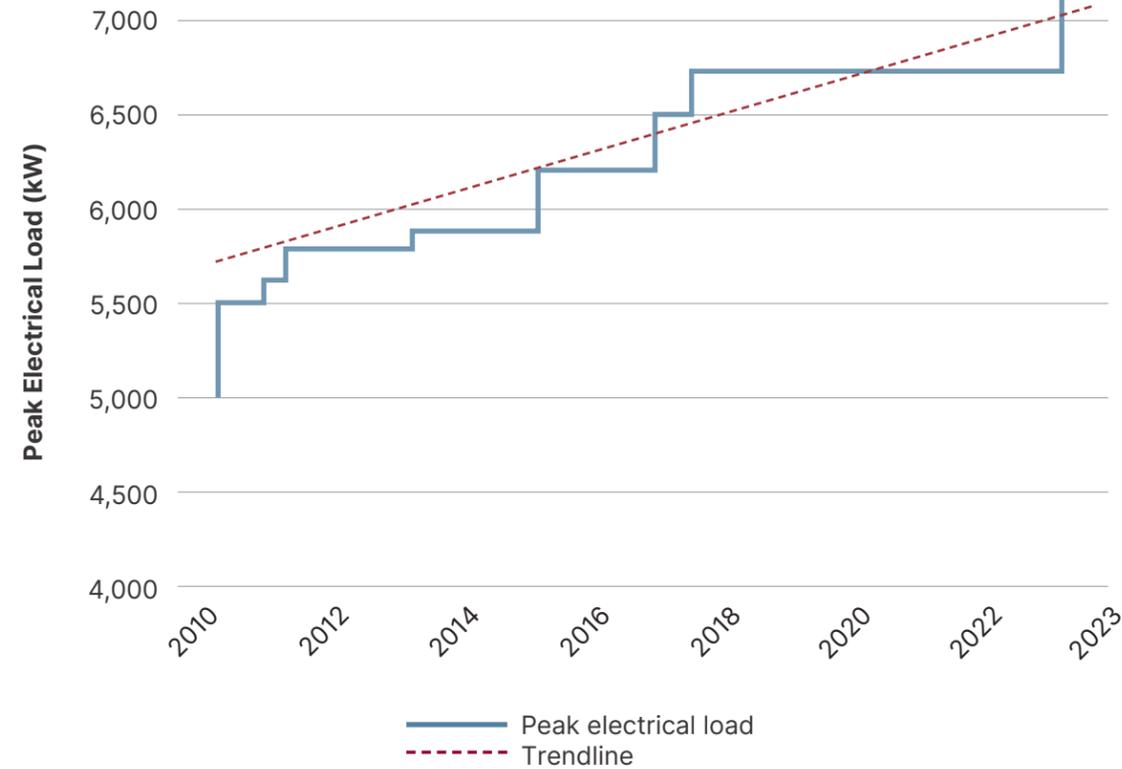
Buildings with high steam use that aren’t attributed to a higher intensity use (e.g., science buildings, natatoriums, etc.) should be targeted for implementation of in-building energy efficiency measures. This graph uses weekly steam condensate data.



Note: Some buildings are showing zero heating energy, and are not shown on this graph. These discrepancies are being evaluated as part of the metering scope and will be addressed in the next phase of the project.

Existing Conditions | Electrical Systems

Campus Peak Electrical Load



Electrical Key Takeaways

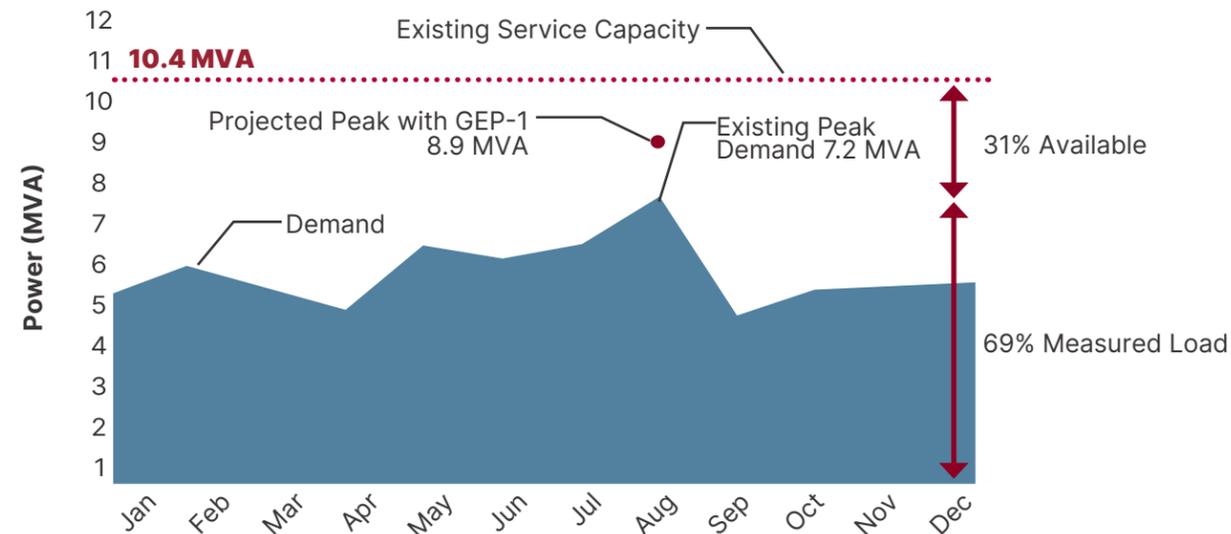
Since the CWU decarbonization plan will rely heavily on electrification, understanding existing campus electrical infrastructure and its capacity for future growth is essential. At a high level, key takeaways include:

- The existing campus peak demand (7.2 MVA) is 70% of existing capacity. This will most likely increase to 80% with the addition of GeoEco Plant 1.
- CWU's electrical load has seen a modest and manageable increase over the past 10+ years.
- This electrification effort represents a significant load addition. The current electrical system will require new infrastructure to support the added load. This is discussed in the next section of this report.

Campus Electrical System

The electrical infrastructure at Central Washington University (CWU) is fed from three (3) 1200 Amp substations, each rated at 12.47kV. Substation 1 on Chestnut St, Substation 2 on Alder St and Substation 3 on Wildcat Way. Substations 1 and 3 contain primary service switchgear with a capacity of 1200A, with distribution switches rated for 600A that feed the campus loop. Substation 2 is fed from City of Ellensburg's (COE) Helena substation, but the feed is currently inactive due to equipment failures and the Helena substation not being dedicated for CWU's campus. During normal operation, COE feeds Substation 1 and Substation 3 from a single dedicated feeder, feeder #12, out of the City East Ellensburg Substation. For redundancy, COE has an additional dedicated feeder, feeder #9, that feeds Substation 3 out of COE's Dolarway Substation. This provides a fully redundant system, with dedicated feeders to CWU that have capacity for the current demand of CWU. Substation 3 feeds the existing heating and cooling plant, in addition to other campus building loads. Substation 1 is responsible for supplying the remainder of the campus building loads. There are four (4) feeders on campus that tie Substation 1 and 3 together and two (2) feeders on campus that tie Substation 1 and 2 together. Substation 1 and 3 each contain (2) utility meters for utility usage history and billing purposes.

Electrical Capacity Analysis



Capacity Analysis

The electrical load curve to the right was provided by COE and depicts a relatively modest growth, with a ~20% increase from 2010 to 2023. Electrical load has increased due to campus growth and the addition of new buildings. However, that electrical load growth was mitigated by implementing energy efficiency programs and replacing older buildings, which had higher energy use, with new energy efficient buildings. The 2023 combined peak demand between Substations 1 and 3 was 7.2 MVA.

The GeoEco Plant associated with the North Academic Complex (GEP-1) will be under construction soon. Per the electrical design drawings, GEP-1 has a total connected load of 2.4 MVA. According to COE, Substation 3 has adequate capacity, but Substation 1 is smaller and has limited capacity for additional load beyond GEP-1. Considering the information provided by COE, the existing capacity of these substations is calculated based on the existing 600A fuses in the Main Service Switchgear at 12.47kV. To maintain a fully redundant system, COE limits the capacity of their dedicated feeders to 80%, which limits the capacity of each dedicated feeder to 10.4 MVA. Assuming the new GEP-1 peaks at 70% of its connected load, bringing the plant online results in a spare capacity of 1.5 MVA. Based on this preliminary analysis, CWU's existing substations most likely cannot accommodate additional GEP's after GEP-1 is complete. This calculation conservatively assumes GEP-1's full load is additive to the existing peak demand. **Once GEP-1 is operational, a study should be performed to understand exact remaining capacity on both substations.**



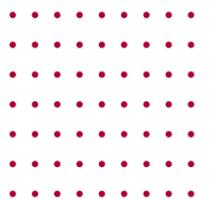
SECTION 3

Decarbonization Solutions



Key Takeaways

- The recommended decarbonized solution is an open-loop geothermal system with nodal GeoEco Plants and 4-pipe distribution.
- Options were compared qualitatively for the three main components of the campus energy system: heat sources and sinks, plant configuration, and distribution piping
- The recommended solution will increase the campus electrical load above the existing capacity. The electrical infrastructure will need upgrading eventually to accommodate this phased electrification.



Decarbonization Solutions | System Scoring

System Scoring Summary

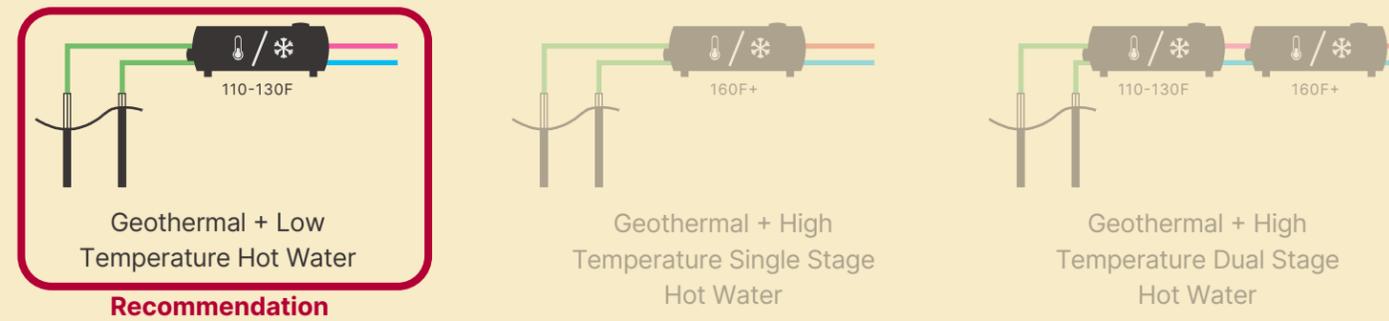
As described in the following pages, options were considered for three main system components: heat sources/sinks, plant configuration, and distribution piping. These are the three main components comprising a campus energy system, and each was considered individually to inform an integrated campus approach. For each system component, the options analysis answers a specific question:

Heat Sources and Sinks: How will CWU generate heating and cooling?

Plant Configuration: Where will those heating/cooling generating sources be located on campus and how many will there be?

Distribution Piping: How will that heating and cooling be conveyed from the generation point to the campus buildings?

Heat Sources & Sinks



Plant Configuration



Distribution Piping



System Scoring Criteria

Through discussion with CWU, the following key priorities and weighting were established to rank the various decarbonized system components. While many criteria are self-explanatory (e.g. first cost), the below criteria require explanation.

Carbon Cost Effectiveness: the amount of carbon reduced per first cost dollar spent. Higher carbon cost effectiveness implies a better “bang for buck”.

Teaching/Curriculum Opportunity: the ability of the decarbonized system to be a showcase for the campus community to view and engage with.

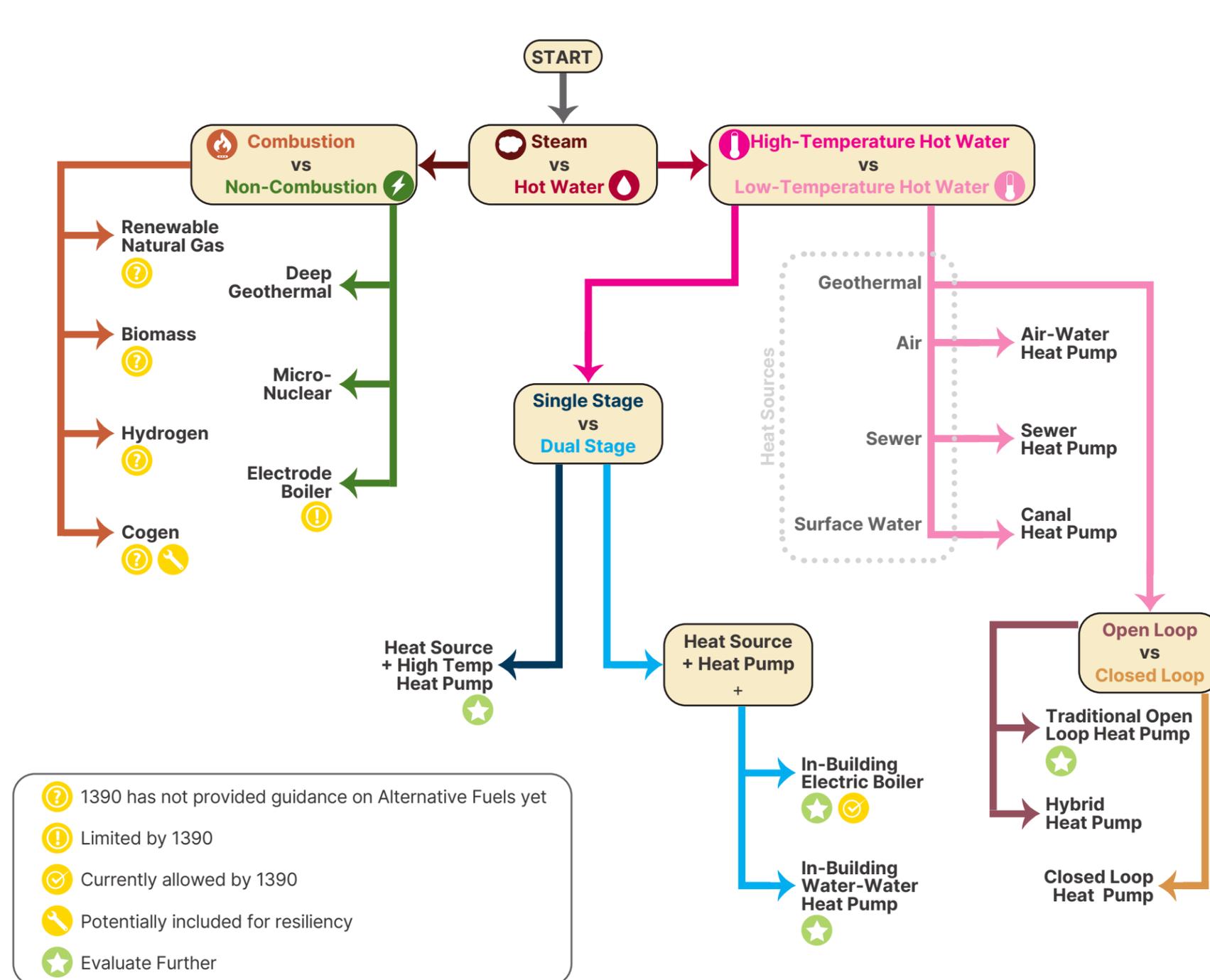
Impact on Utility: replacing fossil fuel heating with electric heating will have a large impact on the utility. Systems that reduce that impact score more favorably.

