INVESTMENT GRADE AUDIT

STATE OF WASHINGTON CAPITOL CAMPUS COMBINED HEAT AND POWER PROJECT

December 2016

WASHINGTON STATE CAPITOL CAMPUS – OLYMPIA WA
CAMPUS COMBINED HEAT AND POWER PROJECT

PROJECT DEVELOPMENT TEAM

- DEPARTMENT OF ENTERPRISE SERVICES (OWNER / TEAM LEAD)
- UMC ENERGY & ENVIRONMENT (ESCO)
- ZGF ARCHITECTS (PRODUCTION PLANT CONCEPTS)
- WOOD HARBINGER (PRELIMINARY CHP DESIGN)
- BN BUILDERS (PRODUCTION PLANT AND SITE WORK ESTIMATING)
- EC COMPANY (ELECTRICAL ESTIMATING)

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1.0 EXECUTIVE SUMMARY

Overview of Project Development

In March 2014, the Department of Enterprise Services (DES) partnered with University Mechanical Contractors (UMC) to begin an initial engineering analysis of the existing Capitol Campus steam production plant and distribution system. The intent of this study was to investigate and document the efficiency and safety of the system and propose potential alternatives for serving future campus heating requirements. The results of this initial study outlined several alternatives that would address safety concerns, improve operating efficiency and provide the campus with new district energy production and distribution systems; preparing the campus for the next 100 years.

A key conclusion reached was that converting the campus steam distribution system to hot water and constructing a new production plant incorporating Combined Heat and Power (CHP) as the primary heat source could potentially yield significant financial and environmental benefits.

As a result of this first study, DES again engaged UMC to develop a more detailed Investment Grade Audit to clarify and compare several specific alternatives, based on a 50 year "total cost of ownership" lifecycle analysis. A high level overview of some of the heating system alternatives analyzed included the following (The resulting recommended option is highlighted in 'green'):

- **Business as Usual** – This option assumes that the campus continues to operate on the steam system in the current mode with ongoing investments in the existing infrastructure and equipment.
- **Existing Powerhouse + CHP (Alternative 1a)** – A renovated District Heating Plant with CHP and Thermal Storage located at the existing Powerhouse site. CHP to operate as primary heat source. Steam distribution to be converted to Hot Water (HW).
- **Existing Powerhouse Hot Water Only (Alternative 1b)** – A renovated District Heating Plant located at the existing Powerhouse site. High efficiency hot water boilers to operate as the primary heat source. Steam distribution to be converted to Hot Water.
- **New District Energy Plant + CHP (Alternative 2a)** – A new District Heating Plant with CHP and Thermal Storage located at a new Production Plant site. CHP to operate as the primary heat source. Steam distribution to be converted to Hot Water.
- **New District Energy Plant Hot Water Only (Alternative 2b)** – A new District Heating Plant located at a new Production Plant site. High efficiency hot water boilers to operate as the primary heat source. Steam distribution to be converted to Hot Water.

The intent of this undertaking was to explore the long-term options for the future infrastructure serving the Capitol Campus. The goal was to identify the most cost effective, environmentally sensitive and secure path for serving the heating, cooling and electrical needs of the campus over the next 50 to 100 years. The current maintenance intensive steam system has served the campus since 1920, nearly 100 years. It has inherent inefficiency, hazardous conditions, and the potential for catastrophic failure due to the location of the powerhouse. The powerhouse sits below an unstable marine bluff and on the edge of Capitol Lake/Estuary where there is potential for landslide or flooding from the Deschutes River and sea rise.

Chilled Water Plant Considerations

In addition to the targeted alternatives developed for the District Heating opportunities, UMC was asked to evaluate options to incorporate centralized chilled water (CHW) into the overall plan. Given this directive, considerations were explored for various Capitol Campus-wide chilled water alternatives.

Analysis was made of the opportunity to improve the cooling systems on campus, coincident with the implementation of a new district heating system to minimize construction cost. The new system would provide chilled water to both the East and West Campuses. A preliminary district cooling analysis was performed for both alternatives described below: (See Section 8 for more detail. Again, the recommended option is highlighted in ‘green’).

CHW - Alternative 1

- Alternative 1: Locate a new CHW production plant in the Level 50 mechanical space of OB2 (East Campus), in combination with additional upgrades to the existing Powerhouse CHW production plant (West Campus). Integrate the two CHW production sites to operate collectively.

CHW – Alternative 2

- Alternative 2: Locate a new CHW production plant coterminous with new hot water Production Plant Site. Utilize the new plant to serve the entire campus.

Results of 50-year lifecycle cost analysis

The lifecycle cost analysis performed includes a “total cost of ownership” model, which covers all costs likely to be incurred over the entire 50 year term. These expenditures include capital construction costs (owner equity and debt service), fixed operating costs (equipment overhaul, system renewal, operating labor, minor repairs) and variable operating costs (energy and utility costs). In addition, consideration was given to potential costs that could be realized in the near future, such as the social cost of carbon.

Table 1 District Heating Alternatives (excludes cooling option)
Present Value Summary

		Alt 2a
Present Value Summary (50 Year Costs) - Excluding Cost of Carbon	**BAU**	**District CHP**
District Energy Plant Location	**Powerhouse**	**New Site**
Capital Project Cost (initial capital outlay)	**$15,892,000**	**$95,866,000**
Capital Recovery (includes estimated grants & debt service)	$25,695,949	$104,622,605
Fixed Operating Costs	$105,478,436	$64,377,966
Variable Operating Costs	$44,217,755	-$9,217,056
50 Year Total Cost of Ownership	**$175,392,140**	**$159,783,515**
50 Year Net Present Value (compared to BAU)		**$15,608,625**

50 Year Total Cost of Ownership - Including Social Cost of Carbon (per OFM)	**$188,894,747**	**$163,386,293**
50 Year NPV (compared to BAU) - Including Social Cost of Carbon (per OFM)		**$25,508,454**

50 Year Carbon Emissions (Metric Tons)	**299,138**	**85,214**
Carbon Reduction from BAU		**72%**

Table 2 District Heating & Cooling Alternatives (includes cooling option)
Present Value Summary

		Alt 2a + CHW
Present Value Summary (50 Year Costs)	**BAU**	**District CHP & CHW**
District Energy Plant Location	**Powerhouse**	**New Site**
Capital Project Cost (initial capital outlay)	**$15,892,000**	**$125,358,000**
Capital Recovery (includes debt service)	$31,352,000	$143,710,000
Fixed Operating Costs	$165,881,000	$99,683,000
Variable Operating Costs	$84,125,000	$21,222,000
50 Year Total Cost of Ownership	**$281,358,000**	**$264,615,000**
50 Year Net Present Value (compared to BAU)		**$16,743,000**

50 Year Total Cost of Ownership - Including Social Cost of Carbon (per OFM)	**$301,457,779**	**$274,059,940**
50 Year NPV (compared to BAU) - Including Social Cost of Carbon (per OFM)		**$27,397,839**

50 Year Carbon Emissions (Metric Tons)	**BAU**	**Alt 2a + CHW**
Heating System - Carbon Emissions	299,138	85,214
Cooling System - Carbon Emissions	123,945	107,599
Subtotal - Combined Heating / Cooling Carbon Emissions	**423,083**	**192,814**
Carbon Reduction from BAU		**54%**

Advantages / Disadvantages of each Alternative Analyzed

Business as Usual (BAU):

- Advantages
  - Lowest total capital cost to implement.
  - Requires the smallest footprint for the District Energy plant.

- Disadvantages
  - Higher 50-year total cost of ownership compared to other alternatives.
  - Doesn’t support identified carbon reduction goals.

- Requires millions of dollars of investment in an aging, inefficient steam heating infrastructure.
- Higher ongoing operational costs due to energy inefficiencies.
- Risk to continuity of government from natural disaster associated with the location of the plant
    - Hillside slide risk
    - Lakeside flood risk
- Historic nature of existing Powerhouse facility limits expansion options of the existing facility. Service for future campus expansion would require the construction of additional production plant space, preferably adjacent to the existing Powerhouse.
- Sensitive location at lakeside incurs risk of future environmental regulation that may limit operational or renovation opportunities.

Combined Heat and Power Options

Alt 1a - Existing Powerhouse + CHP:

☐ Advantages
- Lower 50 year lifecycle cost (excluding risk items) compared to BAU.
- Provides a path to meeting the campus carbon reduction goals (delivers an immediate 54% reduction from BAU).
- Reduces utility costs associated with operating the plant by over 65% in the first year of operation; and greater in subsequent years.
- Provides an opportunity for future utilization of carbon friendly and renewable energy sources to be incorporated into the operation of the campus District Energy system.
- Creates a “smart grid” compatible facility capable of working cooperatively with the local utility in modes of operation that benefit both the Campus and the utility.
- Makes the Campus and utility more resilient to power interruptions, such as loss of transmission lines and central power production facilities (wild fires, flooding, earthquake, terrorist, etc.).

☐ Disadvantages
- High level of risk to continuity of government from multiple catastrophic dangers associated with the location of the plant:
    - Hillside slide risk
    - Seismic event risk
- Historic nature of existing Powerhouse facility limits expansion options of the existing facility. Service for future campus expansion would require the construction of additional production plant space, preferably adjacent to the existing Powerhouse.
- Sensitive location at lakeside incurs risk of future environmental regulation that may limit operational or renovation opportunities.

Alt 2a - New District Energy Plant + CHP:

☐ Advantages
- Excellent 50 year lifecycle cost benefit when compared to BAU.

  - Provides the best path to meeting the campus carbon reduction goals (delivers an immediate 54% reduction from BAU).
  - Reduces utility costs associated with operating the plant by over 65% in first year of operation; and greater in subsequent years.
  - Provides an opportunity for future use of carbon- friendly and renewable energy sources for the operation of the campus District Energy system. A new District Energy Plant provides a showcase location of efficiency and technology and creates a model for other State and public sector institutions (universities, colleges, prisons, hospitals, schools, office building complexes, city district energy systems, etc.).
  - Mitigates the risk to continuity of government from risks associated with Alternative 1 and BAU.
  - Creates a “smart grid” compatible facility capable of working cooperatively with the local utility in modes of operation that benefit both the Campus and the utility.
  - Makes the Campus and utility more resilient against utility source power interruptions from loss of transmission lines and central power production facilities impacts (wild fires, flooding, earthquake, terrorist, etc.)

- ❑ Disadvantages
  - Highest total capital cost to implement.
  - Requires more design effort to ensure the building fits into the Capitol Campus Master Plan.
  - Requires utilization of limited available campus construction space.

Heating Only Options (excludes CHP)

Alt 1b - Existing Powerhouse Hot Water Only:

- ❑ Advantages
  - Positive 50 year lifecycle cost benefit (excluding risk items) compared to BAU.
  - Supports identified carbon reduction goals for the campus (21% reduction from BAU).
  - Reduces plant operation utility costs by almost 50% in first year of operation.
  - Provides an opportunity for future use of carbon- friendly and renewable energy sources for the operation of the campus District Energy system.

- ❑ Disadvantages
  - Risk to continuity of government from natural disaster associated with the location of the plant Hillside slide risk
  - Lakeside flood risk
  - Historic nature of existing Powerhouse facility limits future expansion options.

Alt 2b - New District Energy Plant Hot Water Only:

- ❑ Advantages

  - Supports identified carbon reduction goals for the campus (21% reduction from BAU).
  - Reduces utility costs associated with operating the plant by almost 50% in the first year of operation.
  - Provides an opportunity for future use of carbon- friendly and renewable energy sources for the operation of the campus District Energy system. Provides a brand new District Energy Plant
  - Mitigates the risk to continuity of government from environmental risks associated with Alternative 1 and BAU.

- Disadvantages
  - Does not provide a positive 50 year lifecycle cost benefit (unless carbon costs are taken into account) compared to BAU.
  - High total capital cost to implement
  - Requires more design effort to ensure the building fits into the Capitol Campus Master Plan.
  - Requires utilization of limited available campus construction space.

Recommendations

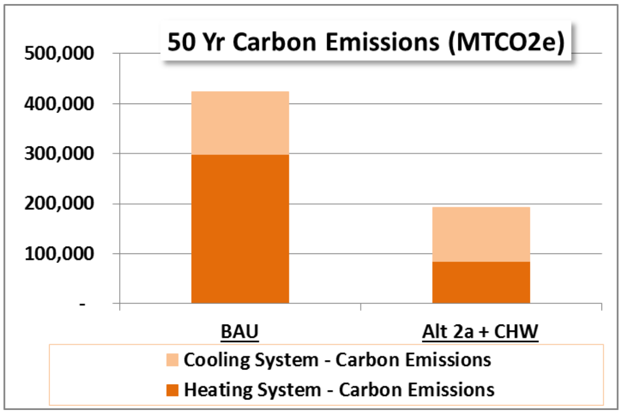
Investing in a new central plant located on the east campus with CHP and chilled water provides reduced operating costs for energy, water, labor, and equipment renewal by an estimated $129 million over 50 years. Alternative 2A provides an average annual avoided cost of $2.5 million and cuts carbon emissions by 54%. Such a project supports the environmental and public expenditure goals of DES and the Governor.

The following table illustrates how each alternative ranks when considering important campus goals. Alternate 2a provides the best overall option to meet campus goals with the least risk.

	Ranking (1 through 5)				
Category	**BAU**	**Alt 1a**	**Alt 2a**	**Alt 1b**	**Alt 2b**
50 Year Lifecycle - Present Value (excluding carbon)	4	1	**2**	3	5
50 Year Lifecycle - Present Value (including carbon)	5	1	**2**	3	4
Most Secure Project (Least Risk)	5	4	**2**	3	1
Carbon Reduction Benefits (50 Year MTCO2e)	5	1	**1**	3	3
50 Year Lifecycle Present Value (including cost of potential risks)	3	4	**1**	5	2
Provides Path to Meeting Long Term Renewable Goals	5	2	**1**	4	3
Greatest Positive Impact on Campus Infrastructure	3	2	**1**	2	1
Subtotal	**30**	**15**	**10**	**23**	**19**

Economic and Social Benefits

The economic and social benefits realized by implementing the Alternative 2a – Capitol Campus District Energy Plant include:



- Greatly Improved Plant Energy Efficiency.
- 50 year total avoided cost of $129 million.
- Significant reduction in carbon emissions – greater than 210,000 MTCO2e over the next 50 years.
- A giant leap forward in meeting long-term sustainability goals - meets the 2035 CO2 reduction goals for the campus.
- An opportunity for future use of carbon-friendly and renewable energy sources (e.g.; hydrogen or biofuel based)
- Reduces operation and maintenance costs with a HW system.
- Provides a safer work environment for operators absent the steam production and distribution.
- Reduces ongoing capital renewal costs.
- Decreases future building capital costs by eliminating the need for heat producing equipment and cooling equipment at each site (including the associated electrical service, access for equipment replacement, large space requirements for maintenance of the equipment, boiler exhaust stacks, cooling towers and associated vapor plumes and the high cost per square foot of the added mechanical space needed).
- Improves architectural design flexibility for future buildings by reducing the requirements for mechanical equipment space.
- Reduces capital cost for future buildings by eliminating stand-alone heating and cooling systems.
- Improves campus heating system reliability.
- Revitalizes failing infrastructure with a better more efficient system.
- Creates a “smart grid” compatible facility capable of working cooperatively with the local utility in modes of operation that benefit both the campus and the utility.

- Makes the campus and utility more resilient against utility source power interruptions from transmission lines and central power production facilities impacts (wild fires, flooding, earthquake, terrorist, etc.)

- Integration of CHW system creates additional opportunities for energy efficient heat recovery.

- Provides groundwork for DES to function as a self-sustaining District Energy utility for the campus.

2.0 PROJECT OVERVIEW

2.1 Project Background

With the aging, inefficient campus steam system approaching 100 years old and with State Agency environmental goals now established in statute (RCW 70.235.050), the Department of Enterprise Services (DES) sought to take the first step in developing an informed decision on a path forward. In 2014 DES, utilizing the Energy Savings Performance Contracting process, secured the services of University Mechanical Contractors (UMC) to evaluate alternatives that would meet efficiency improvement and environmental impact reduction goals in a cost effective way. The first study showed promise for Combined Heat and Power (CHP) in conjunction with thermal storage and a conversion to hot water. This second, more detail economic and technical evaluation was commissioned in 2015 and is the basis for this report.

2.2 Project Objectives

At the outset of this project, specific goals and objectives were developed to guide the direction and intent of this engineering development and analysis. These broad goals are identified below. The overall purpose of this engineering endeavor was to provide an Energy Services Proposal (ESP) with an Investment Grade Audit (IGA) focused on the best overall solution for upgrading the campus heating/cooling production and distribution systems to provide efficient and resilient operation over the next 50 to 100 years.

- ✓ Improve performance and safety of production plant and distribution systems
- ✓ Modernize energy infrastructure based on a 100 year horizon
- ✓ Shape internal rates required to be a self-sustaining District Energy system owner
- ✓ Consider incorporation of all viable, cost effective production/distribution technologies
- ✓ Assess site risks associated with the existing Powerhouse location into long-term planning horizons and consider a more secure plant location
- ✓ Demonstrate technical, economic, and environmental benefits of studied alternatives over a 50 year life cycle vs Business as Usual (BAU)
- ✓ Identify the impact of the project on carbon emission reduction requirements, consistent with 2020, 2035 & 2050 targets
- ✓ Provide flexibility to accommodate future renewable energy source options
- ✓ Deliver a remarkable project that demonstrates the abiding energy vision of the state and its viability for replication at other campus locations

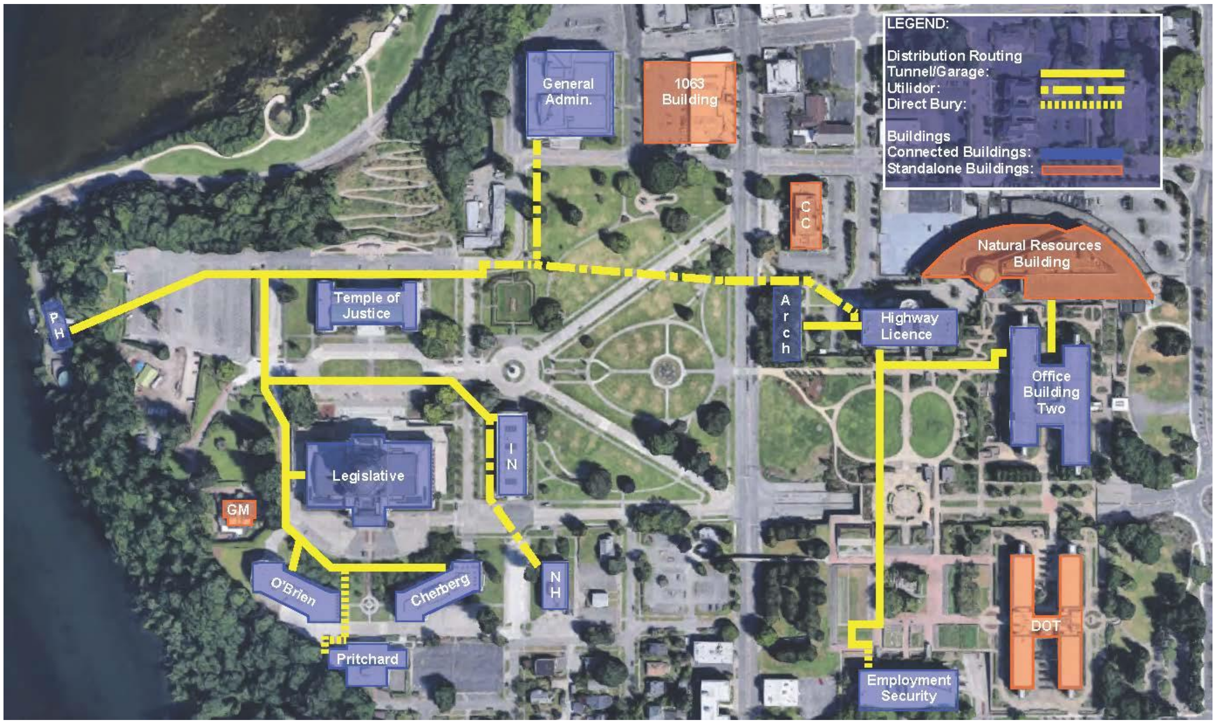
2.3 Alternatives Considered

In the project development phase, it was determined there were three discreet, potential alternatives that would be considered for providing ongoing district heating service to current and future campus facilities. Each of these alternatives were to be considered over a 50 year total cost of ownership lifecycle to determine the most beneficial option for the future direction of a Capitol Campus production plant and distribution system. An overview of the three alternatives considered is provided below and each is described in much greater detail in Sections 4 - 6.

Business as Usual

The “Business as Usual” (BAU) alternative is the benchmark alternative that identifies the costs for the continuation of the current steam heating systems over the foreseeable future. This benchmark scenario includes ongoing reliance on the existing Powerhouse and steam district energy system. It includes the utilization of stand-alone heating systems in buildings not currently served by the steam distribution and for all facilities contemplated for future construction. This BAU alternative also assumes that existing systems will continue to be renewed, with anticipated efficiency improvements as these systems are upgraded in the future (for both the production plant and the distribution system).

BAU - Overview of Existing Steam Distribution System



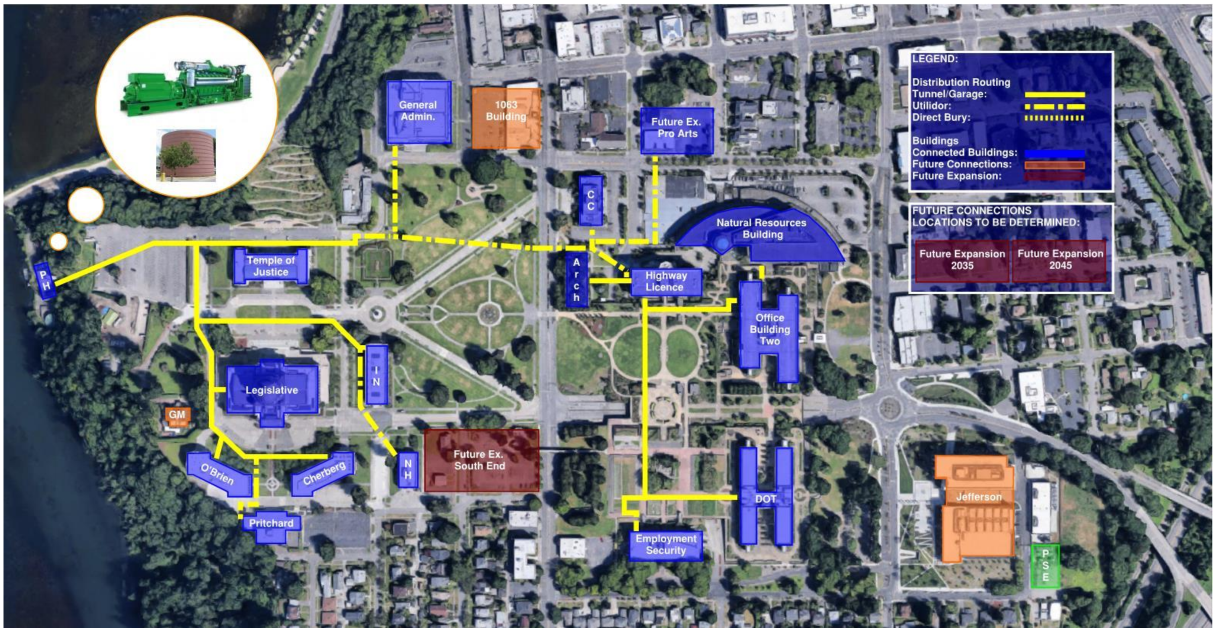
Alternative 1a (Existing Powerhouse + CHP)

Alternative 1a is based upon upgrading and modifying the existing steam distribution system to a new heating hot water distribution system. The existing Powerhouse production plant location will be revised and expanded to incorporate combined heat and power (CHP) as the primary heating source for the campus with high efficiency hot water boilers as backup. In addition, a large thermal energy storage tank will store excess heat from the CHP unit and utilize this heat effectively during low load periods (ie: nighttime, morning warm-up and weekend hours). This utilization of thermal storage will work to improve the overall operating efficiency of the heating system.

This new district energy system will then serve as the primary heat production plant for the existing buildings currently served by the steam system. In the long term, the system could be connected to serve all existing and planned buildings on campus as well; however this will require extensive building additions to the current Powerhouse production plant to provide sufficient space for the new equipment.

- Replace the existing steam production boilers with a baseload heating cogeneration unit (either a reciprocating engine or gas turbine) and provide backup/peaking with high efficiency hot water boilers.
- Incorporate a thermal energy storage system to efficiently store and dispatch excess heat from the CHP unit as available and needed.
- Operate the cogeneration unit as a “heat load following” system with all generated power under the minimum electrical load and used “inside the fence” of the campus.
- Replace steam distribution with a new, efficient hot water distribution system.
- Integrate new hot water energy transfer stations at each connected facility to transfer heat from the distribution loop to the building for both space heating and domestic hot water.
- Eliminate direct steam heating equipment in buildings and upgrade to hot water.
- Identify and mitigate existing site facility risks associated with the existing Powerhouse site (hillside slide concerns, flood risks from Capitol Lake, required seismic upgrades to the building and boiler stack).
- Develop long term concept scope for future Chilled Water (CHW) plant expansion / upgrades (feasibility analysis & rough order of magnitude (ROM) estimates only) that would delineate a future direction for the CHW system under this alternative.

Alt 1a - Overview of Proposed Distribution System



Alternative 1b (Existing Powerhouse Hot Water Only)

Alternative 1b is much the same as Alt 1a; however it excludes the CHP equipment and thermal energy storage tank. High efficiency HW boilers will be utilized as the primary district heating production source for the campus in this option.

Alternative 2a (New District Energy Plant + CHP)

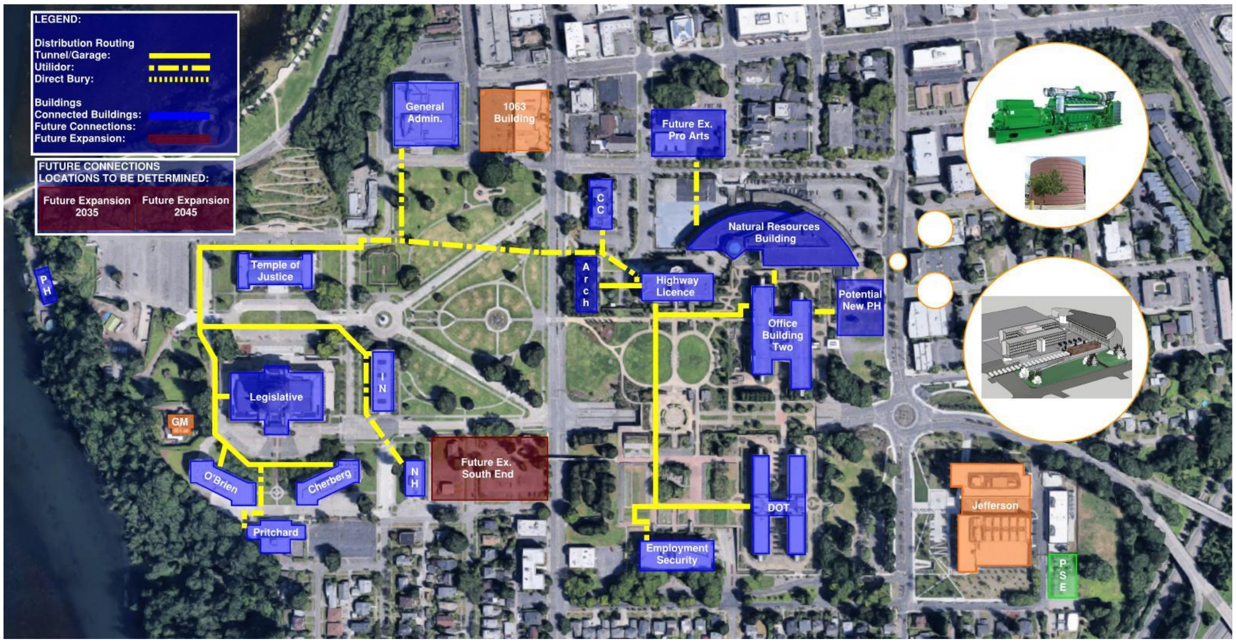
Similar to the Alternative 1, Alternative 2a is based upon first upgrading and modifying the existing steam distribution system to a new heating hot water system. In addition, a new production plant will be construction to incorporate combined heat and power (CHP) as the primary heating source for the campus with high efficiency hot water boilers as backup. In addition, a large thermal energy storage tank will store excess heat from the CHP unit and utilize this heat effectively during low load periods (ie: nighttime, morning warm-up and weekend hours). This utilization of thermal storage will work to improve the overall operating efficiency of the heating system.

The proposed new plant location will be on the east campus, adjacent to OB2 (as shown in the campus map below). There are some inherent advantages to this location. First, it is in close proximity to the existing campus electrical substation and natural gas lines that will be required. It provides easy access for distribution piping for centralization of all campus district energy systems (both heating and cooling). Also, the proposed site mitigates the inherent risks currently associated with the existing powerhouse location (including hillside slide concerns, flood risks from Capitol Lake, seismic upgrades to the building and boiler stack).

This new, efficient district energy system will serve as the primary heating production system for the existing buildings currently served by the steam system. In the long term, the system could be connected to serve all existing and planned buildings on campus.

- Design and build a new structure to house a district heating plant with space as required for CHW production and associated cooling towers
- Replace the existing steam production boilers with a base load heating cogeneration unit (either a reciprocating engine or gas turbine) and provide backup/peaking with high efficiency hot water boilers.
- Incorporate a thermal energy storage system to efficiently store and dispatch excess heat from the CHP unit as available and needed.
- Operate cogeneration as a “heat load following” system with all generated power under the minimum electrical load and used “inside the fence” of the campus
- Replace steam distribution with a new, efficient hot water distribution system.
- Integrate new hot water energy transfer stations at each connected facility to transfer heat from the distribution loop to the building for space heating and domestic hot water heating.
- Eliminate direct steam heating equipment in buildings and upgrade to hot water.
- Identify and mitigate existing site facility risks associated with the existing Powerhouse site (hillside slide concerns, flood risks from Capitol Lake, required seismic upgrades for the building and boiler stack)
- Develop long term concept scope for future CHW plant expansion / upgrades (feasibility analysis & ROM estimates only) that would delineate a future direction for the CHW system under this alternative.

Alt 2a - Overview of Proposed Distribution System



Alternative 2b (New District Energy Plant Hot Water Only)

Alternative 2b is similar to Alt 2a; however it excludes the CHP equipment and thermal storage. It utilizes high efficiency HW boilers as the primary district heating production source for the campus.

2.4 Other Options & Technologies Evaluated

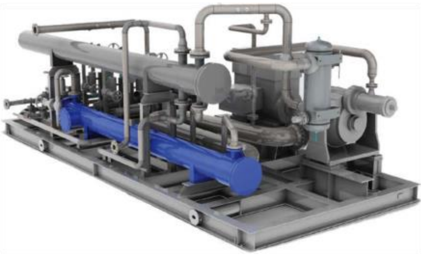
In addition to the primary alternatives considered, numerous technologies and options were taken into consideration for inclusion in the proposed district energy production plant. A few of these technologies analyzed during this process are listed below.

While the utilization of these and other technologies are not included in the proposed plan at the outset, the intent of the development process is to construct open flexibility into the overall system. This flexibility should allow for potential implementation of these, and other technologies as opportunities arise in the future on the path to reducing carbon and reaching Net Zero.

1. Integration of off-peak heat consuming technologies to extend power generation and minimize summer electrical peak loads
    - Absorption or adsorption cooling utilizing waste heat **–** Absorption / Adsorption cooling technologies utilize heat (or in this case waste heat) to drive a refrigeration cycle that generates chilled water for cooling. This option allows the cogeneration system to provide additional power for the campus while also serving the base cooling load. Since the lowest campus heating needs correspond with the highest cooling requirements, this option provides an ideal balance to allow additional generation during summer months

    - Bottoming cycle power generation (such as an organic Rankine cycle) – ORC is a thermodynamic process that utilizes heat to drive a refrigeration cycle that operates a generator. By utilizing an ORC, additional power could be generated for the campus utilizing waste heat from the CHP plant.

2. Heat recovery from chillers or other low temperature heat sources (such as data centers). The implementation of a low temperature hot water system opens the door to the incorporation of lower grade waste heat sources for the campus.

3. Renewable options deemed to have technical and/or economic benefit to the State of Washington (i.e. solar thermal, geo-exchange, or other technologies as viable). These technologies continue to improve and offer opportunities for "heat recovery" from the sun, earth or other sources.

4. Utilization of renewable fuel sources (i.e. biogas, landfill gas, digester gas, biomass, gasification of biosolids, etc). The application of renewable fuels provides a means to help the greater community by providing a market for these valuable fuel sources, while also providing a path to net zero.

5. Utilize the proposed Cogeneration for optional standby / emergency power to serve the capitol campus. Incorporating the CHP power generation into the standby grid for the campus will provide targeted resiliency.

6. Implementation of conservation on a parallel path (i.e. demand side energy reductions, solar PV applications, etc). The continued focus on reducing energy usage at the building level should continue throughout the capitol campus. This effort will help reduce the overall campus load, freeing up capacity for expansion to additional facilities and potentially to the greater community.

2.5 Serving Future Campus Growth

As a part of Alternatives 1 & 2, it was determined that all future facilities constructed on campus should be served by the new District Energy Heating Plant. The proposed distribution system will be designed to handle future load growth over the next 50 years and beyond, as identified in coordination with the campus master planning team during the development of this project. In addition, it is assumed that all existing facilities on campus that are not currently served by the existing Powerhouse will eventually be connected to the new system; corresponding with required in-building system renewal timing. Alternately, it was assumed that, under the BAU option, future loads were analyzed as being constructed with stand-alone heating systems due to distribution system limitations.

The anticipated schedule to incorporate existing and future facilities into the new system is provided in the following tables.

Connected Building	Zone	sqft	Connected Capacity (MMBtu/h)	Year Connected	0 2018	1 2019	2 2020	7 2025	17 2035	22 2040	24 2042	27 2045	50 2068
Archives Bldg	east	51,500	1.1	2018	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Cherberg	west	100,377	6.4	2018	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Employment Security	east	93,200	3.8	2018	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
GA Bldg.	west	283,865	11.4	2018	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
Highway-License	east	193,900	6.2	2018	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Insurance	west	65,502	2.7	2018	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Legislative	west	235,500	11.8	2018	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
Natural Resources (MUA)	east	387,558	3.9	2018	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Newhouse	west	25,084	0.5	2018	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
OB-2	east	379,204	15.7	2018	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7
O'Brien	west	100,700	9.3	2018	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
Pritchard (Library)	west	55,485	3.0	2018	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Temple of Justice	west	85,900	2.6	2018	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Natural Resources (DHW)	east	387,558	1.0	2020			1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Court	east	40,948	1.6	2020			1.6	1.6	1.6	1.6	1.6	1.6	1.6
Future Expansion - 1	west	200,000	6.1	2020			6.1	6.1	6.1	6.1	6.1	6.1	6.1
Transportation	east	206,100	2.1	2020			2.1	2.1	2.1	2.1	2.1	2.1	2.1
Future Expansion - 2	west	225,000	6.8	2025				6.8	6.8	6.8	6.8	6.8	6.8
Future Expansion - 3	west	21,400	6.1	2035					6.1	6.1	6.1	6.1	6.1
Governor's Mansion	west	200,000	3.2	2035					3.2	3.2	3.2	3.2	3.2
1063 Bldg	west	215,000	6.5	2040						6.5	6.5	6.5	6.5
Jefferson Building - Office / Retail	east	240,594	7.3	2042							7.3	7.3	7.3
Jefferson Building - Datacenter	east	132,503	0.0	2042							0.0	0.0	0.0
Future Expansion - 4	east	200,000	6.1	2045								6.1	6.1
				connected capacity (MMBtu/h)	**78.3**	**78.3**	**89.0**	**95.9**	**105.1**	**111.6**	**118.9**	**125.0**	**125.0**
				diversified peak (MMBtu/h)	**40.1**	**40.1**	**49.6**	**53.4**	**63.9**	**69.5**	**74.0**	**79.4**	**79.4**

Annual Heat Delivered to Buildings (MMBtu/yr)	**30,237**	**30,237**	**37,379**	**40,241**	**48,106**	**52,327**	**55,744**	**59,828**	**59,828**
Load Increase from Baseline %	0%	0%	24%	33%	59%	73%	84%	98%	98%
Required Plant Installed Capacity	75	75	75	75	90	105	105	105	105
	2018	2019	2020	2025	2035	2040	2042	2045	2068

Building Connected	Zone	Bldg sqft	Connected Capacity (MMBtu/h)	Year Connected	2018	2020	2025	2030	2035	2040	2042	2045	2068
Archives Bldg	east	51,500	1.1	2018	51,500	51,500	51,500	51,500	51,500	51,500	51,500	51,500	51,500
Cherberg	west	100,377	6.4	2018	100,377	100,377	100,377	100,377	100,377	100,377	100,377	100,377	100,377
Employment Security	east	93,200	3.8	2018	93,200	93,200	93,200	93,200	93,200	93,200	93,200	93,200	93,200
GA Bldg.	west	283,865	11.4	2018	283,865	283,865	283,865	283,865	283,865	283,865	283,865	283,865	283,865
Highway-License	east	193,900	6.2	2018	193,900	193,900	193,900	193,900	193,900	193,900	193,900	193,900	193,900
Insurance	west	65,502	2.7	2018	65,502	65,502	65,502	65,502	65,502	65,502	65,502	65,502	65,502
Legislative	west	235,500	11.8	2018	235,500	235,500	235,500	235,500	235,500	235,500	235,500	235,500	235,500
Natural Resources	east	387,558	4.8	2018	387,558	387,558	387,558	387,558	387,558	387,558	387,558	387,558	387,558
Newhouse	west	25,084	0.5	2018	25,084	25,084	25,084	25,084	25,084	25,084	25,084	25,084	25,084
OB-2	east	379,204	15.7	2018	379,204	379,204	379,204	379,204	379,204	379,204	379,204	379,204	379,204
O'Brien	west	100,700	9.3	2018	100,700	100,700	100,700	100,700	100,700	100,700	100,700	100,700	100,700
Pritchard (Library)	west	55,485	3.0	2018	55,485	55,485	55,485	55,485	55,485	55,485	55,485	55,485	55,485
Temple of Justice	west	85,900	2.6	2018	85,900	85,900	85,900	85,900	85,900	85,900	85,900	85,900	85,900
Capital Court	east	40,948	1.6	2020		40,948	40,948	40,948	40,948	40,948	40,948	40,948	40,948
Future Expansion - 1 (ProArts site)	west	200,000	6.1	2020		200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Transportation	east	206,100	2.1	2020		206,100	206,100	206,100	206,100	206,100	206,100	206,100	206,100
Future Expansion - 2 (South End)	west	225,000	6.8	2025			225,000	225,000	225,000	225,000	225,000	225,000	225,000
Future Expansion - 3	west	21,400	6.1	2035					21,400	21,400	21,400	21,400	21,400
Governor's Mansion	west	200,000	3.2	2035					200,000	200,000	200,000	200,000	200,000
1063 Bldg	west	215,000	6.5	2040						215,000	215,000	215,000	215,000
Jefferson Building - Office / Retail	east	240,594	7.3	2042							240,594	240,594	240,594
Jefferson Building - Datacenter	east	132,503	0.0	2042							132,503	132,503	132,503
Future Expansion - 4	east	200,000	6.1	2045								200,000	200,000
				connected square footage	**2,057,775**	**2,504,823**	**2,729,823**	**2,729,823**	**2,951,223**	**3,166,223**	**3,539,320**	**3,739,320**	**3,739,320**

In addition to the anticipated future load growth that will occur from connecting to additional facilities, there is the potential for ongoing load reduction at existing facilities due to efforts at demand-side conservation. This potential concurrent load reduction could free up capacity. It is anticipated that this available capacity could open future opportunities to further expand the overall district energy system for service to a growing facility base. Any future expansion would serve to increase the system financial and carbon benefits.

2.6 Meeting Carbon Neutral Goals

The implementation of the recommended alternative 2a provides a significant leap in the overall goal of reaching both short term and long term carbon neutral goals. As shown in the table below, this initial step reduces carbon emissions from the production and distribution of both heating and cooling on campus by over 50%. In addition, it provides both the path and tools to making additional strides and eventually meeting the long term goal of net zero.

50 Year Carbon Emissions (Metric Tons)	**BAU**	**Alt 2a + CHW**
Heating System - Carbon Emissions	299,138	85,214
Cooling System - Carbon Emissions	123,945	107,599
Subtotal - Combined Heating / Cooling Carbon Emissions	**423,083**	**192,814**
Carbon Reduction from BAU		**54%**

Overview of Current Campus Carbon Reduction Goals

Capitol Campus operations are the responsibility of the Department of Enterprise Services. DES is a Cabinet Agency. As such DES must comply with all Statutes applicable to State Agencies and DES must comply with all Governor Executive Orders.

Excerpts from Applicable Statutes Related to Carbon Reduction Goals:

RCW 70.253.020 - Greenhouse gas emissions reductions—reporting requirements

(1)(a) The state shall limit emissions of greenhouse gases to achieve the following emission reductions for Washington State:

(i) By 2020, reduce overall emissions of greenhouse gases in the state to 1990 levels;

(ii) By 2035, reduce overall emissions of greenhouse gases in the state to twenty-five percent below 1990 levels;

(iii) By 2050, the state will do its part to reach global climate stabilization levels by reducing overall emissions to fifty percent below 1990 levels, or seventy percent below the state's expected emissions that year.

NEW SECTION. RCW 70.235.050 reads as follows:

(1) All state agencies shall meet the statewide greenhouse gas emission limits established in RCW 70.235.020 to achieve the following, using the estimates and strategy established in subsections (2) and (3) of this section:

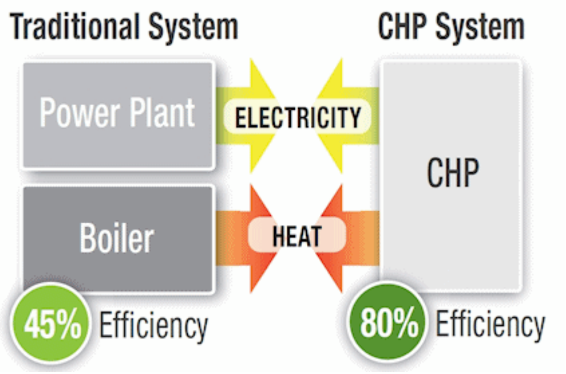
(a) By July 1, 2020, reduce emissions by fifteen percent from 2005 emission levels;

(b) By 2035, reduce emissions to thirty-six percent below 2005 levels; and

(c) By 2050, reduce emissions to the greater reduction of fifty-seven and one-half percent below 2005 levels, or seventy percent below the expected state government emissions that year.

2.7 Overview of Combined Heat and Power

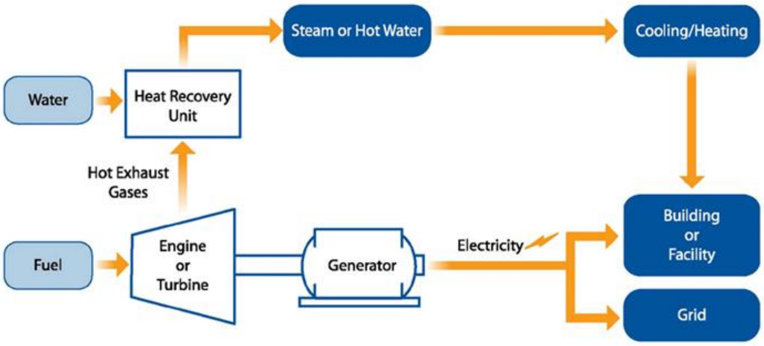
Also known as cogeneration, combined heat and power (CHP) is a way to increase the efficiency of power plants. Interestingly enough, most conventional power plants produce waste heat as a by-product of generating electricity and then discharge this valuable heat resource to the atmosphere. Standard power plants effectively use just 40 percent of the fuel they burn to produce electricity. Sixty percent of the fuel used in the electric production process ends up being rejected or "wasted" up the smokestack as heat. One of the biggest uses of fossil fuel globally is for generating this same heat resource. CHP offers the opportunity to generate electricity locally and capture the waste heat for use in heating buildings and neighborhoods**.**



CHP along with thermal storage creates a “smart grid” compatible facility capable of working cooperatively with the local utility in modes of operation that benefit both the Campus and the utility. Examples include afternoon CHP operation in the late summer and fall when hydroelectric resources can be limited. This type of operation would help the local utility especially as Washington eliminates coal generated power. The heat generated by the CHP can be stored in the thermal storage tanks for utilization during morning warm up and for reheat in buildings with Variable Air Volume (VAV) systems, a very common building HVAC system.