Scoring Variable	Weighting
First Cost	5%
Utility Cost	10%
Maintenance Cost	25%
Carbon Cost Effectiveness	15%
Resiliency	20%
Teaching/Curriculum Opportunity	5%
Impact on Utility	20%

Decarbonization Solutions | Heat Sources & Sinks Options

System Considerations

The heat source/sink is the core of a mechanical system, as this is where heating and cooling are generated. This is also the crux of decarbonization; the existing mechanical system uses fossil fuels to generate heating, whereas a decarbonized system does not. Given the clean power provided to the City, which is predominately produced by hydropower, electrification of the heating plant is a key consideration for decarbonization. However, this is not the only consideration, and the project team began by considering all options. The flowchart below summarizes the brainstorming effort, and a full list of options is included in the appendix. **Open loop geothermal is recommended, as it is a cost-effective decarbonized system.**



Hot Water

- Viable path to decarbonization.
- Significantly improved efficiencies and heat recovery opportunities.
- Typically will require distribution infrastructure upgrades and may require building-level system upgrades.

High-Temperature Hot Water (HTHW):

- Most existing CWU buildings currently operate with HTHW.
- Does not require upgrades to existing HTHW in-building mechanical systems.
- Requires either two-stage heating systems, or high temperature heat pumps, which are an emerging technology.

Low-Temperature Hot Water (LTHW):

- Lowest amount of mechanical plant equipment needed.
- Minimal in-building retrofits needed if systems can accommodate lower temperatures. If not, this may require significant in-building upgrades. Requires upgrades to all steam or HTHW building-level systems.
- Easy to design for new construction buildings.

Steam

- No viable path to HB 1390 compliance as rules are currently written.
- Can leverage existing distribution infrastructure and meet steam process or humidification demands.
- Inefficient production and difficult to decarbonize.
- Regardless of the outcome of this plan, the steam system will be maintained for resiliency and backup.

Combustion:

- Could reuse some or all of existing boiler plant infrastructure.
- Alternative fuels can be difficult and expensive to procure, with large storage space requirements.

Non-Combustion:

- Carbon-free
- Most technologies are still emerging at this scale. (e.g. micro-nuclear)
- Electric resistance heating is limited to only 10% by HB 1390.
- Deep geothermal is possibly feasible, but requires further study and would most likely have a large first cost.

Decarbonization Solutions | Geothermal Considerations

Geothermal Considerations

Preliminary hydrogeologic models developed in 2022 were revisited to identify and screen wellfield design alternatives to supply the range of nodal central utility plants currently under consideration. The results from the past models for wellfield yield and design (depth, diameter, and spacing of wells, water levels, etc.) were used to screen potential locations for new nodal plants and determine likelihood of meeting target yields from the ground-source heat pump (GSHP) system.

Note: A test well is being drilled on campus in the coming months. Results from that well will be used to validate geothermal viability.

Findings:

- 1 The Site is underlain by an aquifer referred to as the upper Ellensburg Formation. Within the upper Ellensburg Formation, there are expected to be a 'shallow' (e.g., 300-600 feet) and 'deep' (e.g., 800-1,000 feet) sand and gravel production zones.
- 2 A preliminary investigation of water right and Underground Injection Control (UIC) program requirements suggests that an open-loop system could successfully be permitted at the Site.
- 3 Overall, this study identified favorable conditions for a high capacity open-loop GSHP wellfield at the Site. Preliminary modeling suggests that campus-wide heating and cooling loads could be met through several "nodal systems" right sized to the energy loads of the facilities served, or a high-yielding wellfield centered around a campus-wide central utility plant. Preliminary locations for nodal GSHP wellfields are shown in the appendix of this report.
- 4 In the next phase of this project, modeling and analysis of groundwater and heat flux will consider heating and cooling loads for respective nodal systems to develop location-specific recommendations for wellfield design.

Alternatives:

Open-loop wellfield alternatives include nodal systems (i.e., several supply and return well pairs serving multiple buildings) and a centralized wellfield system. Results from the existing models suggest that a centralized wellfield would require 8 paired supply and return wells (16 total wells) centered around a central utility plant. Due to the large infrastructure requirements, the centralized wellfield alternative was not retained in the analysis. Nodal GSHP wellfields and utility plants were retained, and location alternatives were considered.

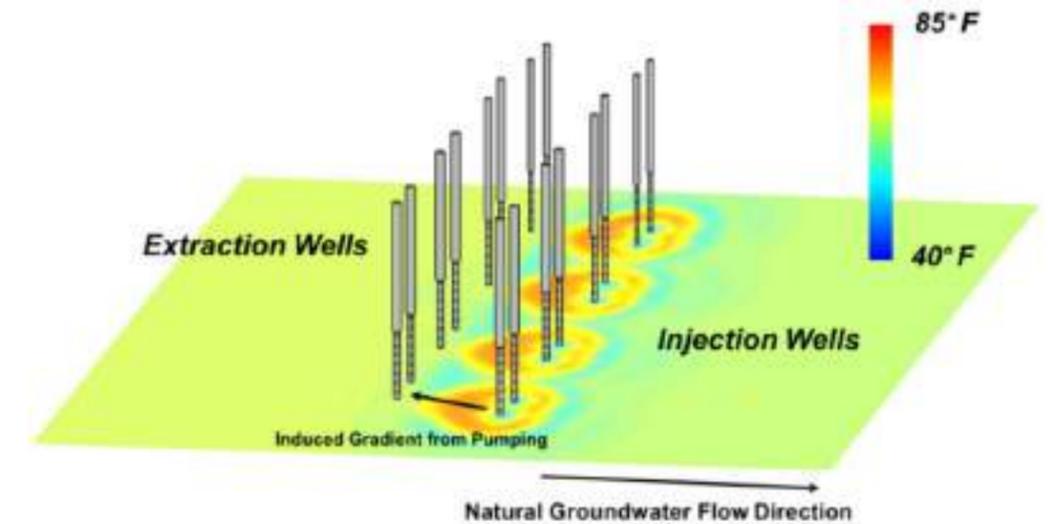
Multiple wellfield construction alternatives were identified for further consideration in the next phase of this project. Supply and return wells can be completed in the 'shallow' (e.g., 300-600 feet deep) or 'deep' (e.g., 800-1,000 feet deep) aquifer zones. Deeper wells are expected to have higher yields as they penetrate a greater number of water-bearing units, but construction and maintenance costs are greater. Wells and well pairs may be completed in the shallow aquifer, deep aquifer, or a combination thereof, depending on desired yield and well spacing and subject to permitting constraints.

Modeling and preliminary well siting completed to-date suggests that wells should be spaced a minimum of 700 feet apart. Well spacing and completion depths will be evaluated through additional modeling and analysis in the next phase of this project.

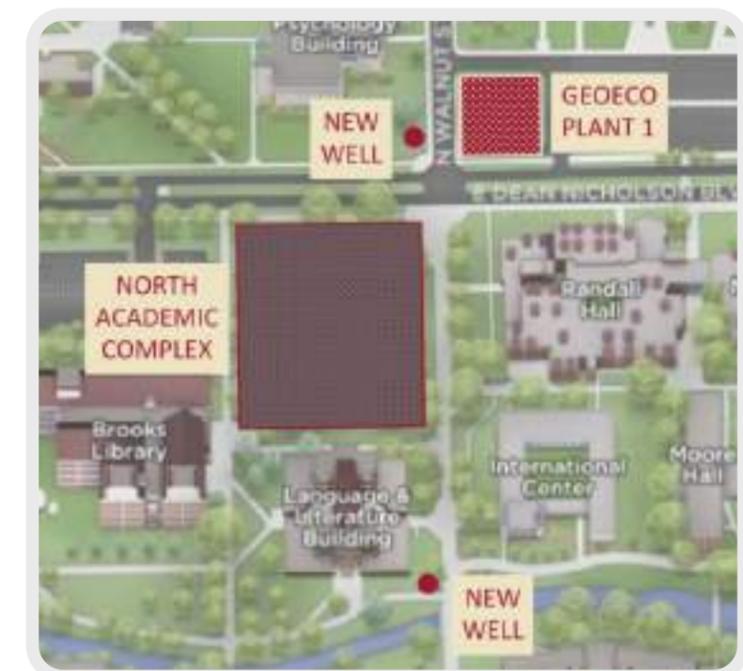
Buildout Considerations:

CWU is currently planning to drill and test an initial well to support the GSHP system at the North Academic Complex (pictured right) which should be used to support design for subsequent drilling efforts. Under the nodal GSHP system alternative, each system can begin construction with a single pair of supply and return wells, with additional wells installed as demand increases. The most important considerations for phasing are: (1) that well diameters and depths are large/deep enough to accommodate future increases in pump capacity; (2) that wells are properly spaced to ensure that interference doesn't occur as production increases in the future; and (3) that wells are properly oriented relative to the groundwater flow direction to maximize thermal attenuation.

Further details related to well construction and cost considerations are summarized in detail in the appendix of this report. These considerations will be further evaluated and discussed under the next phase of work as nodal GeoEco Plants are developed.



Hydrogeologic model showing impact of potential wellfield



GeoEco Plant 1 and Associated Wells

Decarbonization Solutions | Heat Sources & Sinks Criteria Scoring

	EXISTING SYSTEM	GEOTHERMAL + LOW TEMPERATURE HEATING HOT WATER (LTHW)	GEOTHERMAL + HIGH TEMPERATURE SINGLE STAGE HEATING HOT WATER	GEOTHERMAL + HIGH TEMPERATURE DUAL STAGE HEATING HOT WATER	DECARBONIZED STEAM
DESCRIPTION	Gas-fired steam boilers	Open loop geothermal with water-to-water heat pumps providing 110-130°F hot water.	Open loop geothermal with single high-temp heat pump providing 160°F+ hot water.	Open loop geothermal with two heat pumps. The first provides 110-130°F hot water and the second boosts the temperature up to 160°F+.	Electric boilers or boilers using alternative fuels (e.g. hydrogen, renewable natural gas) provide steam to existing systems.
SYSTEM DIAGRAM					<p>As it is currently written, HB 1390 only allows for 10% of annual heating to be provided by gas or electric resistance, which are currently the only two market-ready steam sources available. Thus, this is not a viable option. If 1390 changes the 1390 requirement, or allows for alternative fuels (e.g. biomass, hydrogen), then this option could be reconsidered.</p>
FIRST COST	—	\$\$\$\$\$	\$\$\$\$\$	\$\$\$\$\$	
UTILITY COST	—	\$\$\$\$\$	\$\$\$\$\$	\$\$\$\$\$	
MAINTENANCE COST	—	\$\$\$\$\$	\$\$\$\$\$	\$\$\$\$\$	
CARBON COST EFFECTIVENESS	—	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	
RESILIENCY / REDUNDANCY	—	🔧🔧🔧🔧🔧	🔧🔧🔧🔧🔧	🔧🔧🔧🔧🔧	
TEACHING / CURRICULUM OPPORTUNITY	—	🎓🎓🎓🎓🎓	🎓🎓🎓🎓🎓	🎓🎓🎓🎓🎓	
ABILITY TO REDUCE IMPACT ON UTILITY	—	⚡⚡⚡⚡⚡	⚡⚡⚡⚡⚡	⚡⚡⚡⚡⚡	
ADVANTAGES	<ul style="list-style-type: none"> Existing state- no modifications required 	<ul style="list-style-type: none"> Better cost/ton Builds on existing LTHW infrastructure Fewer pieces of equipment 	<ul style="list-style-type: none"> Fewer pieces of equipment Avoids potentially expensive in-building retrofits 	<ul style="list-style-type: none"> Avoids potentially expensive in-building retrofits 	
DISADVANTAGES	<ul style="list-style-type: none"> High carbon footprint Doesn't comply with 1390 	<ul style="list-style-type: none"> Might require some substantial building retrofits to convert to LTHW 	<ul style="list-style-type: none"> High temperature heat pumps are an emerging technology 	<ul style="list-style-type: none"> High first cost High O&M costs 	
OVERALL SCORE	—	4.15	3.10	1.60	

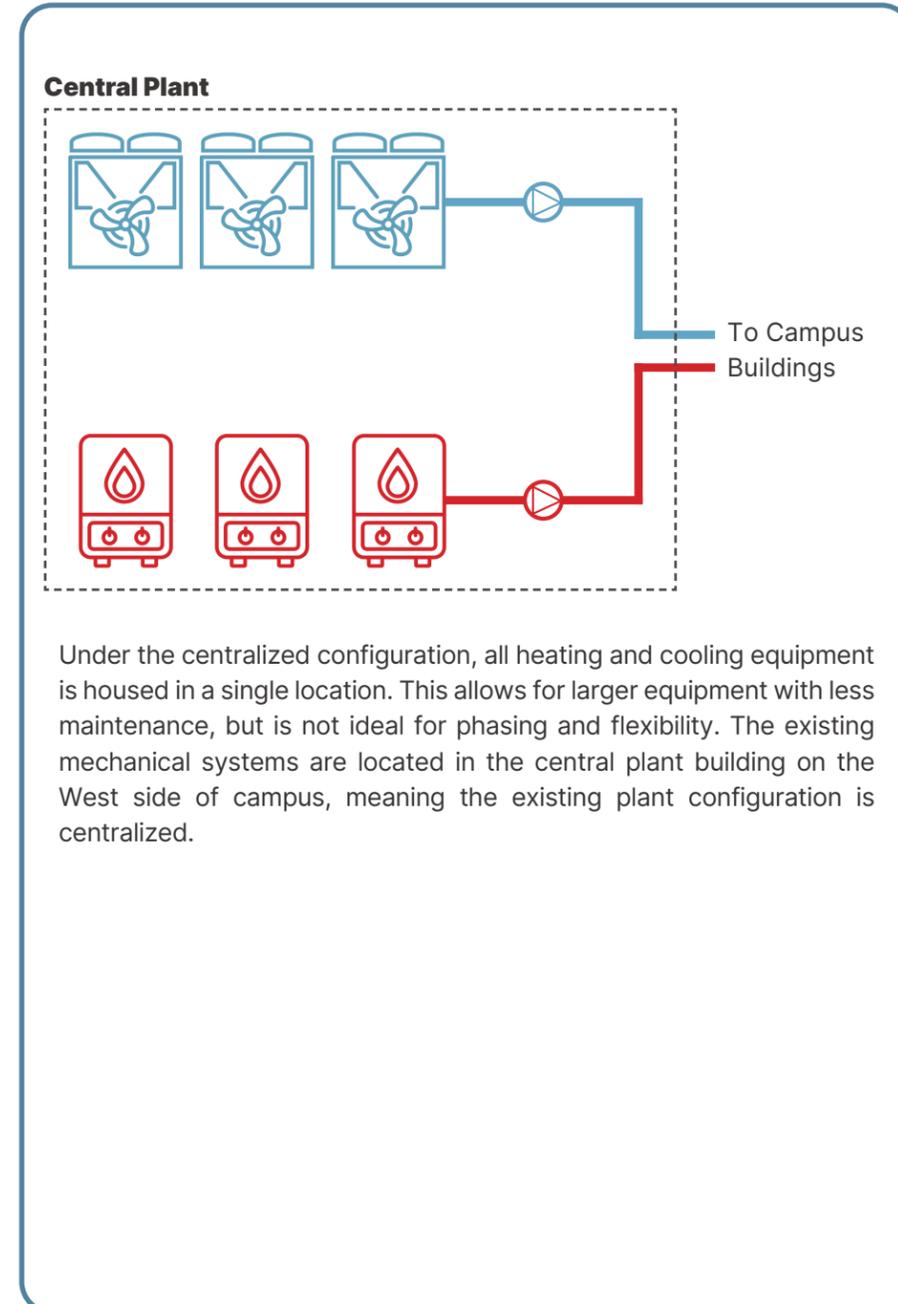
VERDICT While low temperature is the best-scoring option, most likely the recommended solution will employ a mix of these options. This depends on the operating conditions of in-building heating systems, as some buildings may need extensive retrofit to accommodate a low temperature heating system. This will be evaluated further in the next phase of this project.

Decarbonization Solutions | Plant Configuration Options

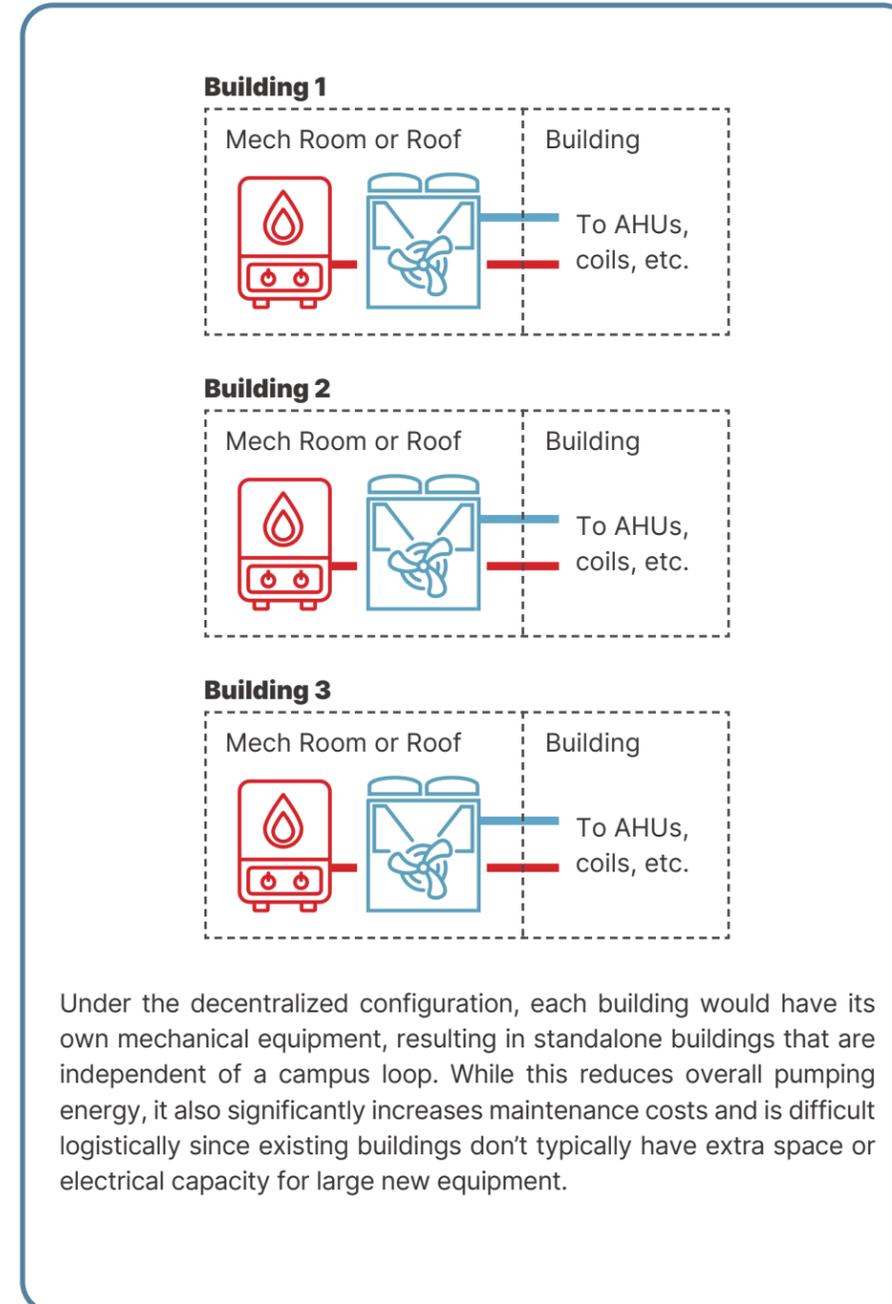
Plant Configuration Considerations

The plant configuration dictates where the primary mechanical equipment is located and how many pieces of equipment comprise the system. The notable trade-offs between options include maintenance, phasing, and space requirements. The existing system on campus contributes to the recommendation for CWU, as it is difficult to go from a fully centralized system to a decentralized system. **The nodal system is recommended, as it is the most flexible for phasing, and has the best mix of resiliency and maintenance costs.**

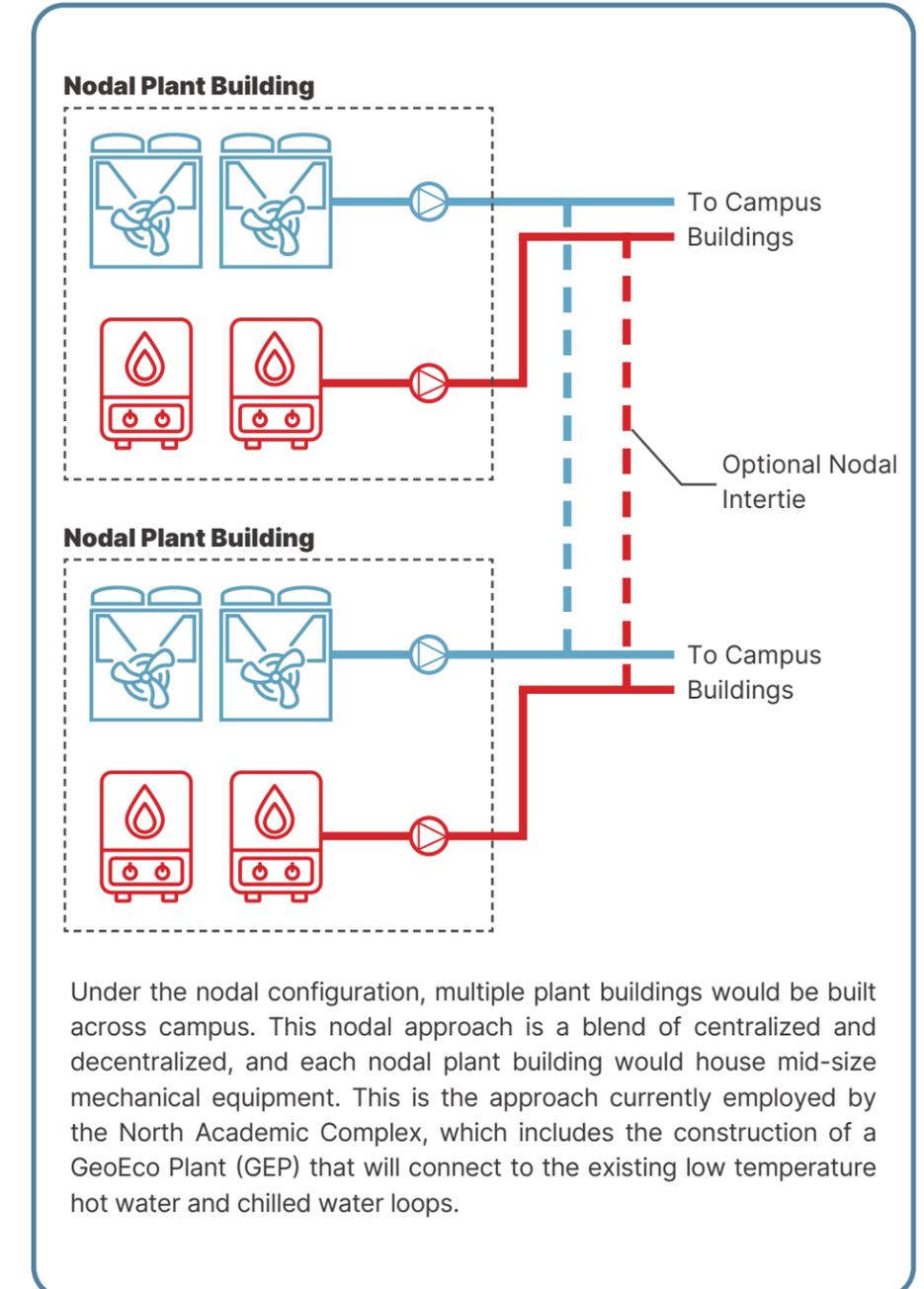
Centralized



Decentralized



Nodal



Decarbonization Solutions | Plant Configuration Criteria Scoring

	EXISTING SYSTEM	CENTRALIZED	DECENTRALIZED	NODAL
DESCRIPTION	Centralized	Most similar to the existing central plant configuration, with all major mechanical equipment located in one central location.	Major pieces of mechanical equipment (i.e. water-to-water heat pumps, air-source heat pumps) at each building to make hydronic heating water and chilled water at the building level.	Multiple "nodal" plants, each with major mechanical equipment, spread across campus. This is the current strategy employed by the first GeoEco plant. There are currently (2) nodal plants funded, with potentially (3-5) additional plants needed.
ADAPTABILITY WITH EXISTING PIPING CONFIGURATION AND PLANS FOR GEOECO PLANTS	—	MEDIUM - While this would be a shift away from the current GeoEco strategy, it would still be well-adapted to the current chilled water and low-temperature hot water piping.	LOW - The existing chilled water distribution piping is not adaptable to this configuration and would be rendered obsolete.	HIGH - This is in-line with the current GeoEco strategy and is also well-adapted to the current chilled water and low-temperature hot water piping.
FIRST COST	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$
UTILITY COST	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$
MAINTENANCE COST	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$
CARBON COST EFFECTIVENESS	—	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂
RESILIENCY / REDUNDANCY	—	🔧 🔧 🔧 🔧 🔧	🔧 🔧 🔧 🔧 🔧	🔧 🔧 🔧 🔧 🔧
TEACHING / CURRICULUM OPPORTUNITY	—	🎓 🎓 🎓 🎓 🎓	🎓 🎓 🎓 🎓 🎓	🎓 🎓 🎓 🎓 🎓
ABILITY TO REDUCE IMPACT ON UTILITY	—	⚡ ⚡ ⚡ ⚡ ⚡	⚡ ⚡ ⚡ ⚡ ⚡	⚡ ⚡ ⚡ ⚡ ⚡
ADVANTAGES	<ul style="list-style-type: none"> High load density delivery Existing state- no modifications required 	<ul style="list-style-type: none"> Less maintenance Fewer wells Reduced well maintenance Reduced infrastructure costs Doesn't require new mechanical plant buildings across campus 	<ul style="list-style-type: none"> Doesn't require new or modified distribution piping 	<ul style="list-style-type: none"> Ideal for phasing Flexible to evolving campus plans Lower conveyance piping costs for geothermal Lower likelihood of overdesigning wellfields
DISADVANTAGES	<ul style="list-style-type: none"> High energy cost High maintenance cost High carbon footprint Doesn't comply with 1390 	<ul style="list-style-type: none"> Higher piping costs for geothermal Less redundancy / resiliency Harder to phase, resulting in larger capital requests New hot water distribution piping has high impact to campus 	<ul style="list-style-type: none"> More maintenance No heat sharing Higher O&M costs Space constraints in buildings 	<ul style="list-style-type: none"> More maintenance than central system High impact to campus: requires new mechanical plant buildings and new hot water distribution piping
OVERALL SCORE	—	4.05	1.90	4.25