CHP with thermal storage also makes a campus and utility more resilient against utility source power interruptions from transmission lines and central power production facilities outages (wild fires, flooding, earthquake, terrorist, etc.)

CHP Technologies



Today's market conditions increasingly favor distributed generation fueled by natural gas and fuels. The addition of heat recovery from the power generating source and thermal storage makes the economics all the more attractive. When developing a distributed generation system, there are two primary power sources: reciprocating engines and turbines. Both systems have been proven throughout the US and the world in many thousands of cogeneration installations.

Over the years, both of these technologies have continued to improve in overall operating efficiency, reliability, operating costs and emissions performance. Neither technology is necessarily superior to the other. Instead, each has attributes that make it the most suitable for a specific application due to conditions of fuel type availability and quality, thermal and electric load profile, physical space, local conditions, or other factors. There are also applications where reciprocating engines and turbines work together and provide the ideal levels of electrical reliability, efficiency and economic benefits.

In addition to the economic benefits, CHP can help organizations live up to their sustainability, carbon-reduction and energy-conservations goals.

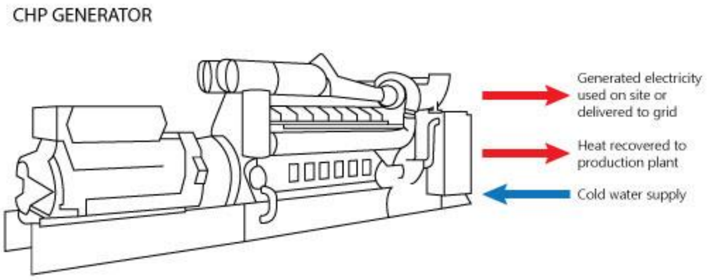
As distributed generation resources, both reciprocating engines and turbine are fairly easy to install. In addition, up-front costs per kW are relatively low. The reliability is high, often up to 98 percent annually when properly maintained and operated. Both can also operate efficiently on a variety of fuels, systems are able to accommodate available space through various, flexible configurations.

Natural Gas Reciprocating Engine

Reciprocating engines generally are more fuel-efficient than turbines in pure electric power applications. They have lower initial cost per kW in smaller projects (less than 5 MW) and are more tolerant of high altitude and higher ambient temperatures. They operate on low-pressure fuel (up to 5 psi). This eliminates the costs to install and operate a gas compressor system.

While the utilization of utility provided natural gas is the most common application, engines readily accept many alternative fuels, such as biogas, digester gas and landfill gas, as well as specialized fuels like coke gas and coal mine methane.

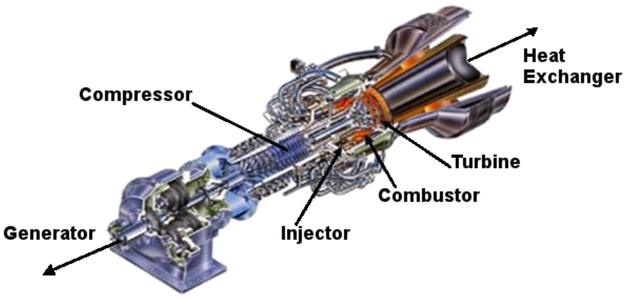
Utilized in a CHP application, engines have multiple recoverable heat sources. These include heat streams linked to exhaust, jacket water, aftercooler and oil cooler. These recovered heat resources can be used to produce warm water, hot water and even medium-pressure steam (from exhaust).



One of the most obvious points of differentiation is an engines ability to follow variable loads and to come online quickly (in most cases within 30 seconds). These attributes makes them good candidates for distributed generation in support of electric utility grids. Often, utilities need more capacity to fulfill high-cost peak demands that may occur only during a few weeks each year. This ongoing need can sometimes be filled with, fast-online resources located near the point of end use. Fuel oil powered generators typically been utilized for this purpose. With stricter air-quality regulations coming into effect in recent years, coupled with an increase in fuel oil prices, gas-engines are becoming better suited to provide this resource.

Natural Gas Turbine

When utilized in a CHP application, the best asset of a gas turbine is their high heat-to-power ratio. Turbines can produce large volumes of exhaust gas at very high temperatures (often up to 900°F). This high pressure, high volume exhaust is capable of generating high-quality, high-pressure steam, as well as high temperature hot



water.

Turbine emissions are also lower than that of a reciprocating engine. They are ideally suited for loads of 5 MW and up; although continued improvements and modifications to technologies are opening the door to turbine utilization in much smaller applications. They can operate on low-energy fuels and perform extremely well with high-Btu fuels, such as propane.

With a high uptime, turbines offer full-load operation for extended annual hours with very little downtime required for maintenance. Turbines are also relatively lightweight with a compact footprint when compared to a reciprocating engine. Today's turbines have a simple design (ie: no liquid cooling system and no spark plugs). Major overhauls require only combustor replacement after about 60,000 hours of duty.

2.8 Thermal Storage

Hot water thermal energy storage (TES) is a means to collect and productively use waste heat supply from a cogeneration system or other intermittent waste heat source. It also extends the availability of cogeneration alternatives to serve the campus load and displace natural gas boilers when the daily heat load profile varies above and below the output capacity of the system installed. By doing this, it serves to shave the peak load capacity and distribution system requirements which help to reduce the installed capital cost of the installed production equipment. Lastly, it enables the cogeneration to run intermittently (daily cycle) during the lowest load periods during the summer. This will address minimum equipment turndown capability and facilitate scheduled maintenance.

During the development of this project, UMC analyzed the footprint, and physical volume of appropriately sized single thermal energy storage with an atmospheric top. This puts constraints on the maximum temperature and the location (hydraulically) where it would be placed. A tank can also be designed with a pressurized top to enable greater temperatures and more flexibility in siting; however, this would be significantly more expensive.

Hot water storage is applied to all alternatives considered in this analysis for the reasons noted above. Obviously the campus architect would play a key role if the thermal energy storage tank was located on the campus. Appropriate steps could be taken to minimize any perceived adverse visual impact.

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3.0 CAMPUS POWERHOUSE STEAM SYSTEM HISTORICAL ANALYSIS

3.1 Existing Powerhouse District Energy Plant

Steam Production Plant Overview

The main Powerhouse structure was completed in 1921 and is located on the West side of the campus next to Capitol Lake. There are two floors; the first floor houses the steam boilers and offices. The second floor was added on in the mid 70's and houses the primary cooling equipment (including chillers, pumps, electrical gear for the building and chilled water chemical treatment). The cooling towers are also located on the 2nd level, exterior to the plant at each end of the Powerhouse.

The Powerhouse produces steam utilizing three, 30,000 lbm/hr steam boilers. Boilers B-1 and B-2 are Cleaver Brooks D-52, water-tube type, with Coen 235 DAZ 24 burners built in 1970. These two boilers also have constant volume forced draft fans and were installed in 1974. Boiler B-3 is a Wickes Boiler Company, two-drum, type SIAL-24 with a Coen Co. 275-81 burner. B-3 was installed in 1960 and has a variable frequency drive on the indirect draft fan and a constant volume drive for the forced draft fan.

Each boiler has a full digital interface with the Campus Metasys control and monitoring system. Individual, single-stage stack economizers have been installed at each boiler. These economizers are rated for 30,000 lbm/hr water and 33,990 lbm/hr flue gas. The economizers recover heat directly to the boiler feedwater prior to entering each boiler.

The boilers are all dual fuel capable, operating primarily on natural gas. Backup fuel is number 2 fuel oil which is stored in an above ground tank directly south of the Powerhouse.

The steam deaerator tank is located on the south side of the Powerhouse on an elevated mezzanine. The deaerator takes steam at ~15psi and feed water at roughly 175F and heats the feed water to approximately 240F to remove a majority of the dissolved air in the water. There are two 30-hp pumps that provide feed water from the deaerator tank to the boilers. The deaerator gets its steam from a direct line from the steam header that runs through a pressure reducing valve to output 15psi steam.

Condensate is collected and stored in a 1500 gallon receiver tank. Makeup water is added to the system at the receiver tank. Water softeners are used to pretreat the incoming makeup water. There are three 1.5-hp condensate pumps available to pump the condensate from the receiver tank to the deaerator and are currently manually operated.

The following tables provide an overview of the current steam plant production equipment.

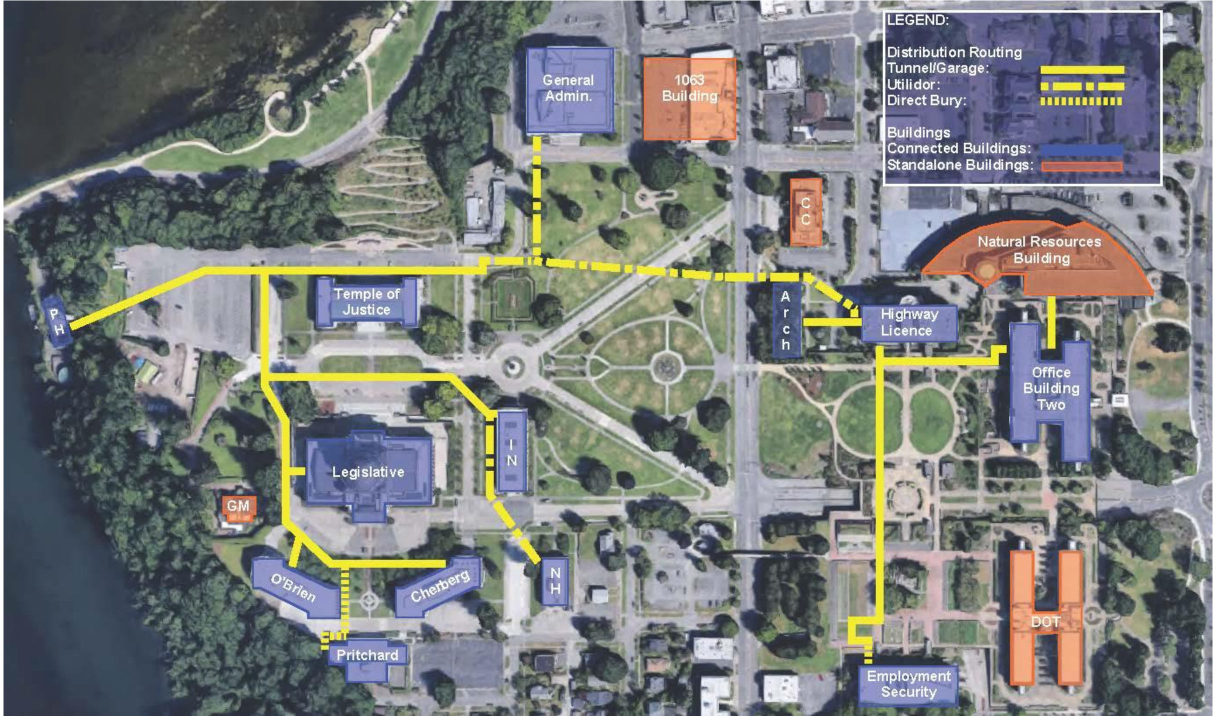
Major Equipment List		
Description	Quanity	Rated Capacity
Boilers #1,#2, #3	3	30,000 lbm/hr
Economizers #1, #2, #3	3	30,000 lbm/hr Water 33,990 lbm/hr Flue Gas
Deaerator	1	15 psi steam input
Condensate Tank	1	1500 gal
Blowdown Tank	1	3 gpm
Steam Flow Meter	1	0-75,000 lbm/hr
Feed Water Pumps	2	30 HP
Condensate Pumps	3	1-1/2 HP

A schematic diagram showing the current steam production plant layout can be found in the Appendix.

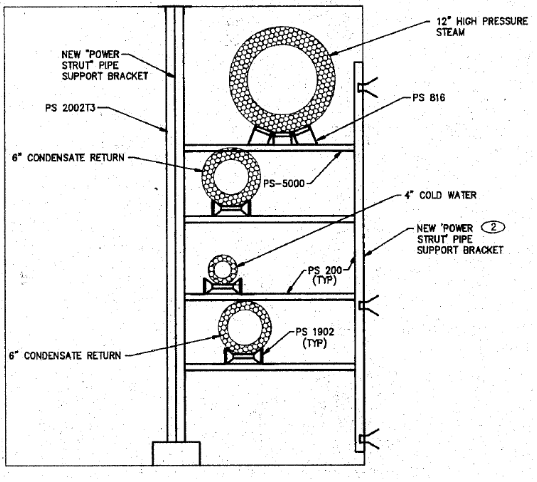
Existing Distribution System Overview

The campus is divided into two areas called East and West Campus (divided by Capitol Way). The West Campus system serves the following buildings: Temple of Justice, Legislative, O'Brien, Pritchard, Cherberg, Insurance, Newhouse, and General Administration buildings. The East Campus system serves Archives, Highways Licenses, Office Building Two, and Employment Securities buildings. In total there is approximately 2.7 miles of steam and condensate piping connecting the buildings across the East and West Campus.

Campus Steam Distribution System



The West Campus connects buildings to the steam plant with piping running through a walk-able tunnel system. The tunnel system is designated as a “permit-required confined space” requiring safety procedures and protocols before entry to the tunnel. The entry points to the tunnel are at every building and via manholes distributed throughout the tunnel system. The tunnel is ventilated with several intake and exhaust fans located throughout the tunnel system.



The typical dimensions of the tunnel are roughly 6’-6” in height by 5’ wide. There are two segments of tunnel that are only 4’ wide; the branch to the Insurance building and the main run between manholes 1B and 9 (the segment of pipe north of the Temple of Justice that runs East/West). Please note that two condensate lines are only present in the segment of tunnel stretching from the Powerhouse to manhole 1B.

The tunnel supports pipes using support rollers spaced roughly every 9 feet (as called out in 1994 Utility Improvement Drawings). The High Pressure Supply (HPS) line has 2” thick insulation with an aluminum jacket on all pipe sizes and the High Pressure Return (HPR) has 1” thick insulation with an aluminum jacket on all pipe sizes.

In addition to the tunnel there are areas that utilize utilidor and direct bury to distribute the pipe runs to individual buildings. The branch lines that run to Newhouse, General Administration, and the main line starting from man-hole 10 (just past the GA building branch) to the East Campus all are utilidor. The line that runs to Pritchard is direct bury.

The East Campus connects buildings through a series of utilidor direct bury, and open pipe distribution hung from the underdeck of an open parking garage. The HPS line in the East Campus also has 2” thick insulation with an aluminum jacket on all pipe sizes and the HPR line has 1” thick insulation with an aluminum jacket on all pipe sizes.

Buildings on Capitol Campus

The following table provides an overview of the buildings on the state campus.

WA State Captial Campus											
		Cooling	**Heating**							**Condensate**	
WEST CAMPUS											
Building	**Sq. Ft.**	**Tons**	Heating Coils (HW/Steam)	HPS Steam Pipe Size (in.)	Cond. Pipe Size (in.)	Installed HX (BTU/h)	HVAC (Lb/hr)	Domestic Heating Type	Domestic BTU/h	Condensate Reciever Capacity (GPM)	Condensate Reciever Size (Gal)
Legislative Building	235,500	650	HW Only	5	3	11,775,000	11980	HHW	840,000	75	80
O'Brien	100,700	250	HW Only	4	3	9,150,000	9,433	Steam with Electric Backup	184,248	45	52
Cherberg	100,377	275	HW Only	6	4	4,600,000	4,829	Steam Only	1,750,000	65	60
Newhouse	25,084	N/A	Steam/HW	2	1-1/2	498,000	513	Electric	20,472	30	30
Pritchard (Library)	55,485	95	Steam Only	4 LPS	1.5	2,910,000	3,000	Electric	81,888	20	20
Governor's Mansion	21,400	35	Independent HW	N/A	N/A	N/A	N/A	Electric	246,666	N/A	N/A
Insurance	65,502	100	Steam/HW	2	1.5	2,620,080	2,701	Electric	40,956	20	54
Temple of Justice	85,900	120	Steam/HW	2.5	1.5	2,531,600	2,595	Steam Only	30,717	30	40
GA Bldg.	283,865	600	Steam Only	6	4	11,354,600	11,706	Steam Only	92,151	135	135
EAST CAMPUS											
OB-2	379,204	900	HW Only	6	2.5	15,500,000	15,500	Steam with Electric Backup	153,583	75	75
Highway-License	193,900	320	HW Only	4	2	6,037,500	6,038	Steam Only	184,302	30	45
Archives Bldg	51,500	70	HW Only	1.5	1	1,091,250	1,125	Electric Only	20,472	12	9
NRB	387,558	700	Electric	N/A	N/A	N/A	N/A	N. Gas Boiler	960,000	N/A	N/A
Transportation	206,100	500	Electric	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Employment Security	93,200	190	Steam Only	4	2	3,728,000	3,843	Steam Only	30,717	39	39
Capitol Court	40,948	N/A	Independent HW	N/A	N/A	N/A	N/A	Electric Only	30,708	N/A	N/A
Building Totals	2,472,019	4,805				**71,796,030**	**73,264**	**0**	**4,666,880**	**576**	**639**
POWERHOUSE											
Powerhouse	**10,000**	**1,360**	Steam	12	(2) 6	87,300,000	**90,000**			**180**	**2,100**

Note: Buildings listed as “N/A” are not currently connected to the campus distribution system.

Review of Past Studies & Modifications

The Capitol Campus steam production plant was initially constructed and commissioned in 1920. Since the original design inception, there have been numerous studies, retrofits and recommendations performed; all in an effort to resolve issues, while improving operation & efficiency. Following is an overview of some of these modifications & recommendations:

Wieland, Lindgren and Associates – 1982 (Phase 1 and Phase 2)

- Replaced/repaired insulation at various locations along West Campus Steam System and building mechanical rooms
- Removing of Soils building from steam line
- Installation of feedwater stack economizers for all three boilers
- Installation of boiler continuous blow down flash tank and heat recovery heat exchanger
- Installation of new burner on Boiler 3
- Miscellaneous powerhouse piping replacements/additions

Richmond Engineering - 1994

- Installation of “Power Strut” pipe support brackets throughout West Campus Tunnel
- Replaced various steam traps in West Campus Tunnel
- Replaced various expansion joints in West Campus Tunnel
- Replaced various steam/condensate meters and valves in West Campus Tunnel
- Replaced/repaired insulation at various locations along West Campus steam system
- Miscellaneous tunnel piping replacements

McKinstry Retrofits – 2004 to 2014

- Various mechanical room projects
- Replacement of steam/domestic hot water heaters with electrical domestic hot water heaters
- Removal of the Governor’s Mansion from the steam distribution system

University Mechanical Contractors – 2015

- Performed detailed audit and analysis of existing steam production and distribution systems
- Provided itemized list of safety concerns and priorities
- Performed upgrades for highest priority safety issues
- Performed analysis of District Energy options including: Distributed Generation (to allow for summer shutdown; Steam Conservation Opportunities; Steam-to-Hot Water Conversion; Combined Heat and Power.

3.2 Steam Production and Distribution Efficiency Analysis

Review of Operation

The existing steam production plant operates continuously year round, rotating between boilers B-1, B-2, and B-3 as needed. One boiler is typically designated as the primary boiler while an additional boiler is kept warm in hot-standby for backup. B-3 is the preferred boiler for summer usage as it is believed to have the highest turndown of the three boilers. The current operating pressure of the system is 110-120 psi steam.

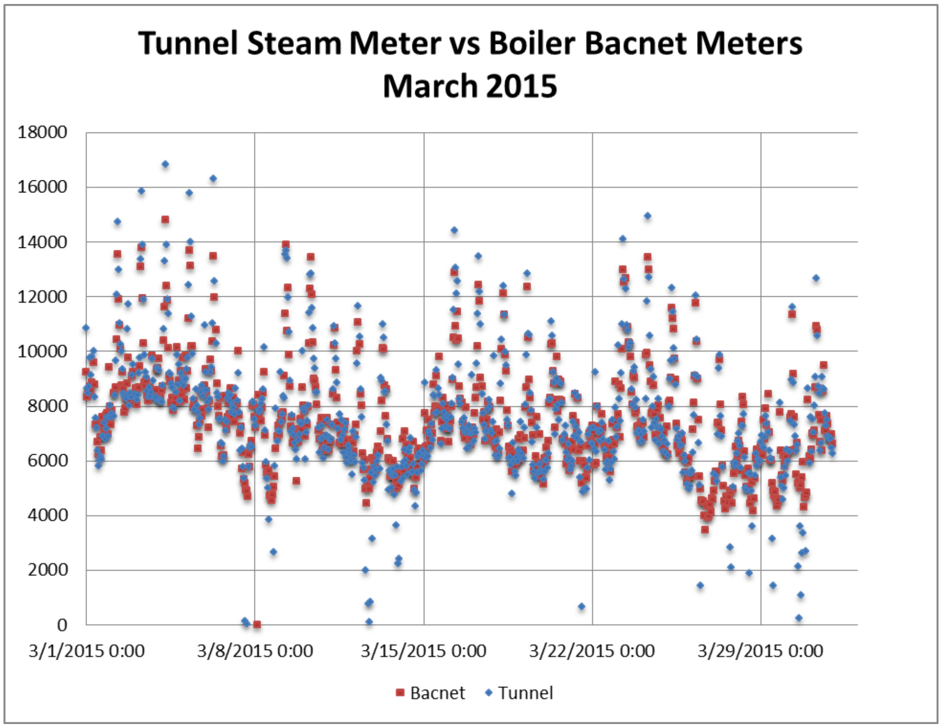
Condensate is returned to the system by condensate receivers at each building pumping directly into the atmospheric line. The distribution system’s traps return condensate by direct connection to the condensate line, utilizing steam pressure to move the condensate into the line in many places. Once in the condensate line, gravity returns the condensate to the Powerhouse and collects into a 500 gallon condensate receiver. From there it is pumped into the main 1500 gallon receiver tank.

Verification of Production

UMC used two methods to verify the steam production from the Powerhouse. The first method was to compare the individual boiler BACnet meters against the main steam meter located in the tunnel, outside of the Powerhouse building.

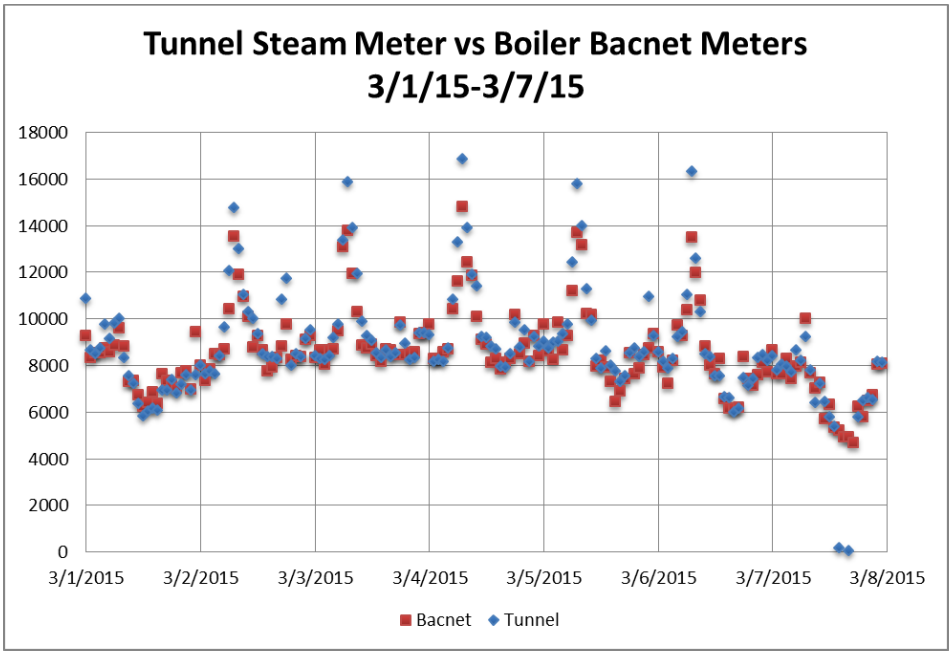
The following graph displays the steam production for March 2015. As the graph shows, there is significant overlap of the two meters. Overall the two meters read, on average, within 15% of each other. The tunnel meter does appear to be inaccurate at roughly 4,000 lbm/hr or below and begins to read slightly higher than the BACnet meters above 14,000 lbm/hr.

March 2015 Steam Production

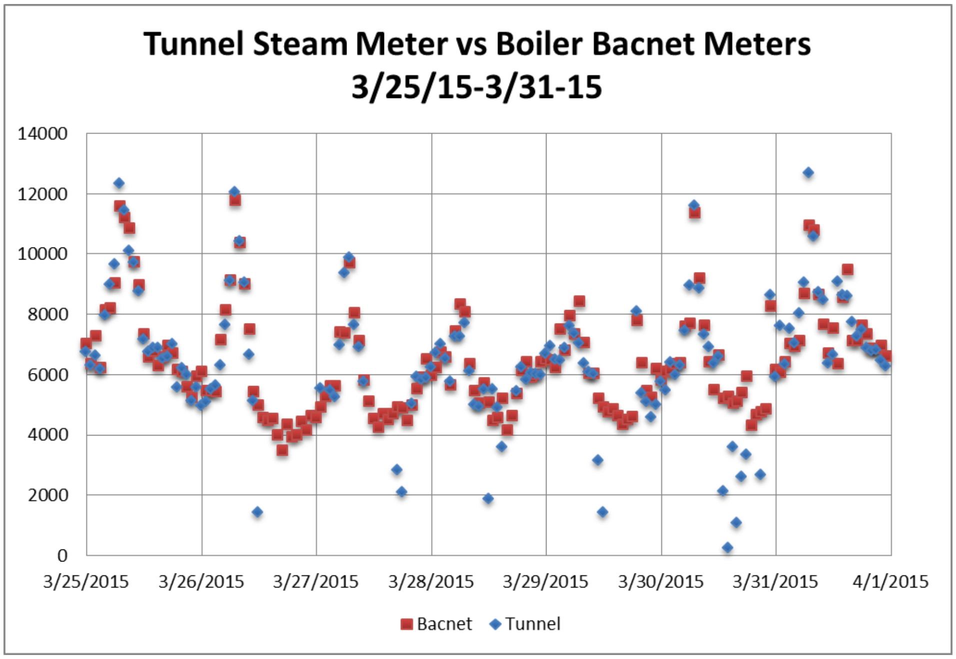


The following two graphs show a week's worth of production from the beginning and ending of March. The graph showing 3/1/15 through 3/7/15 data demonstrates the increase in difference in readings between the two meters above 14,000 lbm/hr production. The graph showing 3/25/15 through 3/31/15 demonstrates the tunnel meter's inaccuracy below 4,000 lbm/hr.

Steam Production

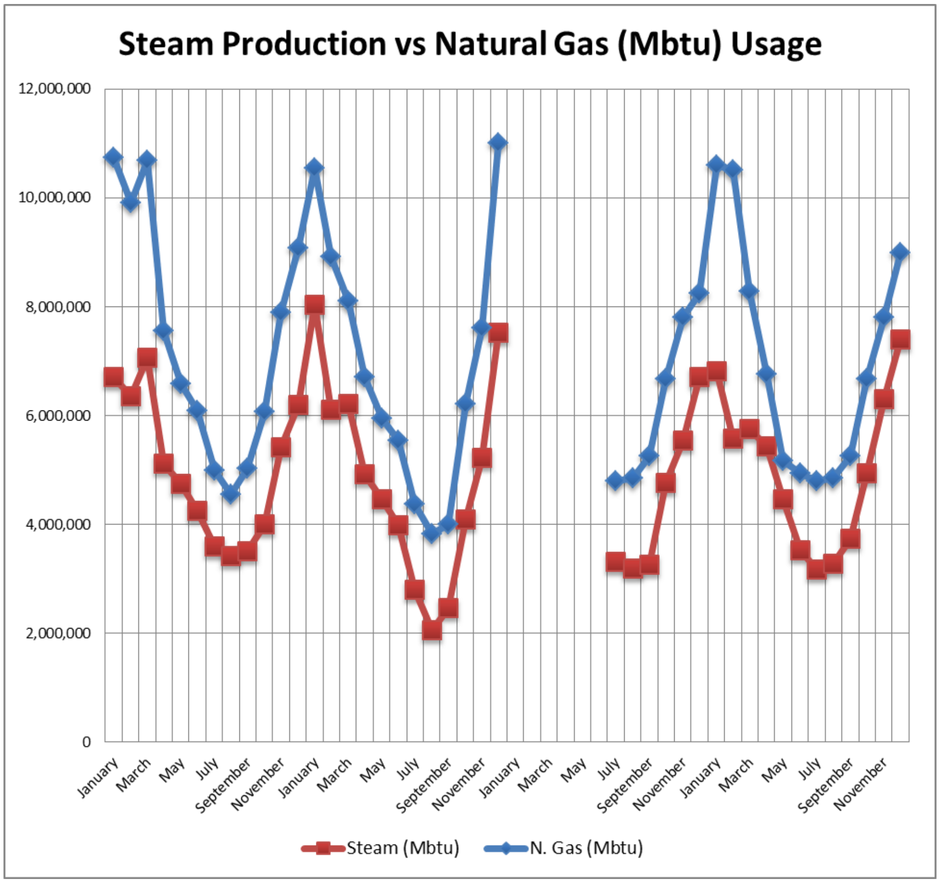


Steam Production



The above graphs show that both the individual BACnet boiler meters as well as the main meter in the steam tunnel agree in their readings of the steam production. This agreement reinforces the validity of the steam readings as we would expect a significant discrepancy between the two sets of data if steam production was erroneous.

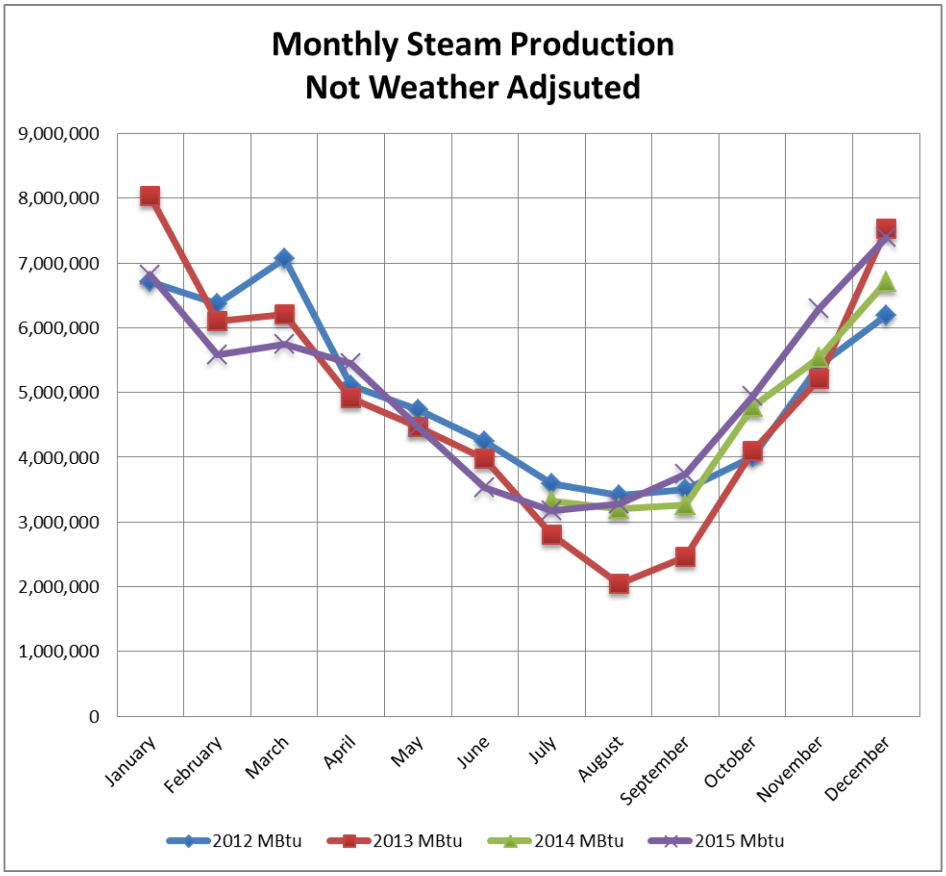
The second method UMC utilized to verify steam production was to compare the trend in steam production to natural gas consumption. When overlaying the two graphs of usage we would expect the curve of each to follow in the same general trending direction since the only variable between the two is the overall boiler efficiency. The following graph shows the trend in production and therm consumption. As you can see from the graph, both of the curves follow the same general trend. The separation between the two lines arises from changes in the overall boiler efficiency. This also tracks with what we would expect of the system as you can see the efficiency improves (distance between lines increases) in the winter and the efficiency decreases in the summer.



The above graph adds another layer of validity to the steam production readings. With this and the agreement of two separate meters, UMC feels confident that the steam meters on the campus are reading reliable values. We have used them in the analysis presented in this report.

Steam Production and Operation

To determine steam production UMC analyzed provided manual boiler logs from 2012 and 2013 and BACnet metering data for 2014-2015. The plant produced an average of 59,550,000 pounds of steam per year over that period. January is the largest steam producing month, averaging 7,190,000 pounds of steam. August is the least steam producing month averaging 3,000,000 pounds. The following graph shows the campus steam production (note that the steam production has not been weather adjusted).



Steam production showed a significant drop for summer 2013. UMC was informed there was construction on the campus from July-September 2013 that affected steam service.

Another item to note is that the Governor's mansion was removed from the steam system in summer of 2014.

Steam Production

Year	2012 - (5797 HDD)			2013 - (5679 HDD)		
Month	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms
January	9,024	6,713,954	107,482	10,800	8,035,500	105,400
February	9,142	6,362,679	99,114	9,090	6,108,184	89,295
March	9,495	7,064,642	106,926	8,349	6,211,600	81,103
April	7,101	5,112,632	75,606	6,828	4,916,096	67,134
May	6,372	4,740,449	65,835	6,001	4,464,764	59,554
June	5,897	4,245,947	60,857	5,530	3,981,388	55,511
July	4,827	3,591,187	49,932	3,770	2,804,871	43,743
August	4,593	3,416,841	45,481	2,755	2,049,650	38,313
September	4,866	3,503,503	50,333	3,426	2,466,900	40,039
October	5,385	4,006,706	60,780	5,503	4,094,362	62,107
November	7,516	5,411,485	78,919	7,245	5,216,266	76,072
December	8,326	6,194,397	90,888	10,112	7,523,356	110,097
Summary	6,879	60,364,422	892,153	6,617	57,872,937	828,368
Year	2012 - (5797 HDD)			2013 - (5679 HDD)		
Month	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms
January	9,024	6,713,954	107,482	10,800	8,035,500	105,400
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December	8,326	6,194,397	90,888	10,112	7,523,356	110,097
Summary	6,879	60,364,422	892,153	6,617	57,872,937	828,368
Year	2014 - (5158 HDD)			2015 - (4856 HDD)		
Month	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms	Average Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms
January	10,376	7,719,978	106,338	9,148	6,815,867	86,177
February	10,008	6,725,448	97,050	8,321	5,582,843	74,145
March	8,230	6,122,768	84,571	7,724	5,746,905	77,104
April	6,536	4,705,604	64,860	7,559	5,442,687	70,868
May	5,190	3,861,342	53,248	5,995	4,460,037	63,197
June	4,619	3,325,505	46,549	4,886	3,523,277	48,376
July	4,455	3,314,431	44,000	4,261	3,169,858	41,963
August	4,297	3,196,644	43,758	4,417	3,282,434	39,433
September	4,537	3,266,667	42,642	5,182	3,730,714	45,830
October	6,414	4,772,126	57,541	6,648	4,946,322	56,597
November	7,698	5,542,339	61,869	8,751	6,300,446	76,142
December	9,011	6,704,346	98,000	9,947	7,400,479	88,383
Summary	6,781	59,257,198	800,426	6,903	60,401,868	768,215

The majority of the steam produced is utilized for heating purposes. In addition, the deaerator uses steam to ensure that that the water entering the boiler is oxygen and sediment free. The steam mass required, roughly ~3,000,000 lbm, accounts for ~5% of the total steam produced yearly. It is worthwhile to note that a majority of this steam energy is not a loss, as only a portion of this steam is vented.

The steam system also consumes electricity to run the various fans and pumps. The majority of the equipment in the Steam Plant does not include variable frequency drives (VFD) for their motors. Only the indirect draft fan on B3 has a VFD. As such the electric energy consumption from the steam production equipment is fairly constant each month, averaging 43 kW and 31,500 kWh.

In addition to electricity, the steam system also consumes water due to various losses and uses in the system. Makeup water was trended over a one week period to determine average usage. From the trending the system loses roughly 2,100 gallons per day. This comes out to 11% of the total water in the system per year if no increase in loss is assumed for the winter months when production increases.

Makeup Water Trend

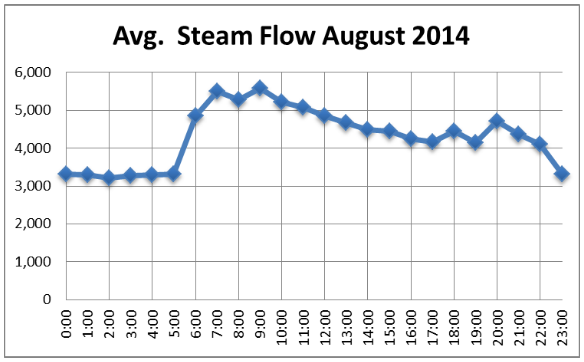
Date	Gallons	Hours	GPM
8/28/2014	1296	11.33	1.9
8/29/2014	2044	24	1.4
8/30/2014	2527	24	1.8
8/31/2014	1991	24	1.4
9/1/2014	1646	24	1.1
9/2/2014	1605	24	1.1
9/3/2014	1981	24	1.4
9/4/2014	1434	14.5	1.6

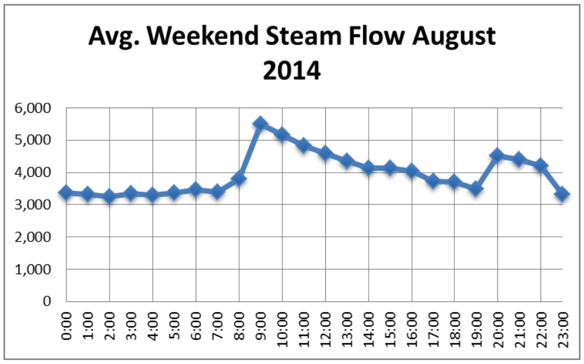
Avg Flowrate (GPM):	1.5
Avg Daily Gallons:	2114

Finally UMC analyzed the gaseous emissions associated with the steam plant. Yearly, the steam plant produces roughly 4700 MTCO2 per year. This value comes from the 855,641 average yearly therm usage and the expected electrical usage of 313,956 kWh. The plant also produces roughly 5.7 MTNOx per year per EPA AP-42 calculation.

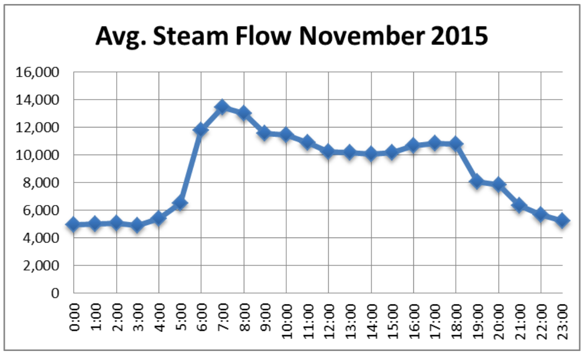
Observed System Operating Characteristics

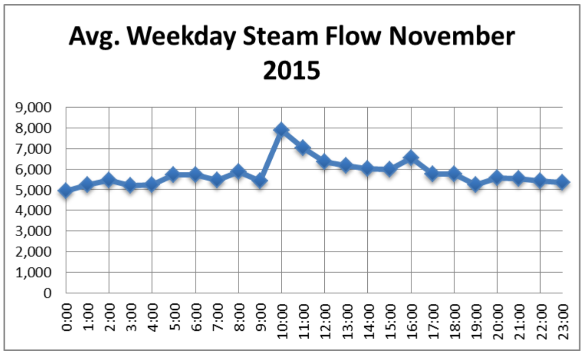
The following two charts display a typical day's production trend. The first chart is an average of the overall month and the second chart is an average of weekend production. Some interesting things to note from the graphs: the boilers operate at a minimum of about 3,200 lbm/hr, for the summer months and we have seen a peak load of typically 11,000 lbm/hr for morning warm-up. We also see an increase in production around 8pm-10pm.





For the winter months we see a slightly higher minimum loading of roughly 4,500 lbm/hr with the same general trend of two increases in production throughout the day. Peak load seems to occur consistently at 7:00am throughout the year during the weekday. The weekend data appears to be more flat with a peak loading later in the morning at 10am. This trend was consistent throughout the winter months.





The typical facility operating schedules are as shown below:

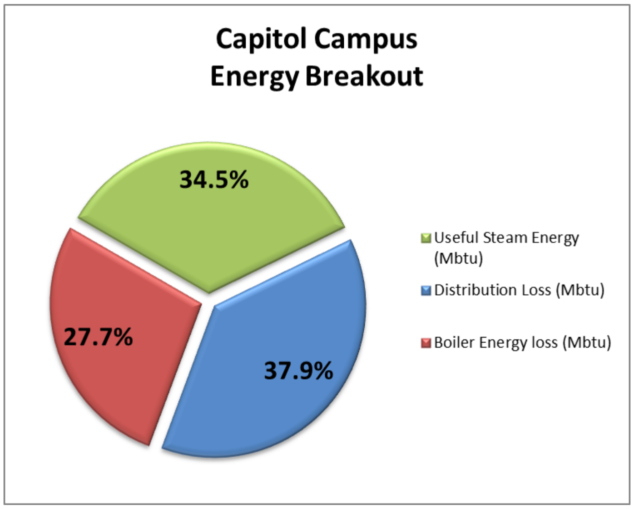
- Weekday (full occupancy) Operation: Weekdays from 6:00am to 8:00pm (This is the normal occupied period for most buildings on the West and East Campus)
- Off-Hour (low occupancy) Operation: Weeknights from 8:00pm 6:00am and weekends. The off-hour operation has some distinct operating characteristics, including:
    - Weeknights from 8:00pm – 10:00pm: cleaning crews working in facilities.

  - Weekends from 9:00am – 4:00pm: some occupancy and operation of select areas.

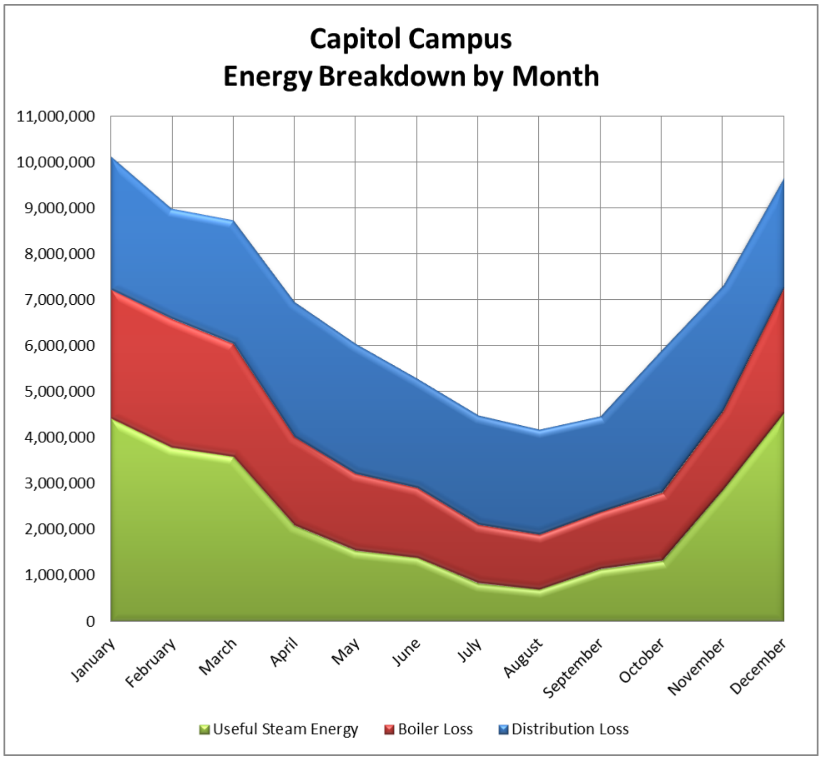
Production Plant Efficiency Analysis

The production plant operating efficiency was developed by determining boiler thermal efficiency and standby losses. The following table gives an overview of the last four years of system usage and efficiencies. UMC determined that the four year average steam system efficiency is 35%. How this value is determined is discussed in the following sections.