Decarbonization Solutions | Distribution Piping Options

Distribution Piping Considerations

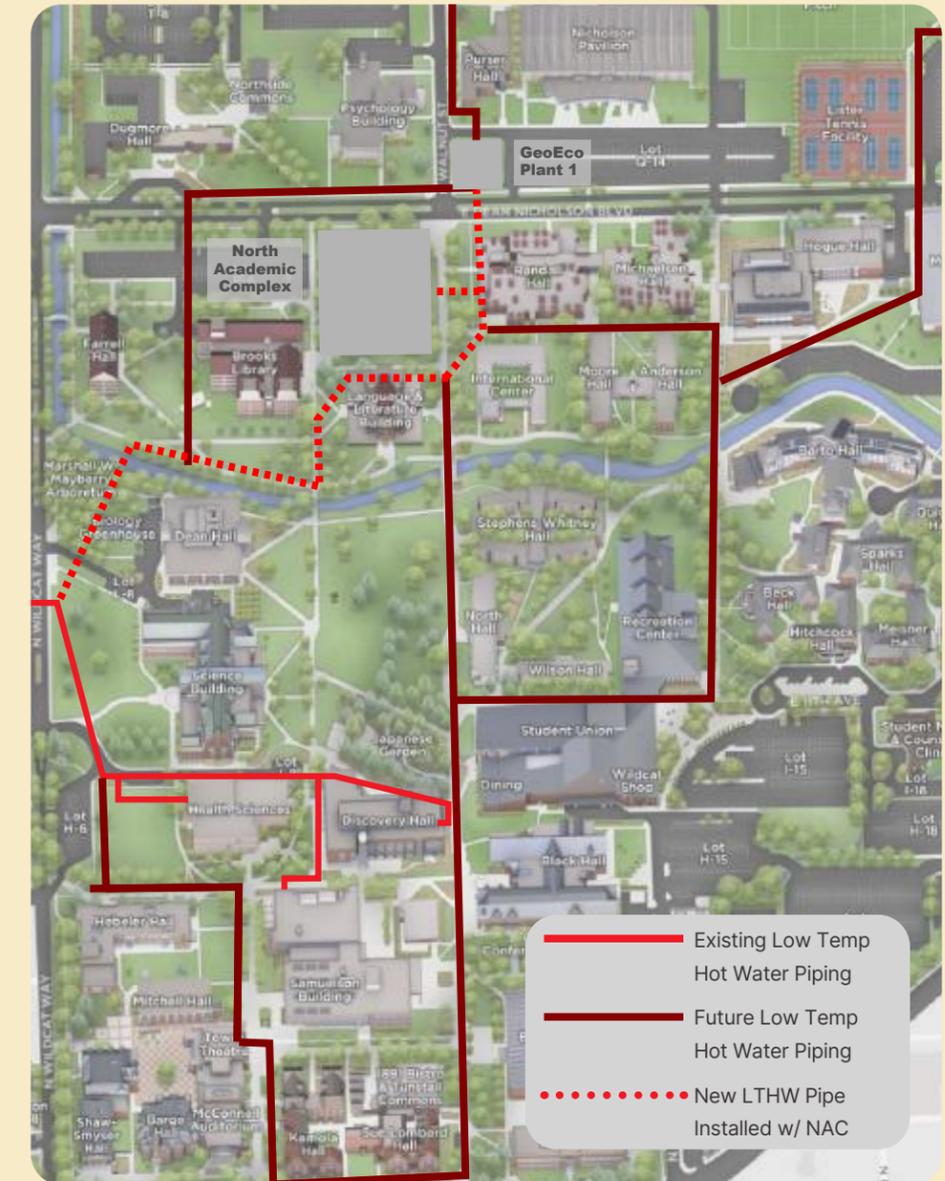
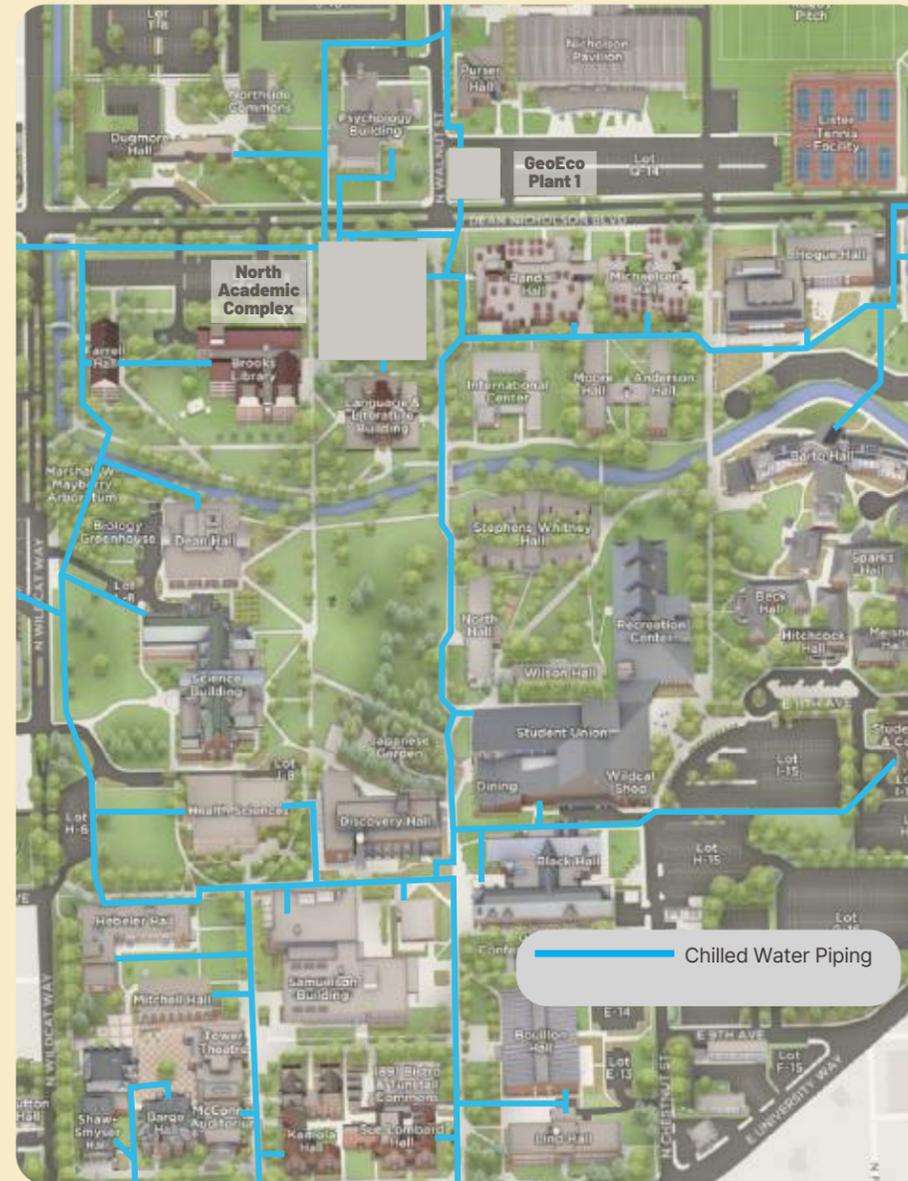
The distribution piping dictates how the heating and cooling are distributed across campus to the connected buildings. While distribution options are being considered on their own on this page and the next, they are closely linked to plant configuration, as described below. In addition, the existing piping configuration plays a big role in the recommendation for CWU, since burying distribution piping is capital intensive and interrupts campus operations. **The 4-pipe system is recommended, as it integrates well with the existing mechanical and piping systems. It reuses the existing chilled water distribution piping, and also builds on the existing low temperature hot water loop.**

4-Pipe

This piping option employs (2) pipes for chilled water and (2) for low temperature hot water (LTHW). This is similar to the existing piping, which currently has 2 pipes of steam, and 2 pipes of chilled water to serve the majority of the campus. In addition, 2 pipes of low temperature hot water currently serve three buildings. This option would reuse existing chilled water piping, and would expand the existing low temperature hot water piping, as shown in the campus maps to the right.

2-Pipe

This piping option employs an “ambient” loop, also known as a “condenser water” loop. As opposed to chilled water (typically ~44°F) and hot water (typically 120°F+), the ambient loop circulates water at approximately 60°F-80°F year-round. Heating/cooling are provided from the loop via compressor-driven heat pumps in individual buildings or at nodal plant buildings. While 2-pipe is a good solution when building a brand new system, it’s applicability to CWU’s campus is limited by the existing central systems and buildings. A decentralized configuration is most likely not feasible given electrical, structural, and space constraints in the existing buildings. In addition, a 2-pipe system is not compatible with a centralized plant configuration. Thus, a nodal plant configuration is the only viable option. However, to adapt to a nodal plant configuration new ambient loop piping would need to be installed. While this would add some resiliency and heat sharing capability, the added cost and complexity of the additional piping would negate these benefits, meaning this system is not recommended for CWU.



Note: these maps are highly conceptual, and will be refined in the next phase of this study. The steam piping is not shown for clarity, but it could still be maintained for resiliency, providing a redundant heating source.

Decarbonization Solutions | Distribution Piping Criteria Scoring

	EXISTING SYSTEM	2-PIPE	4-PIPE	STEAM
DESCRIPTION	4-Pipe: (2) Steam and (2) Chiled Water	This system would employ an “ambient” loop, which would circulate water around campus at approximately 60-80°F year-round, to provide heating and cooling to campus.	This system would employ (2) heating hot water pipes and (2) chilled water pipes to provide heating and cooling to campus.	This system would employ (1) steam supply and (1) steam condensate pipe and (2) chilled water pipes to provide heating and cooling to campus. As it is currently written, HB 1390 only allows for 10% of annual heating to be provided by gas or electric resistance, which are currently the only two market-ready steam sources available. Thus, this is not a viable option. If 1390 changes the 1390 requirement, or allows for alternative fuels (e.g. biomass, hydrogen), then this option could be reconsidered.
ADAPTABILITY WITH EXISTING PIPING CONFIGURATION AND PLANS FOR GEOECO PLANTS	—	LOW - Existing steam & chilled water would be obsolete. Depending on the placement of the building-side mechanical system, the low temperature hot water loop could likely be reused.	MEDIUM - Would add new heating hot water piping to expand the low temperature hot water loop. The existing chilled water piping would be reused.	
COMPATIBLE HEAT SOURCE & SINK OPTIONS	—	Either a geothermal system or boilers/air-source heat pumps	Either a geothermal system or a traditional chiller/boiler	
COMPATIBLE PLANT CONFIGURATIONS	—	Either decentralized or nodal	Either centralized or nodal	
FIRST COST (PIPING ONLY)	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	
UTILITY COST	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	
MAINTENANCE COST	—	\$ \$ \$ \$ \$	\$ \$ \$ \$ \$	
CARBON COST EFFECTIVENESS	—	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	CO ₂ CO ₂ CO ₂ CO ₂ CO ₂	
RESILIENCY / REDUNDANCY	—	🔧 🔧 🔧 🔧 🔧	🔧 🔧 🔧 🔧 🔧	
TEACHING / CURRICULUM OPPORTUNITY	—	🎓 🎓 🎓 🎓 🎓	🎓 🎓 🎓 🎓 🎓	
ABILITY TO REDUCE IMPACT ON UTILITY	—	⚡ ⚡ ⚡ ⚡ ⚡	⚡ ⚡ ⚡ ⚡ ⚡	
ADVANTAGES	• Takes advantage of existing infrastructure	• Simple piping configuration	• Takes advantage of existing infrastructure	
DISADVANTAGES	• High Maintenance • Doesn't comply with 1390 • Inefficient due to line thermal losses	• Requires new piping across campus • Renders much of the existing infrastructure obsolete	• Requires new piping across campus	
OVERALL SCORE	—	3.30	3.45	

Decarbonization Solutions | Electrical System Impacts

Electrical Key Takeaways

This electrification effort represents a significant load addition that will impact the campus electrical system. Key takeaways include:

- **Preliminary estimates suggest the load could increase by up to 18 MVA** once the 15 year transition to electric heating is complete. This is a preliminary conservative estimate that will be refined in the next phase of this project.
- The existing electrical system will require new infrastructure to support the added load.
- Utility coordination is under way to plan for this total future load, as well as the phasing plan over 15 years.