Month	Avg OAT	HDD	Avg Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms	N. Gas Input Energy (Mbtu)	Overall Boiler Eff	Distribution Loss (Mbtu)	Distribution Efficiency	Useful Steam Energy (Mbtu)	Net System Efficiency
January	37	790	9,837	7,321,325	101,349	10,134,925	73%	2,899,216	60.4%	4,422,109	43.6%
February	42	662	9,140	6,194,789	89,901	8,990,100	69%	2,405,233	61.2%	3,789,556	42.2%
March	45	618	8,450	6,286,479	87,426	8,742,600	72%	2,700,761	57.0%	3,585,717	41.0%
April	49	487	7,006	5,044,255	69,617	6,961,700	73%	2,941,766	41.7%	2,102,488	30.2%
May	55	323	5,889	4,381,648	60,459	6,045,850	73%	2,826,597	35.5%	1,555,051	25.7%
June	61	181	5,233	3,769,029	52,823	5,282,325	71%	2,369,089	37.1%	1,399,940	26.5%
July	66	114	4,328	3,220,087	44,910	4,490,950	72%	2,377,672	26.2%	842,415	18.8%
August	66	102	4,015	2,986,392	41,746	4,174,625	71%	2,276,916	23.8%	709,476	17.0%
September	60	222	4,503	3,241,946	44,711	4,471,100	72%	2,083,949	35.7%	1,157,997	25.9%
October	52	414	5,988	4,454,879	59,256	5,925,625	76%	3,115,972	30.1%	1,338,907	22.6%
November	43	684	7,802	5,617,634	73,251	7,325,050	77%	2,734,807	51.3%	2,882,828	39.4%
December	41	775	9,349	6,955,644	96,842	9,684,200	72%	2,407,157	65.4%	4,548,487	47.0%
Summary	51	5,372	6,795	59,474,106	822,291	82,229,050	72.3%	31,139,136	47.6%	28,334,970	34.5%



The distribution losses increase in the shoulder seasons and peak in the summer months. Overall, July and August appear to be the least efficient months for the steam system. A visual breakdown of overall energy usage is shown in the chart below.



Boiler Plant Thermal Efficiencies

The boiler plant thermal efficiency was determined by dividing the energy of the steam produced by consumed natural gas energy. The energy imparted to the steam is 993 btu/lbm, based on leaving steam at 110 psi (enthalpy of 1191 btu/lbm) and 230F feedwater (enthalpy of 198 btu/lbm).

As you can see from the above table, the average thermal efficiency of the boilers is roughly 72%. UMC attributes this low efficiency to two reasons: first, the age of the boilers which are 46yrs, 46yrs, and 56yrs for B1, B2, and B3 respectably. The second reason is that the boilers spend a majority of the year operating at or below 20% output of a single boiler. In 2015 the boilers spent roughly 50% of the year at or below 20% loading and 70% of the year at or below 25% loading. This creates the additional inefficiencies due both to the low load and to boiler cycling.

The data regarding steam generation comes from analysis of the provided boiler logs and BACnet meter trending. The data for boiler fuel input comes from the natural gas utility bills. It is important to note that this boiler efficiency value includes energy usage by the standby boiler. At this point we are unable to breakout the energy usage associated with the standby boiler.

Plant Equipment Efficiencies

The plant also utilizes various fans and pumps in the process of generating and distributing steam. The individual equipment's nameplate efficiencies can be found in the Fan and Pumps table in section 3.4.

Distribution Efficiencies

The Steam System Standby Loss value shown in the Capitol Efficiency table above comes from a regression analysis of the average steam production. The regression analysis can be found in the baseline section of this report (section 3.4). Based on this regression analysis and reinforced by the trending that has been completed, there is a significant amount of energy used by the system when there is no useful heat load on it.

UMC was able to break out some of the potential major sources of energy loss that comprise the distribution loss number, including makeup water energy and distribution piping heat loss.

The makeup water is potentially the largest single component of the distribution loss. The energy required to bring water from 60F to 110psi steam is 1163 btu/lbm. At nearly 6.0 MMlbm of water per year (assuming constant loss throughout the year from previous trending) this amounts to 7,000 MMBtu of energy per year to turn the water to steam. This, roughly 11% system water loss, accounts for ~23% of the distribution loss energy. The following table is an overview of the makeup water energy loss.

Makeup Water Energy

Total Makeup Water	5,987,272	lbm
Inlet Water Temperature	60	F
Water Enthalpy	28	btu/lbm
110psi Steam Enthalpy	1191	btu/lbm
Enthalpy of Vaporization	1163	btu/lbm
Energy Required	6,963,197	Mbtu

The next largest component of the distribution loss is from the insufficient insulation on the steam piping. The current system utilizes 2" insulation. The piping also roller supports. At each support location roughly 1' of insulation is missing and is only covered with an aluminum jacket. As you can see from the table below, it is estimated that 6,300 MMBtu of energy is loss due to the lack of insulation. This energy loss comprises an estimated 21% of the distribution loss.

Steam Pipe Heat Loss

Nominal Pipe Size	Inches	12	10	8	6	5	4	2.5	2	1.5
Steam Pipe Lengths	Feet	2285	105	555	1430	20	1245	700	432	155
Existing BTU/hr/ft loss	btu/hr/ft	150	129	110	90	79	66	45	43	35
Existing MBTU Loss	Mbtu	2,996,485	118,930	536,257	1,121,149	13,897	723,517	276,737	161,818	47,998

Pipe Supports		101	0	25	69	1	0	38	0	0
Equivalent Uninsulated Length	Feet	17	0	4	12	0	0	6	0	0
Equivalent BTU/hr/ft Loss	btu/hr/ft	1291	0	897	703	600	0	332	0	0
Pipe Support MBTU Loss	Mbtu	190,371	0	32,726	70,840	875	0	18,436	0	0

Total BTU Loss	Mbtu	3,186,856	118,930	568,982	1,191,989	14,772	723,517	295,173	161,818	47,998

In addition to the steam piping heat loss, significant energy is loss when the condensate is returned from the system due to the minimal 1” insulation. Per the table below it is estimated that 3,000 MMBtu of energy is loss due to the lack of insulation. This energy loss comprises about 10% of the distribution loss. This value as determined by taking the temperature of saturated water at 10psi (typical building side operating pressure) and the reported return condensate temperature from the boiler logs.

Condensate Pipe Heat Loss

2012-2013 Production Avg	59,232,111	lbm
Water at 240F	208	btu/lbm
Water at 190F	158	btu/lbm
Energy Loss per lbm	50	btu/lbm
Total BTU Loss	2,961,606	Mbtu

Simultaneous Heating and Cooling

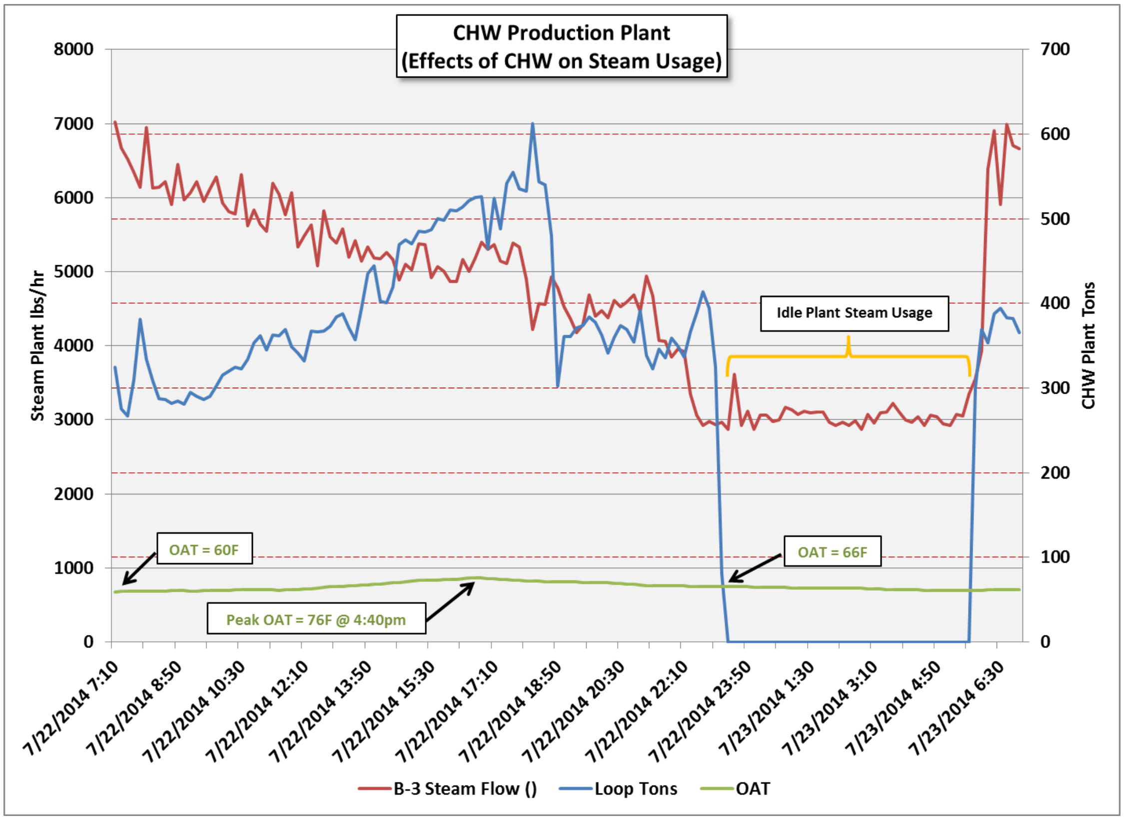
In addition to the safety and operational issues it has been observed that the campus has a problem with simultaneous heating and cooling.

The following charts demonstrate the interrelationship between summer steam usage and chilled water usage as shown on two different days. Over a 2 month period the average idle steam load is around 3,000 lbs/hr. When a chiller is running the flow rate increases to around 6,000 lbs per hour with peaks of up to 8,000 lbs/hr. The building warm up usage ranges from 5,000 to 8,000 lbs per hour as the buildings go through the unoccupied to occupied transition.

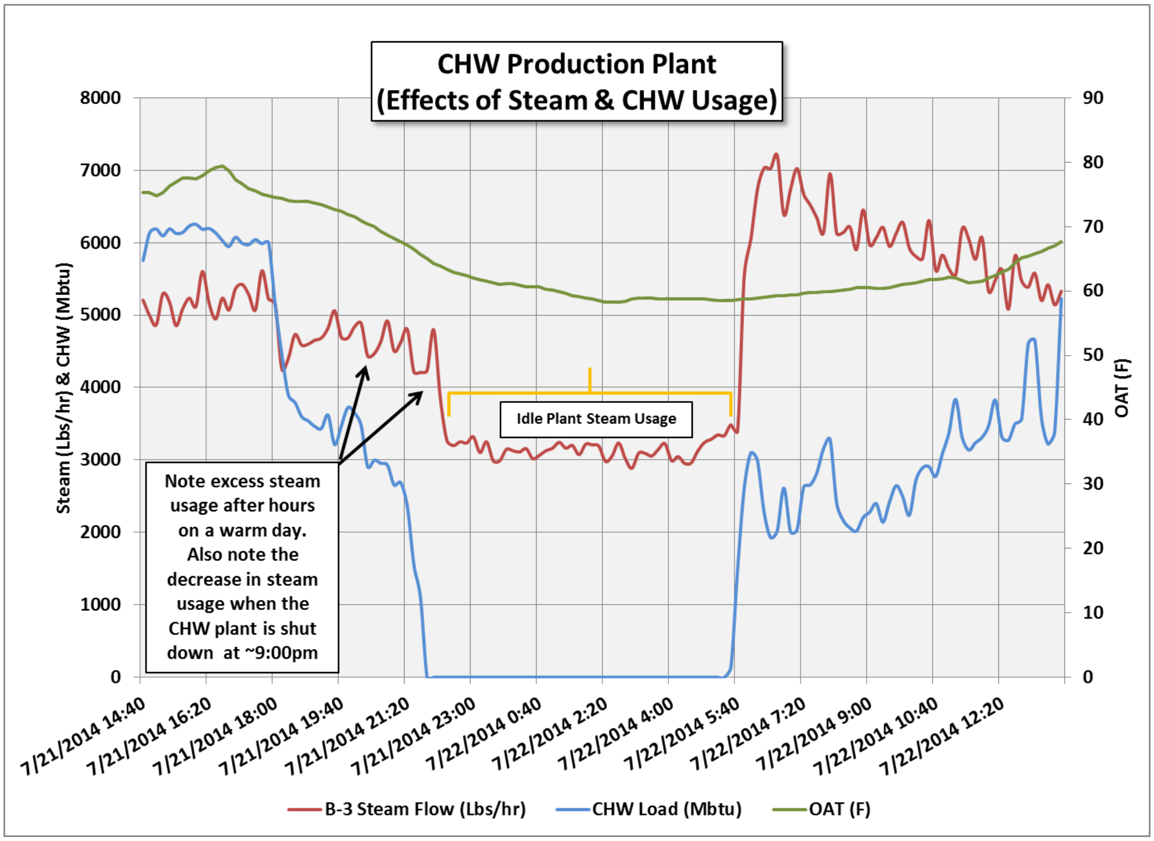
The chart below indicates a reasonable assessment of normal operation of the cooling/heating systems and their relationship during a typical daily cycle. The steam usage shows:

- Morning warm-up
- Preliminary heating for occupied mode, calling for heat to the heat exchangers to bring the heating water/domestic hot water temperatures to set point. This is affected by the operation of the CHW system which increases the steam reheat requirements.

- A steady state mode for buildings that require preheat or reheat for occupancy comfort
- The reduced demands as buildings stage down to unoccupied mode
- Night steam usage to maintain system integrity
- Beginning the cycle all over again.



The following chart more clearly shows the increased steam usage that occurs when the CHW system is operating. In this chart (which spans a 2 day period), it is easy to see the excess steam usage during the after-hours period from 6:00pm to 9:00pm on July 21st. During this period, even though it is a warm day, the steam plant still operates at over 4,500 lbs/hr due to the continued operation of the CHW plant. Once the CHW plant is shut down at 9:00pm, the steam usage throttles back to its idle load of ~3,000 lbs/hr. This chart also clearly illustrates the morning warm-up load on the plant during the summer period.



Note excess steam usage after hours on a warm day. Also note the decrease in steam usage when the CHW plant is shut down at ~9:00pm

3.3 Review of Steam Distribution System and Buildings Safety and Operating Issues

In UMC’s previous Investment Grade Audit (IGA), “Analysis of Steam System Safety and Operational Issues”, a number of items were documented regarding the steam system. A brief overview of the items found is as follows:

- Water hammer in steam and condensate piping at various locations
- Non-steam rated valves utilized on steam system
- Aging flash tanks, some non-ASME rated
- Ground union connections used on steam system
- Steam relief line terminating at grade in lawn grate
- Various non-working meters

Please refer to the previous IGA (DES contract # 2014-926 G (1-1)) Phase II for a full list of safety and operational items that were documented. At this point in time, some of the safety items identified in that report have been addressed. So far, UMC is aware that the water hammer issue at the Powerhouse has been addressed. At the time of writing this IGA (October 2016), UMC is aware that the water hammer at the Highway License building is currently being addressed with an ongoing project.

3.4 Existing System Baseline

Historical Utility Analysis

The historical natural gas utility usage was analyzed and expressed in the table below. As you can see from the table, the cost of natural gas for the Steam plant has decreased over the years. This is due to the unit cost per therm decreasing from $0.80 in 2011 to $0.65 in 2013. Please note that there appears to be an error in July/December 2014 therm data as usage is well below normal.

Steam Plant Natural Gas Utility Usage

Year	2011		2012		2013		2014		2015		2016	
January	96,470	$76,896	107,482	$80,652	105,400	$68,529	106,338	$68,784	86,177	$59,595	90,433	$43,898
February	97,439	$77,648	99,114	$74,543	89,295	$58,397	97,050	$62,861	74,145	$51,187	81,991	$39,761
March	85,044	$68,040	106,926	$80,248	81,103	$53,241	84,571	$55,283	77,104	$53,525	82,808	$40,360
April	84,759	$67,988	75,606	$56,910	67,134	$44,449	64,860	$42,802	70,868	$49,182	-	-
May	70,287	$57,087	65,835	$49,775	59,554	$36,045	53,248	$35,735	63,197	$44,376	-	-
June	55,908	$45,881	60,857	$46,206	55,511	$36,738	46,549	$31,385	48,376	$34,484	-	-
July	42,906	$35,694	49,932	$38,302	43,743	$29,330	10,789	$8,019	41,963	$30,056	-	-
August	39,678	$33,161	45,481	$35,069	38,313	$25,933	43,758	$29,803	39,433	$28,693	-	-
September	42,914	$35,700	50,333	$38,592	40,039	$27,010	42,642	$28,735	45,830	$32,709	-	-
October	54,763	$44,979	60,780	$46,169	62,107	$40,761	57,541	$38,672	56,597	$38,426	-	-
November	68,662	$52,933	78,919	$53,429	76,072	$49,508	61,869	$42,768	76,142	$39,016	-	-
December	93,163	$70,192	90,888	$59,379	110,097	$70,705	2,891	$2,000	88,383	$42,617	-	-
Total:	831,993	$666,199	892,153	$659,276	828,368	$540,644	672,105	$446,847	768,216	$503,866	255,232	$124,019

The historical electrical utility usage was also analyzed and compared to the modeled plant energy usage to confirm that the baseline electrical plant energy usage was reliable. This was completed by performing a utility balance to extrapolate the annual utility bill electrical usage that is attributable to the steam production equipment only. Since the utility meter for the Powerhouse also measures the other equipment in the facility (i.e.: chillers, chiller equipment, lighting, plug loads, etc.); this had to be taken into account.

Below is the annual electrical utility bill for 2013.

Powerhouse Electrical Utility Usage

MON - YR	KWH	KWH $	KW	KW $	ELECTRIC $
Jan-13	42,928	$2,437	107	$396	$2,833
Feb-13	36,366	$2,065	114	$422	$2,487
Mar-13	38,200	$2,169	104	$385	$2,554
Apr-13	51,296	$2,913	565	$2,091	$5,003
May-13	103,247	$5,862	587	$2,172	$8,034
Jun-13	162,453	$9,224	603	$2,231	$11,455
Jul-13	177,457	$10,076	636	$2,353	$12,429
Aug-13	171,538	$9,740	614	$2,272	$12,012
Sep-13	129,632	$7,361	593	$2,194	$9,555
Oct-13	29,572	$1,679	572	$2,116	$3,796
Nov-13	39,024	$2,216	105	$389	$2,604
Dec-13	49,362	$2,803	108	$400	$3,202
Subtotals	**1,031,074**	**$58,544**	**4,708**	**$17,420**	**$75,964**

To determine the average electrical usage associated with the steam generating equipment, UMC determined an average kW and kWh value. The majority of the equipment utilized by the system runs at constant volume, as such, the electrical usage month to month should be fairly constant across months. UMC estimates the steam generating equipment to consume 377,468 kWh per year with an average electrical demand of 43 kW.

Although there is no identifiable metered water utility usage for the steam plant (since the usage is lumped in with the main campus meter), this usage was determined from manual trending. This trending showed that an average of 2,114 gallons per day for a total of about 771,610 gallons per year (1,032 CCF per year) is utilized by the facility.

Production Equipment

Boilers 1 and 2 each have a 30-hp constant volume forced draft fans that operate when their boiler is operating. Boiler 3 has a 15-hp constant volume forced draft fan as well as a 20-hp indirect draft fan that is operated by a variable frequency drive. All three boilers are served by two 30-hp feed water pumps. In addition to the feedwater pumps, there is a single 1.5-hp condensate pump that pumps condensate from the receiver tank to the deaerator tank.

The motor nameplate data was gathered for each of the above equipment and estimated full load kW for each component was determined (provided in the following table).

Production Plant Fans and Pumps

Equipment	HP	Rated Efficiency	Full Load Amps	Volts	Full Load kW
B1 Draft Fan	30	94	38	460	27.2
B2 Draft Fan	30	94	38	460	27.2
B3 Draft Fan	15	91	18.1	460	13.0
B3 Indirect Draft Fan	20	90	24.8	460	17.8
FW Pump-1	30	91	33.7	460	24.2
FW Pump-2	30	91	33.7	460	24.2
Condensate Pump	1.5	-	4.25	460	3.0

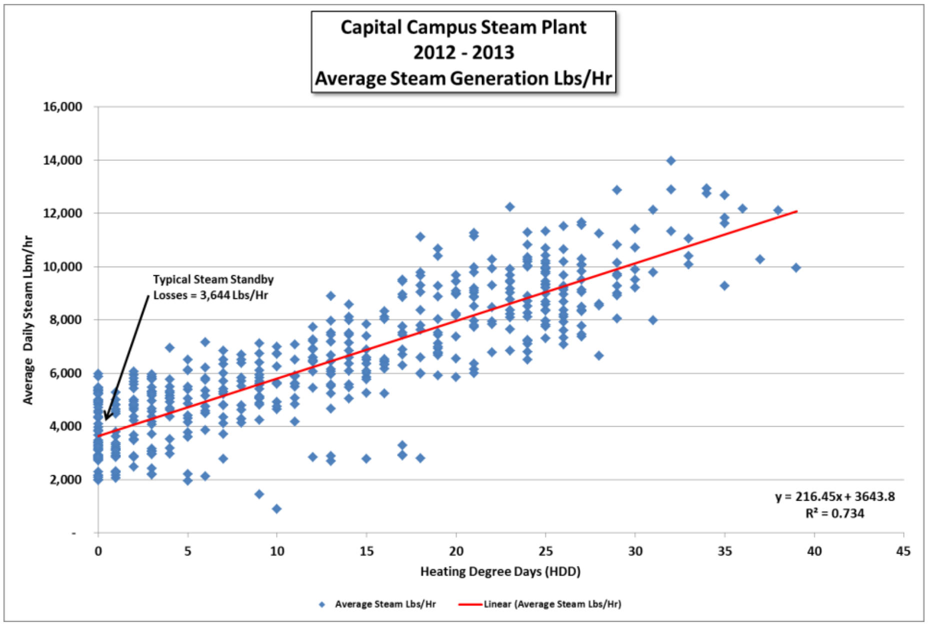
Steam Production Plant Annual Operating Baseline

The following table provides the annual operating baseline for the Steam Production Plant. This table was developed utilizing a steam plant production model and was balanced against real time trend data and historical utility usage. This baseline will be utilized to measure future energy savings.

Month	HDD Normals 1981-2005	Avg Steam Flow (Mbtu/h)	Total Steam Produced (Mbtu)	N. Gas Therms	N. Gas Input Energy (Mbtu)	Overall Boiler Eff	Distribution Loss (Mbtu)	Distribution Efficiency	Useful Steam Energy (Mbtu)	Net System Efficiency
January	769	9,568	7,120,798	98,573	9,857,335	72%	2,819,808	60%	4,300,990	44%
February	680	9,397	6,369,110	92,431	9,243,081	69%	2,472,916	61%	3,896,194	42%
March	680	9,297	6,917,089	96,196	9,619,589	72%	2,971,681	57%	3,945,408	41%
April	509	7,318	5,268,967	72,718	7,271,831	72%	3,072,817	42%	2,196,150	30%
May	368	6,704	4,987,625	68,820	6,881,984	72%	3,217,512	35%	1,770,112	26%
June	227	6,575	4,735,535	66,369	6,636,891	71%	2,976,603	37%	1,758,932	27%
July	138	5,244	3,901,638	54,415	5,441,488	72%	2,880,921	26%	1,020,717	19%
August	151	5,916	4,400,001	61,507	6,150,684	72%	3,354,694	24%	1,045,307	17%
September	214	4,343	3,126,961	43,125	4,312,519	73%	2,010,036	36%	1,116,925	26%
October	445	6,440	4,791,415	63,733	6,373,266	75%	3,351,363	30%	1,440,052	23%
November	611	6,967	5,016,002	65,406	6,540,559	77%	2,441,917	51%	2,574,085	39%
December	809	9,759	7,260,488	101,086	10,108,627	72%	2,512,655	65%	4,747,832	47%
Summary	5,601	7,294	63,895,629	884,379	88,437,855	72.2%	34,082,923	46.7%	29,812,706	33.7%

A regression analysis was also completed to gain an understanding of the base load of the campus steam system. This base load is the minimum steam flow rate required to run the system and is used to determine the steam system standby loss.

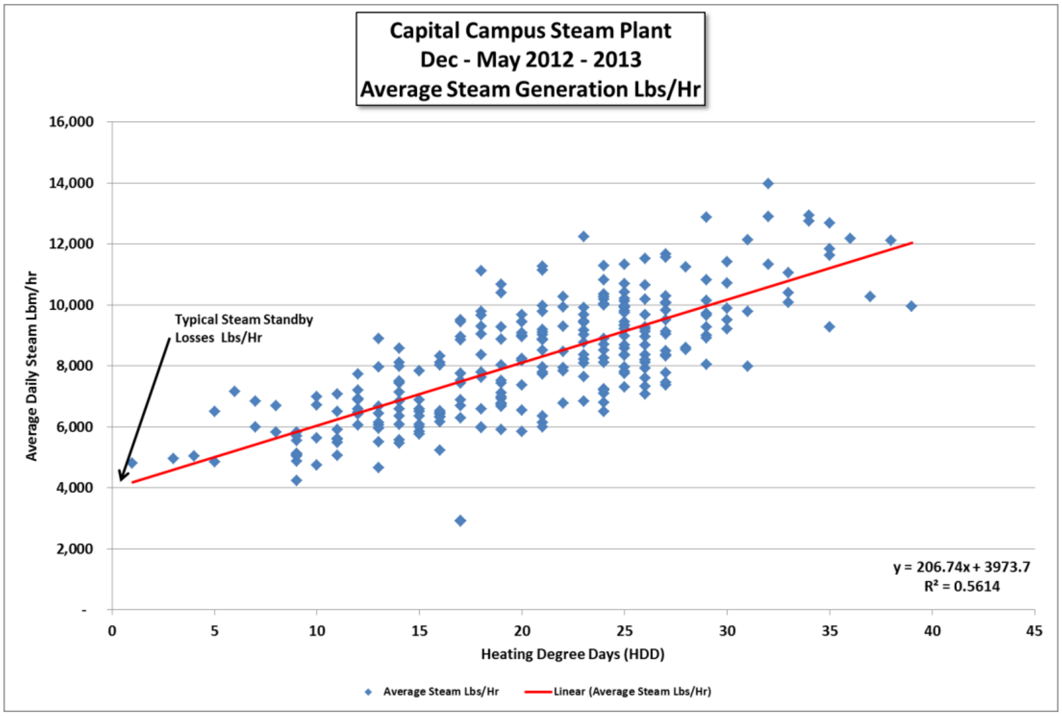
The following graph displays steam production per day from the boiler logs versus heating degree days (HDD) for 2012 and 2013. From the graph the baseline for the steam system is a daily average of ~3,644 lbm/hr over the entire year.

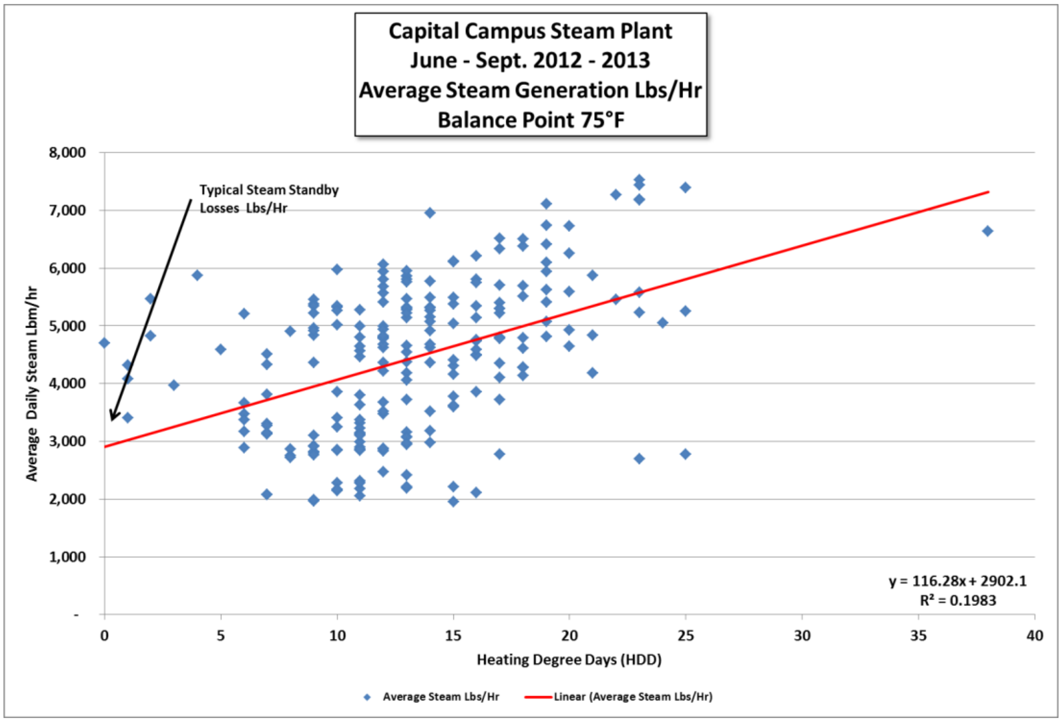


This baseline of 3,644 lbm/hr represents only a daily average over the entire year. To gain more understanding of how the system operates at different times of the year two more regression analyses were completed: one for winter baseline determination and one for summer baseline determination. The following two graphs display the analysis for winter and summer.

Per the charts, we expect the winter baseline to be an average of 3,975 lbm/hr on any given day in November – February. For the summer months of June – September, we expect an average of 2,900 lbm/hr for a baseline. For the shoulder months we assume that the baseline would be the average between the winter and summer months. This comes out to 3450 lbm/hr for March-May and October.

Overall the charts appear to provide an accurate representation as we have seen a trended average low of 3,300 lbm/hr from July – September and 5400 lbm/hr for November.





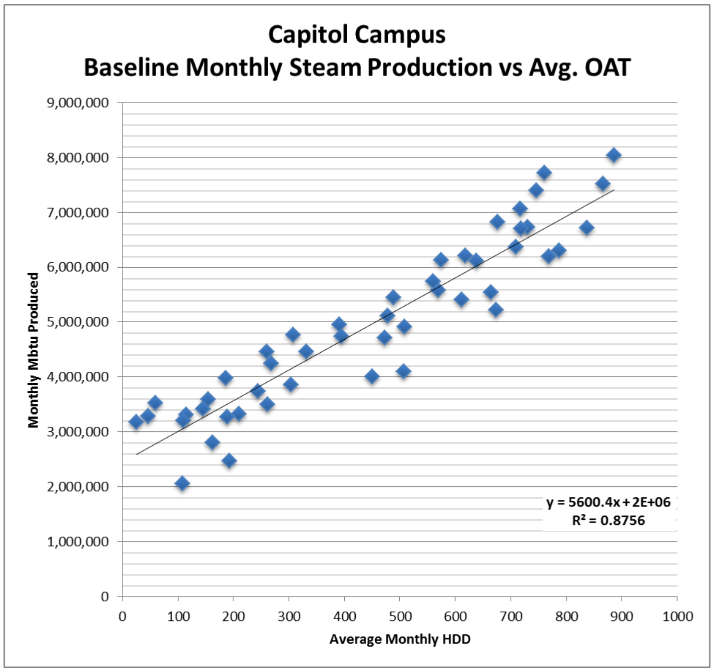
HDD Weather Bin Analysis for Baseline Year

The following table illustrates the Normal Weather Bins for Olympia. The Powerhouse historical energy usage for 2012 was utilized as the annual base utility year to balance the annual steam plant energy usage. As compared to the TMY2 typical weather data for Olympia, the 2012 weather had 102% of the normal Heating Degree Days (HDD) and compared to the TMY3 data, 2012 was also very typical year with 103% of the normal HDD. This weather data will be taken into account when comparing energy usage versus the baseline annual usage.

Heating Degree Day Historical Weather Bins – Olympia

	TMY2 Normals Based on 1971-2000 Year Records		TMY3 Normals Based on 1981-2005 Year Records		2012		2013		2014		2015	
Month	Normal HDD	% of Annual	Normal HDD	% of Annual	HDD	% of Normal	HDD	% of Normal	HDD	% of Normal	HDD	% of Normal
January	813	14%	769	14%	837	15%	886	16%	761	14%	677	12%
February	652	11%	680	12%	709	13%	638	11%	731	13%	569	10%
March	668	12%	680	12%	717	13%	618	11%	575	10%	561	10%
April	549	10%	509	9%	478	9%	508	9%	473	8%	489	9%
May	364	6%	368	7%	395	7%	332	6%	304	5%	260	5%
June	209	4%	227	4%	268	5%	187	3%	210	4%	59	1%
July	137	2%	138	2%	155	3%	162	3%	115	2%	25	0%
August	141	2%	151	3%	145	3%	108	2%	110	2%	47	1%
September	242	4%	214	4%	262	5%	193	3%	189	3%	245	4%
October	473	8%	445	8%	450	8%	507	9%	308	5%	391	7%
November	642	11%	611	11%	612	11%	674	12%	664	12%	787	14%
December	803	14%	809	14%	769	14%	866	15%	718	13%	747	13%
Totals	**5693**	**100%**	**5601**	**100%**	**5797**	**103%**	**5679**	**101%**	**5158**	**92%**	**4856**	**87%**

The future energy usage will be annualized for comparison to the baseline data with the use of a data regression analysis to correlate plant energy usage with comparative weather data. The following chart illustrates a regression analysis for the 2012 and 2015 HDD weather versus the monthly steam production plant steam energy generation for the same years.



3.5 Utility Providers

Utility Suppliers

The individual utility suppliers are listed below.

Electricity & Natural Gas

Puget Sound Energy provides electricity and natural gas for the facility. The observed electrical blended rate over 12 months in 2015 is $0.0865/kwh. The average gas rate over this same period is approximately $0.6559/therm. The detailed baseline utility rates are shown below.

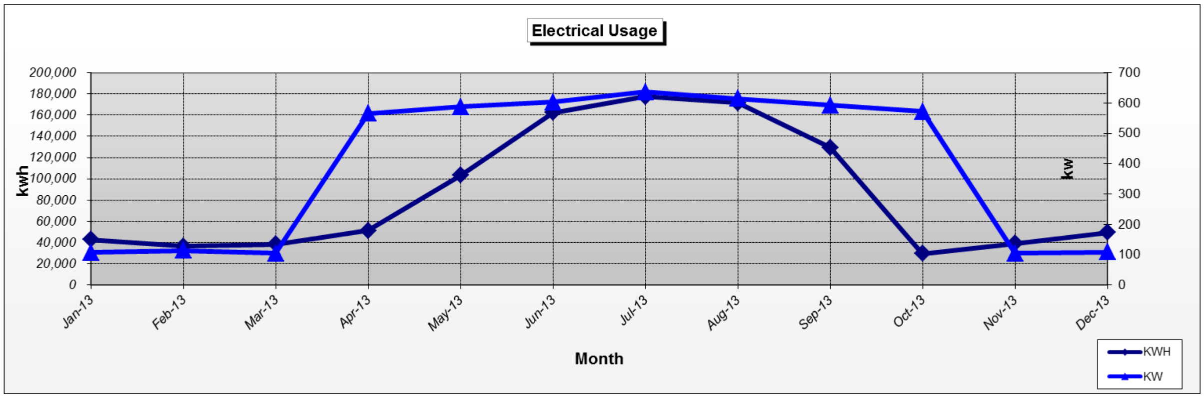
Water/Wastewater

The City of Olympia provides water for the facility. The campus is charged two different water usage rates depending on summer and non-summer usage. For the summer months of July – October the utility rate is $10.15/CCF and for non-summer usage the utility rate is $9.05/CCF. The detailed baseline utility rates are shown below.

Electric Utility Data

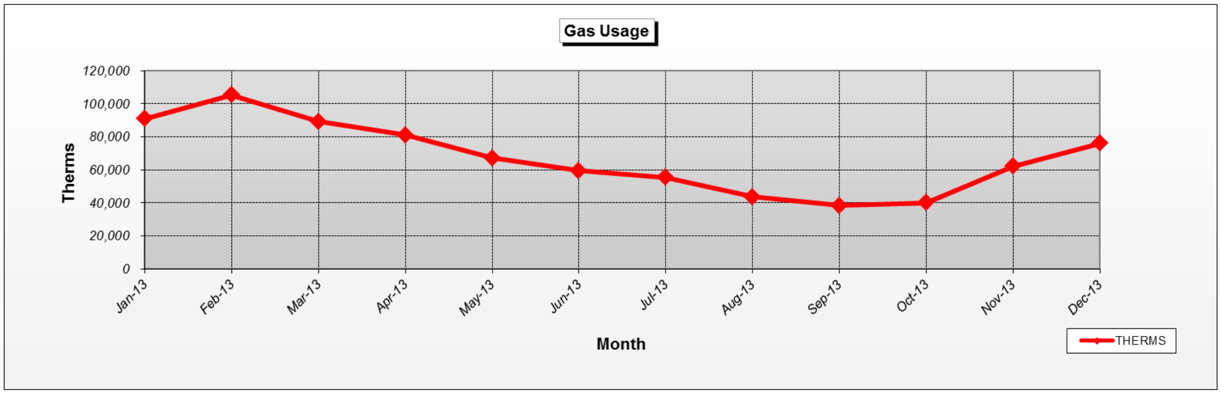
Throughout a 12 month period from January 2013 through December 2013, the facility consumed an average of 1,031,074 kWh/year of electricity at the powerhouse. The annual electric demand for the same period was 4,708 kW, with a monthly peak of 636 kW in July of 2013 and a monthly low of 104 kW in March of 2013.

The following charts shows historical electric consumption and demand from January 2013 through December 2013.



Natural Gas Utility Data

Throughout a 12 month period from January 2013 through December 2013, the facility consumed an average of 809,159 therms/year of gas, with a monthly peak of 105,400 therms in January 2013 and a monthly low of 38,313 therms in August of 2013. The following chart shows historical gas consumption from January 2013 through December 2013.



Water/Sewer Utility Data

The water / sewer utility that serves the Powerhouse also serve a large portion of the West Campus facilities. As such, there is no access to current utility information that is directly relatable to the Powerhouse water usage.

Utility Rate Structure

Utility costs used for savings calculations will be based on the utility rate in effect for the predominant bill or the utility rate in effect for the corresponding period of the Baseline period, whichever is greater. The rate, in effect during the Baseline period, will be designated the floor price, and is shown below for each utility.

Electricity		
Tariff Number or Designation:	Schedule 49 High Voltage General Service	
Utility Name:	Puget Sound Energy	
Rate Structure:	N/A	Basic Charge
Electricity	$ 0.060195	$ per kWh (includes itemized charges) [2]
Demand	$ 3.70	$ per kVa
	9.0%	City of Olympia Tax Rate
Total Elect Rate (including Tax)	**$ 0.06598**	**$ per kWh**
	$ 4.033	**$ per kW**
Blended Rate	$ 0.0865 kWh	Average $ per kwh[1]

1. Based on baseline load profile from 2015
2. Includes: Energy Charge, Low Income Program, Property Tax Tracker, Expedited Rate Filing Rate Adj., Revenue Decoupling Adj. Mechanism (Surcharge), Power Cost Adjustment Clause, Federal Wind and Power Credit, Electric Cons. Program Charge, Merger Credit, Regulatory Asset Tracker, and Renewable Energy Credit.

Natural Gas		
Tariff Number or Designation:	Schedule 85 Interruptible Service With Firm Option	
Utility Name:	Puget Sound Energy	
Rate Structure:	$ 628.14	Basic Charge
Delivery Charge	$ 0.169960	Delivery Charge - $ per therm (First 25,000 Therms)
	$ 0.106980	Delivery Charge - $ per therm (Next 25,000 Therms)
	$ 0.071990	Delivery Charge - $ per therm

		(Next 50,000 Therms)
	$ 0.050030	Delivery Charge - $ per therm (Next 100,000 Therms)
Cost of Gas	$ 0.339140	$ per therm
Gas Conservation Charge	$ 0.015930	$ per therm
Merger Credit	$ (0.000430)	$ per therm
Tax	9.0%	City of Olympia Tax Rate
2015 Average Annual Gas Cost	**$ 0.6559**	**$ per therm**[1]

1. Based on baseline load profile from 2015
2. Includes: Total Delivery Charge, Purchase Gas Costs, Deferred Account Adjustment, Gas Conservation Program Charge, and Merger Credit.

Water/Waste Water		
Tariff Number or Designation:	Commercial Water/ Wastewater Rates	
Utility Name:	City of Olympia	
Rate Structure:		
Water:	$ 1,099.20	Basic Charge
	$ 2.39	Winter Rate per CCF
	$ 3.33	Summer Rate per CCF
Wastewater:	$ 39.34	City Fee – Fixed (<1.4 CCF)
	$ 2.81	City Fee – Variable (1.4 CCF+)
	$ 72.12	Lott Fee – Fixed (<1.8 CCF)
	$ 4.01	Lott Fee – Variable (1.8 CCF+)
Tax	9.0%	City of Olympia Tax Rate
2015 Total Costs	**$1,198.13**	**Basic Charge**
	$ 10.04	**Winter Rate per CCF**
	$ 11.06	**Summer Rate per CCF**

1. City of Olympia utilizes a bi-monthly billing cycle

4.0 PROJECT ANALYSIS – BUSINESS AS USUAL

4.1 Overview of Business as Usual Option

The "Business as Usual" (BAU) alternative is intended to illustrate the continuation of the current heating systems over the foreseeable future. This includes the ongoing utilization of the existing Powerhouse steam district energy system stand-alone heating systems in buildings that are not currently on the steam distribution, plus all facilities projected to be constructed in the future.

4.2 Production Plant & Distribution

The existing Powerhouse Steam Production Plant and distribution systems are described in full in Section 3 of this report. In general, the steam produced by three boilers located at the Powerhouse is utilized to serve most of the existing facilities on both West and East Campus.

4.3 Operating Costs – District Heating

During the development of the detailed lifecycle cost analysis, UMC worked closely with DES to identify and document the ongoing costs associated with the continued operation of the existing system. These costs were categorized as 'Fixed Operating Costs" (which includes Major Overhaul, Major Renewal, Operating Labor and Minor Repair / Preventive Maintenance) and Variable Operating Costs (which includes ongoing costs subject to utility market fluctuations for energy, water, water treatment chemicals and carbon). These costs, as documented during this analysis, are identified below. Note: All costs (capital, fixed & operating) shown were developed to accurately define the differential operating costs associated with BAU & each individual alternative. As such, the costs are not intended to identify all heating and cooling costs outside of the targeted scope of work or for buildings not connected to the district energy plant.

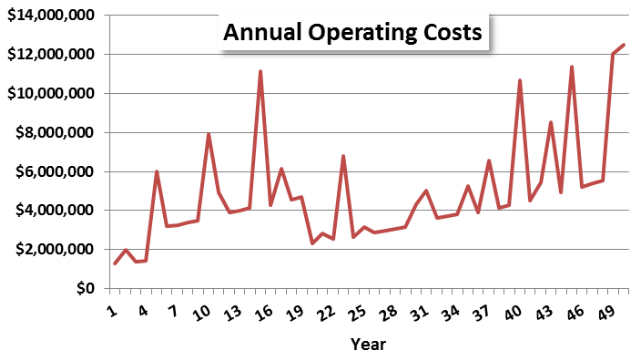
Fixed Operating Costs (District Heating)

- Major Overhaul
    - Major Overhaul is estimated based on lifecycle overhaul/replacement of major equipment located in the Production Plant (as identified below). The estimated cost and schedule for overhaul/replacement is documented and itemized in the Capitol Campus DE Lifecycle Model.
        - Boiler-1
        - Boiler-2
        - Boiler-3
        - Feed-water Pumps
        - DA Tank
        - Stack Economizers
        - Condensate Tank
        - Condensate Pumps

        - Fuel Delivery Tank
- Major Renewal
    - Major Renewal is estimated based on lifecycle renewal/replacement of systems (piping, minor equipment, etc) for plant, distribution and associated in-building systems, excluding the major overhaul of equipment as previously defined above. This information is documented and itemized in the Capitol Campus DE Lifecycle Model.
- Operating Labor
    - Production Plant
        - 4 FTE @ $105,000 / yr ea
    - DE Distribution System
        - 2 FTE @ $105,000 / yr ea
    - Building Systems – Currently Connected to Plant
        - 1 FTE @ $105,000 / yr ea
- Minor Repair / Preventive Maintenance (2015 $ provided by DES)
    - Minor Repair - Production Plant
        - $152,775 / yr
    - Minor Repair - Distribution
        - $25,463 / yr
    - Minor Repair - Building Systems – Currently Connected to Plant
        - $25,463 / yr
    - Minor Repair – Stand-Alone Building Systems (Future Connections)
        - Estimated as a % of sqft increase based on existing building systems connected to plant
    - Preventive Maintenance
        - $291,600 / yr

Based on the Fixed Costs identified above (and in the Lifecycle Model), the following tables provide an overview of the 50 year costs utilized in the model.

Campus Heating Economics	50 Yr PV
Fixed Operating Cost	
Major Overhaul	$ 9,669,277
Major Renewal	$ 35,245,943
Operating Labor	$ 36,880,784
Minor Repair	$ 23,682,432
Subtotal - Fixed Operating Cost	**$ 105,478,436**



Variable Operating Costs (District Heating)

The variable operating costs include all energy & utility costs (natural gas, fuel oil, electricity & water/sewer) as well as other costs that are directly connected to these utility costs (ie: water treatment/chemicals & social cost of carbon). These costs as utilized in the lifecycle model are identified below.

- Natural Gas – Powerhouse DE System
    - Baseline Usage (as defined in Section 3) - Based on 2015 annual cost to operate Production Plant
    - System Efficiency: Gas to Useful Heat
        - Baseline Efficiency
            - Powerhouse Boiler Eff = 67% (annual operating eff)
            - Distribution Eff = 51%
            - Overall Annual Operating Eff = 34%
        - 50 year changes to BAU operating efficiency. The lifecycle model takes into account future potential improvements in the system operating efficiency that could occur from ongoing renewal of the production & distribution systems. These improvements are integrated into the model at the assumed point that the renewals take place. The upgraded efficiencies are as shown below.
            - Powerhouse Boiler Eff (after renewal) = 73%
            - Distribution Eff (after renewal) = 65%
            - Overall Annual Eff (after renewal) = 47%
- Natural Gas – Future Stand-Alone System
    - System Efficiency: Gas to Useful Heat
        - Stand-Alone Boiler Eff = 85% (annual operating eff)
        - Stand-Alone Distribution Eff = 85%
- Electricity
    - The electrical usage associated with the production and distribution of the heat throughout the campus has been estimated and is included in the lifecycle model. This estimated electrical usage is documented in the model and as shown below.
        - Estimated Electrical Usage at Powerhouse = 377,468 kWh per 2015 usage (approximately 12 kWh/MMBtu including heating production/distribution, lighting and misc. usage)

    - Estimated Electrical Usage at Buildings Connected Powerhouse = 22 kWh/MMBtu (includes HW distribution pumping and condensate return pumps)
    - Estimated Electrical Usage at Stand-Alone Buildings = 25 kWh/MMBtu (includes HW production & distribution within the stand-alone buildings)
- Water / Wastewater
  - The water/wastewater usage is intended to capture the cost of water associated with ongoing make-up water required to serve the existing system. This was estimate and confirmed via instantaneous monitoring of the Powerhouse steam system makeup water meter.
  - Estimated Water/Wastewater usage = 12.3 gallons / MMBtu
- Cost of Carbon
  - The lifecycle model has been developed with an ability to calculate the cost effects of potential future carbon tax as developed and documented in the Office of Financial Management LCCA tool. As such, the estimated cost associated with carbon emissions is provided in the lifecycle model "Carbon (OFM)" worksheet. A sample of the first 8 years of affected cost is provided in the table below.

Impact Year	2016	2017	2018	2019	2020	2021	2022	2023
2015$	$ 67.3	$ 68.4	$ 69.5	$ 70.7	$ 73.0	$ 74.1	$ 75.2	$ 76.4

  - The site emission factors utilized in the lifecycle model are provided below.

Site Emission Factors	CO2e (MTons/Unit)	Unit
Electricity	0.000412	KWh
Natural Gas	0.005311	Therm
Diesel/#2	0.009610	Gallons
#5/#6 Oil	0.009617	Gallons
Gasoline	0.008094	Gallons
LPG	0.005264	Gallons
District Heat	0.066394	mmBTU
Coal	0.097922	mmBTU
Biomass	0.095053	mmBTU
Biodiesel	0.008835	Gallons
Ethanol	0.005229	Gallons

4.3 Operating Costs – District Cooling

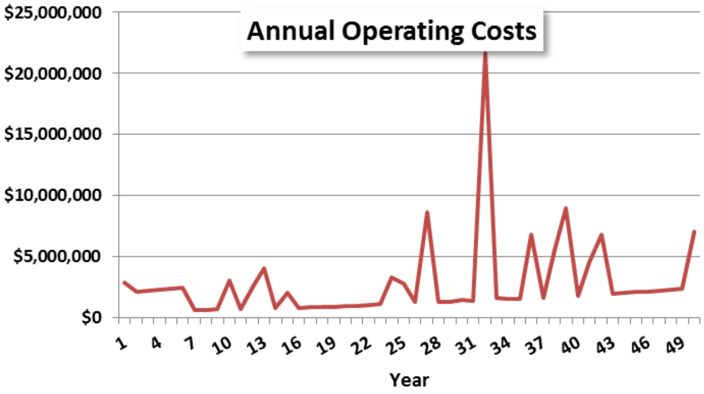
During the development of the detailed lifecycle cost analysis, UMC worked closely with DES to identify and document the ongoing costs associated with the continued operation of the existing system. These costs were categorized as 'Fixed Operating Costs" (which includes Major Overhaul, Major Renewal, Operating Labor and Minor Repair / Preventive Maintenance) and Variable Operating Costs (which includes ongoing costs subject to utility market fluctuations for energy, water, water treatment chemicals and carbon). These costs, as documented during this analysis, are identified below. Note: All costs (capital, fixed & operating) shown were developed to accurately define the differential operating costs associated with BAU & each individual alternative. As such, the costs are not intended to identify all heating and cooling costs outside of the targeted scope of work or for buildings not connected to the district energy plant.

Fixed Operating Costs (District Cooling)

- Major Overhaul
  - Major Overhaul is estimated based on lifecycle overhaul/replacement of major equipment located in the Production Plant (as identified below). The estimated cost and schedule for overhaul/replacement is documented and itemized in the Capitol Campus DE Lifecycle Model.
    - Chiller-1 (Powerhouse)
    - Chiller-2 (Powerhouse)
- Major Renewal
  - Major Renewal is estimated based on lifecycle renewal/replacement of systems (piping, minor equipment, etc) for plant, distribution and associated in-building systems, excluding the major overhaul of equipment as previously defined above. Note: the major overhaul costs for distributed CHW systems located throughout the campus were included in this section as an overall system costs (rather than separating chillers into the “major overhaul” portion. This information is documented and itemized in the Capitol Campus DE Lifecycle Model.
- Operating Labor
  - Production Plant
    - 0.5 FTE @ $105,000 / yr ea
  - DE Distribution System
    - 0.5 FTE @ $105,000 / yr ea
  - Building Systems – Currently Connected to Plant
    - 1 FTE @ $105,000 / yr ea
- Minor Repair / Preventive Maintenance (2015 $ provided by DES)
  - Minor Repair - Production Plant
    - $75,000 / yr
  - Minor Repair - Distribution
    - $20,000 / yr
  - Minor Repair - Building Systems – Currently Connected to Plant
    - $20,000 / yr
  - Minor Repair – Stand-Alone Building Systems (Future Connections)
    - Estimated as a % of sqft increase based on existing building systems connected to plant
  - Preventive Maintenance
    - $20,000 / yr

Based on the Fixed Costs identified above (and in the Lifecycle Model), the following tables provide an overview of the 50 year costs utilized in the model.

Campus Cooling Economics	**50 Yr PV**
Fixed Operating Cost	
Major Overhaul	$ 4,883,005
Major Renewal	$ 30,970,443
Operating Labor	$ 16,216,003
Minor Repair	$ 8,332,139
Other Costs	
Subtotal - Fixed Operating Cost	**$ 60,401,589**



Variable Operating Costs (District Cooling)

The variable operating costs include all energy & utility costs (natural gas, fuel oil, electricity & water/sewer) as well as other costs that are directly connected to these utility costs (ie: water treatment/chemicals & social cost of carbon). These costs as utilized in the lifecycle model are identified below.

- Electricity
    - The electrical usage associated with the production and distribution of the heat throughout the campus has been estimated and is included in the lifecycle model. This estimated electrical usage is documented in the model and as shown below.
        - Estimated Electrical Usage at Powerhouse = 514,736 kWh for 2018 usage. Estimated assuming 0.65 kW/Ton for CHW plant and distribution (including chillers, pumps and cooling towers)
        - Estimated Electrical Usage at Stand-Alone Buildings = 6,474,978 kWh for 2018 usage. Estimated assuming an average of 0.96 kW/Ton for distributed CHW production and distribution (including chillers, pumps and cooling towers)
- Water / Wastewater
    - The water/wastewater usage is intended to capture the cost of water associated with ongoing make-up water required to serve the existing system. This was estimate and confirmed via instantaneous monitoring of the Powerhouse steam system makeup water meter.
    - Estimated Water/Wastewater usage = 1.81 gallons / Ton-Hr

- Cost of Carbon
    - The lifecycle model has been developed with an ability to calculate the cost effects of potential future carbon tax as developed and documented in the Office of Financial Managements LCCA tool. As such, the estimated cost associated with carbon emissions is provided in the lifecycle model “Carbon (OFM)” worksheet. The $/MTCO2e and the site emission factors are shown in Section 9.

4.4 Production Plant & Distribution Site Risks

The BAU option has some inherent risks that will have to be addressed if the Powerhouse site is to be maintained long-term. Given the critical nature of the district heating plant for serving the heating needs of the majority of the facilities on campus, it is extremely important that any potential risks that could affect the operation of the facility be addressed. There are several very real risks that if not addressed could result in the long-term disabling of the plant as well as risking operating personnel life safety. This section provides a detailed overview of the potential risks that have been identified.

DES and UMC has identified five (5) areas of risk that will require some level of significant remediation at the Powerhouse site during the course of our study: the hill side above the Powerhouse, low-lying infrastructure flooding, seismic upgrades, bank erosion, and existing fuel tank(s) removal have been identified.

Hillside Slide Risks

Washington State General Administration (GA) funded an evaluation to give their staff sufficient information regarding stability of slopes around the Capitol Campus (Capitol) and the potential resultant consequences of a landslide (slide) should one or more occur. In August 6, 2009 Golder Associates (Golder) provided their risk evaluation response in a meeting to the (GA) staff. Golder’s final Technical Memorandum regarding Stability and Risk Evaluation Update was officially provided on November 12th of the same year. This memo presents Golder’s findings for the slide areas, including the hill side above the Powerhouse. This memorandum finds two types of slides that could occur at the Powerhouse site. The first is the potential for a deep slide, which has a low likelihood of failure, and a high consequence should it slide. The second is a shallow slide potential, which has a high likelihood to occur and a high consequence should it slide. A low consequence means public perception and some maintenance requirements by GA. If the hill slides it will have high consequences regardless of the slide type, which means extensive damage to buildings, campus infrastructure, and large scale loss of utility services. Historically shallow landslides have occurred episodically and have been documented during periods of heavy rainfall. Generally shallow slides range from twenty to fifty feet wide with lengths varying from tens of feet to the entire slope. A slide here might be categorized as “when” not “if” it occurs without remediation.

Golder’s memorandum provides for five (5) actions for remediation: maintenance, instrumentation, grading, in-situ reinforcement, and soldier pile / tieback wall. See attached Table 6 from Golder’s memorandum. Golder’s memorandum also provided some indication that the hill side has been further disturbed with some attempts at remediation. They found that uncontrolled fill above the Powerhouse may have been placed and then removed in 2002. The hill side may have been re-graded and reinforced with geogrid reinforcement (geogrids observed). Golder searched the archives and did not find any design or construction document related to the observed geogrids. Golder did find possible design inclinations for flattened slope in the GA archives; however this work does not appear to have occurred. These additional actions demonstrate that the hill side has been further disturbed.

In December of 2009 Golder published another Technical Memorandum regarding Revised Schematic Design Alternatives to the GA. This memorandum describes four (4) design alternatives to address stability risks on the Capitol slopes: instrumentation, soldier pile wall, reinforced slope, and vegetation management. This document provided estimates for design and construction, which is the basis for UMC discussion of cost. These costs are not included in UMC proposal as directed by DES and are provided for reference only. In order for the estimates to be complied Golder completed schematic designs. Golder qualified these designs as not being sufficient for bidding or construction.

The table below demonstrates the approximate cost estimate to remediate the hill side.

HILL SIDE REMEDIATION	**ESTIMATED TOTAL**
Instrumentation	$281,000
Soldier Pile Wall (shallow failure)	$1,107,000
Reinforced Slope at Powerhouse (deep-seated failure)	$3,672,000
Vegetation Management (5 year program)	$1,278,000
Park / Walk Path (Landscaping / Nature Walk)	$300,000
TOTAL (ROM)	$6,638,000

Flooding

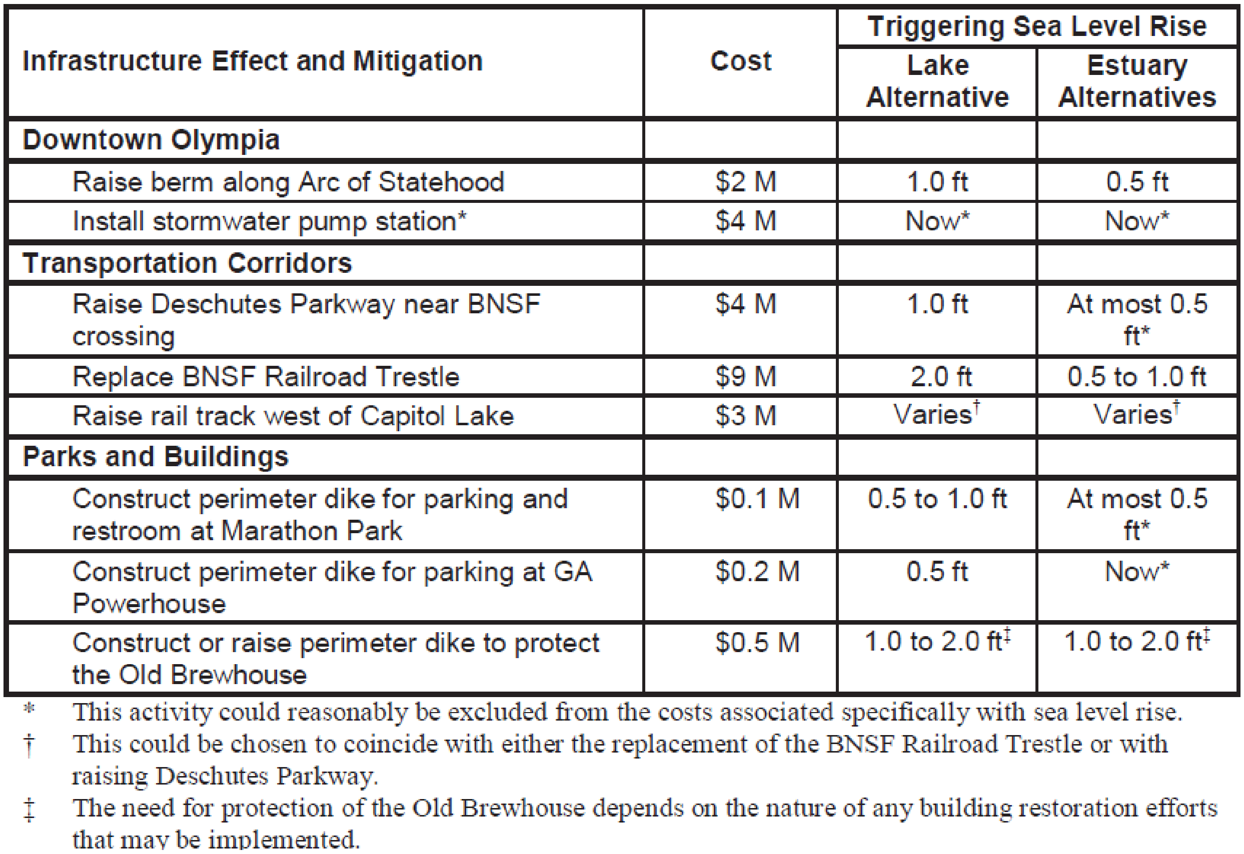
In 2008 the GA commissioned a study to develop an understanding of the different future management alternatives for Capitol Lake (Lake). In particular, a goal of the Capitol Lake Adaptive Management Plan (CLAMP) Steering Committee was to complete a study that evaluated the possibility of a restored estuary as an alternative to the continued management actions necessary to maintain the Lake in this setting. Moffatt & Nichol (M&N) completed this study in their Capitol Lake Alternatives Analysis Low-Lying Infrastructure report date November 17, 2008.

As a piece of M&N's report they provided an assessment of the effects of sea level rise on low-lying infrastructure in the vicinity of the Lake. The report compares possible future management alternatives: continued management of the Lake as a lake (the Lake Alternative), and restoration of the Deschutes Estuary with or without a separate reflecting pool (the Estuary Alternatives).

This report goes on to study the future risk from flooding. M&N's result rely on recent hydraulic modeling conducted and prepared by them. Their results concluded that peak flood elevations were identical for the two Estuary Alternatives. Their study looked at increases in mean sea level of 0.5 feet, 1.0 feet, and 2.0 feet for both a 2-year and 100-year flood.

In M&N's Table ES-2 they identified major effects, mitigation measures, and costs associated with the sea level rise. Within this Table the Powerhouse was identified as needing a perimeter dike for parking at a 2008 cost of $200,000 due to modeled flooding at 0.5 feet of sea level rise. Further, Table 6 of M&N's report demonstrates that much of the park infrastructure (includes Powerhouse) around the Lake is vulnerable to flooding, and will remain so under either lake management alternative or mean sea level increases.

Table ES-2. Effects and Mitigation Measure for Sea Level Rise



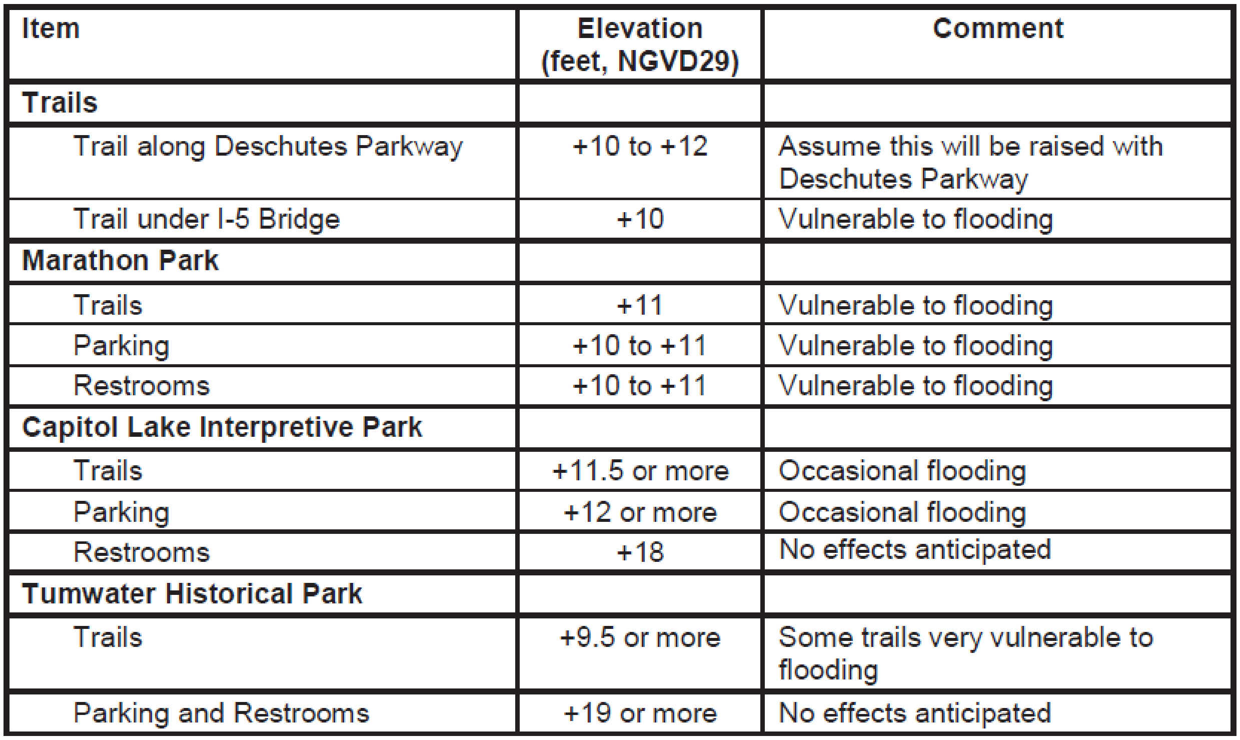
Infrastructure Effect and Mitigation	Cost	Triggering Sea Level Rise	
		Lake Alternative	Estuary Alternatives
Downtown Olympia			
Raise berm along Arc of Statehood	$2 M	1.0 ft	0.5 ft
Install stormwater pump station*	$4 M	Now*	Now*
Transportation Corridors			
Raise Deschutes Parkway near BNSF crossing	$4 M	1.0 ft	At most 0.5 ft*
Replace BNSF Railroad Trestle	$9 M	2.0 ft	0.5 to 1.0 ft
Raise rail track west of Capitol Lake	$3 M	Varies[†]	Varies[†]
Parks and Buildings			
Construct perimeter dike for parking and restroom at Marathon Park	$0.1 M	0.5 to 1.0 ft	At most 0.5 ft*
Construct perimeter dike for parking at GA Powerhouse	$0.2 M	0.5 ft	Now*
Construct or raise perimeter dike to protect the Old Brewhouse	$0.5 M	1.0 to 2.0 ft[‡]	1.0 to 2.0 ft[‡]

* This activity could reasonably be excluded from the costs associated specifically with sea level rise.

[†] This could be chosen to coincide with either the replacement of the BNSF Railroad Trestle or with raising Deschutes Parkway.

[‡] The need for protection of the Old Brewhouse depends on the nature of any building restoration efforts that may be implemented.

Table 6. Parks and Trails Infrastructure and Approximate Elevations



Item	Elevation (feet, NGVD29)	Comment
Trails		
Trail along Deschutes Parkway	+10 to +12	Assume this will be raised with Deschutes Parkway
Trail under I-5 Bridge	+10	Vulnerable to flooding
Marathon Park		
Trails	+11	Vulnerable to flooding
Parking	+10 to +11	Vulnerable to flooding
Restrooms	+10 to +11	Vulnerable to flooding
Capitol Lake Interpretive Park		
Trails	+11.5 or more	Occasional flooding
Parking	+12 or more	Occasional flooding
Restrooms	+18	No effects anticipated
Tumwater Historical Park		
Trails	+9.5 or more	Some trails very vulnerable to flooding
Parking and Restrooms	+19 or more	No effects anticipated

The report goes on to provide evidence that the Powerhouse itself is not subject to flooding only the parking area. It states that a perimeter dike structure, approximately 400-feet long, could be constructed to protect the parking lot. This dike would also provide additional protection to the Powerhouse.

As part of UMC's study we contacted M&N to sort out what this means such that a contractor could reasonably estimate a construction cost, M&N proposed to analyze three proposed concept-level plans up to schematic design:

1. Berm into water – no reduction in upland parking but possible complicated permitting process;
2. Berm on land only – reduction in upland parking but possible simple permit process; and
3. Arc of Statehood-like feature – no reduction in upland parking and possible simple permit process.

What was not considered in M&N's initial report was the bathtub effect that would be caused by simply adding a dike. The design contemplated by the berm / retaining wall would include bring the complete area behind the berm (complete civil elevation change) being filled in such that a bathtub effect could not occur.

The below table demonstrates the approximate cost estimated to remediate the flooding potential. This total was carried in UMC BAU and Alt 1 summaries. UMC was not able to clearly define construction cost without designs; as result the costing reflects the risk.

FLOOD REMEDIATION	ESTIMATED TOTAL
Conceptual Design	$74,000
Final Design	$618.000
400-foot dike (w/ permits)	$1,815,000
Site preparation and fill	$687,000
New asphalt, stripping, & landscape	$1,186,000
TOTAL (ROM)	$4,380,000

Seismic Upgrades and Concerns

The Powerhouse structure had a seismic retrofit in the 1980's. The structural frame that was installed is evident. This retrofit is now thirty plus years old and civil / structural codes have changed significantly in that time. By todays standard it is our understanding that the Authorities Having Jurisdiction (AHJ) would require UMC to bring not only the building into full compliance with current codes but the exterior exhaust stack as well. We also believe that the AHJ would classify the Powerhouse as a critical facility as would DES by its very nature and use. This classification changes the seismic importance factor from a 1.0 (baseline) to a 1.5.

The below table demonstrates the approximate cost estimated to seismically upgrade the Powerhouse and its exhaust stack.

SEISMIC UPGRADE REMEDIATION	ESTIMATED TOTAL
Design	$244,000
Structural retrofit (w/o masonry upgrades)	$1,756,000
TOTAL (ROM)	$2,000,000

Aboveground Storage Tank (AST) Removal

At the Powerhouse site there is an existing ~30,000 gallon fuel oil AST. As part of UMC's BAU, Alt 1, and Alt 2 budgets this AST will be removed. The existing secondary containment system would remain. Our proposal to remove the tank does not include any brown field remediation, as a separate study would be required to determine the full costs. Even with a full study there are no guarantees as to how contamination of a leak could have spread into the hill side or contamination of the Lake. UMC did not carry a budget for removal, remediation, disposal, and backfill of contaminated soils as these are undefinable. UMC also did not carry any cost for ecological impact or remediation due to contamination of the estuary's (Deschutes River or Capitol Lake).

A formal site assessment is not required for closure of an AST by Ecology. However, upon demolition owners of an AST system used for fuel supply are wise to investigate and document the baseline environmental conditions. Assessment support for the AST demolition will be conducted consistent with the Ecology Guidance for UST Site Assessments to the extent practicable. For the AST, samples will be collected from below the bottom of the tank following demolition, within the secondary containment area and in association system piping to the extent pipes are removed or exposed. UMC has budgeted for Golder to provide support and testing for this work. Golder's cost are for: One (1) groundwater sample to be collected for chemical analysis from the AST location, and six (6) samples will be collected in association with the AST demolition.

The below table demonstrates the approximate cost estimated to remove the AST at the Powerhouse.

ABOVEGROUND STORAGE TANK (AST) REMOVAL REMEDIATION	ESTIMATED TOTAL
Golder Support & Testing	$19,500
AST Demolition	$980,500
TOTAL (ROM)	$1,000,000

Erosion Control of the Bank

It has been observed over the past several years that the bank continues to erode where the flow of the Deschutes River meets the bank in front of the secondary containment system for the AST at the Powerhouse. A continuation of erosion may undercut and remove support of the AST. To maintain the existing riverbank, UMC will secure Golder's support to perform the following services:

- Assess the erosive capacity of the flowing water relative the erosion resistance capability of the bank material.
- Identify potential remedial alternatives.
- Design preferred remediation alternative

Once we are contracted for design we will have the ability to increased level of assessment and evaluation, whereby we will have a better understanding of the forces exerted on the bank and the ability of the bank to resist erosion. We will also better understand potential downstream impacts of the proposed remediation measure, including the potential that the remediation could result in new areas of erosion to develop downstream. The additional baseline information reduces uncertainties in the design. Without the additional baseline information and assessment, additional uncertainty is present in the design. This requires more conservative assumptions, leading to a more costly design to build. We will work together to develop a scope of work to mitigate the bank erosion while balancing risk, consequence, and cost.

The construction of an erosion mitigation structure in the Lake adjacent to the Powerhouse will require coordination and permitting from several government agencies. The estimated timeline for obtaining the necessary permits to complete the work is 9 to 12 months; beginning after the design of the mitigation is complete. The following provides a list of the anticipated permits (and lead agencies) required to support the erosion mitigation task and near shore aspects of the Powerhouse construction.

- State Environmental Policy Act (SEPA) environmental impact statement (EIS) or checklist if the project qualifies for the off ramp. - City of Olympia
- Section 404 permit for waterward work or adjacent wetlands. - United States Army Corp of Engineers (ACOE)
- Joint Aquatic Resources Permit Application (JARPA) and Hydraulic Project Approval (HPA) - ACOE and Washington Department of Fish and Wildlife (WDFW), respectively
- Shoreline Development Permit (SSDP) - City of Olympia Substantial
    - A grading permit or permit related to the restoration would be needed
    - This will require: CAO report, Stormwater Report, Geotechnical Report, Possibly Mitigation Plan and analysis of the following shoreline master program element - No Net Loss, Allowed Uses for what the site restoration would be
    - Demolition Permit - City of Olympia

The estimated cost to provide permitting support, including identification of necessary permits, application, and on-going support through the permitting process is $40,000. Actual permitting costs (and schedule) will be dependent on the actual permits required for the project. Note the permitting support is assumed to only be provided for the erosion mitigation repair and support near shore aspects of the adjacent to the Powerhouse. If additional permitting support is needed for other components of the project, it would need to be taken out of contingency.

The below table demonstrates the approximate cost estimated to remediate the erosion of the bank at the Powerhouse.

BANK EROSION REMEDITAION	**ESTIMATED TOTAL**
Design	$125,000
Permitting Support	$40,000
Construction of remediation	$835,000
TOTAL (ROM)	$1,000,000

Safety Concerns

In 2015, UMC performed an investigation focused on operational and safety issues. The results of this report illustrated an aging system that was in need of significant renewal and equipment upgrades just to maintain the current level of service for the

Capitol Campus. For detailed information on the findings of this investigation, please see the “Steam Production Plant – Phase II Analysis of Steam System Safety & Operational Issues”, dated April 2015.

5.0 PROJECT ANALYSIS – ALTERNATIVE 1

5.1 Overview of Alternative 1a & 1b

Alternative 1a

As previously discussed, Alternative 1a consists of a renovated District Heating Plant with CHP and Thermal Storage located at the existing Powerhouse site. CHP will serve as primary heat source. The existing steam distribution will be converted to Hot Water (HW).

Alternative 1b

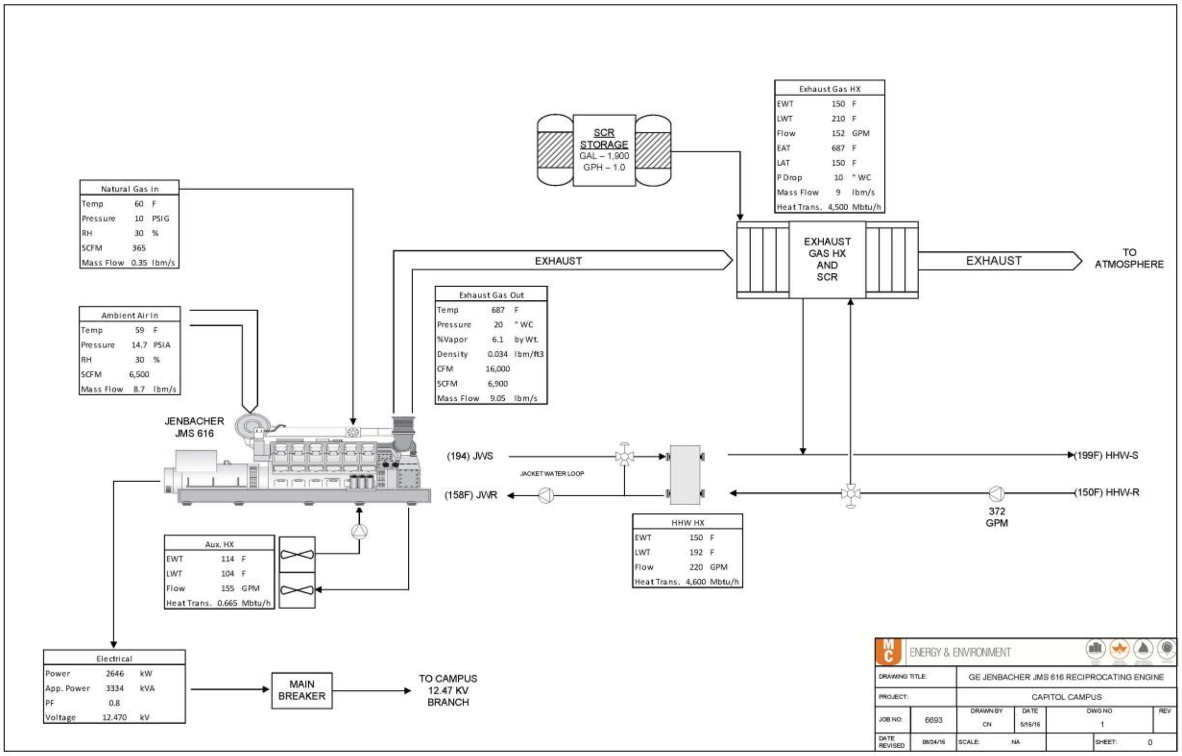
Alternative 1b is the same as alternative 1a with the exception that Alt 1b will utilize high efficiency heating Hot Water Boilers as the primary heating source for the campus in lieu of CHP and thermal storage. As such, Alt 1b excludes all CHP equipment and associated systems.

5.2 Production Plant

Alternative 1a will expand and modify the existing Powerhouse location to allow for operation as a CHP plant with high efficiency heating hot water peaking and backup boilers. Given the current size and location of the Powerhouse, the plant will need to be fully renovated and expanded to incorporate sufficient capacity to handle all current loads as well as future growth capacity for the Capitol Campus.

The initial production plant heating system will include sufficient equipment capacity to serve the projected campus load (including growth) through 2035. The production system will include the following.

- (1) Cogeneration (CHP) system capable of providing between 8,000 and 12,000 Mbtuh of heating hot water. The primary generating equipment could be either a natural gas powered reciprocating engine (similar to a GE Jenbacher) or a gas turbine (similar to an OPRA). This cogeneration unit will provide between 1.8 and 2.6 MW of electricity during peak operation.
- (3) High efficiency heating hot water boilers sized at 15,000 Mbtuh each. These boilers will be installed with individual condensing stack economizers that will allow combustion operating efficiencies of up to 95%.
- (1) 1,800,000 gallon thermal storage tank. This tank will store excess heat from the CHP system during peak operation and utilize this heat to serve the campus heating requirements during low load periods such as night and weekend operation hours.
- The proposed backup fuel source will be provided by a compressed natural gas contract/storage system.



The existing Powerhouse building will be modified internally, while maintaining the external historical nature of the facility. This building will be renovated to include the (3) heating hot water boilers (with room for a future boiler), the electrical equipment and the primary system control room.

A new, separate structure will be constructed directly adjacent to the Northeast corner of the Powerhouse to house the proposed CHP equipment. This structure will be approximately 10,000 sqft and will include a structure retaining wall to protect the facility to a degree against potential hillside slide concerns (additional discussion on hillside slide risks and other site concerns is provided the next section).

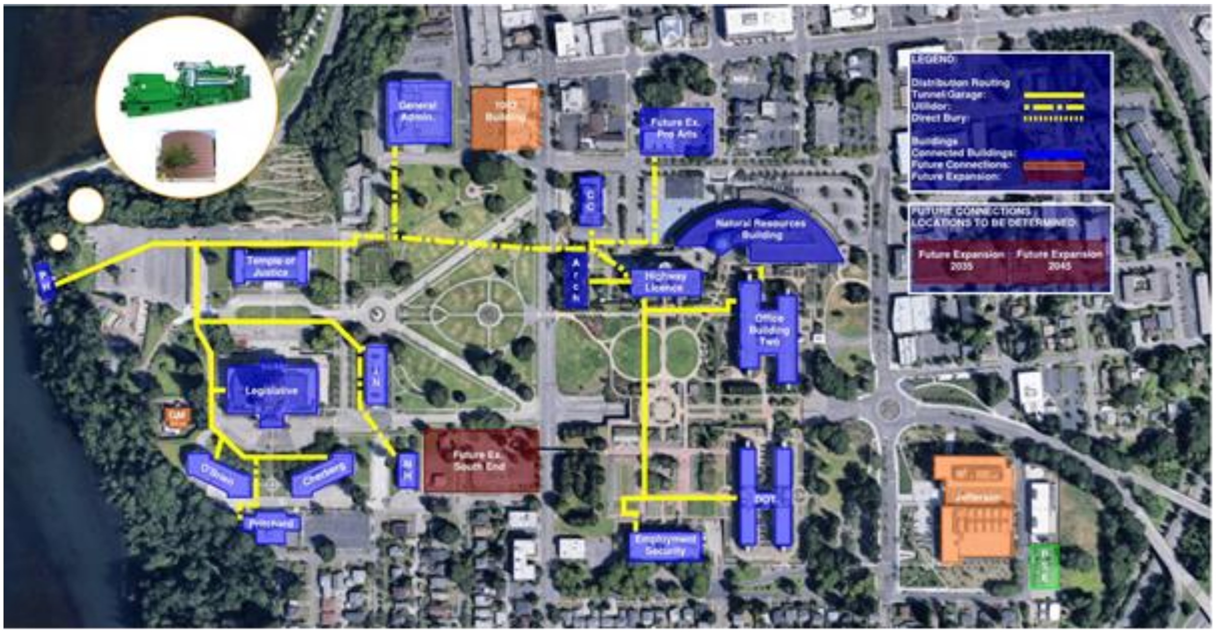
5.3 Production Plant Site Risks

The Alt 1 option has some inherent risks (similar to BAU) that will have to be addressed if the Powerhouse site is to be maintained long-term. Given the critical nature of the district heating plant for serving the heating needs of the majority of the facilities on campus, it is extremely important that any potential risks that could affect the operation of the facility be addressed in affectively. There are several very real risks that if not addressed could result in the long-term disabling of the plant as well as risking operating personnel life safety. A detailed overview of these risks, which are the same as the BAU alternative, is provided in Section 4.4. These risks include the following:

- ✓ Hillside Slide Risks
- ✓ Lakeside Flood Risks
- ✓ Seismic Upgrade Requirements and Concerns
- ✓ Lakeside Permitting Concerns and Delay Costs
- ✓ Fuel Tank Leak Risks

5.4 Distribution System

The existing steam distribution system will be replaced with a new, hot water distribution loop. This HW distribution pumping system will be located in the Production Plant for distribution throughout the east and west campus'. The new distribution loop would take advantage of the existing tunnel system on West Campus as well as utilizing the open area in the large underground parking garage on East Campus. Distribution loops outside of either the tunnel or parking garage would be implemented utilizing a trenched, direct bury application similar to that recently utilized at the University of British Columbia as well as numerous other district energy locations throughout US, Canada and Europe. Following is an overview of the proposed distribution system routing for the campus.

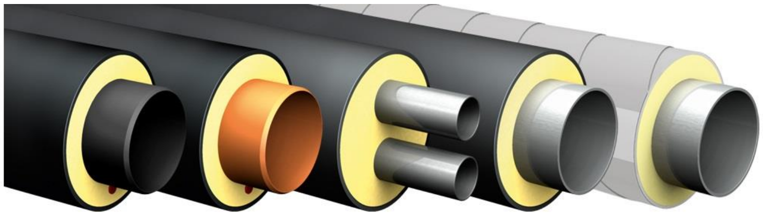


The proposed distribution system will be designed to handle future load growth over the next 50 years and beyond, as has been identified in coordination with the campus master planning team during the development of this project.

5.5 Energy Transfer and In-Building Systems

The facilities served from the Production Plant will utilize an energy transfer station (ETS) to transfer the heating energy from the campus distribution loop to the individual building heating system. These ETS units will utilize a pre-fabricated system designed with internal control optimization to efficiently and effectively transfer the heating to serve the comfort heating load and the DHW heating load of each facility (with a few exceptions for specific buildings that do not have centralized DHW systems that can be economically modified for service from the DE plant)

The figures shown above and below illustrate the indirect energy transfer stations and pre-insulated hot water piping. The transfer stations shown are water-to-water heat exchangers. Pre-insulated welded steel piping is used in direct buried applications and site-insulated welded steel pipe used for applications in existing tunnels as applicable. Other materials (such as HDPE) may be economically viable in lower supply temperature applications or on the building side of heat exchangers where appropriate.



Pre-Insulated Piping

6.0 PROJECT ANALYSIS – ALTERNATIVE 2

6.1 Overview of Alternative 2a & 2b

Alternative 2a

As previously discussed, Alternative 2a consists of a new District Heating Plant with CHP and Thermal Storage located at a new Production Plant site. The CHP system will operate as the primary heat source. The steam distribution will be converted to Hot Water.

Alternative 2b

Alternative 2b is the same as alternative 1a with the exception that Alt 2b will utilize high efficiency heating Hot Water Boilers as the primary heating source for the campus in lieu of CHP and thermal storage. As such, Alt 2b excludes all CHP equipment and associated systems.

6.2 Production Plant

Alternative 2a will move the District Energy Production Plant to a completely new location; eliminating the inherent risks associated with the existing Powerhouse location. This new site, adjacent to and just East of office building OB2, will be designed to house all district energy heating production equipment as well as provide space for a new district energy cooling production plant that can be utilized to serve both East and West Campus'.

The heating production plant will incorporate a CHP plant as the primary heating source for the campus, along with high efficiency hot water peaking and backup boilers.

The initial production plant heating system will include sufficient equipment capacity to serve the projected campus load (including growth) through 2035. The production system will include the following.

- (1) Cogeneration (CHP) system capable of providing between 8,000 and 12,000 Mbtuh of heating hot water. The primary generating equipment could be either a natural gas powered reciprocating engine (similar to a GE Jenbacher) or a gas turbine (similar to an OPRA). This cogeneration unit will provide between 1.8 and 2.6 MW of electricity during peak operation.
- (3) High efficiency heating hot water boilers sized at 15,000 Mbtuh each. These boilers will be installed with individual condensing stack economizers that will allow combustion operating efficiencies of up to 95%.
- (1) 1,800,000 gallon thermal storage tank. This tank will store excess heat from the CHP system during peak operation and utilize this heat to serve the

campus heating requirements during low load periods such as night and weekend operation.