Electrical Impacts

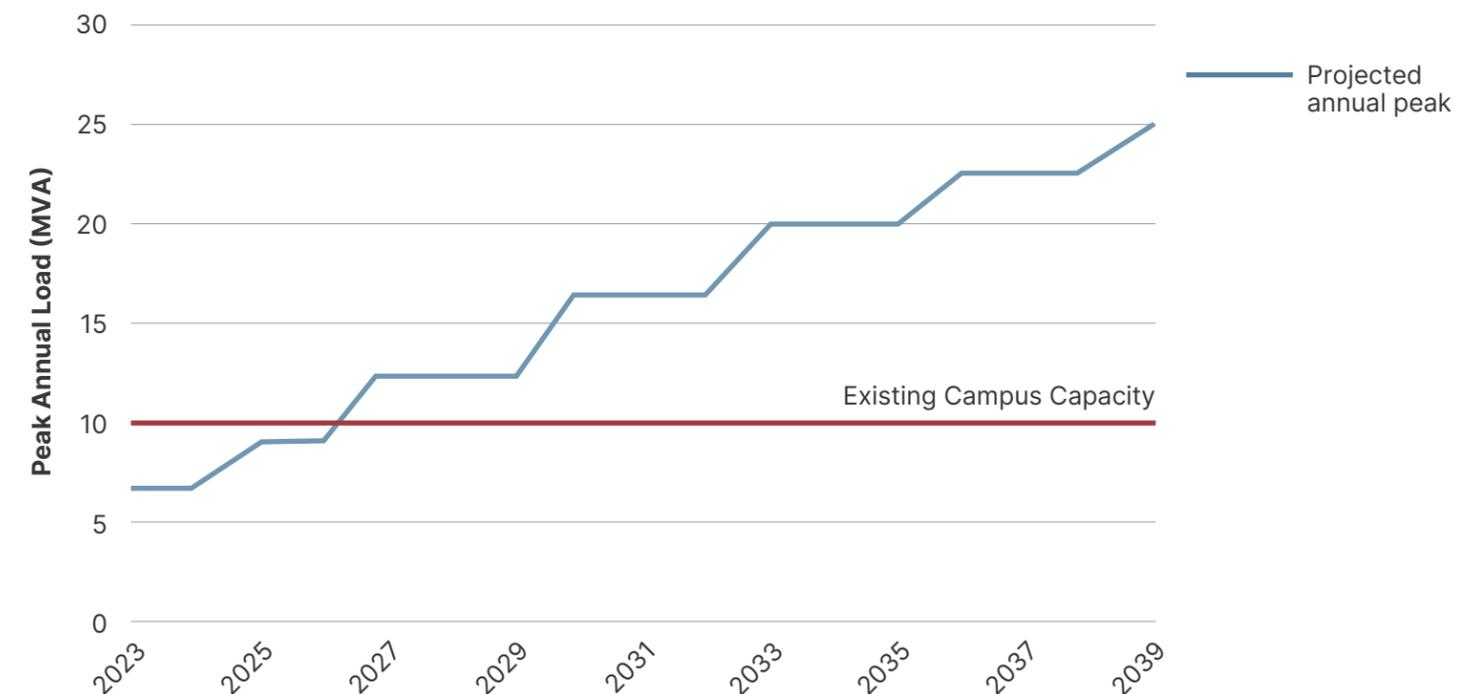
In addition to GeoEco Plant 1 (GEP-1), which is part of the North Academic Complex project, the preliminary decarbonization plan needs up to five added GEP's. The size and quantity of the additional plants will be further evaluated in the next phase of this project. The table below shows the preliminary loads associated with each GEP. The values are based on the electrical schedules and added loads from the GEP-1 project. GEP-2/3/4 are preliminarily 150% the size of GEP-1, while GEP-5/6 are equal to GEP-1. **Note: These numbers are preliminary and conceptual. The sizes of the injection and extraction well pumps are significant and are currently TBD, as they are dependent on the result of the test well. In addition, the below numbers represent the peak installed electrical capacity; the actual peak demand load will most likely be ~75% of the installed load. This will be refined in the next phase of this project.**

GeoEco Plant	Year Online*	Added Load (MVA)
GEP-1	2025	2.4
GEP-2	2027	3.7
GEP-3	2030	3.7
GEP-4	2033	3.7
GEP-5	2036	2.4
GEP-6	2039	2.4
Total Added Load		18.2

*It is currently assumed CWU will receive funding for a new GeoEco Plant every 2-3 years for the next 15 years. These assumptions will be further vetted in the next phase of this project.

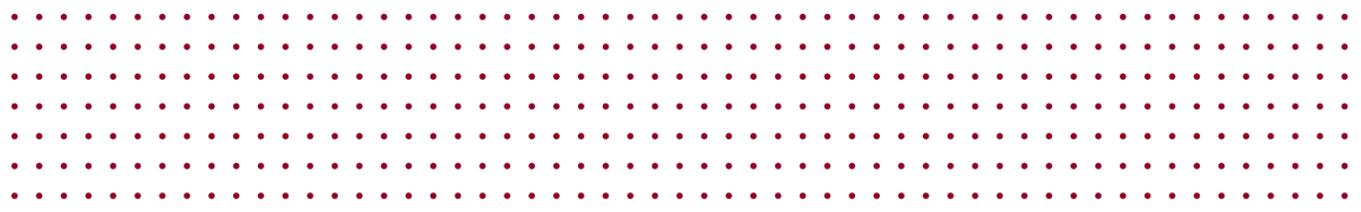
Utility Coordination

As the plan is developed, these added electrical loads are being reviewed with the City of Ellensburg (COE) utility. In a preliminary review meeting with COE, they proposed several potential solutions to serve the added load. To increase capacity the main options entail either 1) adding a third dedicated feeder to an existing substation or 2) constructing a new substation dedicated to these future loads. The City is currently constrained by Bonneville Power Administration's (BPA) limits and the capacity of the transmission lines serving the area. Ellensburg is experiencing a high volume of power requests at single delivery points, which is affecting their ability to meet customer demands. To address this, the city must evaluate which demands align best with community interests, economic growth, and resilience. This evaluation will guide the integration of the project into a long-term strategic plan for the city. These loads will be further coordinated with COE in the next phase of this project.



The graph above depicts the growth in electrical load as the electrified mechanical system is phased over the next 15 years. It is currently assumed CWU will receive funding for a new GeoEco Plant every 2-3 years for the next 15 years. These assumptions will be further vetted in the next phase of this project.

Note: this does not account for load reductions due to energy efficiency and eventually phasing out the existing chillers.



Appendices

APPENDIX A:

Executive Summary - Carbon Intensity Factors

APPENDIX B:

Executive Summary - Campus Engagement Plan

APPENDIX C:

Campus Existing Conditions - Campus Maps

APPENDIX D:

Decarbonization Solutions - Heat Source & Sink Initial Filtering

APPENDIX E:

Decarbonization Solutions - Potential Nodal Plant Map

APPENDIX F:

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APPENDIX G:

Decarbonization Solutions - Geothermal Considerations

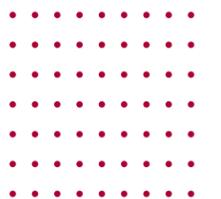
APPENDIX H:

Decarbonization Solutions - Environmental Justice Considerations



APPENDIX A

Executive Summary - Carbon Intensity Factors



Appendix A | Executive Summary - Carbon Intensity Factors

Background

Carbon emissions from natural gas and electricity are calculated using a carbon intensity factor. This factor represents the amount of carbon emitted per unit of energy produced. A lower carbon intensity factor is better, as it means less carbon is emitted to produce energy. The below values are used for calculating annual carbon emissions:

Natural Gas: 11.6 lb/Therm
Electricity: 0.037 lb/kWh

Natural Gas Carbon Intensity Factor

This is the industry-accepted carbon intensity factor for natural gas. It is the factor used for Department of Ecology reporting.

Electricity Carbon Intensity Factor

The concept of an electricity carbon intensity factor differs from that of natural gas, since electricity is produced thru a variety of means. The electricity carbon intensity factor is dictated by the sources used to create electricity, and varies widely across utilities, regions, and states. Sources that create electricity by burning fossil fuels, such as natural gas and coal, have high intensity factors while renewables, nuclear, and hydro have carbon intensity factors of zero. For the Decarb project, there are two electricity carbon intensity factors to consider:

1. City of Ellensburg (COE) Factor - 0.037 lb/kWh - this is the actual carbon emitted by the electricity supplied to CWU.
2. Washington State Average Factor - 0.4738 lb/kWh - this state average number is higher than COE since some utilities in the state have dirtier power.

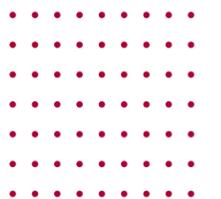
The State Average Factor is required for Department of Ecology reporting, so CWU annual reporting uses this factor. However, **the City of Ellensburg factor is used for this study and throughout this report, as it reflects the true carbon emitted by the systems within the scope of this decarbonization effort.** The table below shows the differences in reporting and intensity factors.

Report	Natural Gas Factor	Electricity Factor	Natural Gas Emissions	Electricity Emissions	Total Emissions
Decarb Plan	11.6 lb/Therm	0.037 lb/kWh	14,103 Metric Tons	717 Metric Tons	14,820 Metric Tons
Annual Dept of Ecology	11.6 lb/Therm	0.4738 lb/kWh	14,103 Metric Tons	8,484 Metric Tons	22,587 Metric Tons



APPENDIX B

Executive Summary - Campus Engagement Plan



CWU DECARBONIZATION PLAN

ENGAGEMENT APPROACH MEMO

Central Washington University (CWU) is developing a Decarbonization Plan to reduce CWU's GHG emissions, build community resilience through equitable strategies, and in alignment with efforts around the region.

Informing the community on decarbonization, and broader climate goals, will support the development of an implementable, accessible, and technically defensible plan. This Engagement Approach provides a **strategic framework for sharing out the Decarbonization Plan to CWU community and key stakeholders**.

This engagement approach is underpinned by a Just Transition framework— focusing on climate actions that most benefit underserved groups, improve access to services, and ensure equitable distribution of benefits, to enhance buy-in for planning outcomes and set communities up for more effective and equitable implementation post-planning.

Engagement Objectives

Through our engagement, we hope to educate the campus community on decarbonization planning efforts and convey the importance CWU campus community's role in decarbonization and broader climate planning efforts at Central. Specifically, our engagement objectives include:

- Share information on technical topics to create a general understanding of energy transitions and operational greenhouse gas emissions reductions.
- Bring students along on the planning process to enhance buy-in for planning outcomes and set the campus community up for more effective and equitable implementation post-planning.
- Encourage members of the campus community to share their values and priorities in regard to decarbonization strategies.

CWU has already conducted extensive engagement for the recent CAP planning effort, and we hope to further build upon this engagement and **pre-existing connection points** with the CWU campus community. This will help to avoid engagement fatigue.

Anticipated Concerns

- **Attendance** – participation in engagement activities to date indicates that campus-wide motivation to be a part of decarbonization-related conversations could use development, and that outside factors that may impact community members ability and/or desire to participate must be considered throughout planning and implementation.
- **Technical nature of topics impacting understanding** – the complexity of and jargon related to greenhouse gas emissions, decarbonization, and climate action planning must be considered during preparation and delivery of content to ensure these barriers do not impact community members' ability to comprehend these concepts.

Key Audiences

The following list includes key audiences to engage about the decarbonizations efforts as identified by the CWU project team. This is not an exhaustive list and will serve as a guide during outreach.

Audience & Description	Internal or external	Groups
Students <i>Current enrolled students at Central Washington University</i>	Internal	<ul style="list-style-type: none"> Student government, student-led environmental club & other RSOs, Wildcat Essentials Coalition, Equity Services Council,
Faculty + Staff <i>Current CWU faculty and staff, specifically Environmental Sciences</i>	Internal	<ul style="list-style-type: none"> Faculty champions, IT, Faculty Senate
Alumni <i>Previous CWU students and faculty</i>	External	<ul style="list-style-type: none"> Donors, recent graduates
City of Ellensburg <i>Key institutional partner</i>	External	<ul style="list-style-type: none"> Government staff who are working in sustainability and/or climate action for the City

PROPOSED ENGAGEMENT STRATEGY

We acknowledge that individuals and organizations within the key audience groups will vary in their understanding of decarbonization and climate action planning. To that end, we will strategically use engagement as a means to provide education and informational resources around the topic of decarbonization and connect with audiences around their priorities and concerns.

A combination of **digital and in-person engagement** will be the primary methods for engaging the campus community. Below are proposed strategies for digital and in-person engagement to reach students and stakeholders.

Sustainability Forums

Through CAP engagement, the CWU project team has already created a successful engagement touchpoint with CWU campus community through the sustainability forums. These forums are a reoccurring space where the campus community connects to share CAP news, promote other sustainability-and-CAP-related events, and learn about new climate and environmental topics from guest speakers.

We propose presenting at one **Sustainability Forum Tuesday, April 23rd**.

Forum overview

The forum should be a mix of an informational presentation on decarbonization, what are the key proposed strategies for CWU decarbonization, and an activity. The focus of this sustainability forum would be to create awareness and understanding for what decarbonization is and how it will be implemented at CWU.