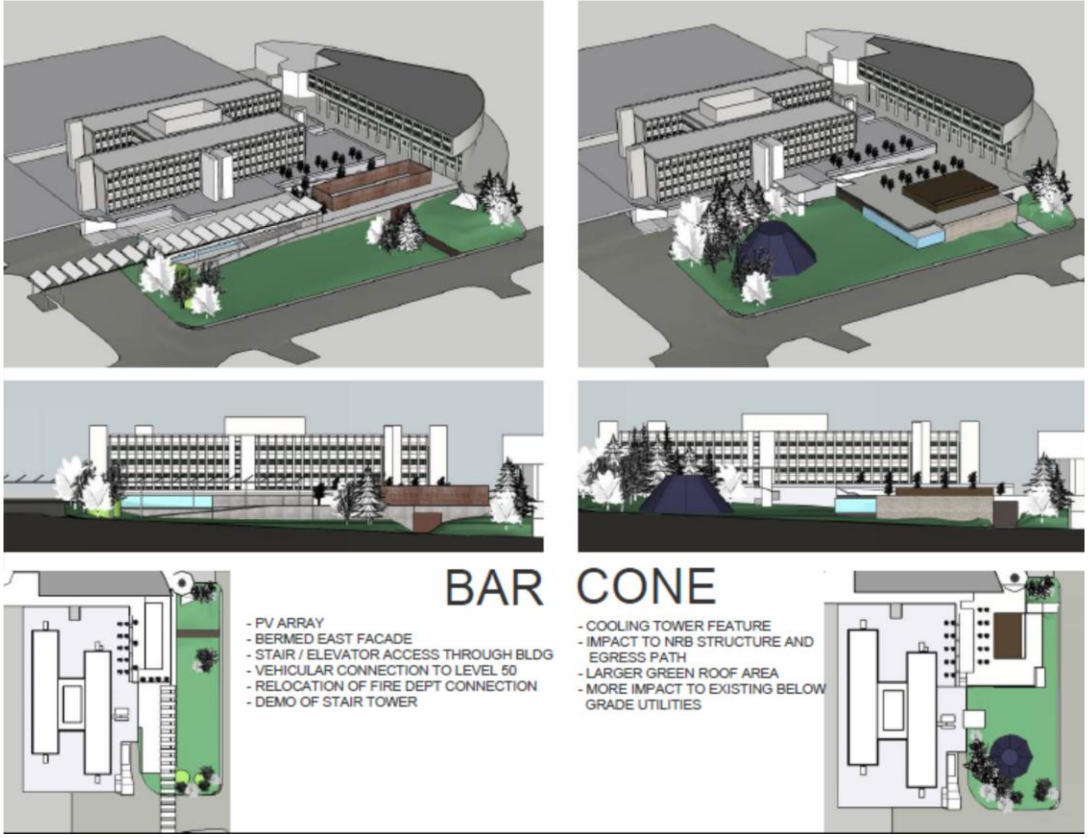
- The proposed backup fuel source will be provided by a compressed natural gas contract/storage system.

The potential new production plant associated with Alternate 2 is targeted to be located on the plot of land directly adjacent and to the East of the existing Office Building Two (OB2). This site is bordered on the South by 14th Ave SE and on the East by Jefferson St SE.


Site for New Production Plant

New Production Plant Concepts

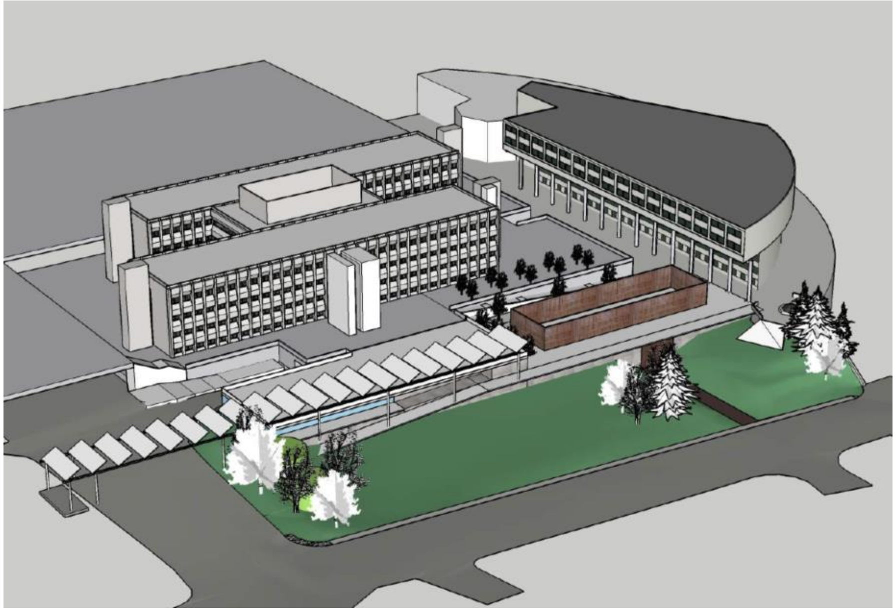
During the development of this Energy Services Proposal, ZGF Architects was engaged to develop several potential facility concepts for the proposed site. This new site provides an open site for construction of the new facility, while also allowing for incorporation of the “50 Level” below grade basement level for connection to OB2 and access from the west side of the site. In association with the DES & UMC development team, ZGF developed two distinct preliminary building concepts designated separately as “BAR” and “CONE”. An overview of these concepts is provided below. (note: the current budget estimate includes the cost associated with implementing the “CONE” concept)

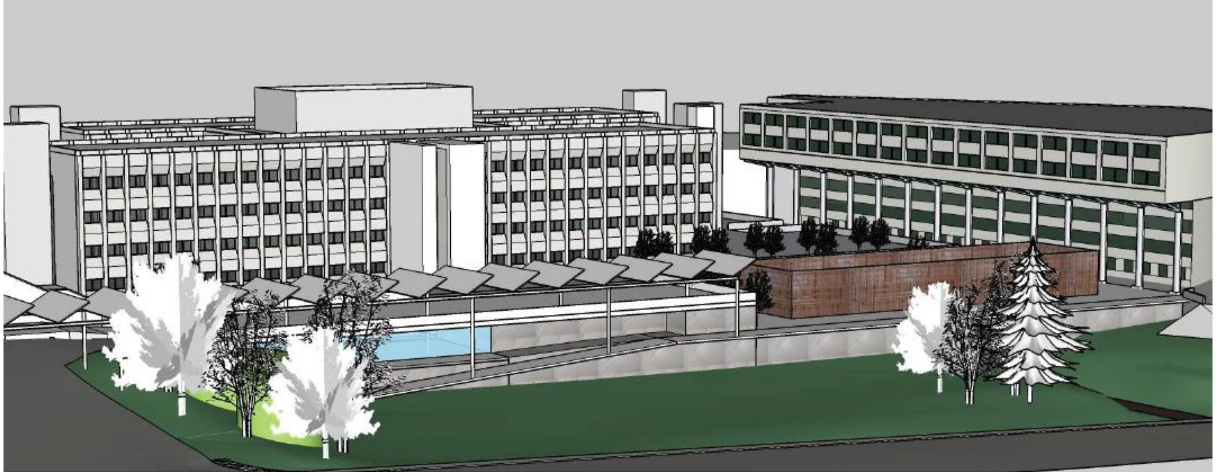


<u>“BAR” Concept</u>

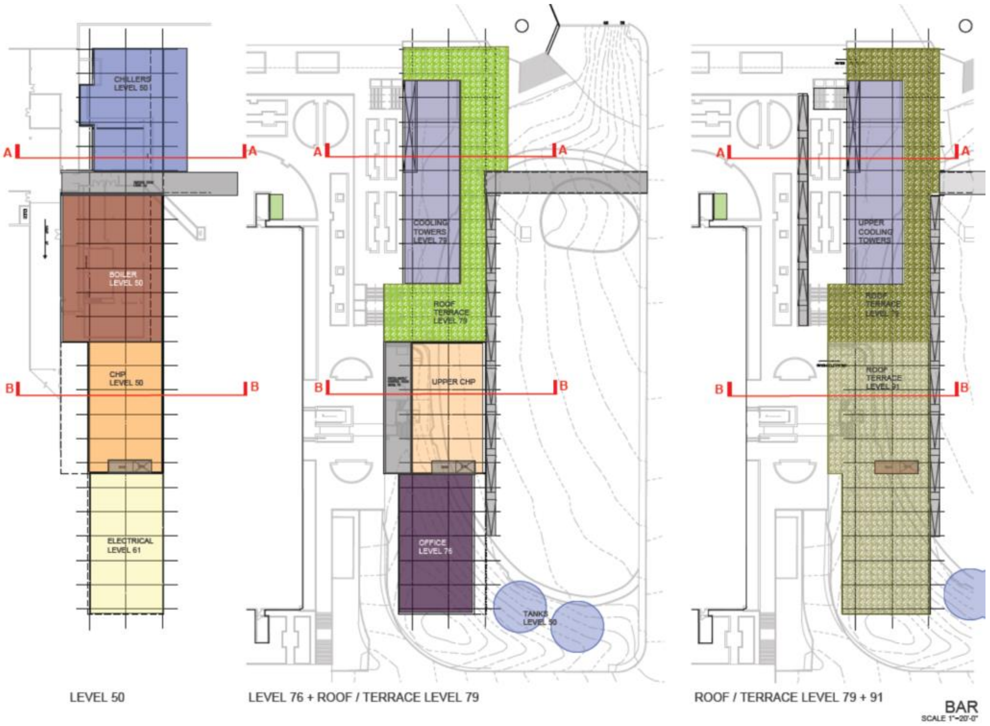
The BAR concept provided an elongated, north-south structure that incorporates the western-most section of the site, fitting directly adjacent to OB2, as shown in the following schematic. While maintaining a large open green space, this facility blends nicely into the landscape of the area, incorporating a roof terrace similar to the existing mezzanine area of OB2.

This option will require the removal of the stairwell located on the east side of OB2 mezzanine. It will be replaced with a walking ramp that provides a path around the exterior of the new facility, starting at grade and ending at the mezzanine level.



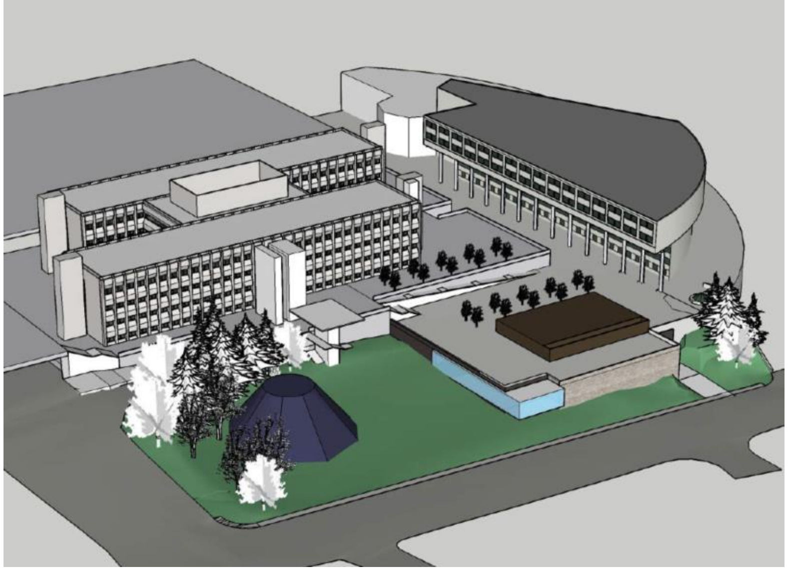


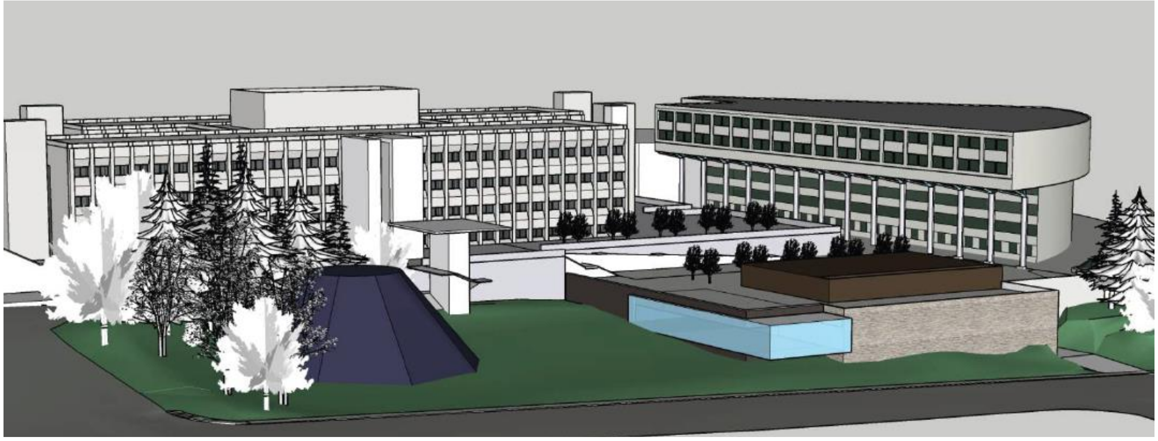
The building will be 2 levels, incorporating design areas for production heating & CHP equipment, production cooling equipment, operator control room & offices and mechanical/electrical space for core facility requirements. In addition, cooling towers will be located on the roof of the facility (screened for aesthetics). There is easy access for maintenance on the north side, with a north-south maintenance aisle for installation and removal of large equipment.



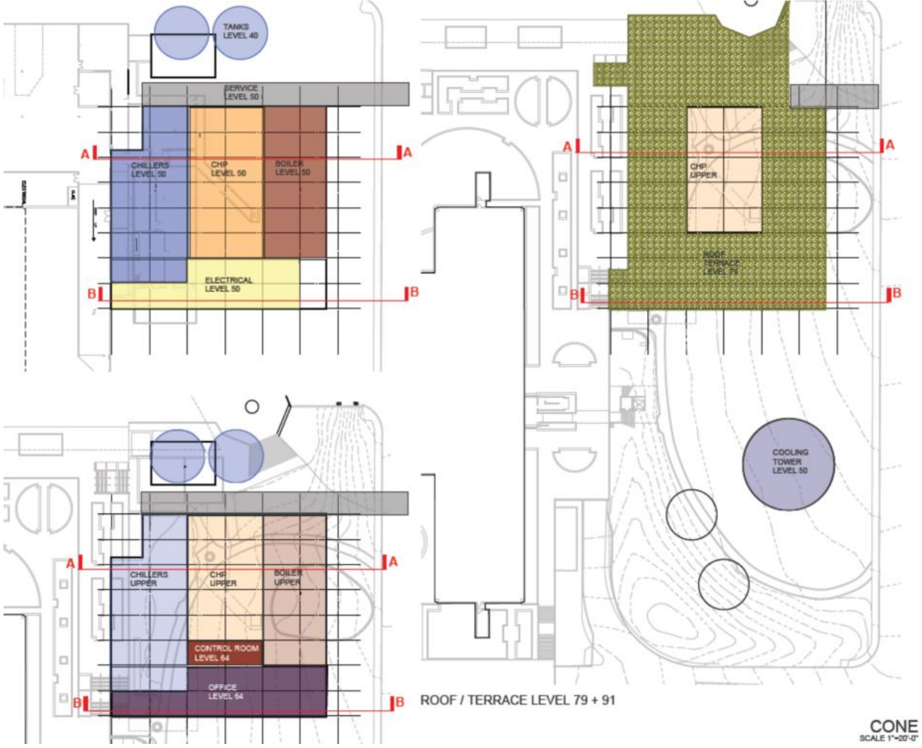
“CONE” Concept

The CONE concept, which is somewhat less expensive than the BAR concept, incorporates a more square facility located primarily at the NW end of the site. This option leaves green space on the south side of the facility, while also maintaining the existing access stairwell to OB2.





Similar to the BAR concept, the building will be 2 levels, incorporating design areas for production heating & CHP equipment, production cooling equipment, operator control room & offices and mechanical/electrical space for core facility requirements. In contrast to the BAR, cooling towers will be located on the exterior of the facility and incorporated into the general space for aesthetics. There is easy access for maintenance with truck access on the north side. This access will allow for direct maintenance access into each primary equipment space (including boiler room, chiller room and CHP room).



6.3 Production Plant Site Risks

The Alt 2 option has some inherent risks, as described below, which will have to be addressed during the construction of the new production plant.

Underground Storage Tank (UST) Removal

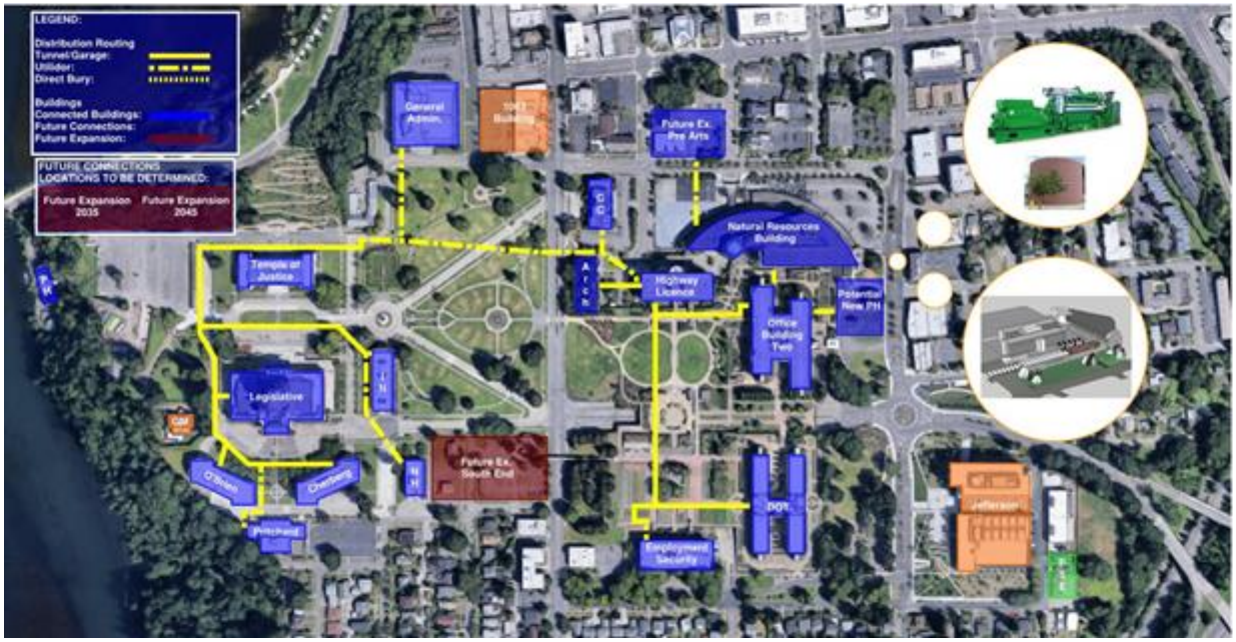
The new site selected for Alt 2 has three existing USTs that serve the emergency generators for OB2 and NRB buildings. To facilitate construction of the new plant these tanks will need to be removed.

The UST Site Assessment will be conducted in accordance with Washington State Department of Ecology's (Ecology) "Guidance for Site Checks and Site Assessments for Underground Storage Tanks (2003)" (Ecology Guidance) through Golder. The site assessment will be conducted by a certified Site Assessor. Our proposed scope of services for the UST site assessment will include:

- Reviewing available information to determine hydrogeological and soil characteristics associated with the site
- Conducting a site inspection to determine or confirm information regarding the physical characteristics of the USTs, associated piping and monitoring system (if present)
- Collect relevant background information pertaining to the subject USTs for inclusion in the report, as practical. Additional site information will be gathered during the actual tank removal (e.g. soil characteristics, tank measure and condition, etc.).
- Preparation of a field sampling and analysis plan and a site specific Health and Safety Plan (HASP) as required for compliance with Ecology Guidance
- Providing oversight of the tank excavation and removal, making visual observations and conducting surveys with a photoionization detector to identify potentially impacted soils
- Conducting confirmatory soil sampling from beneath the USTs, excavation walls, floor, and beneath system piping, stockpiled soils or other potentially impacted soils for chemical analysis. Soil samples will be collected at a minimum rate of one for every 50 feet of piping. All soil samples will be collected in accordance with Ecology's Guidance. The number and location of samples will be influenced by site conditions, location of suspect soils (if present) the excavation method relevant to the location of the USTs within the excavation. Groundwater samples will be collected if observed in the excavation or located within two feet of the bottom of the excavation. Soil and groundwater samples collected during the site assessments to an analytical laboratory for chemical analysis by Northwest Total Petroleum Hydrocarbon – Diesel Extended (NWTPH-Dx).

6.4 Distribution System

The existing steam distribution system will be replaced with a new, hot water distribution loop. This HW distribution pumping system will be located in the Production Plant for distribution throughout the east and west campus. The new distribution loop would take advantage of the existing tunnel system on West Campus as well as utilizing the open area in the large underground parking garage on East Campus. Distribution loops outside of either the tunnel or parking garage would be implemented utilizing a trenched, direct bury application similar to that recently utilized at the University of British Columbia as well as numerous other district energy locations throughout US, Canada and Europe. Following is an overview of the proposed distribution system routing for the campus.



The proposed distribution system will be designed to handle future load growth over the next 50 years and beyond, as has been identified in coordination with the campus master planning team during the development of this project.

6.5 Energy Transfer and In-Building Systems

The facilities served from the Production Plant will utilize an energy transfer station (ETS) to transfer the heating energy from the campus distribution loop to the individual building heating system. These ETS units will utilize a pre-fabricated system designed with internal control optimization to efficiently and effectively transfer the heating to serve the comfort heating load and the DHW heating load of each facility (with a few exceptions for specific buildings that do not have centralized DHW systems that can be economically modified for service from the DE plant)

(Refer to Section 5.5 for figures showing examples of energy transfer station and pre-insulated piping)

7.0 ELECTRICAL SYSTEMS OVERVIEW

7.1 Overview

As previously discussed, the proposed new heating production plant will utilize CHP as a heat load following system, utilizing the electricity that is generated as a by-product of thermal production to offset campus electrical usage. This electrical by-product will increase the plant's efficiency and provide operational redundancy and capacity for future CHP expansion.

The electricity generation system will have enough capacity and backup to assure that the heating hot water plant can produce and distribute heat throughout the campus is case of any future loss of incoming utility power. Emergency generators will be provided to serve the CHP to enable operation during a power outage and CHP restart. This will provide resilient operation of the heating plant during any critical power outage.

The generators will produce power at 12.47 kV instead of 480 V to minimize the amount of wires and losses associate with transmitting power to the local grid. Only one conduit will be needed to transmit power at 12.47 kV. Thus, greater insulation but much less copper and conduit will be required. This is in lieu of 480 V transmission, that would require 5 to 6 conduits full of larger copper wire.

7.2 Flexibility for Future Operations

Because the plant will be a thermal lead generation plant, the amount of electricity produced is directly related to the amount of hot water produced. Anticipated production will be between 2.0 and 2.6 megawatts of electricity, which equates to the minimum campus hot water load. This will allow the CHP to operate 24/7 at a base load if desired. However, the proposed thermal storage tank will provide the opportunity to efficiently sequence the CHP unit for maximum overall efficiency (both thermal & electrical) and benefit to the campus.

The electrical design includes two 12.47 kV feeders and two redundant transformers to serve the plant. They are sized with enough capacity so that either one could carry the full CHP load. Loads are split such that the loss of one feeder or transformer will allow partial operations until the tie breaker is closed.

The feeders and transformers for the chiller plant are will also be fully redundant following plant construction. However, as discussed during the development process, future chiller additions will limit the full redundancy capability from an electrical standpoint should there be a critical loss of utility power.

The electrical design includes emergency power supply to allow a “black start” of the plant after a total outage and to supplement the power requirements of the CHP during an outage.

7.3 Standby Power

During the course of the analysis, the option to include standby power at the plant was analyzed to determine if there were sufficient lifecycle financial benefits to include this as part of the base design. The intent would be to identify key campus loads that could be connected to the CHP unit. These key campus electrical loads could then be supplied with standby power from the cogeneration unit in the case of a critical loss of utility power.

To fully incorporate this option, it was determined that a separate emergency power distribution network would have to be designed, constructed, and connected to the CHP in order to replace the existing emergency generators in each building with the power produced by the CHP. After reviewing these requirements and performing a high level cost estimate, it was determined that this option did not have sufficient financial benefit at this time to warrant incorporation into this project. However, it was determined that this may be of value to review this option again at a later date that corresponds with potential replacement and purchase of new stand-alone facility generators.

Therefore, the electrical design excludes full standby power generation capacity for the campus in the event of an extended loss of utility power as well as emergency power supply for the campus. This is an option that could be included in a future expansion or modification to the plant if it is determined to be cost effective at a later date.

7.4 Proposed Interconnect with PSE

The CHP plant will interconnect and operate in parallel with PSE. The electricity produced by the CHP will not be sold to PSE; it will be used to offset the normal campus consumption. New protective relays will be installed in the PSE substation to allow the campus to generate power safely, in parallel with the utility.

PSE will provide the additional power required for this plant and the rest of the campus. As the amount of electricity produced is directly related to the thermal production, the electrical output of the CHP will fluctuate. Parallel operation enables PSE to provide extra power as needed to manage the fluctuations caused by variations in thermal production and normal daily power consumption.

PSE will also be able to disconnect the CHP from the campus and PSE grid during an outage through a transfer trip scheme to be installed in the PSE substation.

7.5 What Happens in the Event of a Power Outage?

The design intent is to assure continuous hot water for heating to all buildings on the Capitol campus. During a utility power outage, the CHP will be disconnected from the campus grid/utility. It will use its emergency generator and the CHP generator to provide the power necessary to operate the plant, including the hot water distribution pumps, and possibly some loads from the chilled water plant (until chiller plant full build-out).

All of the other campus buildings currently have an emergency generator to provide power for life-safety loads for that building. These units will remain in operation.

During a power outage, the CHP may need to switch to electrical lead with thermal by-product to assure enough electrical production to meet loads. The design includes all of the controls necessary to allow the CHP to switch to electrical lead.

As part of the interconnection agreement, PSE will have the ability to control the breakers at the CHP during an outage to assure that it and the chiller plant are off the grid and safely isolated from PSE.

When the utility power comes back on, the CHP generator will synch back up with the utility, reconnect to the grid, and return to normal parallel operation. IF the switch was made to electrical lead during the outage, the CHP will return to thermal lead operation

8.0 DISTRICT COOLING CONCEPTS

8.1 Analysis of District Cooling Alternatives

In addition to the targeted alternatives developed for the District Heating opportunities, UMC was tasked with providing support to DES in the analysis and development of select District Cooling alternatives associated with implementing a Thermal (District) Energy Master Plan. These cooling options were not developed to the same level as the District Heating alternatives, but on more of a rough order of magnitude (ROM) level.

The following upgrade alternatives have been analyzed and compared on a 50 year lifecycle. Both concepts provide for 3,600 tons firm capacity and full redundancy; including either a 1,500 ton chiller or thermal storage.

Alternative 1 – Chilled Water Production Plant and Distribution System Concept

West Campus CHW Production Plant - Powerhouse

The existing CHW production plant at the Powerhouse is currently comprised of the following equipment.

- (1) Carrier Centrifugal Chiller – 700 Tons (installed 2008)
- (1) Smardt Centrifugal Chiller – 800 Tons (installed 2015)

This site has room to expand to include one additional chiller that could be sized at approximately 700 tons. This is sufficient capacity to serve the entire west campus, including currently planned future facilities. However, this is not sufficient to cover the expansion to an east campus CHW distribution loop.

- Proposed Concept: Expand the Powerhouse CHW plant as required to include an additional high efficiency chiller to bring the total Powerhouse CHW production capacity up to 2,100 tons. This additional chiller could be similar to the existing Smardt chiller (high efficiency, high turndown, oil-less) or possibly an absorption chiller to take additional advantage of the cogeneration equipment during the cooling season.
- Replace the existing “reverse return” CHW distribution loop with a new variable flow primary loop that serves the entire west campus and includes capacity and stub out connections to serve future facilities when they come on line.
- **East Campus CHW Production Plant – OB2 Level 50:** Implement a new east campus CHW production plant located in the “50 level” of OB2. This production plant will be designed to provide 3,000 tons of chiller capacity and space for additional chillers or heat pumps in the future as the campus load grows

- Install a new CHW distribution loop to serve the east campus facilities. This loop will be designed to include capacity and stub out connections to serve future facilities when they come on line.
- Connect the east and west campus CHW loops with a distribution loop bridge located in place of the existing utilidor on the north side of the Archives Building
- Consider installation of ~ 6000 ton-hrs thermal storage at a location near the distribution loop bridge. This thermal storage will be designed to be charged from either the west campus production plant or the east campus production plant at night when conditions are ideal to provide higher pant operating efficiencies. The thermal storage system will have sufficient capacity to serve the entire campus loop for peak periods of a typical summer day.
- Provide location flexibility to take advantage of existing and future alternative cooling technologies as they become viable. These technologies could include (but not be limited to) the following
    - High temperature CO2 refrigerant heat recovery chiller – Provide the opportunity to recover heat from the nearby data center(s) and distribute this higher grade hot water to localized heating loads served by the new heating hot water loop.
    - Adsorption cooling – Provide the opportunity to operate the cogeneration plant for longer periods during the summer; taking advantage of additional electrical generation capacity.
    - Absorption cooling – Provide the opportunity to operate the cogeneration plant for longer periods during the summer; taking advantage of additional electrical generation capacity.
    - Heat Pump technologies (ie: geo-exchange or other option)

Alternative 2 – Chilled Water Production Plant and Distribution System Concept

Proposed Concept:

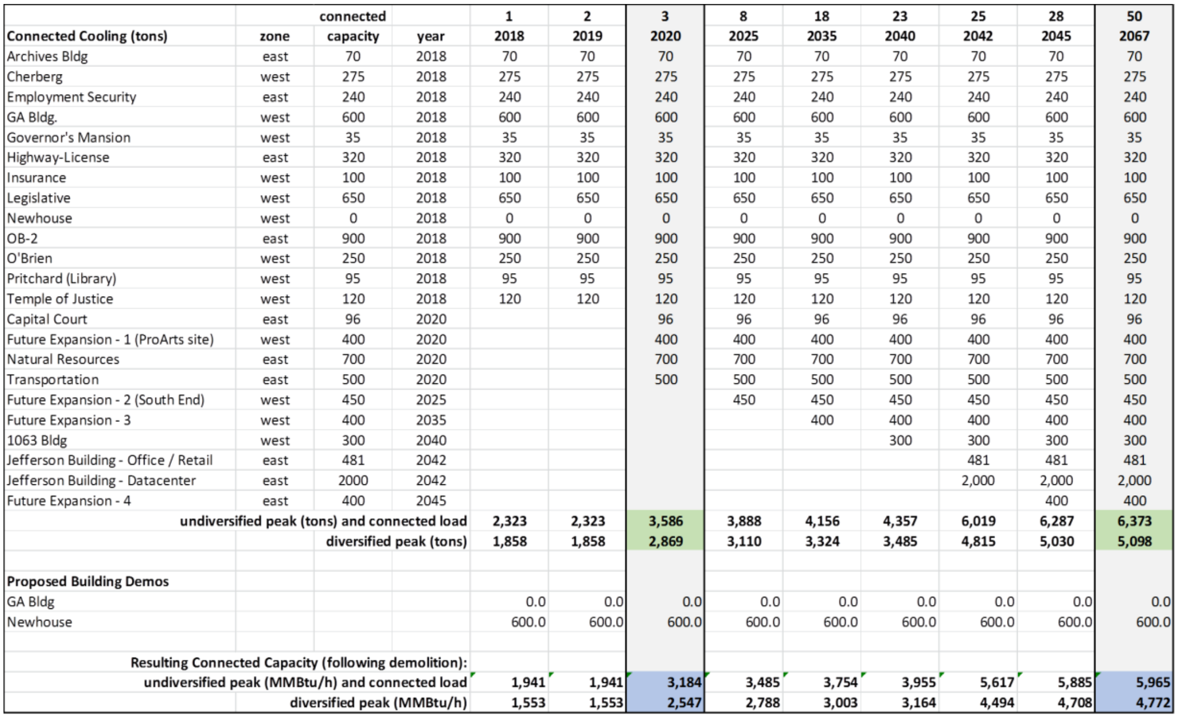
- Construct a new, high efficiency CHW plant located in the new District Energy Plant as proposed on the east side of OB2 with 5,200 tons installed production capacity in three chillers and space for one more chiller or heat pump.
- Abandon the West Campus CHW Production Plant. The existing Smardt 700 Ton chiller can be re-used at the new plant.
- Provide location flexibility to take advantage of existing and future alternative cooling technologies as they become viable. These technologies could include (but not be limited to) the following.

  - High temperature CO2 refrigerant heat recovery chiller – Provide the opportunity to recover heat from the nearby data center(s) and distribute this higher grade hot water to localized heating loads served by the new heating hot water loop.
  - Adsorption cooling – Provide the opportunity to operate the cogeneration plant for longer periods during the summer; taking advantage of additional electrical generation capacity.
  - Absorption cooling – Provide the opportunity to operate the cogeneration plant for longer periods during the summer; taking advantage of additional electrical generation capacity.
  - Heat Pump technologies (ie: geo-exchange or other option)

- Remove the existing “reverse return” CHW distribution loop serving west campus.
- Install a new variable flow primary loop that serves both the east and west campus and includes capacity and stub out connections to serve future facilities when they come on line.
- Consider installation of ~ 6000 ton-hrs thermal storage at a location near the new production plant. This thermal storage will be designed to be charged at night when conditions are ideal to provide higher pant operating efficiencies. The thermal storage system will have sufficient capacity to serve the entire campus loop for peak periods of a typical summer day.

Plan to Address Future Campus Growth

The following table illustrates the anticipated campus CHW capacity growth that will have to be addressed over the next 50 years.



		connected		1	2	3	8	18	23	25	28	50
Connected Cooling (tons)	**zone**	**capacity**	**year**	**2018**	**2019**	**2020**	**2025**	**2035**	**2040**	**2042**	**2045**	**2067**
Archives Bldg	east	70	2018	70	70	70	70	70	70	70	70	70
Cherberg	west	275	2018	275	275	275	275	275	275	275	275	275
Employment Security	east	240	2018	240	240	240	240	240	240	240	240	240
GA Bldg.	west	600	2018	600	600	600	600	600	600	600	600	600
Governor's Mansion	west	35	2018	35	35	35	35	35	35	35	35	35
Highway-License	east	320	2018	320	320	320	320	320	320	320	320	320
Insurance	west	100	2018	100	100	100	100	100	100	100	100	100
Legislative	west	650	2018	650	650	650	650	650	650	650	650	650
Newhouse	west	0	2018	0	0	0	0	0	0	0	0	0
OB-2	east	900	2018	900	900	900	900	900	900	900	900	900
O'Brien	west	250	2018	250	250	250	250	250	250	250	250	250
Pritchard (Library)	west	95	2018	95	95	95	95	95	95	95	95	95
Temple of Justice	west	120	2018	120	120	120	120	120	120	120	120	120
Capital Court	east	96	2020			96	96	96	96	96	96	96
Future Expansion - 1 (ProArts site)	west	400	2020			400	400	400	400	400	400	400
Natural Resources	east	700	2020			700	700	700	700	700	700	700
Transportation	east	500	2020			500	500	500	500	500	500	500
Future Expansion - 2 (South End)	west	450	2025				450	450	450	450	450	450
Future Expansion - 3	west	400	2035					400	400	400	400	400
1063 Bldg	west	300	2040						300	300	300	300
Jefferson Building - Office / Retail	east	481	2042							481	481	481
Jefferson Building - Datacenter	east	2000	2042							2,000	2,000	2,000
Future Expansion - 4	east	400	2045								400	400
undiversified peak (tons) and connected load				**2,323**	**2,323**	**3,586**	**3,888**	**4,156**	**4,357**	**6,019**	**6,287**	**6,373**
diversified peak (tons)				**1,858**	**1,858**	**2,869**	**3,110**	**3,324**	**3,485**	**4,815**	**5,030**	**5,098**
Proposed Building Demos												
GA Bldg				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Newhouse				600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Resulting Connected Capacity (following demolition):												
undiversified peak (MMBtu/h) and connected load				**1,941**	**1,941**	**3,184**	**3,485**	**3,754**	**3,955**	**5,617**	**5,885**	**5,965**
diversified peak (MMBtu/h)				**1,553**	**1,553**	**2,547**	**2,788**	**3,003**	**3,164**	**4,494**	**4,708**	**4,772**

Proposed Concept Implementation Phasing:

- Project can be constructed concurrently with DE/CHP Project
  - This is especially encouraged for distribution system construction efficiency.
- Existing cooling infrastructure also lends itself well to implementing the project in multiple phases dependent upon funding.
  - Powerhouse CHW Plant is new & efficient and can serve W Campus while E Campus Plant is being construction (both Alt 1 & 2)
- Selection and Phasing of the type of optimal production equipment depends upon multiple variables
  - Application of CHP enhances benefits of Absorption
  - Connection of year round loads (ie data center) enhances benefit of heat recovery chiller
  - Market expansion/acceptance in US of high temp CO2 chiller technology also enhances opportunity for heat recovery chiller
  - Future potential PSE rate schedule modifications (i.e. time of day rate) encourages thermal storage

9.0 50 YEAR LIFE CYCLE ANALYSIS

9.1 Assumptions

The development of this lifecycle model was intended to provide a wide range of flexibility for reviewing cost and operating variables that could affect the economic outcome of the 50 year lifecycle comparison. The assumptions utilized were, as much as possible, based on the assumptions included in the OFM LCCA tool. Following is an overview of the base assumptions.

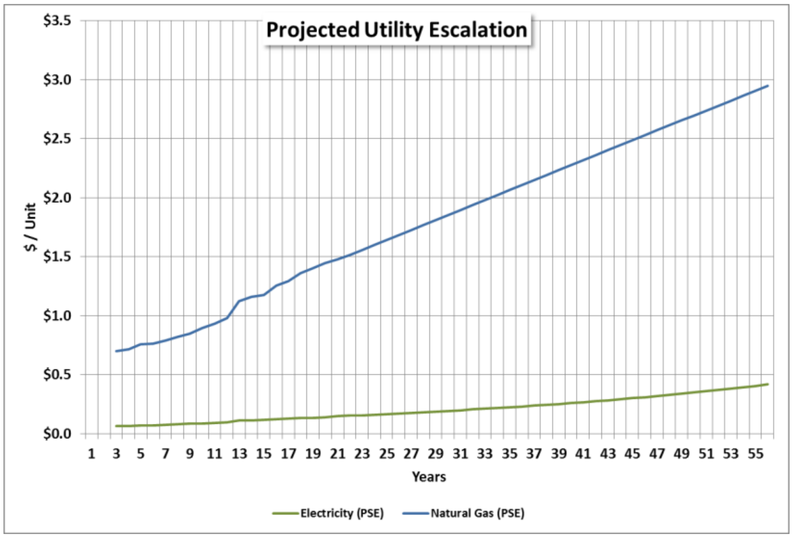
Utility Rates

2016 Rates

- Gas = $0.70 / therm
- Electricity = $0.064 / kWh
- Water/Wastewater (combined) = $8.246 / CCF

Escalators

- General Inflation = 3.01%
- Capital Equipment = 3.01%
- Operating Labor = 3.01%
- Capital Repair = 3.01%
- Chemicals (water treatment) = 3.01%
- Utility Costs – Escalation rates for gas & electric costs are based on the 2015 PSE Integrated Resource Plan (IRP). (The IRP is a forecast of conservation resources and supply-side resource additions that appear to be cost effective to meet the growing needs of PSE customers over the next 20 years.) Escalation rates for all other utility costs and fuels are based upon the assumptions found in the OFM LCCA tool.



Cost of Carbon

The social cost of carbon calculations are taken directly from the OFM LCCA tool which references the “Social Cost of Carbon” (U.S. Government Interagency Working Group on SCC - Table A1 using 2.5% Discount Rate Column). The following tables provide an overview of these calculations, costs and escalators.

Impact Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2015$	$63.8	$65.0	$67.3	$68.4	$69.5	$70.7	$73.0	$74.1	$75.2	$76.4	$77.5

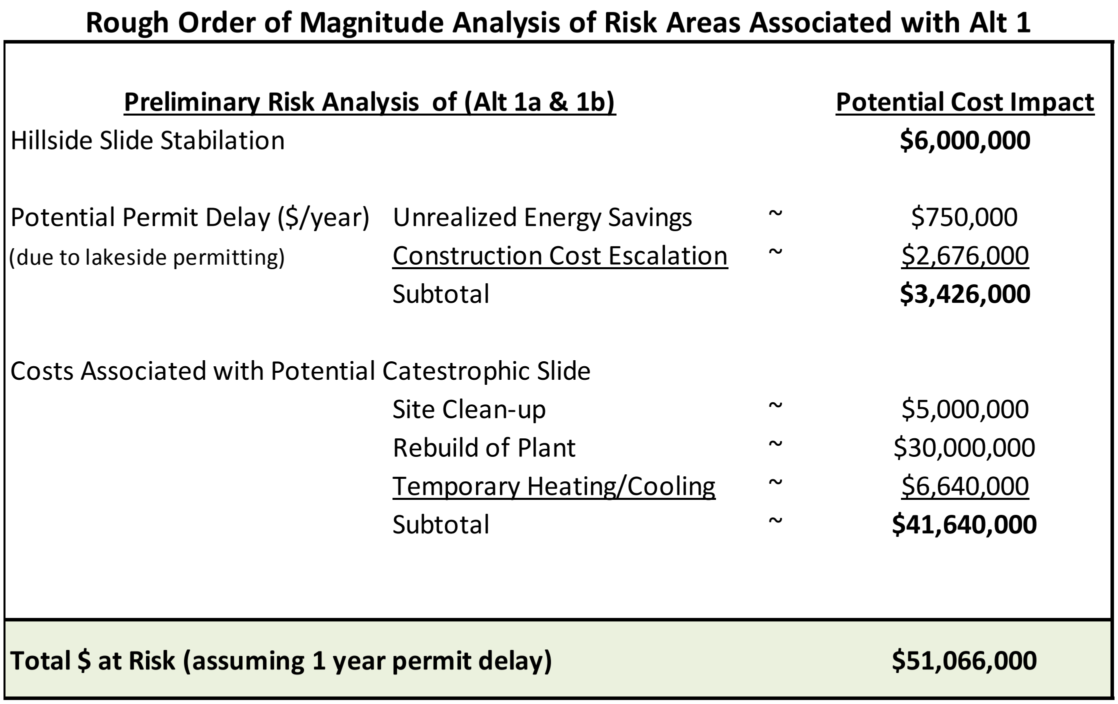
Site Emission Factors	CO2e (MTons/Unit)	Unit
Electricity	0.000412	KWh
Natural Gas	0.005311	Therm
Diesel/#2	0.009610	Gallons
#5/#6 Oil	0.009617	Gallons
Gasoline	0.008094	Gallons
LPG	0.005264	Gallons
District Heat	0.066394	mmBTU
Coal	0.097922	mmBTU
Biomass	0.095053	mmBTU
Biodiesel	0.008835	Gallons
Ethanol	0.005229	Gallons

Treasury Loans

- Cost of Capital = 3.45% (from LCCA)
- Cost of Debt (Treasury Real Estate Loan) = 5.00%
- Cost of Debt (Treasury Equipment Loan) = 3.00%

9.2 Preliminary Risk Analysis

The following table was developed to provide a rough order of magnitude analysis of the additional, potential costs that could be incurred for Alternate 1 due to location catastrophic risks associated with hillside slide and flood threats in addition to potential permit delay.



Rough Order of Magnitude Analysis of Risk Areas Associated with Alt 1

Preliminary Risk Analysis of (Alt 1a & 1b)			**Potential Cost Impact**
Hillside Slide Stabilation			**$6,000,000**
Potential Permit Delay ($/year)	Unrealized Energy Savings	~	$750,000
(due to lakeside permitting)	Construction Cost Escalation	~	$2,676,000
	Subtotal		**$3,426,000**
Costs Associated with Potential Catestrophic Slide			
	Site Clean-up	~	$5,000,000
	Rebuild of Plant	~	$30,000,000
	Temporary Heating/Cooling	~	$6,640,000
	Subtotal	~	**$41,640,000**
Total $ at Risk (assuming 1 year permit delay)			**$51,066,000**

The potential cost for these risks were determined as follows.

- Permit Delay – Any potential permit delay could occur due to the sensitive location of the Powerhouse site on the Shore of Capitol Lake and new or expanded regulatory review. The cost for this delay would be realized as a delay of potential energy savings dollars, as well as the potential escalation of construction costs.
- Costs Associated with Catastrophic Slide – This cost assumes that, in the event of a hillside slide, the Powerhouse plant would be catastrophically affected. In this instance, it was assumed that the building would be a total loss, and significant cleanup would have to occur at the site prior to the re-construction of a new production plant. In addition, there would be significant costs associated with providing temporary heating & cooling to the buildings on campus during the interim period before a new plant could be back up & running.

9.3 Potential Grants and Incentives

The following table provides an overview of the grants and incentives considered during the development of this ESP.

	Estimated Range of Grant		Type of Grant				
	Low	High	EE	C	E	G	
PSE - Schedule 258	$ -	$ 100,000	X		X		PSE - Schedule 258: Large Power User Self-Directed Program. Get up to 70% of the
PSE - Commercial Retrofit Grants	$ 952,000	$ 2,630,000	X		X	X	PSE - Commercial Retrofit Grants. Get up to 70% of the cost covered for energy efficiency upgrades. $0.30/kWh and $5.00/therm of first year savings (lighting at
PSE - Cogeneration/Combined Heat and Power (CHP)	$ 750,000	$ 2,084,000		X			PSE - Cogeneration/Combined Heat and Power (CHP). Up to 70% of the incremental cost compared to a baseline cost effective CHP project.
PSE - Commercial New Construction Grants	$ 10,000	$ 100,000	X		X	X	PSE - Commercial New Construction Grants. Get up to 100% of the incremental cost difference for systems built beyond a code-based system.
Commerce Energy Efficiency Grants	$ 100,000	$ 350,000	X		X	X	Commerce Energy Efficiency Grants. 3:1 match required. Applicable for existing upgrades, not new construction. Competative grant.
TransAlta Coal Transition Grants	$ 100,000	$ 1,000,000	X	X	X	X	TransAlta - Energy Technology Grants for organizations in Washington State. Projects must conserve energy and/or minimize pollution.
Subtotal	**$ 1,912,000**	**$ 6,264,000**					
EPACT - Tax Credit	$ -	$ 390,000	X	X			EPACT Tax Credits dependent upon extension of these credits by federal
Tax Deductions - Development by Private		$ 3,000,000	X	X	X	X	Tax deductions up to $500,000/yr. Under MACRS would allow a 20 year depreciation schedule for power and hot water equipment for the purposes of the sale of energy. Straight line depreciation at 5% per year. This would support a
Subtotal	**$ -**	**$ 3,390,000**					
Federal Grants	$ -	$ 30,000,000					Must be identified at after funding of project - dependent upon availability
Subtotal	**$ -**	**$ 30,000,000**					

After reviewing the grant & incentive opportunities, it was decided to assume $6M in realized grants for the purpose of the economic lifecycle model.

9.4 Results

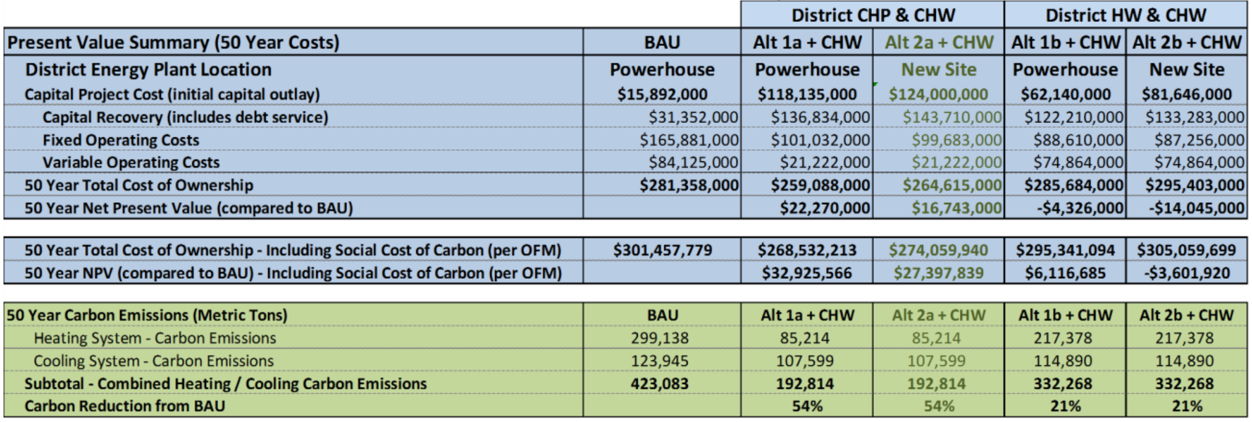
The lifecycle analysis performed includes a “total cost of ownership” model, which covers all costs likely to be incurred over the entire 50 year term. These expenditures included Capital Construction costs (owner equity and debt service), Fixed Variable Costs (equipment overhaul, system renewal, operating labor, minor repairs) and Variable Operating Costs (energy and utility costs). In addition consideration was given to potential costs that could be seen in the near future such as the social cost of carbon.

All costs shown in the following tables are 50 Year “Present Value” cumulative costs. Similarly, the “Net Present Value” is a 50 year cumulative cost and is calculated by subtracting the 50 Year Total Cost of each alternative from the 50 Year Total Cost of BAU.

District Heating Alternatives (excludes Cooling Option)
Present Value Summary

		District CHP		District HW	
Present Value Summary (50 Year Costs) - Excluding Cost of Carbon	**BAU**	**Alt 1a**	**Alt 2a**	**Alt 1b**	**Alt 2b**
District Energy Plant Location	**Powerhouse**	**Powerhouse**	**New Site**	**Powerhouse**	**New Site**
Capital Project Cost (initial capital outlay)	**$15,892,000**	**$90,177,000**	**$95,866,000**	**$62,139,072**	**$81,645,694**
Capital Recovery (includes estimated grants & debt service)	$25,695,949	$98,933,093	$104,622,605	$84,916,679	$94,801,384
Fixed Operating Costs	$105,478,436	$64,365,102	$64,377,966	$53,343,174	$53,350,623
Variable Operating Costs	$44,217,755	-$9,217,056	-$9,217,056	$31,582,535	$31,582,535
50 Year Total Cost of Ownership	**$175,392,140**	**$154,081,140**	**$159,783,515**	**$169,842,388**	**$179,734,541**
50 Year Net Present Value (compared to BAU)		**$21,311,000**	**$15,608,625**	**$5,549,752**	**-$4,342,401**
50 Year Total Cost of Ownership - Including Social Cost of Carbon (per OFM)	**$188,894,747**	**$157,683,918**	**$163,386,293**	**$179,278,800**	**$189,170,953**
50 Year NPV (compared to BAU) - Including Social Cost of Carbon (per OFM)		**$31,210,829**	**$25,508,454**	**$9,615,947**	**-$276,206**
50 Year Carbon Emissions (Metric Tons)	**299,138**	**85,214**	**85,214**	**217,378**	**217,378**
Carbon Reduction from BAU		**72%**	**72%**	**27%**	**27%**

District Heating & Cooling Alternatives (Includes Cooling Option)
Present Value Summary

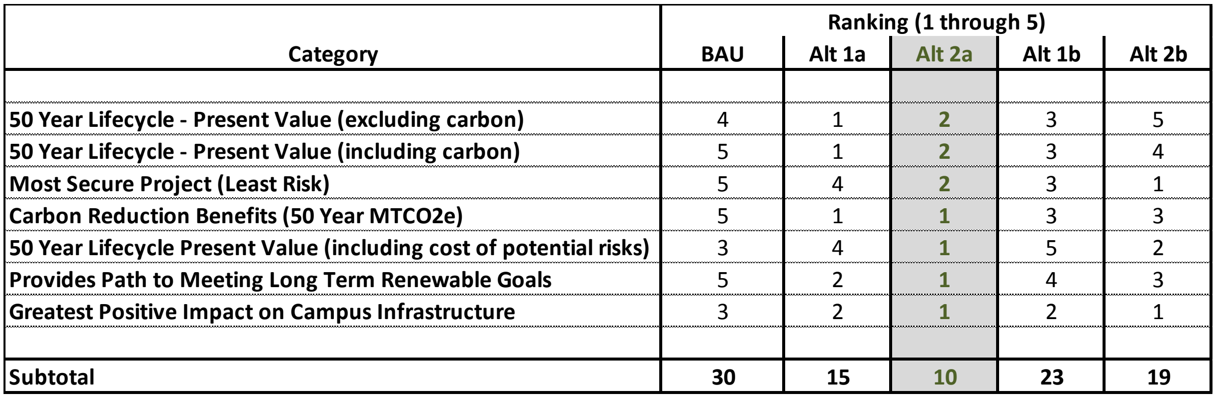


		District CHP & CHW		District HW & CHW	
Present Value Summary (50 Year Costs)	**BAU**	**Alt 1a + CHW**	**Alt 2a + CHW**	**Alt 1b + CHW**	**Alt 2b + CHW**
District Energy Plant Location	**Powerhouse**	**Powerhouse**	**New Site**	**Powerhouse**	**New Site**
Capital Project Cost (initial capital outlay)	**$15,892,000**	**$118,135,000**	**$124,000,000**	**$62,140,000**	**$81,646,000**
Capital Recovery (includes debt service)	$31,352,000	$136,834,000	$143,710,000	$122,210,000	$133,283,000
Fixed Operating Costs	$165,881,000	$101,032,000	$99,683,000	$88,610,000	$87,256,000
Variable Operating Costs	$84,125,000	$21,222,000	$21,222,000	$74,864,000	$74,864,000
50 Year Total Cost of Ownership	**$281,358,000**	**$259,088,000**	**$264,615,000**	**$285,684,000**	**$295,403,000**
50 Year Net Present Value (compared to BAU)		**$22,270,000**	**$16,743,000**	**-$4,326,000**	**-$14,045,000**
50 Year Total Cost of Ownership - Including Social Cost of Carbon (per OFM)	**$301,457,779**	**$268,532,213**	**$274,059,940**	**$295,341,094**	**$305,059,699**
50 Year NPV (compared to BAU) - Including Social Cost of Carbon (per OFM)		**$32,925,566**	**$27,397,839**	**$6,116,685**	**-$3,601,920**
50 Year Carbon Emissions (Metric Tons)	**BAU**	**Alt 1a + CHW**	**Alt 2a + CHW**	**Alt 1b + CHW**	**Alt 2b + CHW**
Heating System - Carbon Emissions	299,138	85,214	85,214	217,378	217,378
Cooling System - Carbon Emissions	123,945	107,599	107,599	114,890	114,890
Subtotal - Combined Heating / Cooling Carbon Emissions	**423,083**	**192,814**	**192,814**	**332,268**	**332,268**
Carbon Reduction from BAU		**54%**	**54%**	**21%**	**21%**

As can be seen from the summary table above, the alternative that displays the best net present value over a 50 year lifecycle is Alternative 1a, followed closely by Alternative 2a. However, this lifecycle analysis excludes costs that could be attributed to Alternative 1a & b; specifically those potential costs that could be realized in the future associated with threats to the security of the existing site and potential issues with permit approval for construction on the sensitive lakeside site (as described in Section 9.2). These costs are further discussed in the sections below.

9.5 Recommendations

Throughout the ongoing analysis of the possible Alternatives, there has been a continuous discussion among the development team as to which of these options provides the most long term benefit, with the least risk, for the Capitol Campus. The following table provides a simplified ranking of each alternative analyzed when considering overall benefit, important campus goals and lifecycle costs.



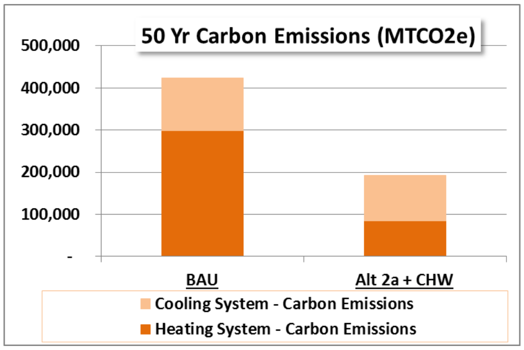
	Ranking (1 through 5)				
Category	**BAU**	**Alt 1a**	**Alt 2a**	**Alt 1b**	**Alt 2b**
50 Year Lifecycle - Present Value (excluding carbon)	4	1	**2**	3	5
50 Year Lifecycle - Present Value (including carbon)	5	1	**2**	3	4
Most Secure Project (Least Risk)	5	4	**2**	3	1
Carbon Reduction Benefits (50 Year MTCO2e)	5	1	**1**	3	3
50 Year Lifecycle Present Value (including cost of potential risks)	3	4	**1**	5	2
Provides Path to Meeting Long Term Renewable Goals	5	2	**1**	4	3
Greatest Positive Impact on Campus Infrastructure	3	2	**1**	2	1
Subtotal	**30**	**15**	**10**	**23**	**19**

As indicated in the above table ***Alternate 2a provides the best overall option*** for meeting the state campus goals with the least risk. At the same time, it sets the campus up in an ideal position for achieving ongoing carbon reduction goals while doing so in a cost effective manner.

Economic and Social Benefit

There are a great number of both economic and social benefits that would be realized with the implementation of the recommended Alternative 2a District Energy Production & Distribution system. These benefits include:

- Greatly Improved Plant Energy Efficiency – Over 40% in Year 1; with a resulting plant operating utility cost of over 70%



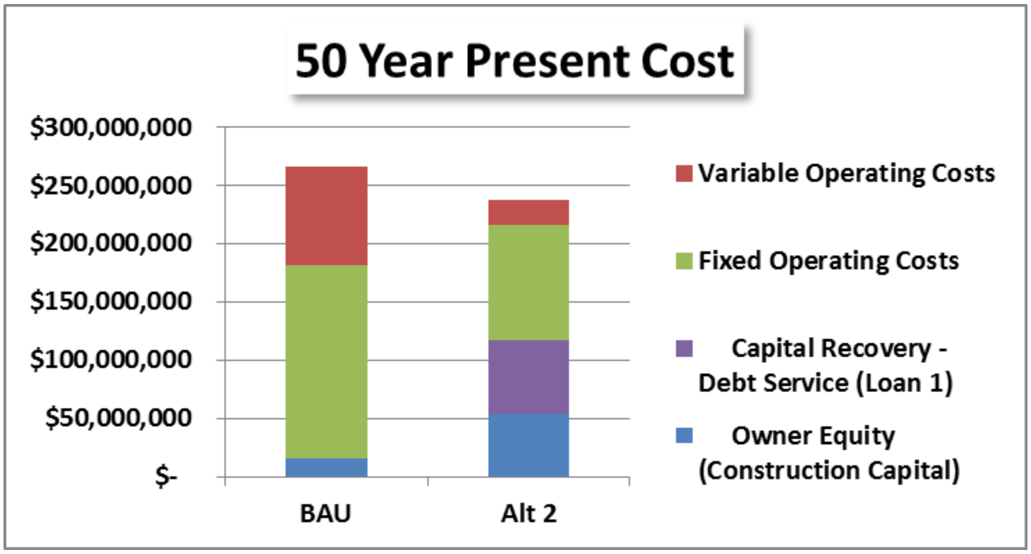
- Excellent Financial Stewardship of Public Funds over a 50 Year Lifecycle – with a Net Present Value of between $12M and $23M
- Significant Reduction in Carbon Emissions – Greater than 210,000 MTCO2e over the next 50 Years
- Significant leap Forward in Meeting Long-Term Sustainability Goals - Sets the Campus in Line with Future Greenhouse Gas (GHG) Reduction Goals (meets the 2035 CO2 reduction goals for the Campus)
- Provides a Real Opportunity to set up the Campus for a Transition to Renewables in the Future (for example; hydrogen or biofuel based)
- Reduced Operation and Maintenance Costs with a Simple and Easy to Maintain HW System
- Provides a Safer Work Environment for Operators
- Reduces Current and Ongoing Capital Renewal Costs
- Decreases Capital Costs Required for Future Buildings by Eliminating the need for Heat Producing Equipment and cooling equipment at each site (including the associated electrical service, access for equipment replacement, large space requirements for maintenance of the equipment, cooling towers and associated vapor plumes and the high cost per square foot of the added mechanical space needed)

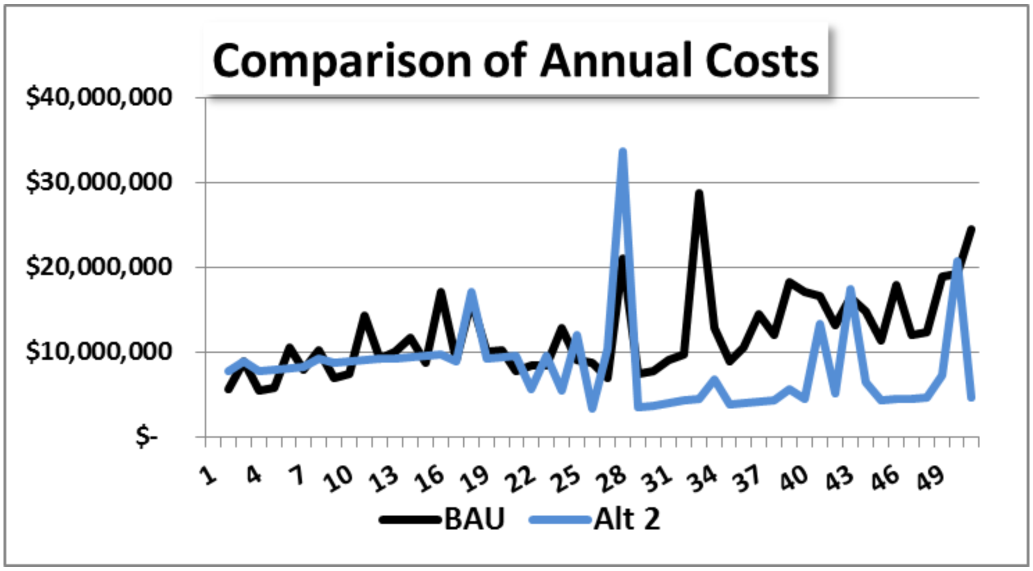
		Alt 2a + CHW
Present Value Summary (50 Year Costs)	**BAU**	**District CHP & CHW**
District Energy Plant Location	**Powerhouse**	**New Site**
Capital Project Cost (initial capital outlay)	**$15,892,000**	**$125,358,000**
Capital Recovery (includes debt service)	$31,352,000	$143,710,000
Fixed Operating Costs	$165,881,000	$99,683,000
Variable Operating Costs	$84,125,000	$21,222,000
50 Year Total Cost of Ownership	**$281,358,000**	**$264,615,000**
50 Year Net Present Value (compared to BAU)		**$16,743,000**

50 Year Total Cost of Ownership - Including Social Cost of Carbon (per OFM)	**$301,457,779**	**$274,059,940**
50 Year NPV (compared to BAU) - Including Social Cost of Carbon (per OFM)		**$27,397,839**

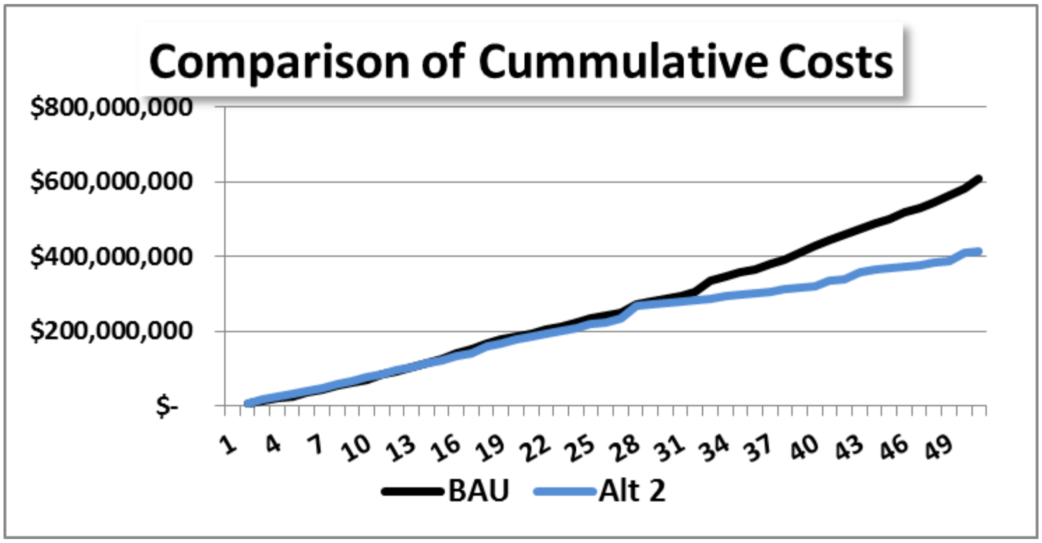
50 Year Carbon Emissions (Metric Tons)	**BAU**	**Alt 2a + CHW**
Heating System - Carbon Emissions	299,138	85,214
Cooling System - Carbon Emissions	123,945	107,599
Subtotal - Combined Heating / Cooling Carbon Emissions	**423,083**	**192,814**
Carbon Reduction from BAU		**54%**

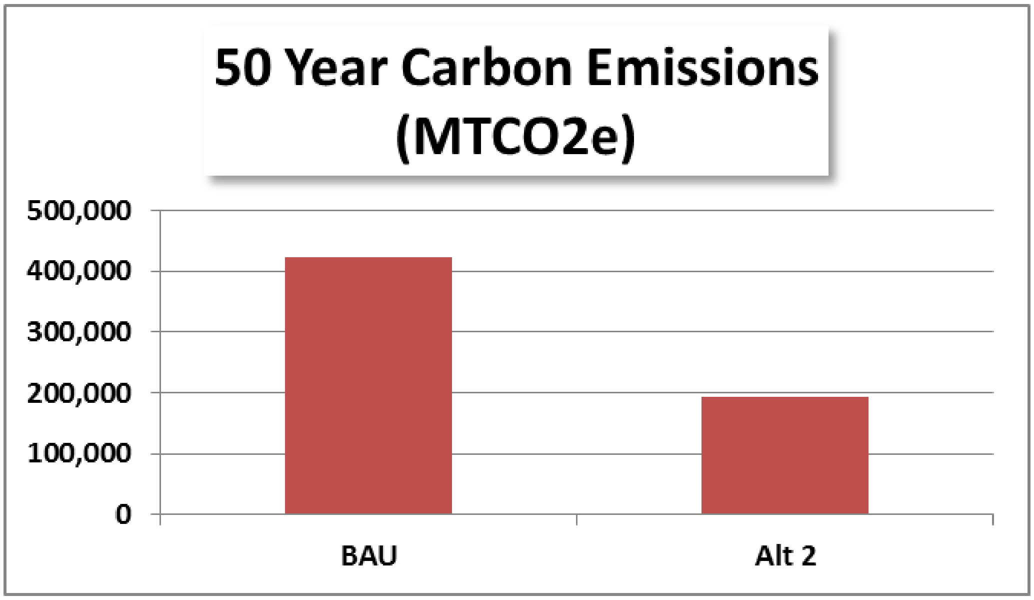
The following tables provide a graphical representation of the key financial and operational features associated with the recommended Alternative 2A.



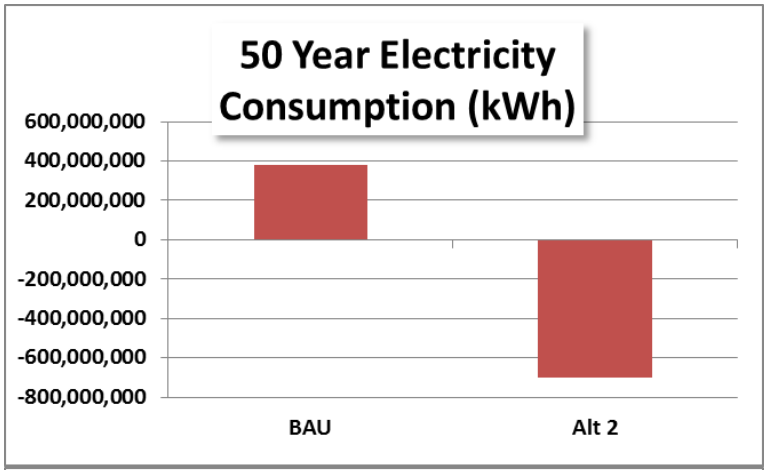


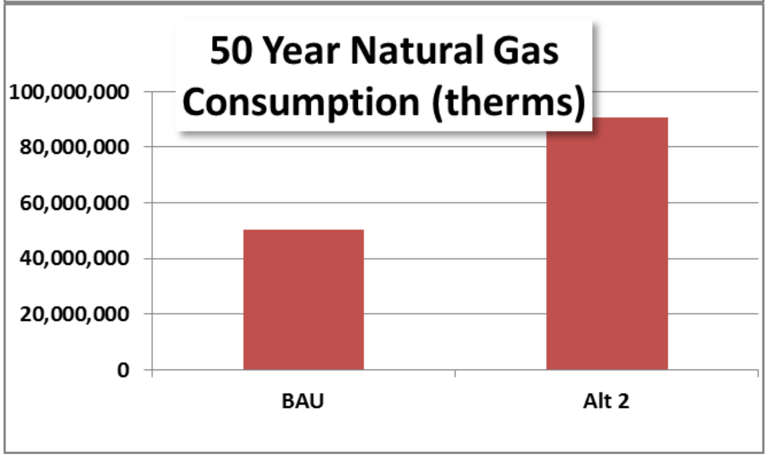
The chart above shows an annual cost comparison of BAU versus Alternative 2 that incorporates all estimated annual costs for energy, operation, renewal and expansion over the next 50 years. The following chart illustrates these same costs on a cumulative basis.



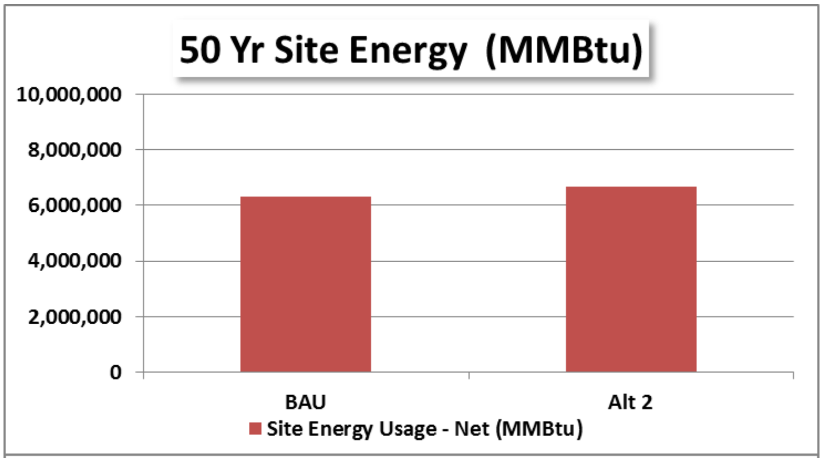


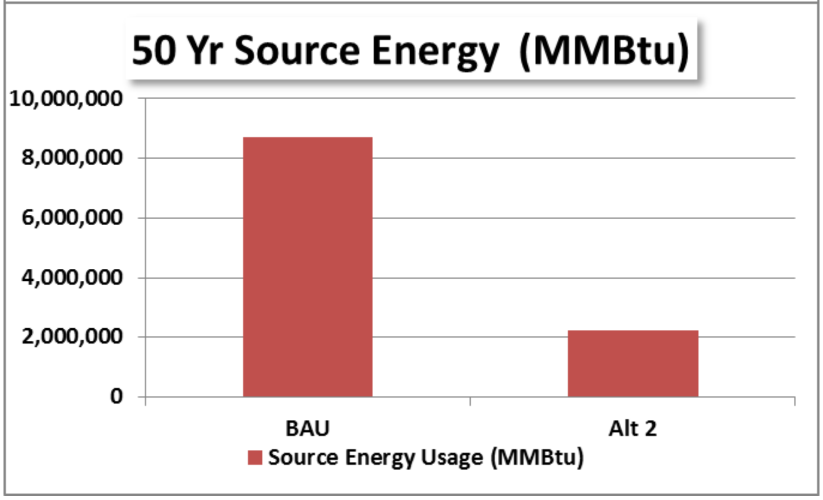
The chart above illustrates the estimated carbon emissions for both the heating & cooling systems over the next 50 years. This carbon emission projection takes into account the net fossil fuels burned and electricity consumed and/or generated over the 50 year period (as illustrated in the charts shown on the right). The additional gas consumption shown on Alt 2 is utilized to generate in excess of 600,000 MWh over the 50 year period. This electrical generation then offsets gas / coal that would be used to produce this same electricity via an existing utility power plant.





The two charts shown on the right illustrate the 50 year “Site” and “Source” energy usage. “Site” energy consists of the energy used specifically at the location served by the district energy plant (ie: the Capitol Campus). The “Source” energy usage takes into account the bigger picture; which also includes the energy used to produce and distribute the electricity from a utility power plant to the intended site. It is important to note that a slight increase in the “Site” energy (MMBtu) produces a very large energy savings at the “Source”; thus resulting in the significant reduction in overall carbon emissions illustrated above.





10.0 IMPLEMENTATION PLAN

10.1 Project Schedule

Task Name	Duration	Start	Finish
STATE of WA CAPITOL CAMPUS - PROJECT SCHEDULE	**1458 days**	**Fri 8/26/16**	**Tue 3/29/22**
Funding & Contract	**303 days**	**Fri 8/26/16**	**Tue 10/24/17**
DES Submit to Legislature	33 days	Fri 8/26/16	Tue 10/11/16
Legislature Budget Preparation	126 days	Wed 10/12/16	Wed 4/5/17
Legislature Session - Funding	124 days	Thu 4/6/17	Tue 9/26/17
Receive Notice to Proceed	0 days	Tue 9/26/17	Tue 9/26/17
Sign Contract	1 mon	Wed 9/27/17	Tue 10/24/17
Preconstruction	**380 days**	**Wed 10/25/17**	**Tue 4/9/19**
Design Development	2 mons	Wed 10/25/17	Tue 12/19/17
Schematic Design	2 mons	Wed 12/20/17	Tue 2/13/18
60% CD Design Documents	2 mons	Wed 10/25/17	Tue 12/19/17
90% CD Design Documents	3 mons	Wed 12/20/17	Tue 3/13/18
Document Review Process	2 mons	Wed 3/14/18	Tue 5/8/18
Analyze and Recommend Critical Scopes	1 mon	Wed 5/9/18	Tue 6/5/18
Permits - City and Local Agencies	4 mons	Wed 5/9/18	Tue 8/28/18
Federal & Local Utilities Rebate Process	6 mons	Wed 10/25/17	Tue 4/10/18
Construction Documents - 100% CD	2 mons	Wed 8/29/18	Tue 10/23/18
Internal Final Cost Budget Review	15 days	Wed 10/24/18	Tue 11/13/18
Submittals	2 days	Wed 10/24/18	Thu 10/25/18
Early Bid Packages & Procurement of Long-Lead Items	6 mons	Wed 10/24/18	Tue 4/9/19
Construction	**595 days**	**Wed 10/24/18**	**Tue 2/2/21**
Early Bid Packages & Procurement of Long-Lead Item	8 mons	Wed 10/24/18	Tue 6/4/19
Site Civil Work	1.5 mons	Wed 10/24/18	Tue 12/4/18
New District Energy Plant	**531 days**	**Wed 12/5/18**	**Wed 12/16/20**
Foundations	1.5 mons	Wed 12/5/18	Tue 1/15/19
Steel Erection	1.5 mons	Wed 1/16/19	Tue 2/26/19
Concrete	2 mons	Wed 2/27/19	Tue 4/23/19
Roofing	1.5 mons	Wed 4/24/19	Tue 6/4/19
Exteriors	2 mons	Wed 6/5/19	Tue 7/30/19
Storefront & Windows	1 mon	Wed 7/31/19	Tue 8/27/19
Carpentry	1.5 mons	Wed 8/28/19	Tue 10/8/19
Finishes	2.5 mons	Wed 10/9/19	Tue 12/17/19
Elevators	0.5 mons	Wed 12/18/19	Tue 12/31/19
Plumbing	4 mons	Wed 1/1/20	Tue 4/21/20
Mechanical	6 mons	Wed 1/1/20	Tue 6/16/20

Electrical	**12 mons**	**Thu 1/16/20**	**Wed 12/16/20**
PSE Connections	1 wk	Thu 1/16/20	Wed 1/22/20
Controls	3 mons	Wed 1/1/20	Tue 3/24/20
Clean-Up	2 wks	Wed 1/1/20	Tue 1/14/20
District Piping Systems	**240 days**	**Wed 12/5/18**	**Tue 11/5/19**
UG Utilities & Trench Piping Systems	12 mons	Wed 12/5/18	Tue 11/5/19
Building Energy Transfer Station (ETS) Connections	10 mons	Wed 11/6/19	Tue 8/11/20
Building Heating Hot Water System Conversions	10 mons	Wed 11/6/19	Tue 8/11/20
Startup & Cx	4 mons	Wed 8/12/20	Tue 12/1/20
Substantial Completion	**30 days**	**Wed 12/2/20**	**Tue 1/12/21**
Final Fire Marshall Inspections	1 wk	Wed 12/2/20	Tue 12/8/20
Punchlists	**30 days**	**Wed 12/2/20**	**Tue 1/12/21**
UMC Internal	2 wks	Wed 12/2/20	Tue 12/15/20
Architect/Engineer	2 wks	Wed 12/16/20	Tue 12/29/20
DES/Owner	2 wks	Wed 12/30/20	Tue 1/12/21
DES Final ESPC Checklist/Inspection	1 wk	Wed 1/13/21	Tue 1/19/21
Owner Occupancy	2 wks	Wed 1/20/21	Tue 2/2/21
Project Completion	0 days	Tue 2/2/21	Tue 2/2/21
M&V	3 mons	Wed 2/3/21	Tue 4/27/21
Continuous Cx	12 mons	Wed 4/28/21	Tue 3/29/22

11.0 APPENDIX

The Appendix is composed of these following sections:

- **Overview of District Energy**
- **CHP - Jenbacher J616 Submittal**
- **CHP - Opra Turbine Submittal**
- **Existing Campus Utilities**
- **Production Plant Concept - “Bar” Mechanical Layouts**
- **Production Plant Concept - “Cone” Mechanical Layouts**
- **Electrical Distribution**

Overview of District Energy

What is District Energy?

District Energy systems are a highly efficient way to heat and cool multiple buildings in a campus setting from a central location. These systems use a network of distribution pipes (often underground) to deliver hot water and/or chilled water to multiple buildings in an area such as a downtown district, college, hospital or other campus setting. This consolidation of thermal loads into a centralized plant provides the ability to greatly reduce energy usage through enhanced production efficiency, reduction in losses and ability to recover sources of waste heat that would be lost in a distributed generation system. It also provides the ability to transition to renewable sources as they become economically and technically viable.

How Does this Compare to Distributed Equipment?

This DE system is in contrast to facilities that use distributed equipment. A distributed system provides individual heating & cooling production equipment at each individual building for the service of that building only.

In the case of a campus that is currently served by old, failing infrastructure associated with a DE system that has not had sufficient funding to provide effective renewal of aging equipment and systems. Consideration is often given to converting to a distributed equipment system in lieu of renovating and improving the existing DE system to current technology standards. The reasoning behind this approach is typically driven by the initial short term capital investment cost savings as opposed to the true lifecycle cost that will occur over the next 10, 30 or 50 years. As a result, ***many systems that go down this road of reverting to distributed equipment end up costing the owner much more money long term*** as well as limiting the opportunity to take full advantage of technologies that can be utilized in a DE system. In addition, converting from an existing DE to distributed equipment requires use of significant space within each building to house the additional heating and cooling equipment; as well as potential new boiler stacks. These are both issues that can impact the architecture and historical nature of many sites, as well as taking up valuable space with in the facility.

Benefits of District Energy for the Capitol Campus

- ***Greatly Improved Energy Efficiency***: District energy systems are among the most efficient ways to distribute electricity as well as heating and cooling (thermal) services, providing efficiency gains up to 80-90% relative to conventional separate generation of electricity, heating and cooling. DE also opens the door to incorporating better technology and sharing of heat sources that further increases production efficiency. This could include such technology as thermal storage, waste heat recovery, solar thermal, heat recovery chillers, organic Rankine cycles and ab(d)sorption chillers just to name a few.

- ***Provides Opportunity to Incorporate Combined Heat and Power*:** Also known as cogeneration, combined heat and power (CHP) is a way to increase the efficiency of power plants. Interestingly enough, most conventional power plants produce waste heat as a by-product of generating electricity and dissipate this heat to the environment without utilizing it in a productive manner. Standard power plants effectively use just 40 percent of the fuel they burn to produce electricity. Sixty percent of the fuel used in the electric production process ends up being rejected or "wasted" up the smokestack. One of the biggest uses of fossil fuel globally is for generating heat. CHP offers the opportunity to generate electricity locally and capture the waste heat for use in heating buildings.

- ***Significant Reduction in Carbon Emissions*:** According to the Copenhagen Center on Energy Efficiency, by 2050, modern DES (District Heating and Cooling with Combined Heat and Power) could avoid over 35 Giga Tons of CO2 emissions at low cost, and deliver 58% of CO2 emission reductions required to keep the global rise in temperature to 2-3°C, while producing significant environmental and economic benefits.

- ***Fuel Flexibility*:** One of the advantages of a DE system is that since it serves so many customers from one location, it can take advantage of efficiencies that are not available to individual buildings. For instance, DE systems can use a variety of conventional energy sources (natural gas, electricity, waste heat, etc) whichever fuel is most cost effective at any given time.

- ***Transition to Renewables***: And because of the system's size, a DE plant can also transition to use renewable fuels as they show environmental and economic viability. This can include sources such as of biomass, food processing waste, geothermal heat, fuel cells, combined heat and power, solar thermal and other sources as they become available.

- ***Ease of Operation and Maintenance***: The consolidation of production equipment into a central location greatly improves the ability to maintain this equipment efficiently and effectively; as compared to distributed systems that have equipment spread throughout each building across an entire campus. As an example, a well-planned DE system may have 5-10 boilers and/or chillers serving 20 buildings compared to a distributed system which would have 40-80.

- ***Reduced Capital Renewal Costs***: The reduction in overall pieces of equipment also greatly reduces the cost to replace this equipment in the future when it reaches the end of its useful life. The DE plant itself benefits from larger, more industrial equipment as compared to individual commercial building equipment. This larger equipment is typically built to last a longer life cycle than the commercial building equipment. Industrial equipment is also typically built to be maintained instead of being replaced.

- ***Decreased Capital Costs for Future Buildings*:** Buildings connected to DE systems also have lower capital costs for their energy equipment because they don't need conventional boilers and chillers. They save valuable upfront dollars they can invest elsewhere. Plus, they save building space that can be used for other more valuable purposes.

- ***Architectural Design Flexibility*:** No boilers or furnaces and roofs free of smoke stacks and cooling towers mean substantially greater building design flexibility. Architects can easily design or renovate buildings to be more versatile and aesthetically pleasing for both potential occupants and the community

- ***Reliability***: DE systems are designed with backup systems readily available and are operated by energy professionals.

- ***Substantial Step towards Meeting Long-Term Sustainability Goals***: The implementation of a DES provides a significant step towards meeting the carbon and sustainability goals set by the state of Washington, especially as it relates to electricity production and the potential for use of renewable energy. DE with CHP, hot water, chilled water, and thermal storage can operate as a "smart grid" campus, with the ability to generate electricity when the utility needs it most, store thermal energy to be used when needed, and generate cooling during off peak times. This type of operation helps to reduce CO2 (locally generated electricity) while also helping to make the grid more resilient, and the campus more secure. With the advent of future technology, this centralized district energy system provides a path towards meeting campus "net 0" goals for carbon.

- ***Revitalizes Failing infrastructure*:** The implementation of a DES, which also includes replacing the inefficient and failing steam distribution system with a more efficient, safer hot water system, provides a tremendous opportunity to replace failing infrastructure with a system designed for the next 100 years.

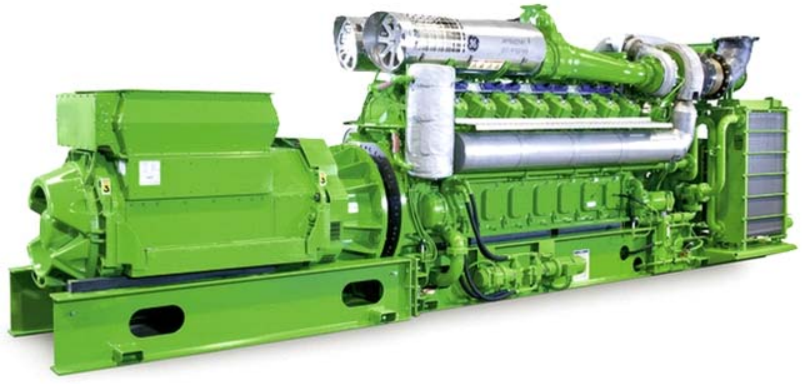
Technical Description

Cogeneration Unit

JMS 616 GS-N.L

Capital Court
JMS 616 F01, 12470V

The ratings in the specification are valid for full load operation at a site installation of 200 ft (60m) and an air intake temperature of T1 < 95 F (35 C). At T1 > 95F (35C), an output de-ration of 1.11%/F (2%/C) will occur.



Electrical output	**2646 kWe**
Thermal output	**4624 Mbtu/hr**

Emission values

NOx < 1.1 g/bhp.hr (NO2)

0.01 Technical Data (at module)

Data at:				**Full load**	**Part Load**	
Fuel gas LHV		BTU/scft		917		
				100%	75%	50%
Energy input		MBTU/hr	[2]	19,995	15,334	10,673
Gas volume		scfhr	*)	21,805	16,722	11,639
Mechanical output		bhp	[1]	3,681	2,760	1,840
Electrical output		kW el.	[4]	2,646	1,980	1,311
Recoverable thermal output						
~ Intercooler 1st stage		MBTU/hr	###	2,307	1,279	490
~ Lube oil (with gearbox)		MBTU/hr		939	840	718
~ Jacket water		MBTU/hr		1,379	1,218	1,030
~ Exhaust gas cooled to 687 °F		MBTU/hr		~	~	~
Total recoverable thermal output		MBTU/hr	[5]	4,624	3,337	2,238
Heat to be dissipated						
~ Intercooler 2nd stage		MBTU/hr	[9]	665	424	242
~ Lube oil (with gearbox)		MBTU/hr		~	~	~
~ Surface heat	ca.	MBTU/hr	[7]	734	~	~
Spec. fuel consumption of engine electric		BTU/kWel.hr	[2]	7,557	7,743	8,144
Spec. fuel consumption of engine		BTU/bhp.hr	[2]	5,432	5,556	5,801
Lube oil consumption	ca.	gal/hr	[3]	0.17	~	~
Electrical efficiency		%		45.2%	44.1%	41.9%
Thermal efficiency		%		23.1%	21.8%	21.0%
Total efficiency		%	[6]	68.3%	65.8%	62.9%
Hot water circuit:						
Forward temperature		°F		194.0	184.0	175.4
Return temperature		°F		158.0	158.0	158.0
Hot water flow rate		GPM		288.0	288.0	288.0

*) approximate value for pipework dimensioning
[_] Explanations: see 0.10 - Technical parameters

All heat data is based on standard conditions according to attachment 0.10. Deviations from the standard conditions can result in a change of values within the heat balance, and must be taken into consideration in the layout of the cooling circuit/equipment (intercooler; emergency cooling; ...). In the specifications in addition to the general tolerance of ±8 % on the thermal output a further reserve of +5 % is recommended for the dimensioning of the cooling requirements.