Goal: Build awareness and understanding	
Proposed Forum Plan	Time
Decarbonization 101 <ul style="list-style-type: none"> Educational lens 	10 min
Q&A with Technical Experts	10 min
CWU Decarbonization Plan <ul style="list-style-type: none"> Highlight that benefits that students have are often because of organizing/efforts of students before them, this is for future CWU students 	5 min
Activity <ul style="list-style-type: none"> Educational focus Jeopardy-style game 	20 min
Close out polling activity <ul style="list-style-type: none"> What do you want to learn more about decarbonization? What could we do to involve more CWU campus community in climate action? 	3 min
Wrap up	2 min

PROMOTION

We will coordinate with the university to create collateral for promotion via their pre-existing communication channels:

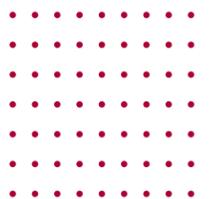
- Announcement in monthly project e-newsletters
- Social media
- Project webpage
- Coordinate with the Publicity Center for development of a half-sheet flyer





APPENDIX C

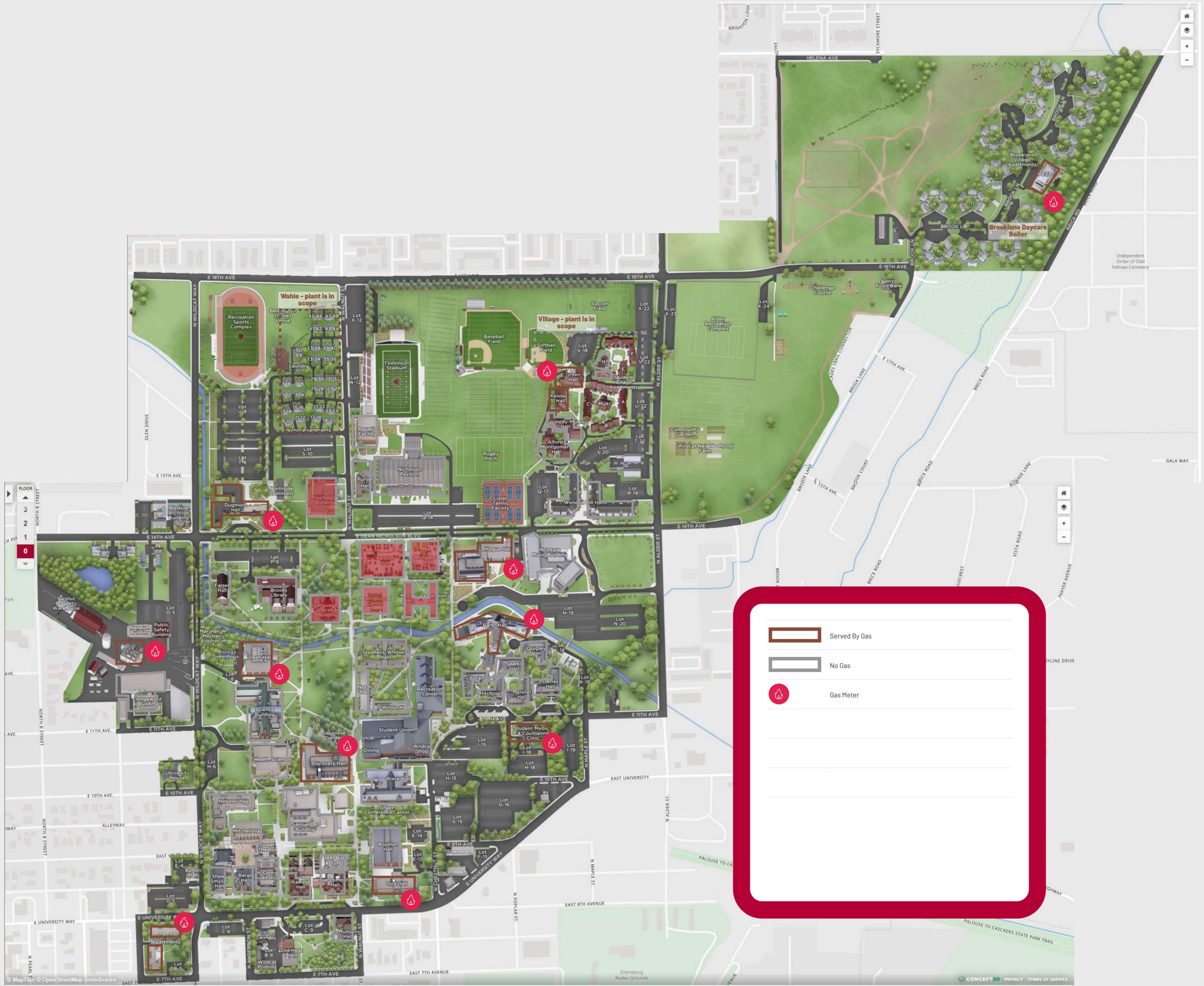
Campus Existing Conditions - Campus Maps



CWU Campus Map - Building Types



CWU Campus Map - Gas Loads and Meters



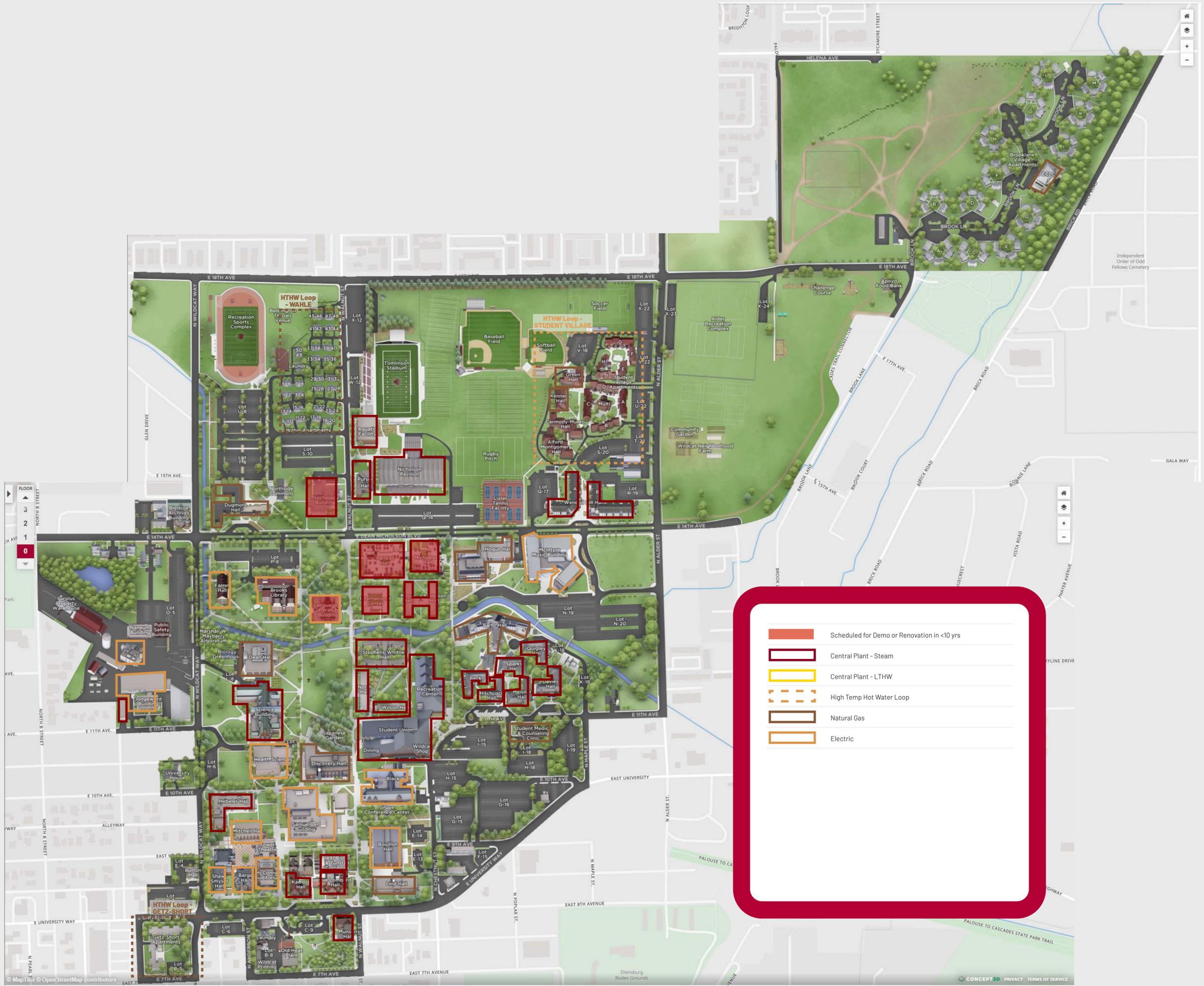
CWU Campus Map - Heating System



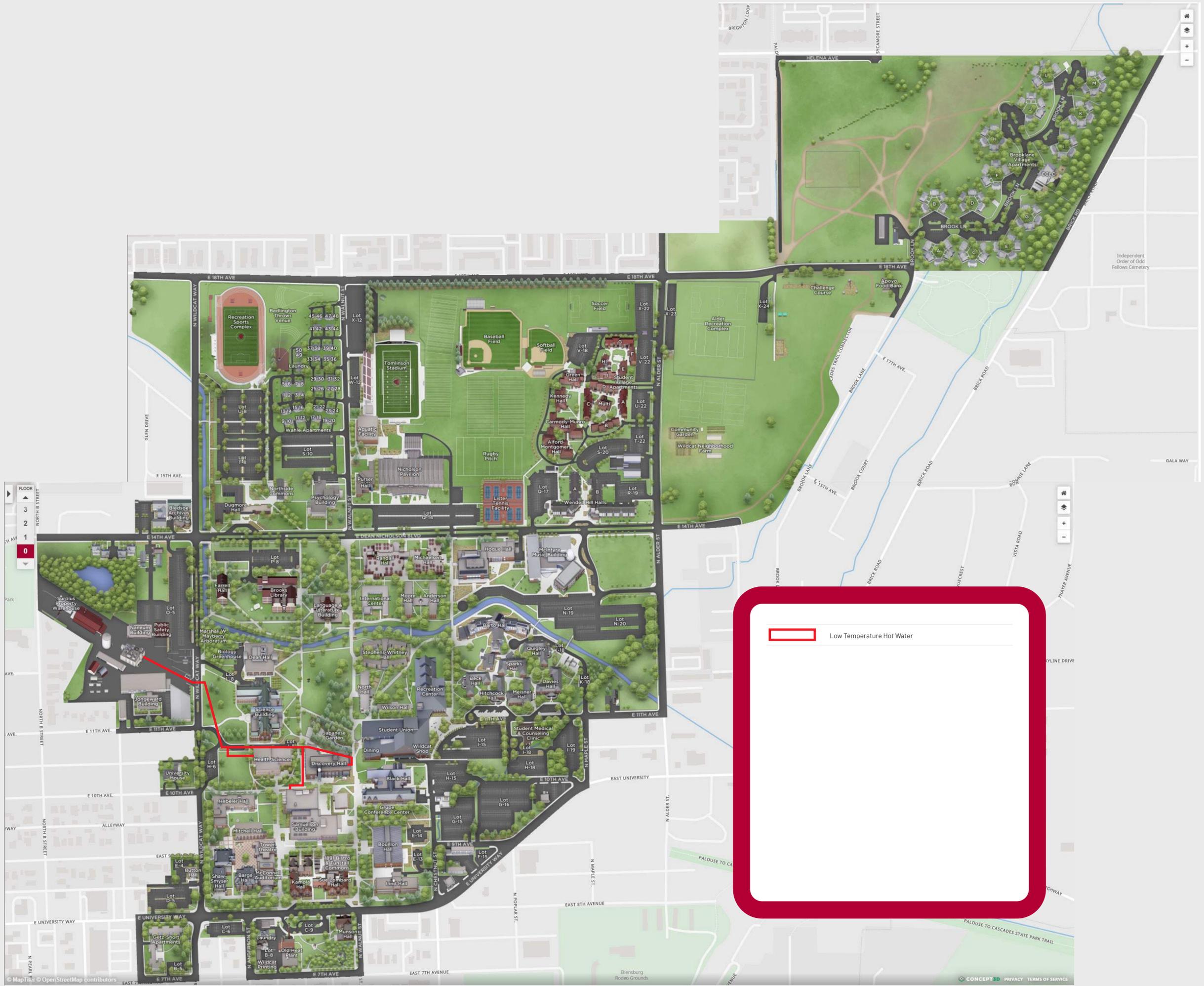
CWU Campus Map - Cooling System



CWU Campus Map - Domestic Hot Water System



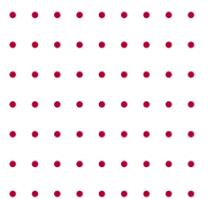
CWU Campus Map - Existing Low Temperature Hot Water Distribution Piping





APPENDIX D

Decarbonization Solutions - Heat Source & Sink Initial Filtering



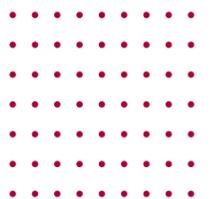
Appendix D | Decarbonization Solutions - Heat Source & Sink Initial Filtering

		Concept	Heating?	Cooling?	Suggested Action	Notes
Steam	Combustion	Renewable Natural Gas Boilers	Yes	No	Fast Fail - Not At Scale Yet	Renewable Natural Gas from market purchase agreement or on-site food service anaerobic digester. RNG markets are currently very cost-prohibitive and have not matured to provide sufficient scale. Additionally, 1390 has not ruled on validity of alternative fuels that use combustion.
		Biomass Boilers	Yes	No	Fast Fail - Not At Scale Yet	Requires consistent supply, is labor-intensive, and requires large footprint for boiler feed. There is also debate as to whether biomass is carbon-free. Additionally, 1390 has not ruled on validity of alternative fuels that use combustion.
		Hydrogen Boilers	Yes	No	Fast Fail - Not At Scale Yet	Provides resiliency thru hydrogen storage, but is not commercially viable at scale yet. CU Boulder is currently undertaking a pilot program for research purposes. Additionally, 1390 has not ruled on validity of alternative fuels that use combustion.
		Cogeneration Boilers	Yes	No	Future Consideration for Resiliency	Provides campus resiliency through on-site power generation, and also reduces electrical load on City Utility. Burns fossil fuels to create heating.
	Non-Combustion	Deep Geothermal	Yes	No	Long-Term Future Consideration	Deep geothermal is possibly feasible, but requires further study and would most likely have a large first cost.
		Micro-Nuclear	Yes	No	Fast Fail - Not At Scale Yet	Microreactors (5-10 MW) are currently in early stage of design/development. Won't be available until late 2020's/early 2030's at the earliest
Electrode Boiler		Yes	No	Fast Fail - Not Allowed by 1390	Can only contribute 10% of annual heat input per HB 1390 requirements, not a solution on its own. Likely improves overall plant heating efficiency ~15-20%	
Hot Water	High Temp	Geo-Exchange + High Temp Heat Pump	Yes	Yes	Analyze Further	High-temperature heat pumps are a quickly emerging technology. While typically used for industrial applications, manufacturers are quickly providing new models with better performance for higher education applications.
		Low Temp HW + In-Building WWHP	Yes	Yes	Analyze Further	1st step heating can be any LTHW concept (e.g. geothermal). 2nd step heat from LTHW to HTHW achieved via water-to-water heat pumps (WWHP) in each building or at certain nodes. In-building WWHPs limited by available mech room space and electrical capacity.
		Low Temp HW + In-Building Elec Boiler	Yes	No	Analyze Further	In-building electric heating is not limited by HB 1390. 1st step heating can be any LTHW concept (e.g. geothermal). 2nd step heat from LTHW to HTHW achieved via electric boiler/heating in each building or at certain nodes. In-building electric heating limited by available mech room space and electrical capacity. Electric boilers are significantly less efficient than WWHPs and aren't ideal for two-step controllability.
	Low Temp	Open Loop Geo-Exchange	Yes	Yes	Analyze Further	Ellensburg aquifer is potentially viable source.
		Hybrid (Darcy) Geo-Exchange	Yes	Yes	Applicable to Standalone Buildings	More applicable for individual building applications. Could work for standalone buildings not connected to campus system.
		Closed Loop Geo-Exchange	Yes	Yes	Fast Fail - Open Loop is More Viable	Viable option for sites that don't have a viable open loop aquifer. More costly per unit capacity than open loop and requires significantly more site area.
		Air-to-Water Heat Pump	Yes	Yes	Potentially Evaluate in Next Phase of Project	Could be included for peaking heating/cooling loads in campus system, depending on aquifer viability and total system cost. Viable option for standalone buildings not connected to campus system.
		Surface Water Exchange	No	Yes	Fast Fail	Environmental concerns, water only available during summer months.
		Campus Sewer Heat Recovery	Yes	Yes	Fast Fail	Largest campus sewer lines are only 8" and 14", which have insufficient flow to make a meaningful impact. Makes more sense for sites that are near very large citywide sewer lines. Otherwise, the added maintenance and cost are not worth the energy recovered.
		In-Building Sewer Heat Recovery	Yes	Yes	Applicable to Standalone Buildings	Could be used to reduce heating/DHW loads for buildings connected to campus system. Could be utilized in residence halls, natatoriums, with high domestic hot water loads.



APPENDIX E

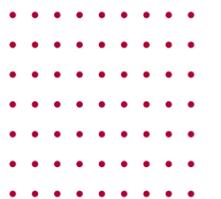
Decarbonization Solutions - Potential Nodal Plant Map





APPENDIX F

Decarbonization Solutions - Utility Coordination Meeting Minutes



Central Washington University – Decarb

Utility Coordination Meeting

February 5, 2024



PROJECT TEAM

Name	Organization	Role / Title	Invited	Present
Brian Goldcrump	McKinstry	Associate Principal Engineer	X	X
Jarred Coulter	McKinstry	Senior Associate Engineer	X	
Jeff Buttermore	McKinstry	Associate Engineer	X	X
Liz McNeal	McKinstry	Lead Electrical Engineer	X	
Jeremiah Eilers	CWU	Building Energy Manager	X	X
Delano Palmer	CWU	Director of Capital Planning and Projects	X	X
Jeff Bousson	CWU	Sustainability Officer	X	X
Gary Gleason	CWU	Construction Project Coordinator	X	X
David Kopczynski	CWU	Construction Project Coordinator	X	X
Buddy Stanavich	City of Ellensburg	Energy Resource Manager	X	X
Paul Meyer	City of Ellensburg	Senior Electrical Engineer	X	X
Nichole Baker	City of Ellensburg	Sustainability and Energy Coordinator	X	X

AGENDA

1. CWU Decarbonization Plan project intro
2. High-level utility infrastructure plans for campus and surrounding areas,
3. Existing capacity and constraints to campus,
4. Explore interruptible tariff options and any utility plans for a demand response program,
5. High-level long-term zero carbon plans, and
6. Recommendations/guidance from utility.

MEETING MINUTES

Project Scope:

- House Bill 1257-1390 - removing all natural gas, replacing with electrification.
- Decarb plan over 15 years.
- Existing steam system need to be replaced.
- Develop nodes, energy districts.
- We have plans to keep gas generator as a backup for extreme cold days.

CWU:

- Jeremiah confirmed that CWU does not have any intention of removing the steam infrastructure from any existing building. They do not want to take any steam piping out at all. It is important to keep the redundancy since it is already in place.
- New buildings are the exception, they are already fitted for low temp heating water.

Utility/Substation Discussion & Scheduled Projects:

- Electrification
 - City evaluating impacts.
 - Currently working on system study includes considerations (EV, building, etc.)
 - Every 7 years - this year is unique due to electrification.
- No feeder improvements scheduled.



- Substation improvement project is happening at Dollar Way substation, which will result in a XFMR upgrade. This may impact our project. Recloser switchgear upgrades. It is one of the subs that is feeding CWU currently.
- CWU (Gary Gleason) has previously asked the utility about extending one of the feeders that serves the University, feeder #12, it goes down Alder. Requesting to extending it to a third point of delivery that is currently open and out of service.
 - Utility was able to provide a cost estimate for this work.
- Utility is conducting a system study alongside ours (McKinstry), any information on load, would like us to keep them in the loop so that they can include in their study.
- CWU has three solar projects on campus.
 - The city is only aware of two of the projects.
 - BPA (transmission/wheeling company) has requirements for DERs when they are in the 5+MW range. (That is above and beyond City of Ellensburg requirements and distribution utility requirements)
 - CWU is interested in more solar.
- CWU has three substations.
 - CWU requested that substation 2 be locked out and not used.
- CWU is fed by two (2) dedicated feeders.
 - One of the feeders is normally powering the entire campus.
 - The other feeder is there as backup.
 - Technically, there is a third feeder to campus, named (E11/2). You may see it on the one line provided by City of Ellensburg (in the notes). That feeder provides the *substation 2* connection, it is also serving surrounding residents (not dedicated feeder).

Demand Data Discussion:

- The feeders are typically limited to 8MW (13MW of full power). With the two dedicated feeders, we can go up to the full 13MW. Utility typically doesn't load feeder over 10 MW (80%).
- The college has a relatively consistent load. Over the past two years, the minimum has been 3.74MW (9/6/21) and 6.5MW peak (peak on 10/10/22 and 12/5/22 <- winter peaking). The college usually around 5.3MW of load.
- Reliability - pretty good.
- Campus recently requested (2) 3 MW generators from the state.

ACTION ITEMS

- COE - Paul
 - Send demand data.
 - Send Utility/CWU single line.
- CWU
 - Sign any NDA's needed.
 - Jeremiah - send campus one-line from Buddy.
 - Jeff to send CAP executive summary.
- McK
 - Keep utility updated on progress.

Central Washington University – Decarb

Utility Coordination Meeting

April 11, 2024



PROJECT TEAM

Name	Organization	Role / Title	Invited	Present
Brian Goldcrump	McKinstry	Associate Principal Engineer	X	X
Jarred Coulter	McKinstry	Senior Associate Engineer	X	X
Jeff Buttermore	McKinstry	Associate Engineer	X	X
Mimi Petersen	McKinstry	Senior Electrical Engineer	X	X
Liz McNeal	McKinstry	Lead Electrical Engineer	X	X
Jeremiah Eilers	CWU	Building Energy Manager	X	X
Delano Palmer	CWU	Director of Capital Planning and Projects	X	X
Jeff Bousson	CWU	Sustainability Officer	X	
Buddy Stanavich	City of Ellensburg	Energy Resource Manager	X	X
Paul Meyer	City of Ellensburg	Senior Electrical Engineer	X	X

AGENDA

1. Request summary of existing electrical infrastructure to better understand the existing substations, meter locations, ties between substations.
2. Existing demand from review of utility demand data differs from what was presented during 02/05/2024 check-in.
3. Discuss current capacity.
4. Electrical impacts due to additional load from GEP-1 through GEP-6.

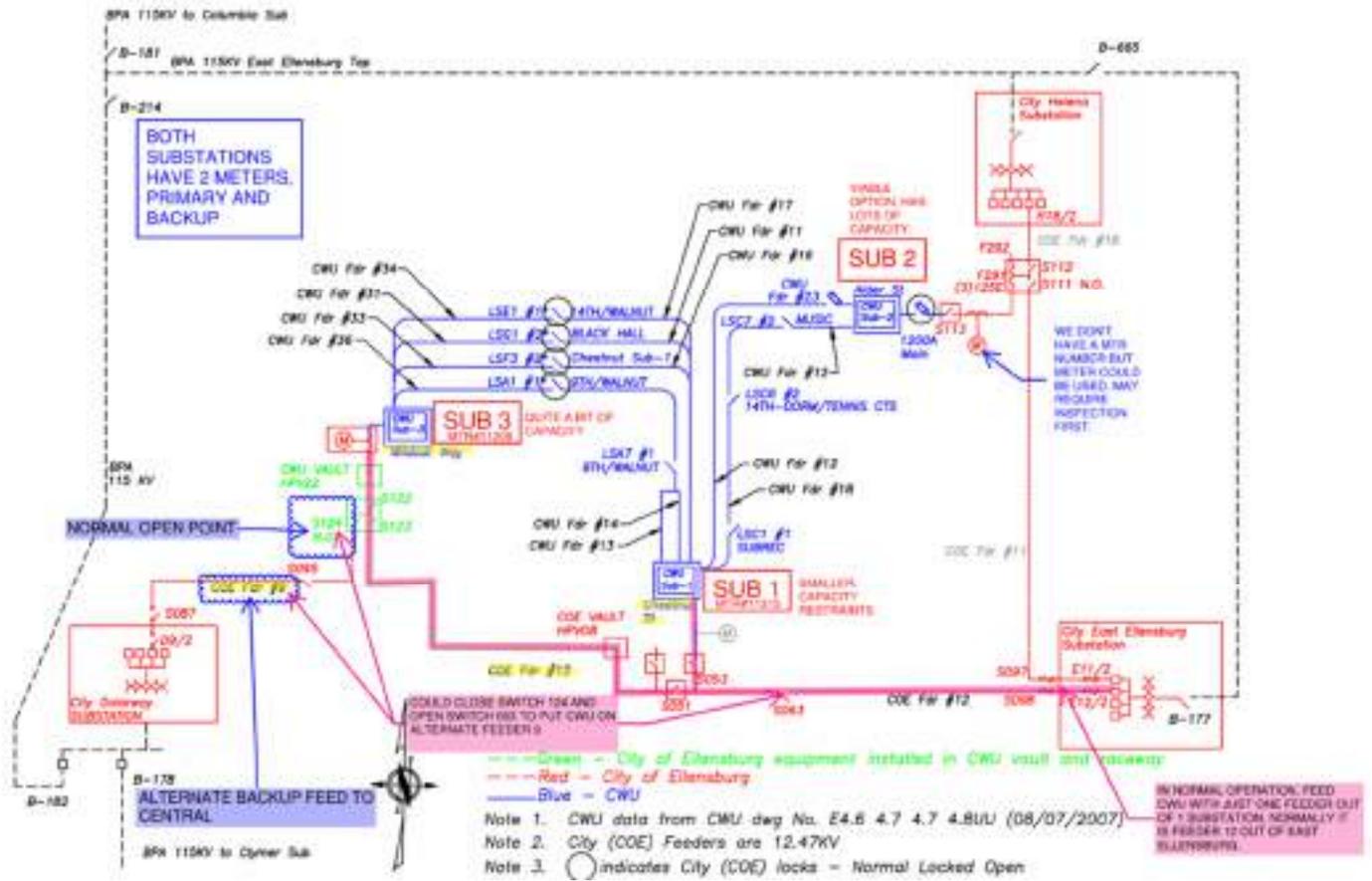
MEETING MINUTES

Feeders/Switches:

- The normal open point is at Switch124 out of Substation 3.
- Feeder #9 serves as an alternate backup feed to the university.
- Feeder 12 extends from Substation 3 to the East Ellensburg substation, serves both points of delivery.
- By closing S124 and opening S063, CWU can be switched to the alternate Feeder #9.
- Typically, CWU is powered by a single feeder from one substation, usually Feeder 12 from East Ellensburg, Substation 1.

Meters:

- Meter E11208 is located at Wildcat Way, and Meter E11315 is at the Chestnut substation.
- Each location is equipped with a primary meter and a secondary backup meter.
- The meters are installed inside the switchgear.



Substation 2:

- Substation 2 primarily feeds residential areas.
- CWU has requested a lockout at this substation.
- Recent equipment failures have been reported on the university side, with specific issues related to tripping and overloads.
- There have been fire alarm and security panel malfunctions.
- Substation 2 has an existing demand meter that requires inspection due to years of inactivity.

Existing Capacity:

- The maximum capacity is confirmed at 10MW.
- While 100% utilization is not permissible, a combination approach to meet higher demand requirements could be used.
- Substation 3, known as Dollarway Sub, has considerable capacity available.
- Substation 1, the East Ellensburg Sub, has observed capacity constraints.
- A detailed study is necessary to determine the exact available capacity.