Main dimensions and weights (at module)(with gearbox)

Length	in	~ 400
Width	in	~ 90
Height	in	~ 110
Weight empty	lbs	~ 67,560
Weight filled	lbs	~ 69,760

Connections

Hot water inlet and outlet	in/lbs	4"/145
Exhaust gas outlet	in/lbs	25"/145
Fuel Gas (at module)	in/lbs	4"/145
Water drain ISO 228	G	½"
Condensate drain	in/lbs	2½"/145
Safety valve - jacket water ISO 228	in/lbs	2x1½"/2.5
Safety valve - hot water	in/lbs	2"/232
Lube oil replenishing (pipe)	in	1.1
Lube oil drain (pipe)	in	1.1
Jacket water - filling (flex pipe)	in	0.5
Intercooler water-Inlet/Outlet 1st stage	in/lbs	4"/145
Intercooler water-Inlet/Outlet 2nd stage	in/lbs	2½"/145

Output / fuel consumption

ISO standard fuel stop power ICFN	bhp	3,681
Mean effe. press. at stand. power and nom. speed	psi	319
Fuel gas type		Natural gas
Based on methane number | Min. methane number	MN d)	94 | 80
Compression ratio	Epsilon	12
Min. fuel gas pressure for the pre chamber	psi	57.2899073
Min./Max. fuel gas pressure at inlet to gas train	psi	58.02 - 116.03 c)
Allowed Fluctuation of fuel gas pressure	%	± 10
Max. rate of gas pressure fluctuation	psi/sec	0.145
Maximum Intercooler 2nd stage inlet water temperature	°F	104
Spec. fuel consumption of engine	BTU/bhp.hr	5,432
Specific lube oil consumption	g/bhp.hr	0.15
Max. Oil temperature	°F	176
Jacket-water temperature max.	°F	203
Filling capacity lube oil (refill)	gal	~ 171

c) Lower gas pressures upon inquiry

d) based on methane number calculation software AVL 3.1 (calculated without N2 and CO2)

0.02 Technical data of engine

Manufacturer		GE Jenbacher
Engine type		J 616 GS-F01
Working principle		4-Stroke
Configuration		V 60°
No. of cylinders		16
Bore	in	7.48
Stroke	in	8.66
Piston displacement	cu.in	6,090
Nominal speed	rpm	1,500
Mean piston speed	in/s	433
Length	in	193
Width	in	74
Height	in	99
Weight dry	lbs	27,558
Weight filled	lbs	29,762
Moment of inertia	lbs-ft^2	1541.76
Direction of rotation (from flywheel view)		left
Radio interference level to VDE 0875		N
Starter motor output	kW	20
Starter motor voltage	V	24

Thermal energy balance

Energy input	MBTU/hr	19,995
Intercooler	MBTU/hr	2,972
Lube oil (with gearbox)	MBTU/hr	939
Jacket water	MBTU/hr	1,379
Exhaust gas cooled to 356 °F	MBTU/hr	2,842
Exhaust gas cooled to 212 °F	MBTU/hr	4,043
Surface heat	MBTU/hr	365

Exhaust gas data

Exhaust gas temperature at (100% / 75% / 50%) load	°F [8]	687 / 783 / 874
Exhaust gas mass flow rate, wet	lbs/hr	32,564 / 23,858 / 16,021
Exhaust gas mass flow rate, dry	lbs/hr	30,554 / 22,317 / 14,947
Exhaust gas volume, wet	scfhr	412,566 / 302,601 / 203,370
Exhaust gas volume, dry	scfhr	372,486 / 271,843 / 181,970
Max.admissible exhaust back pressure after engine	psi	0.725

Combustion air data

Combustion air mass flow rate	lbs/hr	31,669 / 23,173 / 15,545
Combustion air volume	SCFM	6,542 / 4,787 / 3,211
Max. admissible pressure drop at air-intake filter	psi	0.145

Sound pressure level

Aggregate a)	dB(A) re 20µPa	102
31,5 Hz	dB	83
63 Hz	dB	90
125 Hz	dB	96
250 Hz	dB	98
500 Hz	dB	97
1000 Hz	dB	95
2000 Hz	dB	94
4000 Hz	dB	94
8000 Hz	dB	92
Exhaust gas b)	dB(A) re 20µPa	119
31,5 Hz	dB	109
63 Hz	dB	119
125 Hz	dB	128
250 Hz	dB	117
500 Hz	dB	115
1000 Hz	dB	114
2000 Hz	dB	111
4000 Hz	dB	106
8000 Hz	dB	91

Sound power level

Aggregate	dB(A) re 1pW	124
Measurement surface	ft²	1,604
Exhaust gas	dB(A) re 1pW	127
Measurement surface	ft²	67.60

a) average sound pressure level on measurement surface in a distance of 3.28ft (converted to free field) according to DIN 45635, precision class 3.
b) average sound pressure level on measurement surface in a distance of 3.28ft according to DIN 45635, precision class 2.
The spectra are valid for aggregates up to bmep=319.083028 psi. (for higher bmep add safety margin of 1dB to all values per increase of 15 PSI pressure).
Engine tolerance ± 3 dB

0.02.01 Technical data of gearbox

Manufacturer		EISENBEISS
Type		~
Gearbox ratio		1:1.2
Efficiency	%	99.49
Mass	lbs	3,748

0.03 Technical data of generator

Manufacturer		STAMFORD e)
Type		HVSI 804 X e)
Type rating	kVA	3,334
Driving power	bhp	3,662
Ratings at p.f.= 1.0	kW	2,646
Ratings at p.f. = 0.8	kW	2,623
Rated output at p.f. = 0.8	kVA	3,278
Rated reactive power at p.f. = 0.8	kVAr	1,967
Rated current at p.f. = 0.8	A	152
Frequency	Hz	60
Voltage	kV	12.47
Speed	rpm	1,800
Permissible overspeed	rpm	2,250
Power factor (lagging - leading)		0,8 - 1,0
Efficiency at p.f.= 1.0	%	96.9%
Efficiency at p.f. = 0.8	%	96.0%
Moment of inertia	lbs-ft²	3093.49
Mass	lbs	15,966
Radio interference level to EN 55011 Class A (EN 61000-6-4)		N
Ik'' Initial symmetrical short-circuit current	kA	1.36
Is Peak current	kA	3.47
Insulation class		H
Temperature rise (at driving power)		F
Maximum ambient temperature	°F	104

Reactance and time constants (saturated)

xd direct axis synchronous reactance	p.u.	1.97
xd' direct axis transient reactance	p.u.	0.15
xd'' direct axis sub transient reactance	p.u.	0.11
x2 negative sequence reactance	p.u.	0.16
Td'' sub transient reactance time constant	ms	17
Ta Time constant direct-current	ms	67
Tdo' open circuit field time constant	s	5.16

e) GE Jenbacher reserves the right to change the generator supplier and the generator type. The contractual data of the generator may thereby change slightly. The contractual produced electrical power will not change.

0.04 Technical data of heat recovery

General data - Hot water circuit

Total recoverable thermal output	MBTU/hr	4,624
Return temperature	°F	158.0
Forward temperature	°F	194.0
Hot water flow rate	GPM	288.0
Design pressure of hot water	lbs	145
min. operating pressure	psi	51.0
max. operating pressure	psi	131.0
Pressure drop hot water circuit	psi	17.40
Maximum Variation in return temperature	°F	+0/-21
Max. rate of return temperature fluctuation	°F/min	18

General data - Cooling water circuit

Heat to be dissipated	MBTU/hr	665
Return temperature	°F	104
Cooling water flow rate	GPM	154
Design pressure of cooling water	lbs	145
min. operating pressure	psi	7.0
max. operating pressure	psi	73.0
Loss of nominal pressure of cooling water	psi	~
Maximum Variation in return temperature	°F	+0/-21
Max. rate of return temperature fluctuation	°F/min	18

The final pressure drop will be given after final order clarification and must be taken from the P&ID order documentation.

connection variant H

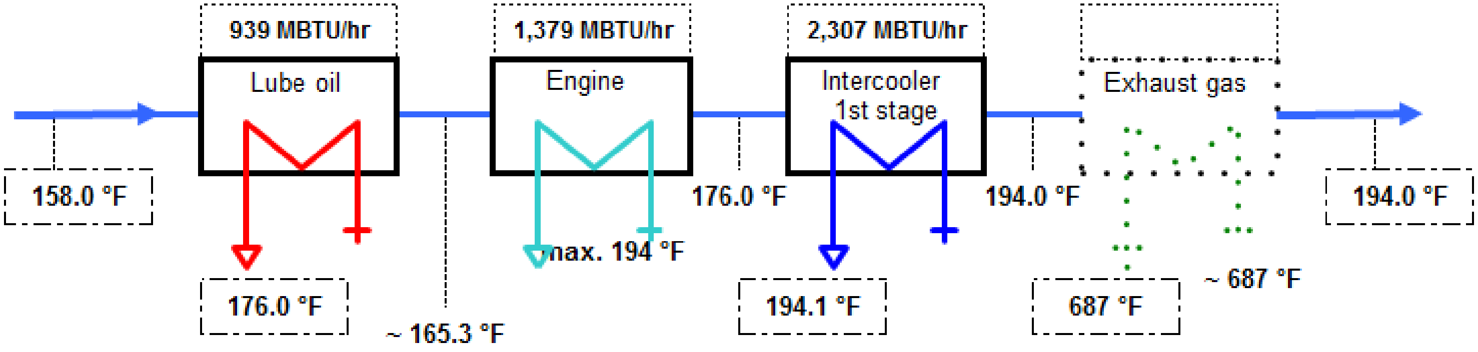
Capital Court **J 616 GS-F01**

Hot water circuit (calculated with Glykol 37%)

Recoverable thermal output = 4,624 MBTU/hr

(±8 % tolerance +5 % reserve for cooling requirements)

Hot water flow rate = 288.0 GPM

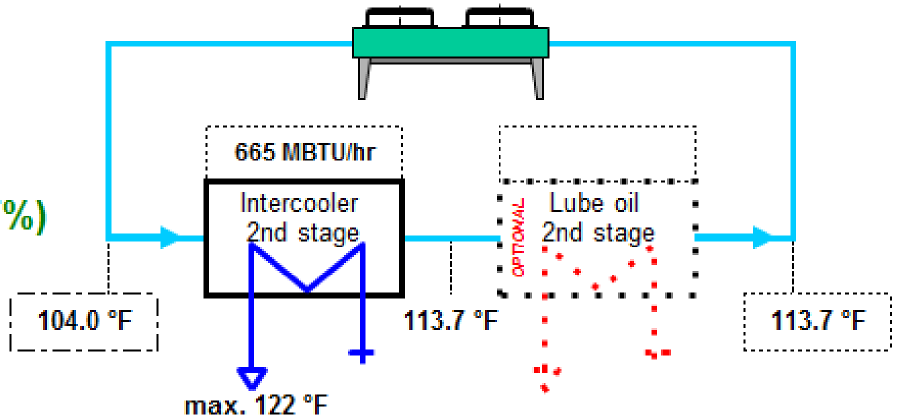


Low Temperature circuit (calculated with Glykol 37%)

Heat to be dissipated = 665 MBTU/hr

(±8 % tolerance +5 % reserve for cooling requirements)

Cooling water flow rate = 154.1 GPM

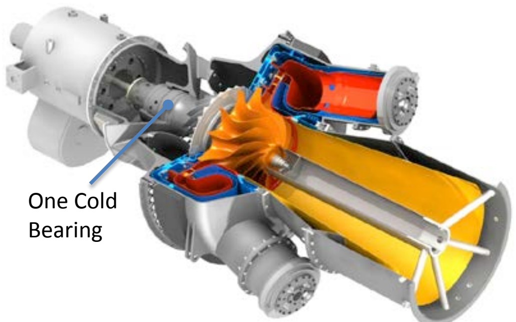


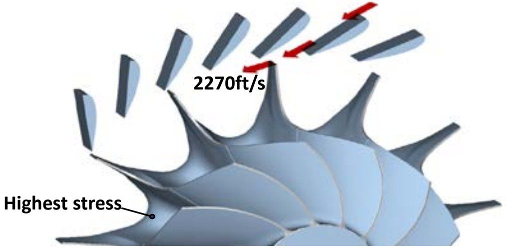
Key Performance Advantages

The OP16 is specifically designed for optimum total system thermal efficiency in a cogeneration application. While the electrical efficiency of the compact radial gas turbine is lower than larger axial (aero-derivative) gas turbine generators, the OP16 has fewer internal pathways for energy loss. Consequently, more thermal energy is retained in the turbine exhaust and is subsequently available to the heat recovery steam generator. The OP16 exhaust gas temperature is 1063°F, compared to a range of 830°F to 945°F from the leading 3.5MW and 7.5MW axial turbines. Some key features include:

- A *single stage centrifugal compressor and single stage radial turbine* (as opposed to multi-stage axial turbines and compressors derived from aerospace applications) offer the optimum balance of power output and efficiency with a simple, robust design.
- With a low pressure ratio of 6.7, the combustor requires a lower fuel pressure than other gas turbines, *reducing the capital cost and parasitic electrical load of gas boost compression*. The pressure ratios for axial turbines range from 10.1 to 17.1.
- The velocity of combustion gas is matched to the turbine blade velocity at the turbine inlet, minimizing blade tip thermal stresses and allowing for *operation at higher temperatures. No blade cooling is required, reducing thermal losses and improving tolerance to foreign object debris*.

Radial Turbine

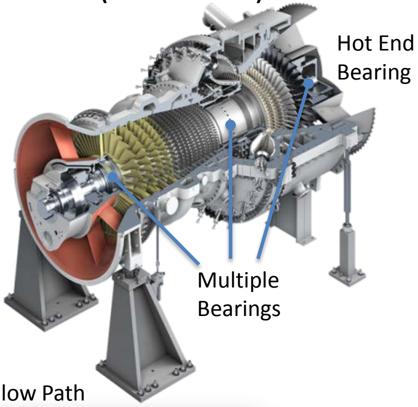




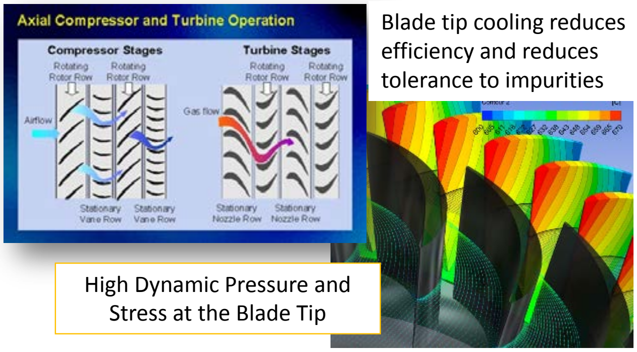
Lower Blade Tip Stress: Higher Temp,

- Gas velocity at inlet matched to tip speed
- Reduces stress at the blade tip
- No blade tip cooling required: higher FOD tolerance
- Highest stress is at root where metal is thickest

Axial (Aeroderivative) Turbine

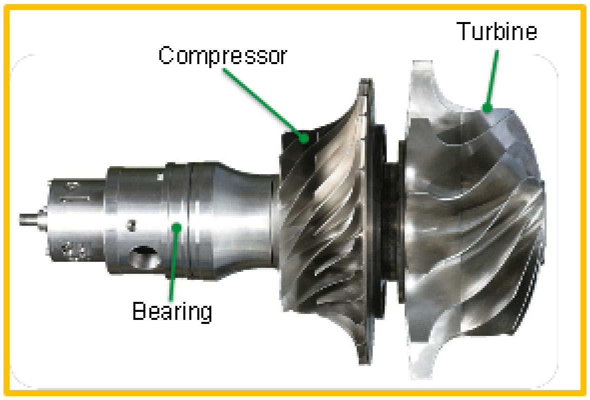


Tortuous Flow Path



Blade tip cooling reduces efficiency and reduces tolerance to impurities

High Dynamic Pressure and Stress at the Blade Tip



- The radial turbine extracts more power in a single stage than axial turbines, resulting in a markedly shorter shaft that can be fully supported by a single bearing located in the cold section of the machine. The single bearing is subjected to a more benign environment, reducing wear and maximizing reliability. Axial turbines require multiple stages of compression and power extraction, longer shafts, and multiple bearings in both the hot and cold ends. *Operation and maintenance costs are 15% lower than those of the leading 7.5MW gas turbine.*

- The compact rotor of the OP16 does not experience bowing or differential cooling upon shutdown. The turbine can be restarted immediately following a shutdown with no cooling time in between. The OP16 is therefore ideal for peaking and load management applications that may require *frequent startup/shutdown cycles. Each OP16 can undergo 6,000 cycles between overhauls.*

- With low rotating inertia, the OP16 can accept and shed load in response to utility dispatch commands at a rate of 100kW/second. *A plant comprised of four OP16s can be dispatched at rates up to 400kW/second.*

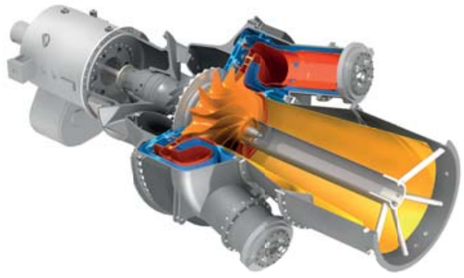
- A compressor bleed bypass system utilized primarily for emissions management during turndown can also decouple generator load from thermal output. *As generator electrical output is modulated under utility dispatch control, thermal output can be maintained steady to provide steam near the peak operating capacity.*

- The OP16 is factory assembled in a 20’x8’x8 ½’ container suitable for indoor or outdoor installation. *The inlet filter and ventilation housing is also factory assembled in an identically-sized container to minimize expensive assembly time in the field.* The entire assembly undergoes final factory acceptance test prior to shipment, ensuring proper fabrication and controls before reaching the site. Installation and commissioning can be completed in as little as seven days.

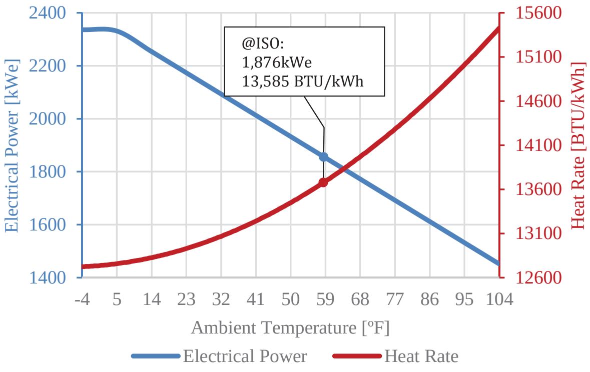
OP16 Datasheet (Imperial)

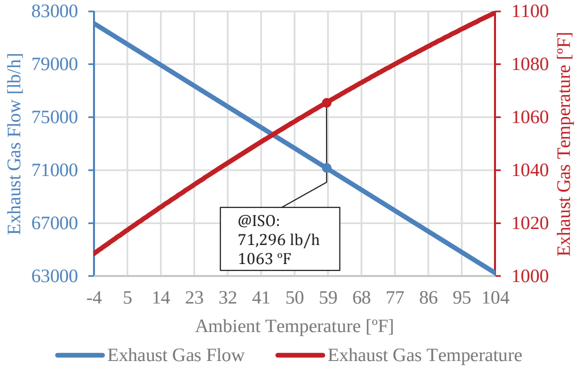
OP16 Gas Turbine Genset Performance for Natural Gas* @ISO conditions		
Power Output *(p.f. = 1)*	*kWe*	1,876
Electrical Efficiency *(p.f. = 1)*	*%*	25.1
Fuel consumption	*MBTU/h*	25,485
Heat Rate *(p.f. = 1)*	*BTU/kWh*	13,585
Exhaust Gas Flow	*lb/h*	71,296
Exhaust Gas Temperature	*°F*	1063
Pressure Ratio	-	6.7:1
Generator Voltage	*kV*	up to 13.8
Frequency	*Hz*	50/60
Noise**	*db(A)*	<80 @ 3ft
Combustion systems available	-	3A (Standard) 3B (Dry-low emissions) 3C (Low calorific fuels)
Time between major overhaul	*hours*	42,500

* Multiple fuels possible: LPG, Diesel, Flare Gas, Biogas, Syngas, Pyrolysis oil etc.
** Lower levels are available upon request

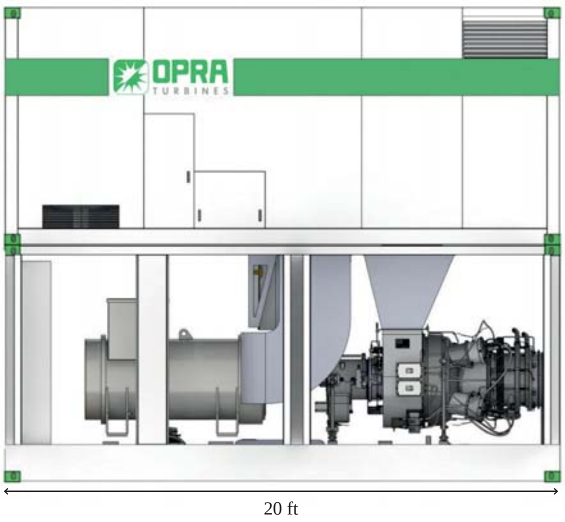


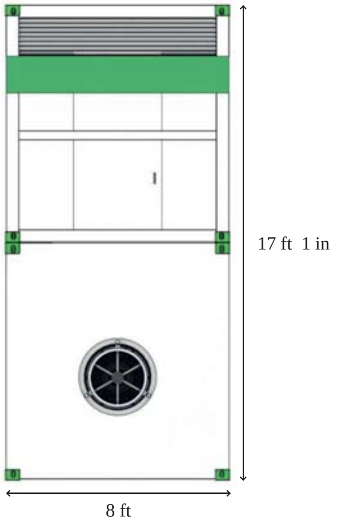
Performance Curves





Dimensions





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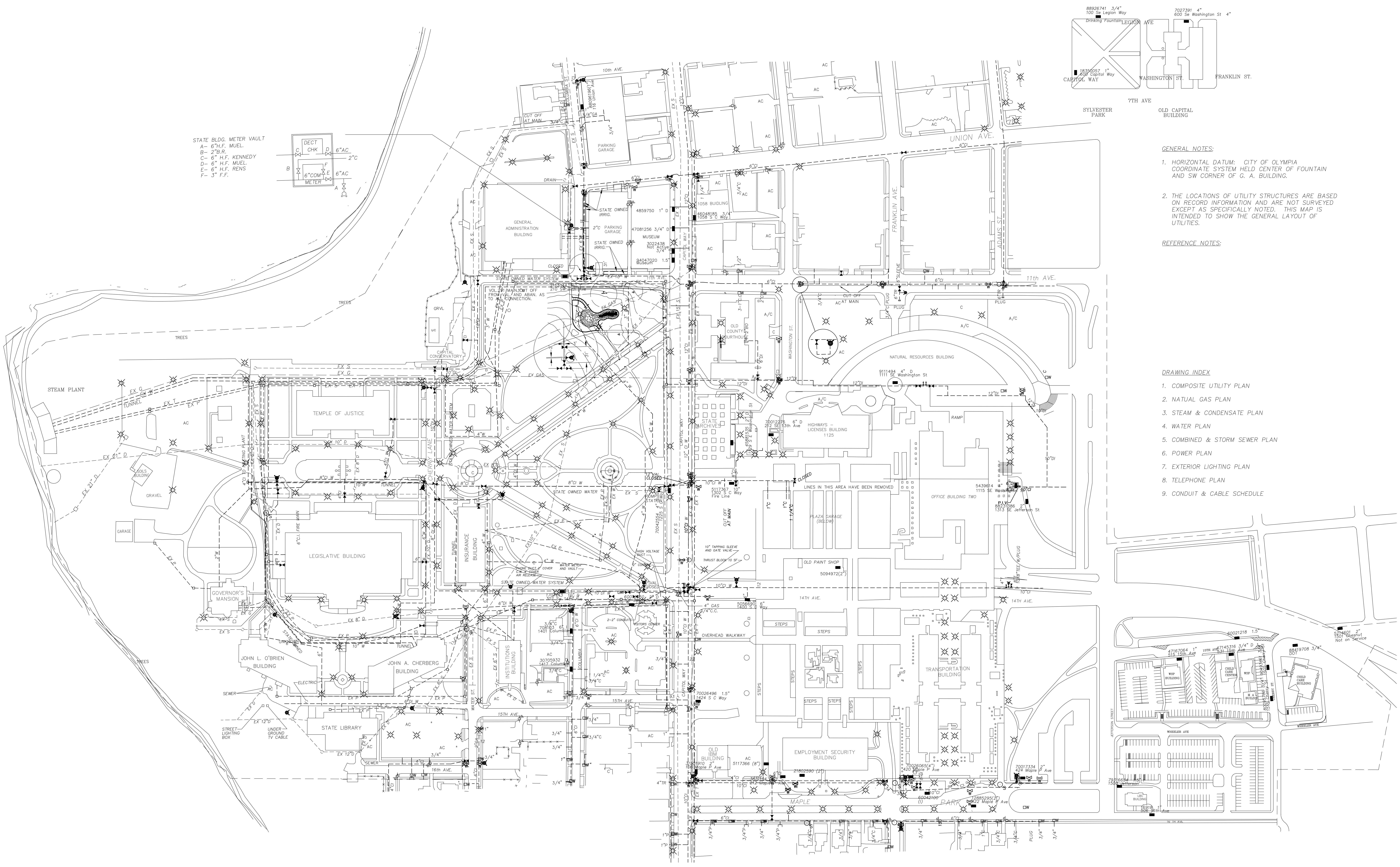

GENERAL NOTES:

1. HORIZONTAL DATUM: CITY OF OLYMPIA COORDINATE SYSTEM HELD CENTER OF FOUNTAIN AND SW CORNER OF G. A. BUILDING.

2. THE LOCATIONS OF UTILITY STRUCTURES ARE BASED ON RECORD INFORMATION AND ARE NOT SURVEYED EXCEPT AS SPECIFICALLY NOTED. THIS MAP IS INTENDED TO SHOW THE GENERAL LAYOUT OF UTILITIES.

REFERENCE NOTES:

DRAWING INDEX

1. COMPOSITE UTILITY PLAN
2. NATUAL GAS PLAN
3. STEAM & CONDENSATE PLAN
4. WATER PLAN
5. COMBINED & STORM SEWER PLAN
6. POWER PLAN
7. EXTERIOR LIGHTING PLAN
8. TELEPHONE PLAN
9. CONDUIT & CABLE SCHEDULE

P:\2900S\2938-02\Acad\Dwg\2938-COMP-UTIL-PLAN.dwg
04-07-2000 0941 hours

WATER SYMBOLS

⋈	GATE VALVE	⊔	2 WATER METERS
	FIRE HYDRANT	○	BLOW-OFF
◀	REDUCER		

FIELD TIES

⋈ W	GATE VALVE	□W	WATER METER
⊙	FIRE HYDRANT	W	VAULT

THE LOCATIONS OF UTILITY STRUCTURES ARE BASED ON RECORD INFORMATION AND ARE NOT SURVEYED. EXCEPT AS SPECIFICALLY NOTED. THIS MAP IS INTENDED TO SHOW THE GENERAL LAYOUT OF THE UTILITY AND AN INDEX TO MORE DETAILED ENGINEERING PLANS.

LEGEND

G	NATURAL GAS	— — —
–	TUNNEL(STEAM/CONDENSATE)	— — — — — —
–	CHILLED WATER	
W	WATER (CITY)	— — — — — —
W	WATER (STATE)	— — — — — —
S	COMBINED SEWER	— — — — — —
D	STORM DRAIN	— — — — — —
P	POWER	— — — — — —
T	TELEPHONE	— — — — — —
–	ABOVEGROUND	———
–	UNDERGROUND	— — —
–	ABANDONED-IN-PLACE	//////////////

N

SCALE: 1"=100'	CAPITOL CAMPUS	DRAWING NUMBER
UPDATED DATE 3/31/00	COMPOSITE UTILITY PLAN	
		SHEET 1 of 9

one inch = one hundred feet

100 50 25 0 100 200

GENERAL

SYMBOL	ABBR	DESCRIPTION
		45
		45 DOWN
		90
	AD	ACCESS DOOR IN CEILING
	AD	ACCESS DOOR IN WALL
		ALIGNMENT GUIDE
		ANCHOR
		AUTOMATIC CONTOL VALVE (3–WAY)
		AUTOMATIC CONTROL VALVE (2–WAY)
		BALANCING VALVE
	BV	BALL VALVE
BOP XX'–XX"	BOP	BOTTOM OF PIPE ELEVATION
		BREAK
	BFV	BUTTERFLY VALVE
		CAP
℄		CENTERLINE
℄ XX'–XX"	CL–EL	CENTERLINE OF PIPE ELEVATION
	CHK	CHECK VALVE
		CIRCUIT SETTER
X X-X		DETAIL TAG
	DN	DOWN
X L-*-* SP*-*		ELEVATION TAG
		FLOW ARROW
		GAS COCK
		GLOBE VALVE
	GV	GATE VALVE
IE XX'–XX"	IE	INVERT PIPE ELEVATION
PITCH 1/X" PER FOOT		PITCH LEFT
PITCH 1/X" PER FOOT		PITCH RIGHT
		PLUG
	POC	POINT OF CONNECTION
	PG	PRESSURE GAUGE
	PRV	PRESSURE REDUCING VALVE
		ROLLING 45 DOWN
		REDUCER
		REDUCING CONCENTRIC
		REDUCING ECCENTRIC
	RV	RELIEF VALVE
X		SHEET NOTE DESIGNATION
		SLEEVE
	SV	SOLENOID VALVE
		TEE DOWN
		TEE
	TH	THERMOMETER
XXXXXXXXX		LONG TAG 9 CHARCTERS MAX
XXXXXX		MEDIUM TAG 6 CHARCTERS MAX
XXXX		SHORT TAG 4 CHARCTERS MAX
TOP XX'–XX"	TOP	TOP OF PIPE ELEVATION
	U	UNION
		UP
		VERTICAL SLEEVE
		VALVE IN PIPE RISE OR DROP
	STR	WYE TYPE STRAINER

PIPING

SYMBOL	ABBR	DESCRIPTION
	AAV	AUTOMATIC AIR VENT
— BFW —	BFW	BOILER FEED WATER
		BUCKET TRAP
— CA —	CA	CONTROL AIR
— CHR —	CHR	CHILLED WATER RETURN
— CHS —	CHS	CHILLED WATER SUPPLY
— CR —	CR	CONDENSER WATER RETURN
— CS —	CS	CONDENSER WATER SUPPLY
		FLANGE
		FLEX
		FLOAT AND THERMOSTATIC
— FOR —	FOR	FUEL OIL RETURN
— FOS —	FOS	FUEL OIL SUPPLY
— FOV —	FOV	FUEL OIL VENT
— G —	G	NATURAL GAS
— GLR —	GLR	GLYCOL RETURN
— GLS —	GLS	GLYCOL SUPPLY
— HCR —	HCR	HIGH PRESSURE CONDENSATE RETURN
— HG —	HG	HOT GAS
— HPS —	HPS	HIGH PRESSURE STEAM
— HWR —	HWR	HEATING HOT WATER RETURN
— HWS —	HWS	HEATING HOT WATER SUPPLY
— LCR —	LCR	LOW PRESSURE CONDENSATE RETURN
— LPS —	LPS	LOW PRESSURE STEAM
	MAV	MANUAL AIR VENT
— MCR —	MCR	MEDIUM PRESSURE CONDENSATE RETURN
M		METER
— MG —	MG	MEDIUM PRESSURE NATURAL GAS
— MPS —	MPS	MEDIUM PRESSURE STEAM
— PCR —	PCR	PUMPED CONDENSATE RETURN
PI	PI	PRESSURE INDICATOR
— RL —	RL	REFER LIQUID
— RS —	RS	REFER SUCTION
		TEMPERATURE PRESSURE TEST PLUG
TI	TI	TEMPERATURE INDICATOR
TS	TS	TEMPERATURE SENSOR
	VB	VACUUM BREAKER
		VENTURI

ABBREVIATIONS

AC	AIR CONDITIONING UNIT
AF	AIRFOIL
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLING UNIT
AMB	AMBIENT
AMS	AIRFLOW MEASURING UNIT
B	BOILER
BDD	BACKDRAFT DAMPER
BHP	BRAKE HORSEPOWER
BI	BACKWARD INCLINED
BOD	BOTTOM OF DUCT
BOT	BOTTOM
BTUH	BRITISH THERMAL UNIT PER HOUR
CC	COOLING COIL
CFM	CUBIC FEET PER MINUTE
CHLR	CHILLER
CLG	CEILING
CNTFGL	CENTRIFUGAL
COMB	COMBUSTION
COND	CONDENSER / CONDENSATE
CONT	CONTINUE / CONTROL
CONTR	CONTRACTOR
CP	CIRCULATING PUMP
CRAC	COMPUTER ROOM AIR CONDITIONING UNIT
CT	COOLING TOWER
CU	CONDENSING UNIT / CUBIC
Cv	FLOW COEFFICIENT
CV	CONSTANT VOLUME
CWP	CHILLED WATER PUMP
D	DRAIN
DB	DRY BULB / DECIBEL
DEG	DEGREE
DIA	DIAMETER
DIM	DIMENSION
DISCH	DISCHARGE
DMPR	DAMPER
DN	DOWN

ABBREVIATIONS

EA	EXHAUST AIR
EAT	ENTERING AIR TEMPERATURE
ECONO	ECONOMIZER
EDH	ELECTRIC DUCT HEATER
EER	ENERGY EFFICIENCY RATIO
EF	EXHAUST FAN
EFF	EFFICIENCY
ELEC	ELECTRIC
ELEV	ELEVATION
EQUIV	EQUIVALENT
ESP	EXTERNAL STATIC PRESSURE
EVAP	EVAPORATOR / EVAPORATIVE
EWT	ENTERING WATER TEMPERATURE
EXH	EXHAUST
EXT	EXTERIOR / EXTERNAL
F	FAHRENHEIT
FC	FORWARD CURVE
FCU	FAN COIL UNIT
FD	FIRE DAMPER / FLOOR DRAIN
FLR	FLOOR
FLTR	FILTER
FOIC	FURNISHED BY OWNER INSTALLED BY CONTRACTOR
FPM	FEET PER MINUTE
FSD	FIRE SMOKE DAMPER
FT	FEET
FTU	FAN TERMINAL UNIT
FV	FACE VELOCITY
GA	GAUGE
GAL	GALLONS
GALV	GALVANIZED
GPM	GALLONS PER MINUTE
GWB	GYPSUM WALLBOARD
H	HUMIDIFIER
HC	HEATING COIL
HD	HEAD
HORIZ	HORIZONTAL
HP	HORSEPOWER
HT	HEAT TRACE
HVAC	HEATING, VENTILATING, AND AIR CONDITIONING
HVACDCS	HVAC DUCT CONSTRUCTION STANDARDS, METAL AND FLEXIBLE (SMACNA)
HX	HEAT EXCHANGER
ID	INDIRECT DRAIN / INSIDE DIAMETER
IN	INCH
KW	KILOWATT
L	LONG / LENGTH
LAT	LEAVING AIR TEMPERATURE
LB	POUND
LWT	LEAVING WATER TEMPERATURE
MBH	THOUSAND BTU PER HOUR
MECH	MECHANICAL
MOD	MOTOR OPERATED DAMPER
MTD	MOUNTED
MVD	MANUAL VOLUME DAMPER
NC	NORMALLY CLOSED / NOISE CRITERIA
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN / NUMBER
NTS	NOT TO SCALE
OBD	OPPOSED BLADE DAMPER
OC	ON CENTER
OD	OUTSIDE DIMENSION OR DIAMETER
OSA	OUTSIDE AIR
P	PUMP
PBD	PARALLEL BLADE DAMPER
PD	PRESSURE DROP / PUMPED DRAIN
PL	PLENUM
POC	POINT OF CONNECTION
PT	POST–TENSION SLAB
QD	QUICK DISCONNECT
RA	RETURN AIR
REF	REFERENCE
REV	REVISION
RF	RELIEF FAN
RH	RELATIVE HUMIDITY
RIO	ROUGH–IN ONLY
RPM	REVOLUTIONS PER MINUTE
SA	SUPPLY AIR
SCFM	STANDARD CUBIC FEET PER MINUTE
SCH	SCHEDULE
SECT	SECTION
SENS	SENSIBLE
SF	SUPPLY FAN / SQUARE FOOT
SL	SOUND LINE (INSIDE DUCT INSULATION)
SMACNA	SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION
SP	STATIC PRESSURE
SQ	SQUARE
SS	STAINLESS STEEL
ST	SOUND TRAP
TBV	TOWER BYPASS VALVE
TCV	TEMPERATURE CONTROL VALVE
TDH	TOTAL DYNAMIC HEAD
TOD	TOP OF DUCT
TOS	TOP OF STEEL
TP	TOTAL PRESSURE
TRNSN	TRANSITION
TSP	TOTAL STATIC PRESSURE
TYP	TYPICAL
UBD	UPBLAST DISCHARGE
UH	UNIT HEATER
UNO	UNLESS NOTED OTHERWISE
VA	VALVE
VAV	VARIABLE AIR VOLUME
VD	VOLUME DAMPER
VENT	VENTILATION / VENTILATOR
VEL	VELOCITY
VFO	VARIABLE FREQUENCY CONTROLLER
VI	VIBRATION ISOLATOR
VIV	VARIABLE INLET VANES
W	INSULATED DUCT / WATT / WIDE
WB	WET BULB (TEMPERATURE)
WG	WATER GAUGE
WT	WEIGHT

GENERAL NOTES

1. DRAWINGS ARE SCHEMATIC IN NATURE AND DO NOT SHOW EXACT ROUTING OR ALL TRANSITIONS/CONNECTIONS/OFFSETS REQUIRED.
2. COORDINATE ALL NEW WORK WITH EXISTING STRUCTURE AND HVAC. FIELD VERIFY EXISTING CONDITIONS.
3. PROVIDE CONNECTIONS AND TRANSITIONS AT EQUIPMENT AS REQUIRED.
4. INSTALLATION SHALL COMPLY TO ALL FEDERAL, STATE AND LOCAL CODES.
5. INSULATION OF DUCT WORK AND PIPING SHALL CONFORM TO THE WASHINGTON STATE ENERGY CODE.
6. USE UNISTRUT CONCRETE INSERTS, OR EQUAL, TO SUPPORT MECHANICAL EQUIPMENT OR DUCTWORK FROM THE P.T. SLAB.
7. ALL WORK SHOWN ON THIS PLAN SHALL CONFORM TO THE 2012 INTERNATIONAL MECHANICAL CODE, 2012 UNIFORM PLUMBING CODE, AND 2012 WASHINGTON STATE ENERGY CODE.

VICINITY MAP

JOB LOCATION

MECHANICAL INDEX OF DRAWINGS

M0.01	MECHANICAL COVER SHEET
M1.10	MATERIAL MATRIX AND EQUIPMENT SCHEDULE
M2.01	OVERALL CAMPUS CHILLED WATER LOOP GENERAL ROUTING
M2.03	OVERALL CAMPUS HEATING WATER LOOP GENERAL ROUTING
M2.04	OVERALL CAMPUS HEATING WATER LOOP GENERAL ROUTING OPTION II
M3.01	CENTRAL PLANT – CONDENSER WATER PIPING DIAGRAM
M3.02	CENTRAL PLANT – CHILLED WATER PIPING DIAGRAM
M3.03	CENTRAL PLANT – HEATING WATER PIPING DIAGRAM
M6.13	CENTRAL PLANT – BAR LAYOUT CONFIGURATION
M8.01	AIRFLOW RISER DIAGRAMS
MP6.10	CENTRAL PLANT – FIRST FLOOR EQUIPMENT PLAN

Issue:

No. Rev. Desc. Date

Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: DEPARTMENT OF ENTERPRISE SERVICES

Legal

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Title MECHANICAL COVER SHEET

UNIVERSITY
MECHANICAL
CONTRACTORS, INC.
We Build Value

www.umci.com
11611 49th Place West,
Mukilteo, Washington 98275
Phone: (206) 364–9900
Fax: (206) 361–2126

Drawn By	UMC
Checked By	TEB
Original Issue Date	XX–XX–XXXX
Job No.	6693
Scale	NONE
Sheet No.	M0.01

DUCT INSULATION SCHEDULE

DUCT TYPE [7,8]	LOCATION	TEMP RANGE (DEGREES F)	INSULATION R-VALUE REQUIREMENT	INSULATION TYPE
OUTSIDE AIR [1,2,9]	UPSTREAM OF DAMPER [3]	ALL	R–18 [4]	FIBERGLASS
	DOWNSTREAM OF DAMPER, UNCONDITIONED SPACE	ALL	R–6	FIBERGLASS
	DOWNSTREAM OF DAMPER, CONDITIONED SPACE	ALL	R–8	FIBERGLASS
SUPPLY AIR [5,6,9]	UNCONDITIONED SPACE	ALL	R–6	FIBERGLASS
	OUTSIDE THE BUILDING	ALL	R–8	FIBERGLASS
	CONDITIONED SPACE	<55 OR >105	R–3.3	FIBERGLASS
	CONDITIONED SPACE	55–105	NONE	NA
RETURN AIR [5,6]	UNCONDITIONED SPACE	ALL	R–6 [6]	FIBERGLASS
	CONDITIONED SPACE	NA	NONE [10]	NA
	OUTSIDE THE BUILDING	ALL	R–8	FIBERGLASS
EXHAUST AIR	UPSTREAM OF DAMPER	ALL	NONE	NA
	DOWNSTREAM OF DAMPER [3]	ALL	R–18 [4]	FIBERGLASS

COMPLIANT WITH 2012 WA STATE ENERGY CODE, COMMERCIAL PROVISIONS (WSEC) AND 2012 SEATTLE COMMERCIAL ENERGY CODE (SCEC) WITH UPDATES THROUGH 2015.

NOTES:

1. OUTSIDE AIR DUCTS SERVING INDIVIDUAL SUPPLY AIR UNITS WITH LESS THAN 2,800 CFM TOTAL SUPPLY ONLY NEED R–7 INSULATION.
2. NOT REQUIRED IN UNHEATED EQUIPMENT ROOMS WITH COMBUSTION AIR LOUVERS PROVIDED THE ROOM IS ISOLATED FROM CONDITIONED SPACE WITH R–11 INSULATION.
3. INSULATE BETWEEN EXTERIOR ENVELOPE (WALL OR ROOF PENETRATION) AND ISOLATION DAMPER.
4. MINIMUM R–VALUE FOR OUTSIDE AIR DUCTS IS SAME AS FOR METAL FRAMED WALL PER TABLE C402.1.2. R–18 MEETS THIS EXTERIOR WALL REQUIREMENT FOR CLIMATE ZONES 4 AND 5. KING COUNTY IS ZONE 4C. USE R–21 FOR ZONE 6: FERRY, OKANOGAN, PEND OREILLE, AND STEVENS COUNTIES.
5. INSULATION NOT REQUIRED FOR DUCTWORK WITHIN EQUIPMENT.
6. FOR EXAMPLE, ABOVE CEILING PLENUMS WITH DUCTED RETURN ARE CONSIDERED UNCONDITIONED SPACE; HOWEVER, WHERE DESIGN TEMPERATURE DIFFERENCE BETWEEN THE INTERIOR AND EXTERIOR OF THE DUCT OR PLENUM DOES NOT EXCEED 15 F, NO INSULATION IS REQUIRED.
7. INSULATION FOR PLENUMS SHALL BE THE SAME AS ABOVE FOR DUCTS, DEPENDING ON SERVICE. REFER TO OUTSIDE AIR, SUPPLY, RETURN, OR EXHAUST SERVICE.
8. PROVIDE ALL SERVICE JACKET FOR ALL DUCTS, EXCEPT PROVIDE WEATHERPROOF ALUMINUM JACKET FOR DUCTS OUTSIDE THE BUILDING.
9. PROVIDE VAPOR–RETARDER MASTIC ON SUPPLY AIR AND OUTSIDE AIR DUCTS AND PLENUMS.
10. RETURN AIR PLENUMS WITH PERMANENT OPENINGS TO CONDITIONED SPACE ARE CONSIDERED CONDITIONED SPACE.