Central Washington University – Decarb

Utility Coordination Meeting

April 11, 2024



From City of Ellensburg (Buddy Stanavich):



Load Verification:

- Non-coincident peaks - are observed from utility data, which could be because of reconfigurations.
- Coincident peak data provided by Buddy indicates a usage of 6.2MW, which should be utilized for calculations.
- The load has been consistent over time, despite the addition of buildings and implementation of energy improvements.

GEP Additional Loads:

	kVA
GEP 1	2433.739
GEP 2	3650.609
GEP 3	3650.609
GEP 4	3650.609
GEP 5	2433.739
GEP 6	2433.739
TOTAL	18253.04

- These reflect installed loads, but actual usage.
- There are two feeders currently, with the potential need for at least a third feeder from an existing substation.
- A comprehensive study is required to determine how these additional loads could be supported.
- There are numerous factors to consider before making any commitments.
- At a minimum, an additional feeder is necessary, but the specifics of how and where are yet to be determined.
- The utility's capacity to serve the additional load is a concern.
- The city is approaching a limit imposed by BPA on their transmission line that serves the area.
- The high demand from single points of delivery is directly affecting the city's ability to serve their customers, which in turn impacts BPA's transmission capacity.
- Implementing a demand shedding mechanism could be a viable option.
- The steam plant will remain operational for a certain period.
- There is a possibility of adding feeders on a pathway at their 40-acre site, located behind Helena.
- The size of the solar array is uncertain, but a 10MW capacity is estimated, assuming 4 acres per solar array.

Additional mechanical context:

- Load impacts.



- This is the rated load; it would never actually occur. Peak load would be 2/3 to 3/4 maybe?
 - Won't use all pump power - heating and cooling won't operate at same time, ~120 kVA of pumps is redundant.
- This is conservative - hot water will have less line losses, be more efficient in general.
- Summer peak load (cooling) will be a bit lower with higher efficiency cooling.
 - When chillers are retired, will get some installed load back.
- Phasing:
 - Contingency plan - peak could temporarily be met by steam boilers if utility can't meet new load.
 - This is phased over 15 years.

Phasing:

- 18MW phased over 15 years.
- It takes about 10 years to build a substation, immediate planning for a new substation is essential.
- The BPA transmission constraint is a significant challenge for such a project, necessitating close collaboration with BPA. Buddy's support will be crucial in this aspect.

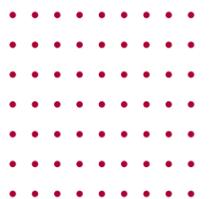
Forecasting and Planning:

- BPA's forecast, which utilizes historical data and known future loads, likely hasn't accounted for this new load, which will have a substantial impact on their transmission.
- As discussions with city officials begin, it's important to determine which demands align best to serve the community. The city will need guidance to integrate the project into a long-term strategy.
- BPA conducts a forecast every two years and high-level planning annually to consider various scenarios.
- Over forecasting can lead to increased charges, as it gets built into the billing structure.
- - The City of Ellensburg has a fixed monthly charge with BPA based on the forecast, with credits or penalties applied accordingly.
- It's confirmed that GEP-1 is included in their forecast, with an online date set for January 2026.



APPENDIX G

Decarbonization Solutions - Geothermal Considerations





MEMORANDUM

Project No. 230536

May 16, 2024

To: Brian Goldcrump, McKinstry
cc: Central Washington University

From:



ISABELLAH V VON TRAPP

Isabellah von Trapp, LHG
Project Hydrogeologist
isabellah.vontrapp@aspectconsulting.com

Andrew Austreng, LHG, RG
Principal Hydrogeologist
andrew.austreng@aspectconsulting.com

**Re: Central Washington University Decarbonization Study
Task 2 Energy Solutions: GSHP Alternatives Development**

Aspect Consulting (Aspect) is supporting McKinstry on Central Washington University's (CWU) Decarbonization Study. Task 2 under this study evaluated hydrogeologic conditions to identify and develop preliminary wellfield design alternatives to supply ground source heat pump (GSHP) systems across the CWU campus. This memorandum documents the results of the study.

We started by reviewing City of Ellensburg production supply well data, regional hydrogeologic reports, geologic maps and cross-sections, Aspect files, and multiple Washington State Department of Ecology (Ecology) databases (well logs, water rights, cleanup sites, and water quality atlas) to assess hydrogeologic conditions that would affect well yield and permitting requirements. Preliminary hydrogeologic models Aspect developed for CWU in 2022 were also revisited to identify and screen wellfield design alternatives to supply the range of nodal central utility plants currently under consideration by the McKinstry team.

The focus of this initial wellfield alternatives development and screening was to determine if the conceptual heating and cooling loads for nodal central utility plant locations could provide the target yields and operate effectively without interference. The results from the past models for wellfield yield and design (depth, diameter, and spacing of wells, water levels, etc.) were

extrapolated (without updating the existing models) to screen potential locations for new nodal plants and determine likelihood of meeting target yields from the GSHP system.

Findings

1. The Site is underlain by a productive aquifer, referred to as the upper Ellensburg Formation. Water is produced in coarse-grained sand/sandstone and gravel/conglomerate layers, confined by impermeable silt and siltstone layers referred to as “confining units.” These confining units hydraulically isolate the productive aquifer system from nearby surface water, simplifying permitting considerations and minimizing the variability in water supply temperature. Within the upper Ellensburg Formation, there are expected to be shallow (e.g., 300-600 feet) and deep (e.g., 800-1,000 feet) production zones.
2. A preliminary investigation of water right and Underground Injection Control (UIC) program requirements suggests that an open-loop system could successfully be permitted at CWU.
3. Overall, this study identified favorable conditions for a high capacity open-loop GSHP wellfield at CWU. Preliminary modeling suggests that campus-wide heating and cooling loads could be met through several "nodal systems" right sized to the energy loads of the facilities served, or via a high-yielding wellfield centered around a campus-wide central utility plant. A map showing preliminary locations for nodal GSHP wellfields, based on utility plant clusters developed by the McKinstry team and screened against hydrogeologic considerations, is included with this memo. Generalized GSHP wellfield design considerations for these nodal systems are discussed in the following sections.¹

Alternatives

Open-loop wellfield alternatives include nodal systems (i.e., several supply and return well pairs serving multiple buildings; the number of well pairs is dependent upon on individual system loads) and a centralized wellfield system. For CWU, results from the existing groundwater and heat flux models suggest that a centralized wellfield would require eight paired supply and return wells (16 total wells) centered around a central utility plant. Due to the large infrastructure requirements (well size, well equipment, and long conveyance piping runs), the centralized wellfield alternative was not retained in the analysis. Nodal GSHP wellfields and utility plants were retained, and location alternatives developed by McKinstry were considered.

Multiple wellfield construction alternatives were identified for further consideration under the next task. Supply and return wells can be completed within what is referred to as either the shallow (e.g., 300-600 feet deep) or deep (e.g., 800-1,000 feet deep) aquifer zones. Deeper wells are expected to have higher yields as they penetrate a greater number of water-bearing units, but construction and maintenance costs are greater. Wells and well pairs may be completed in the shallow aquifer, deep

¹ In the next phase of this project, modeling and analysis of groundwater and heat flux will consider heating and cooling loads for respective nodal systems to develop location-specific recommendations for wellfield design.

aquifer, or a combination thereof (e.g., supplied from the deeper aquifer and returned to the shallow aquifer) depending on desired yield and well spacing and subject to permitting constraints.

Modeling and preliminary well siting completed to date suggests that wells should be spaced a minimum of 700 feet apart. Well spacing and completion depths will be evaluated through additional modeling and analysis in the next phase of this project.

Well Construction Considerations

Well construction requirements are dependent on the target yield and site constraints at each nodal system. Well completion depths at the sites could range from approximately 300 to 1,000 feet deep. The diameter of each well will depend on multiple factors, including completion depth, target yield (larger wells can accommodate larger pumps), and whether the well will serve as a supply or return well. To allow for proper GSHP optimization and maintain long-term system operations, supply and return wells must be properly oriented relative to groundwater flow, which must be further defined at later phases of work.

Wells must be constructed so that they can be accessed for future maintenance and pump service. Supply wells will need to be constructed to have enough overhead clearance to allow for a boom truck to pull/replace the pump. If the well is deep and targets a high yield, a line-shaft driven pump may be needed, which includes a motor mounted at the wellhead and requires a small wellhouse/enclosure for the motor and controls (submersible motors and return wells would not require this type of enclosure).

WAC 173-160-171(3)(b)(i) and (3)(b)(iii) specify that water wells should be located 5 feet from existing building structures and 50 feet from sewer lines.

Wells should be outfitted with pitless adapters. 3R valves (or similar) are likely not needed due to anticipated shallow static water levels (i.e., 20-50 feet below ground surface).

Buildout Phasing Considerations

We understand that CWU is currently planning to drill an initial well to support the GSHP system at the North Academic Complex. Initial well drilling and testing efforts should be used to support design for subsequent drilling efforts. Under the nodal GSHP system alternative, each system can begin construction with a single pair of supply and return wells, with additional wells installed as demand increases. The most important considerations for this phasing are:

- that well diameters and depths are large/deep enough to accommodate future increases in pump capacity;
- that wells are properly spaced so interference does not occur as production increases in the future; and
- that wells are properly oriented relative to the groundwater flow direction to maximize thermal attenuation.

These considerations will be further evaluated and discussed under the next phase of work as nodal utility plant alternatives are developed.

Cost Considerations

The costs for wellfield construction increase with well completion depth and well size; however, larger and deeper wells will likely provide higher yield and result in an “economy of scale” for the wellfield. Increased separation between the supply and return wells will also proportionally increase conveyance costs. Targeting different “completion zones” within the Ellensburg Formation would spread thermal impacts both laterally and vertically across the aquifer and may reduce well spacing requirements between the supply and return well pairs and nodal systems. These considerations will be further evaluated and discussed under the next phase of work as nodal utility plant alternatives are developed.

Limitations

Work for this project was performed for McKinstry (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting’s original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Attachments: Attachment 1 – Preliminary Nodal GSHP Wellfield Map

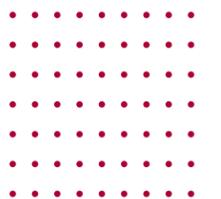
ATTACHMENT 1

Preliminary Nodal GSHP Wellfield Map



APPENDIX H

Decarbonization Solutions - Environmental Justice Considerations



Environmental Justice Measures | Approach & Assessment

Approach

The following considerations were made for each decarbonization system alternative for heat sources/sinks, plant configuration, and piping distribution.

- Potential equity benefits and disbenefits
- Equity considerations during implementation
- Link to related resources

While the assessment notes explicit EJ considerations when relevant, not all evaluated elements had explicit EJ considerations. This is indicated by “N/A”. An indication of “N/A” does not necessarily mean there aren’t equity implications or resources available, but that there are none documented to support a finding.

Heat Sources & Sinks

	GEOTHERMAL + LOW TEMPERATURE HEATING HOT WATER (LTHW)	GEOTHERMAL + HIGH TEMPERATURE SINGLE STAGE HEATING HOT WATER	GEOTHERMAL + HIGH TEMPERATURE DUAL STAGE HEATING HOT WATER
EQUITY RANK			
EQUITY IMPACTS	This may require substantial building retrofits that may affect building users and campus community. However, requires fewer equipment and less maintenance overall, which could be beneficial under a just transition framework.	May be beneficial because it avoids disruptive retrofits. However, emerging technology may require initial training/ re-training for maintenance, which may present additional barriers for maintenance workers under the just transition framework.	May be beneficial because it avoids disruptive retrofits.
EQUITY IMPLEMENTATION CONSIDERATIONS	Retrofits at any scale should be mindful of accessibility considerations for the campus community and surrounding community members. Opportunities to mitigate this include providing alternative routes if key routes are affected or scheduling retrofit improvements during less busy seasons (e.g., summers). While no anticipated costs will be passed down to students initially due to anticipated capital funding requests, alternatives that have higher energy maintenance or utility costs could potentially pass down costs to students in the future through increased facility fees.		
RESOURCES	<p>“Workforce Policy for a Just Transition”, Roosevelt Institute. https://rooseveltinstitute.org/wp-content/uploads/2022/05/RI_Just_Transition_202206.pdf</p> <p>“Creating the workforce needed for building retrofits”, C40/National League of Cities. https://c40.my.salesforce.com/sfc/p/</p>		

Environmental Justice Measures | Approach & Assessment

Plant Configurations

	CENTRALIZED	DECENTRALIZED	NODAL
EQUITY RANK			
EQUITY IMPACTS	Less redundancy and overall resiliency for building users if centralized system fails. Additionally, new hot water piping necessary for this can lead to disruption for campus community.	Less redundancy and resiliency for individual buildings if system they depend on fails.	More redundancy to allow for continuous service even if a system fails, ensuring system reliability for the campus community. While there will be impacts for construction, the phased approach may reduce this nuisance impact for the campus community.
EQUITY IMPLEMENTATION CONSIDERATIONS	Consider the sequencing and timing of major capital projects to reduce impact to the campus community and the surrounding community reliant on E Dean Nicholson Blvd.		
RESOURCES	"Reduce Impacts of Campus Construction Projects with Thorough Disruption Avoidance Planning", Mortenson. https://www.mortenson.com/newsroom/campus-construction-disruption-avoidance		

Distribution Piping

	2-PIPE	4-PIPE
EQUITY RANK		
EQUITY IMPACTS	Primary impact is the disruption from the installation of piping. Some major disruptions could include installation adjacent to major streets (e.g., E Dean Nicholson Blvd.) or residence halls (e.g., Kamola Residence Hall).	
EQUITY IMPLEMENTATION CONSIDERATIONS	Consider the sequencing and timing of major capital projects to reduce impact to the campus community and the surrounding community reliant on E Dean Nicholson Blvd.	
RESOURCES	N/A	