PIPE INSULATION SCHEDULE

INSULATION SPEC	PIPING SYSTEM	TEMP RANGE (DEGREES F)	CONDUCTIVITY BTU*IN/ (HR*FT^2*F)	MEAN RATING TEMP (DEGREES F)	INSULATION TYPE	VAPOR BARRIER REQUIRED?	PIPE INSERT NOTE	PIPE SIZE				
								<1"	1" TO <1 1/2"	1 1/2" TO <4"	4" TO <8"	8" & OVER
DOMESTIC COLD	DOMESTIC COLD NON–POTABLE COLD	ALL	0.21 – 0.27	75	FIBERGLASS	YES [11]	A	1/2" [6]	1/2" [6]	1"	1"	1–1/2"
DOMESTIC HOT [1]	DOMESTIC HOT NON–POTABLE HOT	105–140	0.21 – 0.28	100	FIBERGLASS	NO	B	1"	1"	1–1/2"	1–1/2"	1–1/2"
STORM DRAIN [2,3]	STORM DRAIN	ALL	0.21 – 0.27	75	FIBERGLASS	YES [11]	B	1"	1"	1"	1"	1"
HEATING WATER [4]	HEATING WATER – LOW TEMP	105–140	0.21 – 0.28	100	FIBERGLASS	NO	C	1"	1"	1–1/2"	1–1/2"	1–1/2"
	HEATING WATER – HIGH TEMP	141–200	0.25 – 0.29	125	FIBERGLASS	NO	C	1–1/2"	1–1/2"	2"	2"	2"
CHILLED WATER [4]	CHILLED WATER	40–60	0.21 – 0.27	75	FIBERGLASS	YES	D	1/2" [6]	1/2" [6]	1"	1"	1"
CONDENSER WATER [4,5]	CONDENSER WATER	40–60	0.21 – 0.27	75	FIBERGLASS	YES [7]	E	1/2" [6]	1/2" [6]	1"	1"	1"
GENERATOR EXHAUST [8]	GENERATOR EXHAUST	UP TO 1100	0.45	300	CAL–SIL	NO	G	3"	3"	3"	3"	3"
REFRIGERATION [9]	REFRIGERATION SUCTION	<40	0.20 – 0.26	75	ELASTOMERIC	YES	H	1/2" [6]	1"	1"	1"	1–1/2"
CONDENSATE DRAIN [10]	COIL CONDENSATE DRAIN	ALL	0.20 – 0.26	75	ELASTOMERIC	YES	H	1/2" [6]	1/2" [6]	1"	1"	1"

COMPLIANT WITH 2012 WA STATE ENERGY CODE, COMMERCIAL PROVISIONS (WSEC) AND 2012 SEATTLE COMMERCIAL ENERGY CODE (SCEC) WITH UPDATES THROUGH 2015.

NOTES:

1. INSULATE DOMESTIC HOT WATER RECIRCULATION PIPING. DO NOT USE INSERTS – INSULATE AROUND HANGER. (UMC STANDARD)
2. INSULATE ALL HORIZONTAL STORM DRAIN PIPING INSTALLED IN CONDITIONED SPACE, INCLUDING PIPING FROM LOWER ROOFS AND DECKS. INSULATE ROOF DRAIN BODIES. (UMC STANDARD)
3. INSULATE FIRST 20 FEET OF HORIZONTAL OVERFLOW STORM DRAIN PIPING INSTALLED IN CONDITIONED SPACE, INCLUDING PIPING FROM LOWER ROOFS AND DECKS. INSULATE ROOF DRAIN BODIES. (UMC STANDARD)
4. PIPING THAT IS PART OF A HEATING OR COOLING SYSTEM CONVEYING FLUIDS BETWEEN 60 F AND 105 F DOES NOT REQUIRE INSULATION. (WSEC 2012)
5. IF EXPOSED CONDENSER WATER PIPING IS USED FOR HEATING AND IS BETWEEN 60 F AND 105 F, INSULATE ALL GROOVED PIPE JOINTS BUT NOT THE PIPE RUN – IN OCCUPIED AREAS ONLY.
6. MINIMUM THICKNESS OF 1/2" IS REQUIRED BY CODE FOR THIS PIPE SIZE. 1" THICK INSULATION IS ALSO ACCEPTABLE AT NO ADDED COST IF PREFERRED BY SUBCONTRACTOR.
7. VAPOR BARRIER REQUIRED ONLY IF CONDENSER WATER IS 60 F OR BELOW.
8. GENERATOR EXHAUST INSULATION IS FOR PERSONNEL PROTECTION – THICKNESS IS NOT DRIVEN BY ENERGY CODE.
9. VERIFY REQUIREMENTS FOR REFRIGERANT SUCTION LINES FOR EACH APPLICATION.
10. INSULATE COIL CONDENSATE PIPING WHERE LOCATED IN CONDITIONED SPACE OR ABOVE CEILING OF CONDITIONED SPACE.
11. IT IS ACCEPTABLE FOR HANGER TO PENETRATE VAPOR BARRIER AT TOP OF PIPE FOR COLD WATER AND STORM DRAIN SYSTEMS.

OTHER GENERAL RULES:

- INSULATE ALL DIRECT BURIED PIPE UNLESS FLUID TEMPERATURE IS 60 F OR BELOW. (WSEC 2012)
- FIELD APPLIED JACKETS:
  - PROVIDE PVC JACKETS IN MECHANICAL ROOMS FROM FLOOR TO 8 FEET ABOVE FLOOR.
  - PROVIDE WEATHERPROOF ALUMINUM JACKETS FOR OUTDOOR INSTALLATIONS.
  - PROVIDE STAINLESS STEEL JACKETS FOR EXPOSED PIPING IN FOOD PREPARATION AREAS.
- FOR ELASTOMERIC PIPING OUTDOORS:
  - PROVIDE UV PROTECTION. PAINT INSULATION WITH 2 COATS OF "WB ARMAFLEX FINISH."
  - WHERE ADDITIONAL PHYSICAL PROTECTION IS REQUIRED, PROVIDE PVC COVER IN LIEU OF UV–RESISTANT PAINT. BASIS OF DESIGN: AIREX MANUFACTURING, INC., MODEL E–FLEX GUARD OR AS APPROVED.
- INSULATE AND HEAT TRACE ALL GREASE WASTE PIPING. POSITION HEAT TRACE EITHER ABOVE AND BELOW, ONE AT THE BOTTOM, OR TWO AT THE BOTTOM CENTERED ON LOWER QUARTER RADIUS.
- DO NOT INSULATE FUEL OIL PIPING.

THERMAL HANGER SHIELD INSERT NOTES:

A. PROVIDE THERMAL INSERTS FOR ALL DOMESTIC COLD WATER PIPING 3" AND LARGER. INSULATE AROUND HANGERS FOR CW PIPING 2–1/2" AND SMALLER.
B. THERMAL INSERTS NOT REQUIRED FOR THIS PIPING SYSTEM. INSULATE AROUND THE HANGERS WHERE INSULATION IS REQUIRED.
C. PROVIDE THERMAL INSERTS FOR HEATING WATER PIPING 2–1/2" AND LARGER. INSULATE AROUND THE HANGERS FOR PIPING SMALLER THAN 2–1/2".
D. PROVIDE THERMAL INSERTS FOR ALL CHILLED WATER PIPING.
E. PROVIDE THERMAL INSERTS FOR CONDENSER WATER PIPING ONLY WHERE INSULATED AND BELOW 60 F OR ABOVE 105 F.
F. PROVIDE THERMAL INSERTS FOR ALL STEAM AND STEAM CONDENSATE PIPING. USE POLYISOCYANURATE INSERT UP TO 292 F/ 45 PSIG. USE CALCIUM–SILICATE INSERT ABOVE 292 F/ 45 PSIG.
G. PROVIDE THERMAL INSERTS FOR ALL ENGINE EXHAUST PIPING, UNLESS PRE–MANUFACTURED DOUBLE–WALL CHIMNEY IS USED.
H. PROVIDE THERMAL SHIELD INSERTS FOR ELASTOMERIC INSULATION OR USE WOOD DOWEL INSERTS WHERE REQUIRED PER MANUFACTURER'S INSTRUCTIONS. FOR SMALL PIPING (<=1–1/4") WITH ELASTOMERIC INSULATION, INSERTS AND DOWELS MAY NOT BE REQUIRED, BUT DO NOT CRUSH INSULATION OR COMPROMISE THE VAPOR BARRIER.

Issue:
No. ◁ ◁ ◁ ◁ ◁ ◁ ◁
Rev. Desc.
Date

Project/Owner Information

CAPITOL CAMPUS
NEW DISTRICT ENERGY PLANT

Project Address:
OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

Legal

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Sheet No. M1.10

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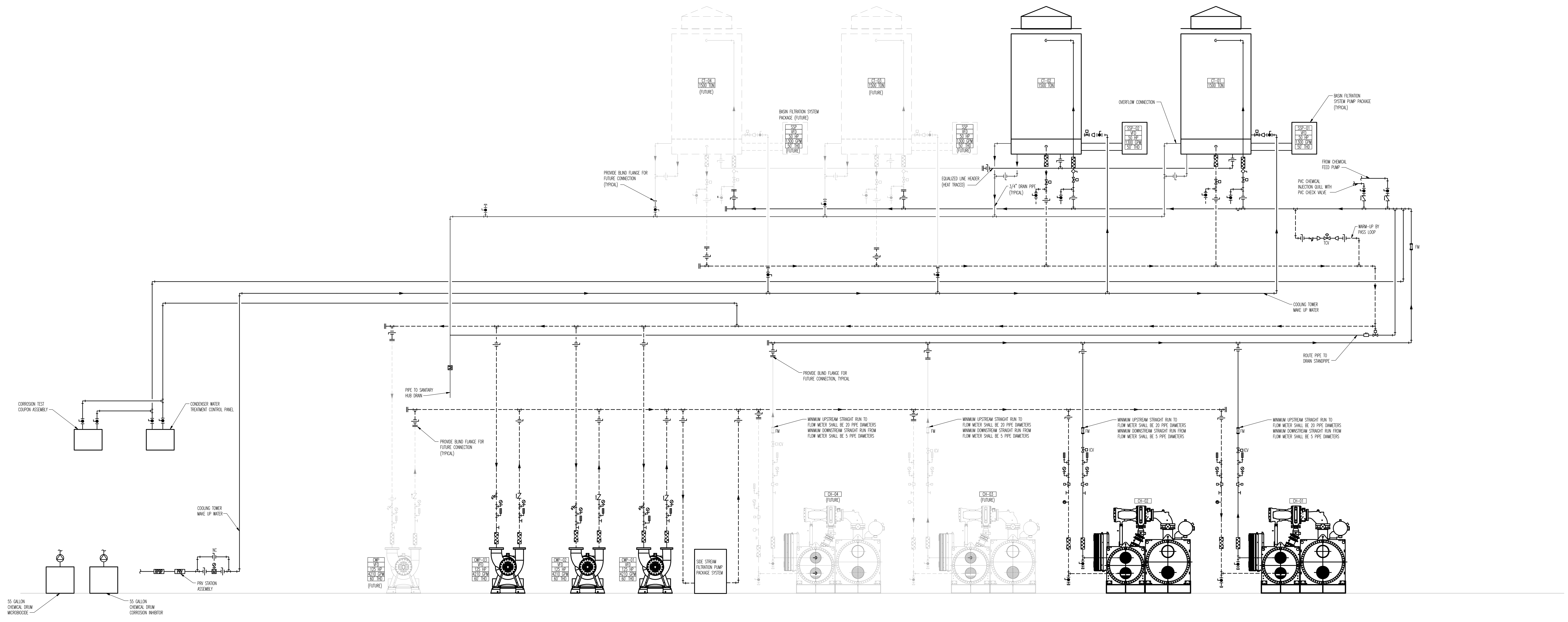

CENTRAL PLANT - CONDENSER WATER PIPING DIAGRAM

SCALE: NONE

Issue:

No.	Rev. Desc.	Date

Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

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Title CENTRAL PLANT - CONDENSER WATER PIPING DIAGRAM

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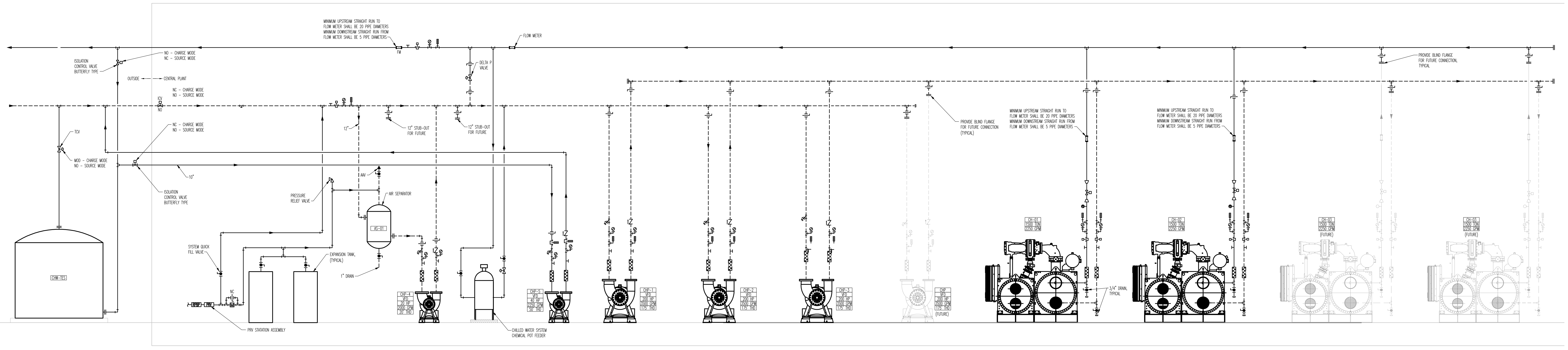

CENTRAL PLANT - CHILLED WATER PIPING DIAGRAM

SCALE: NONE

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Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

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Title CENTRAL PLANT – CHILLED WATER PIPING DIAGRAM

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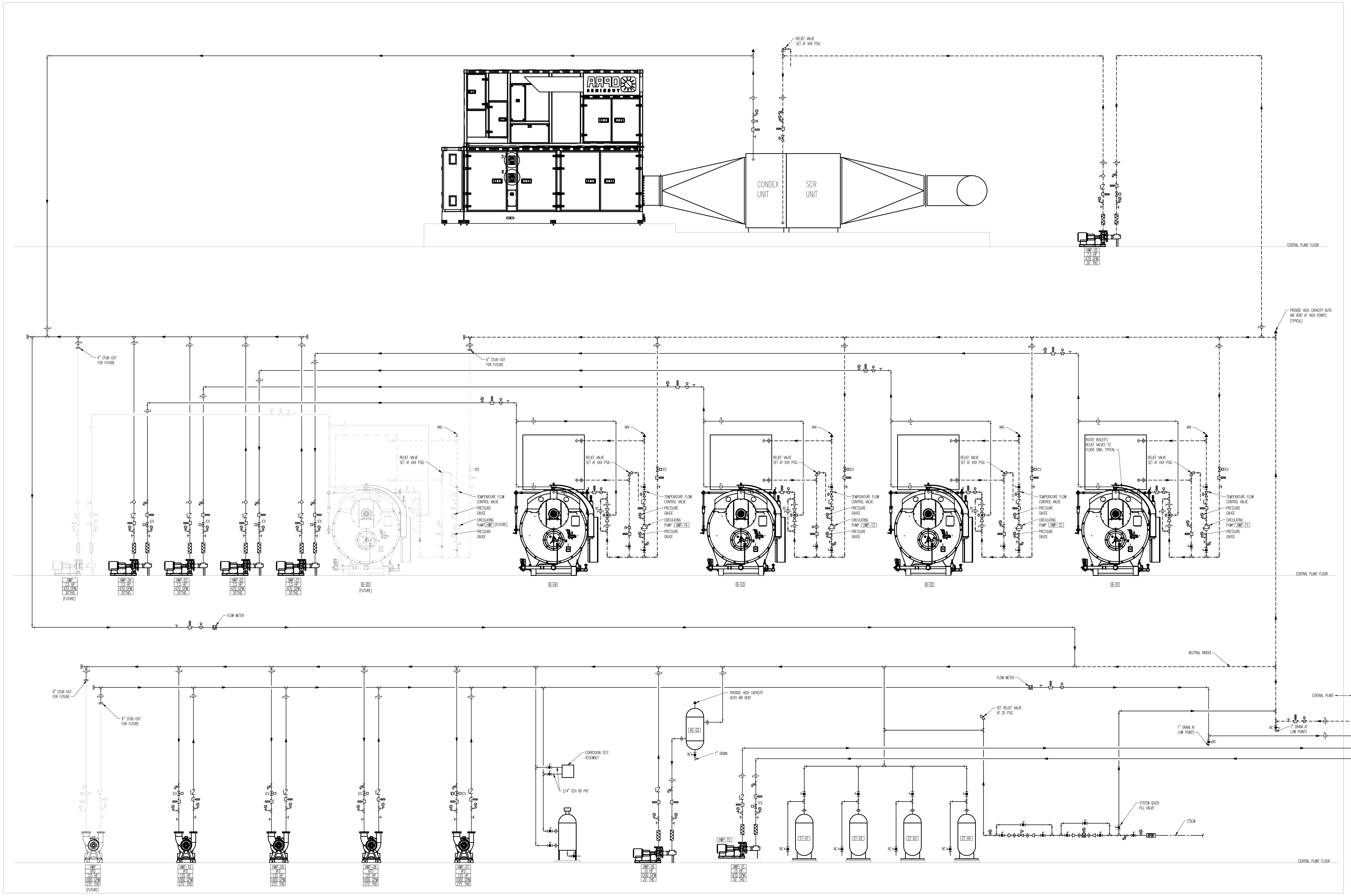

CENTRAL PLANT - HEATING WATER PIPING DIAGRAM

SCALE: NONE

Issue:

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Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

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Title CENTRAL PLANT – HEATING WATER PIPING DIAGRAM

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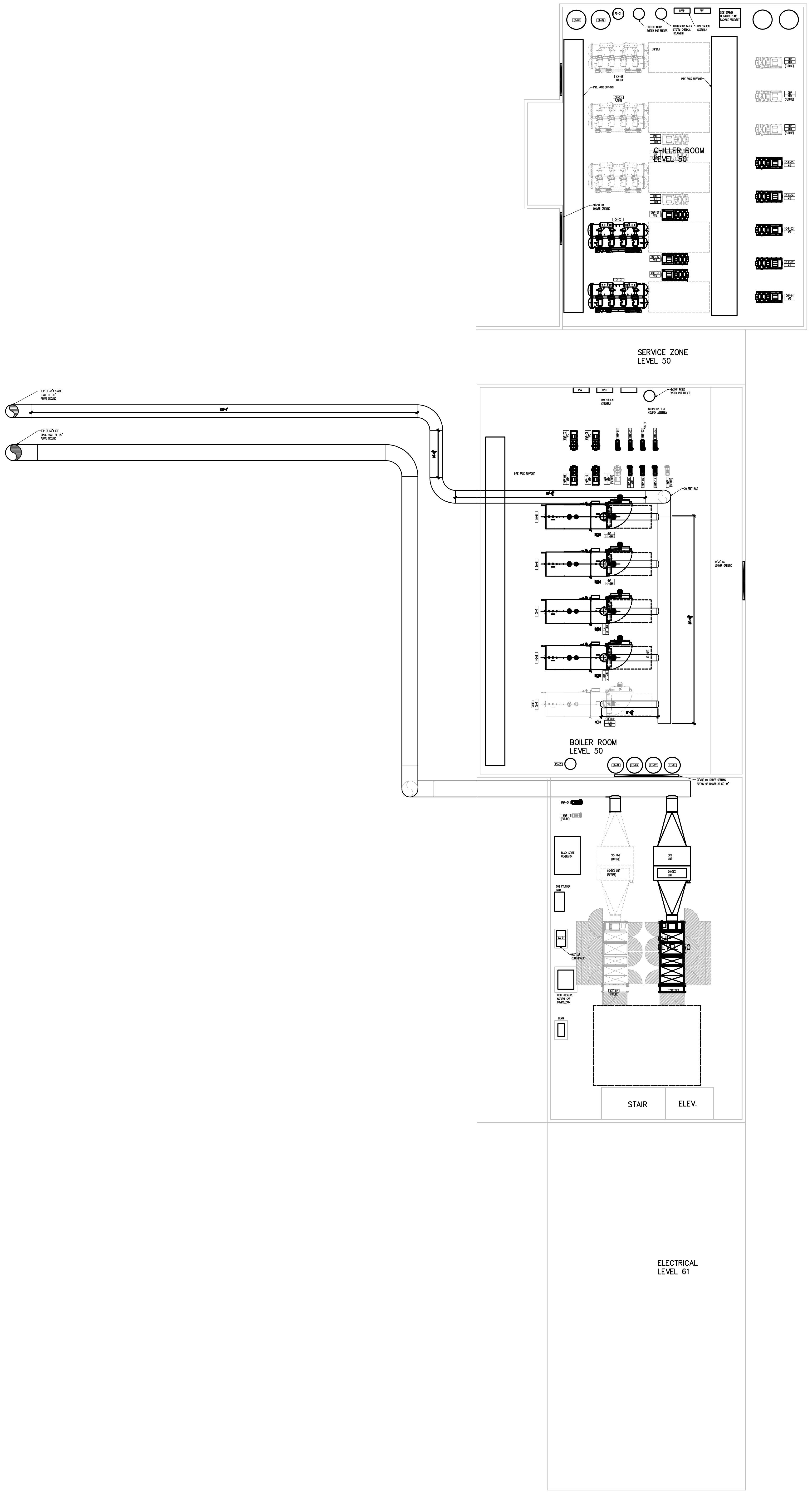
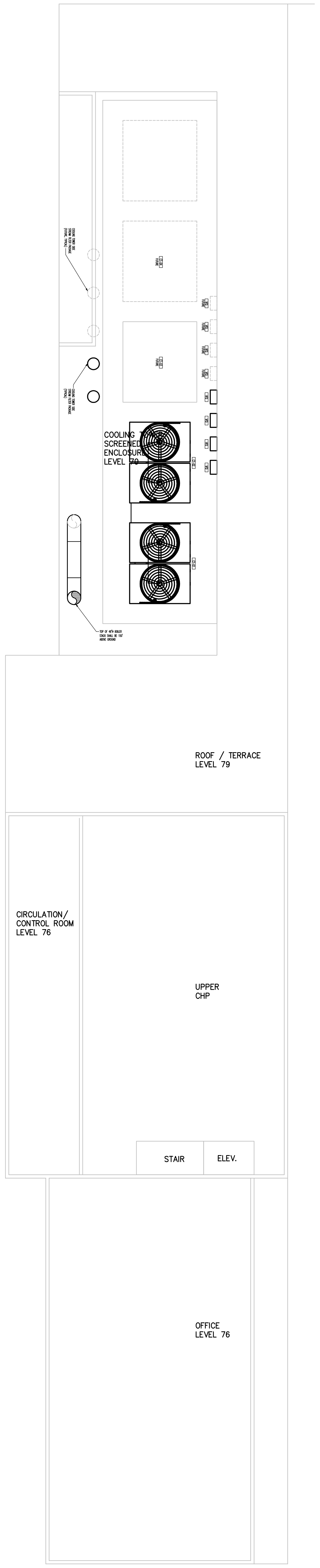


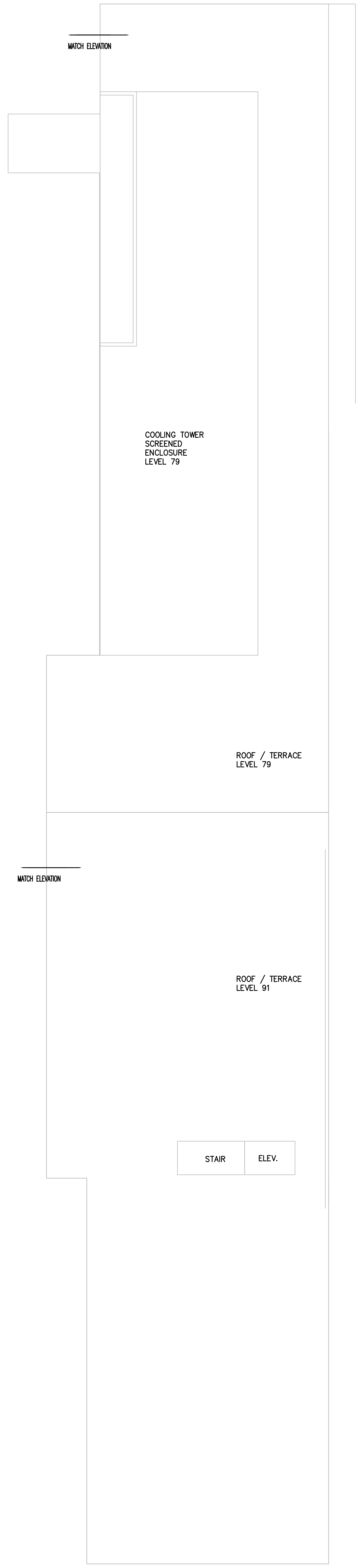
CENTRAL PLANT - LEVEL 50

SCALE: 1/16" = 1'-0"



CENTRAL PLANT - LEVEL 79

SCALE: 1/16" = 1'-0"



CENTRAL PLANT - LEVEL 91

SCALE: 1/16" = 1'-0"

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Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

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Title CENTRAL PLANT - BAR LAYOUT CONFIGURATION

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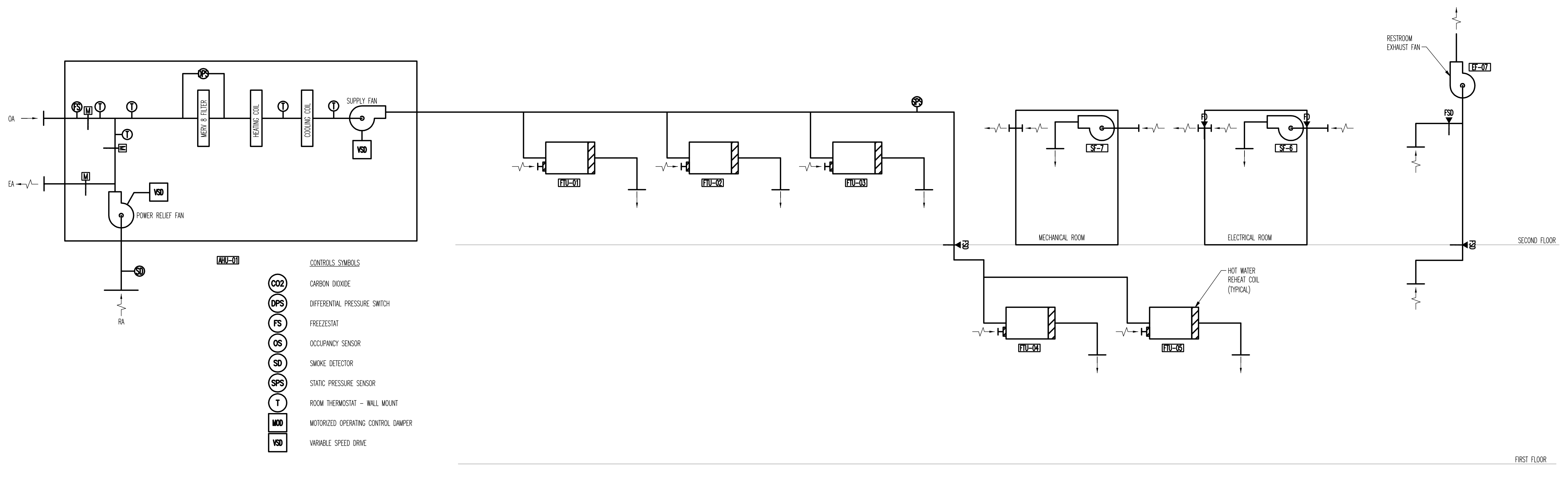
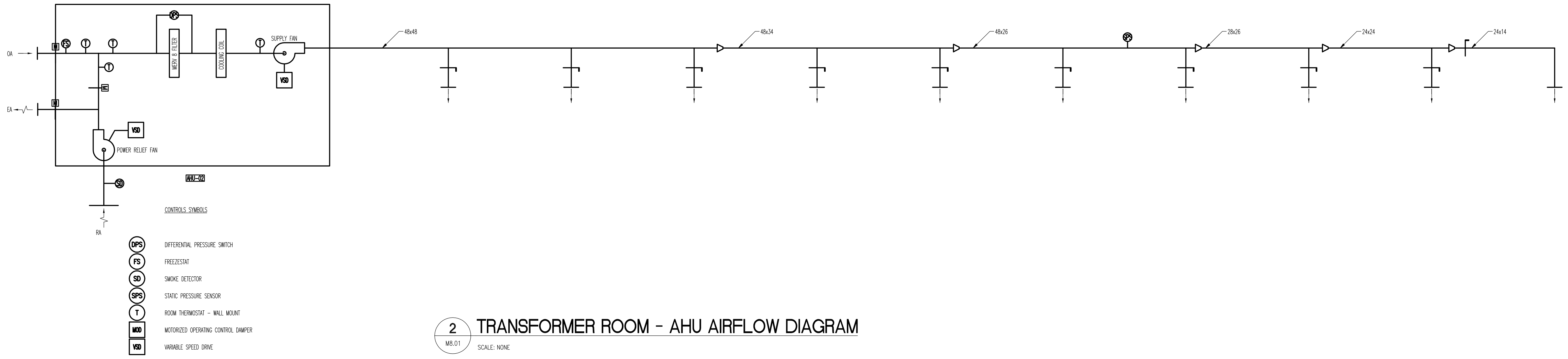
Sheet No.
M6.13



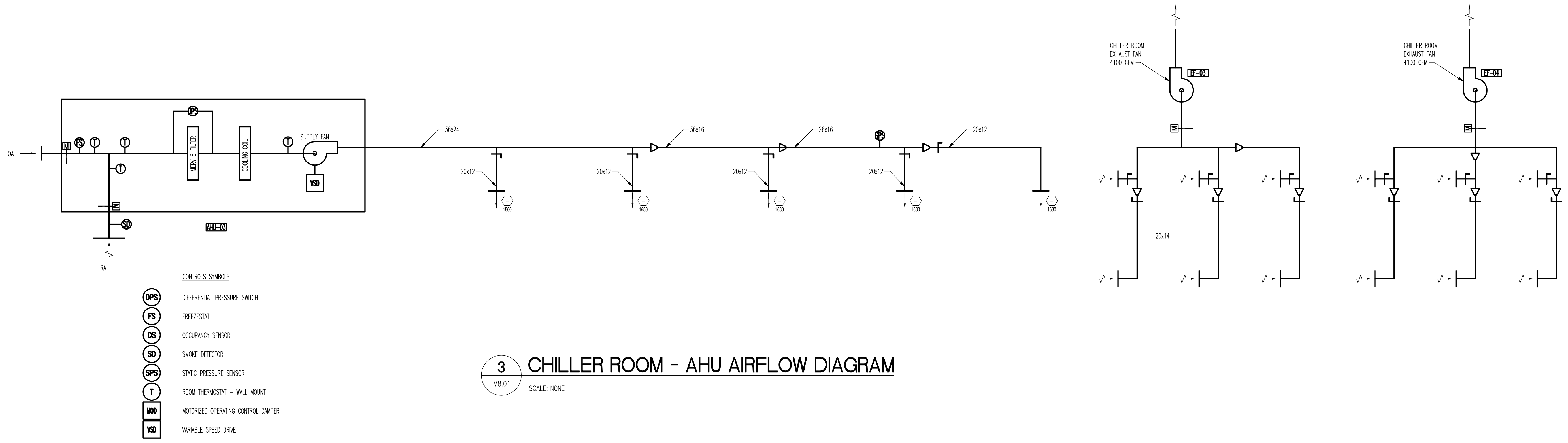
1 M8.01 OFFICE - AIRFLOW DIAGRAM

SCALE: NONE



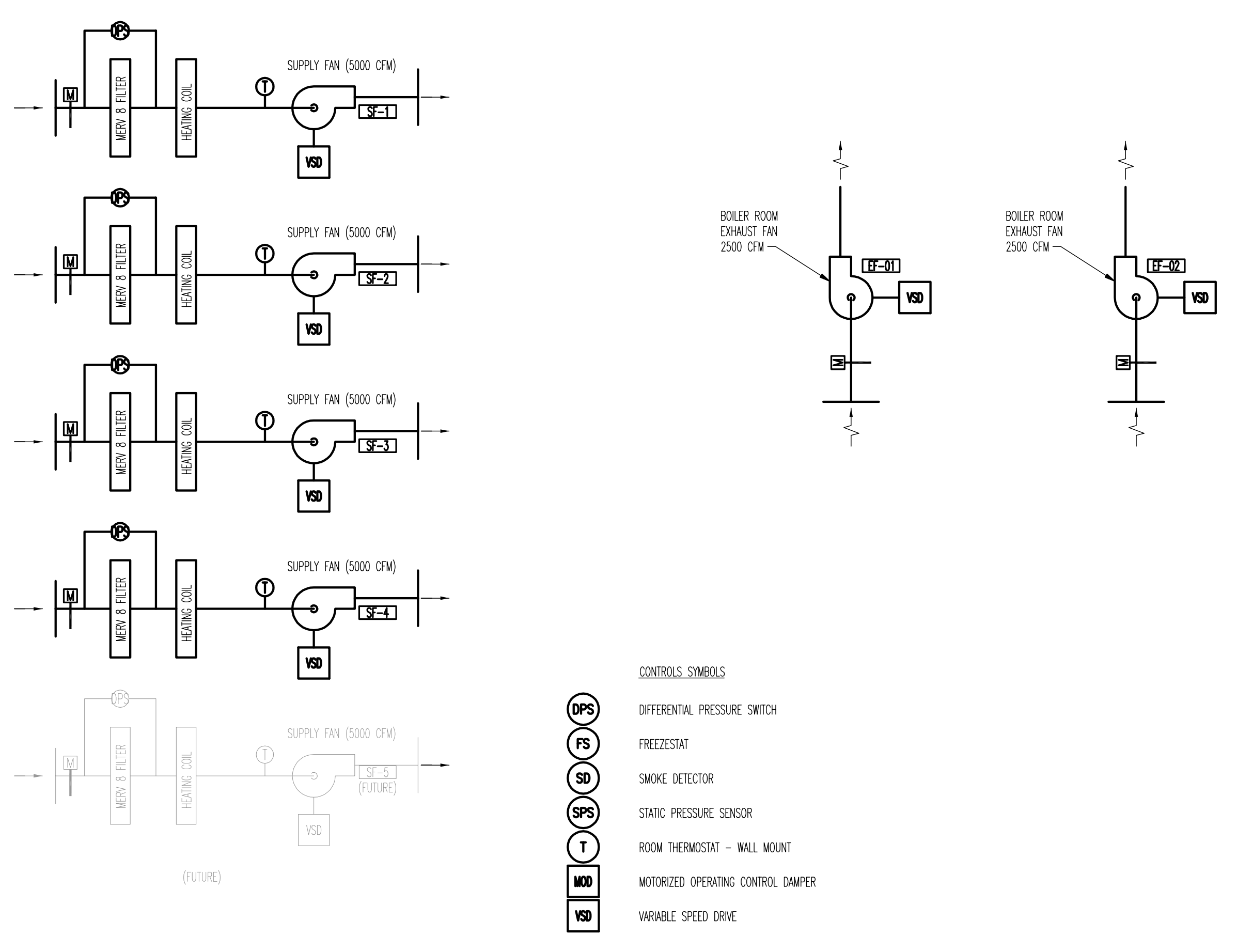
2 M8.01 TRANSFORMER ROOM - AHU AIRFLOW DIAGRAM

SCALE: NONE



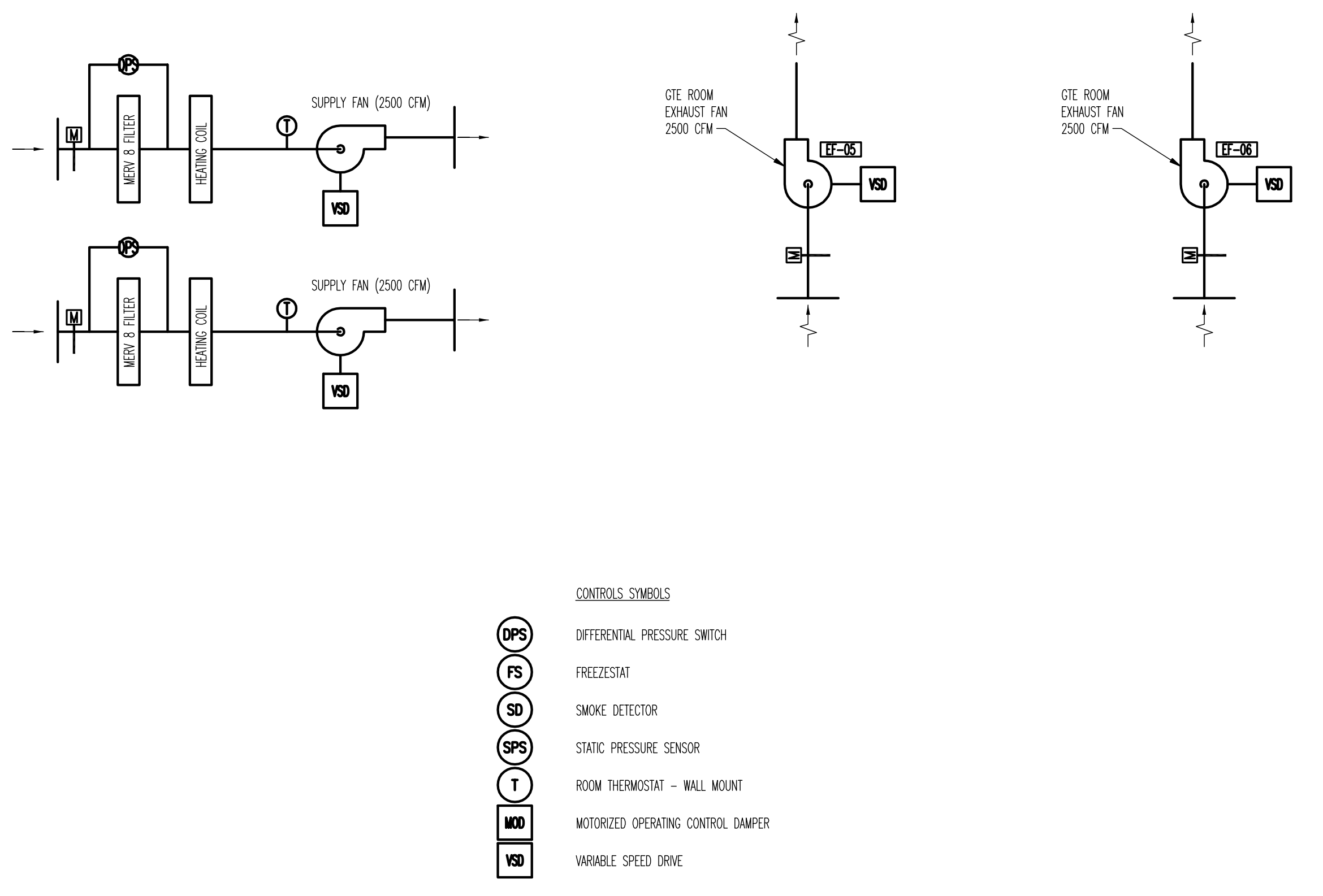
3 M8.01 CHILLER ROOM - AHU AIRFLOW DIAGRAM

SCALE: NONE



4 M8.01 BOILER ROOM - AIRFLOW DIAGRAM

SCALE: NONE



5 M8.01 GTE - AIRFLOW DIAGRAM

SCALE: NONE

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Project/Owner Information

CAPITOL CAMPUS - BAR CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:

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GENERAL

SYMBOL	ABBR	DESCRIPTION
		45
		45 DOWN
		90
	AD	ACCESS DOOR IN CEILING
	AD	ACCESS DOOR IN WALL
		ALIGNMENT GUIDE
		ANCHOR
		AUTOMATIC CONTOL VALVE (3–WAY)
		AUTOMATIC CONTROL VALVE (2–WAY)
		BALANCING VALVE
	BV	BALL VALVE
BOP XX'–XX"	BOP	BOTTOM OF PIPE ELEVATION
		BREAK
	BFV	BUTTERFLY VALVE
		CAP
℄		CENTERLINE
℄ XX'–XX"	CL–EL	CENTERLINE OF PIPE ELEVATION
	CHK	CHECK VALVE
		CIRCUIT SETTER
X X–X		DETAIL TAG
	DN	DOWN
X L–*–* SP*–*		ELEVATION TAG
		FLOW ARROW
		GAS COCK
		GLOBE VALVE
	GV	GATE VALVE
IE XX'–XX"	IE	INVERT PIPE ELEVATION
PITCH 1/X" PER FOOT		PITCH LEFT
PITCH 1/X" PER FOOT		PITCH RIGHT
		PLUG
	POC	POINT OF CONNECTION
	PG	PRESSURE GAUGE
	PRV	PRESSURE REDUCING VALVE
		ROLLING 45 DOWN
		REDUCER
		REDUCING CONCENTRIC
		REDUCING ECCENTRIC
	RV	RELIEF VALVE
X		SHEET NOTE DESIGNATION
		SLEEVE
	SV	SOLENOID VALVE
		TEE DOWN
		TEE
	TH	THERMOMETER
XXXXXXXXX		LONG TAG 9 CHARCTERS MAX
XXXXXX		MEDIUM TAG 6 CHARCTERS MAX
XXXX		SHORT TAG 4 CHARCTERS MAX
TOP XX'–XX"	TOP	TOP OF PIPE ELEVATION
	U	UNION
		UP
●		VERTICAL SLEEVE
		VALVE IN PIPE RISE OR DROP
	STR	WYE TYPE STRAINER

PIPING

SYMBOL	ABBR	DESCRIPTION
	AAV	AUTOMATIC AIR VENT
— BFW —	BFW	BOILER FEED WATER
		BUCKET TRAP
— CA —	CA	CONTROL AIR
— CHR —	CHR	CHILLED WATER RETURN
— CHS —	CHS	CHILLED WATER SUPPLY
— CR —	CR	CONDENSER WATER RETURN
— CS —	CS	CONDENSER WATER SUPPLY
		FLANGE
		FLEX
		FLOAT AND THERMOSTATIC
— FOR —	FOR	FUEL OIL RETURN
— FOS —	FOS	FUEL OIL SUPPLY
— FOV —	FOV	FUEL OIL VENT
— G —	G	NATURAL GAS
— GLR —	GLR	GLYCOL RETURN
— GLS —	GLS	GLYCOL SUPPLY
— HCR —	HCR	HIGH PRESSURE CONDENSATE RETURN
— HG —	HG	HOT GAS
— HPS —	HPS	HIGH PRESSURE STEAM
— HWR —	HWR	HEATING HOT WATER RETURN
— HWS —	HWS	HEATING HOT WATER SUPPLY
— LCR —	LCR	LOW PRESSURE CONDENSATE RETURN
— LPS —	LPS	LOW PRESSURE STEAM
	MAV	MANUAL AIR VENT
— MCR —	MCR	MEDIUM PRESSURE CONDENSATE RETURN
M		METER
— MG —	MG	MEDIUM PRESSURE NATURAL GAS
— MPS —	MPS	MEDIUM PRESSURE STEAM
— PCR —	PCR	PUMPED CONDENSATE RETURN
PI	PI	PRESSURE INDICATOR
— RL —	RL	REFER LIQUID
— RS —	RS	REFER SUCTION
		TEMPERATURE PRESSURE TEST PLUG
TI	TI	TEMPERATURE INDICATOR
TS	TS	TEMPERATURE SENSOR
	VB	VACUUM BREAKER
		VENTURI

ABBREVIATIONS

AC	AIR CONDITIONING UNIT
AF	AIRFOIL
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLING UNIT
AMB	AMBIENT
AMS	AIRFLOW MEASURING UNIT
B	BOILER
BDD	BACKDRAFT DAMPER
BHP	BRAKE HORSEPOWER
BI	BACKWARD INCLINED
BOD	BOTTOM OF DUCT
BOT	BOTTOM
BTUH	BRITISH THERMAL UNIT PER HOUR
CC	COOLING COIL
CFM	CUBIC FEET PER MINUTE
CHLR	CHILLER
CLG	CEILING
CNTFGL	CENTRIFUGAL
COMB	COMBUSTION
COND	CONDENSER / CONDENSATE
CONT	CONTINUE / CONTROL
CONTR	CONTRACTOR
CP	CIRCULATING PUMP
CRAC	COMPUTER ROOM AIR CONDITIONING UNIT
CT	COOLING TOWER
CU	CONDENSING UNIT / CUBIC
Cv	FLOW COEFFICIENT
CV	CONSTANT VOLUME
CWP	CHILLED WATER PUMP
D	DRAIN
DB	DRY BULB / DECIBEL
DEG	DEGREE
DIA	DIAMETER
DIM	DIMENSION
DISCH	DISCHARGE
DMPR	DAMPER
DN	DOWN

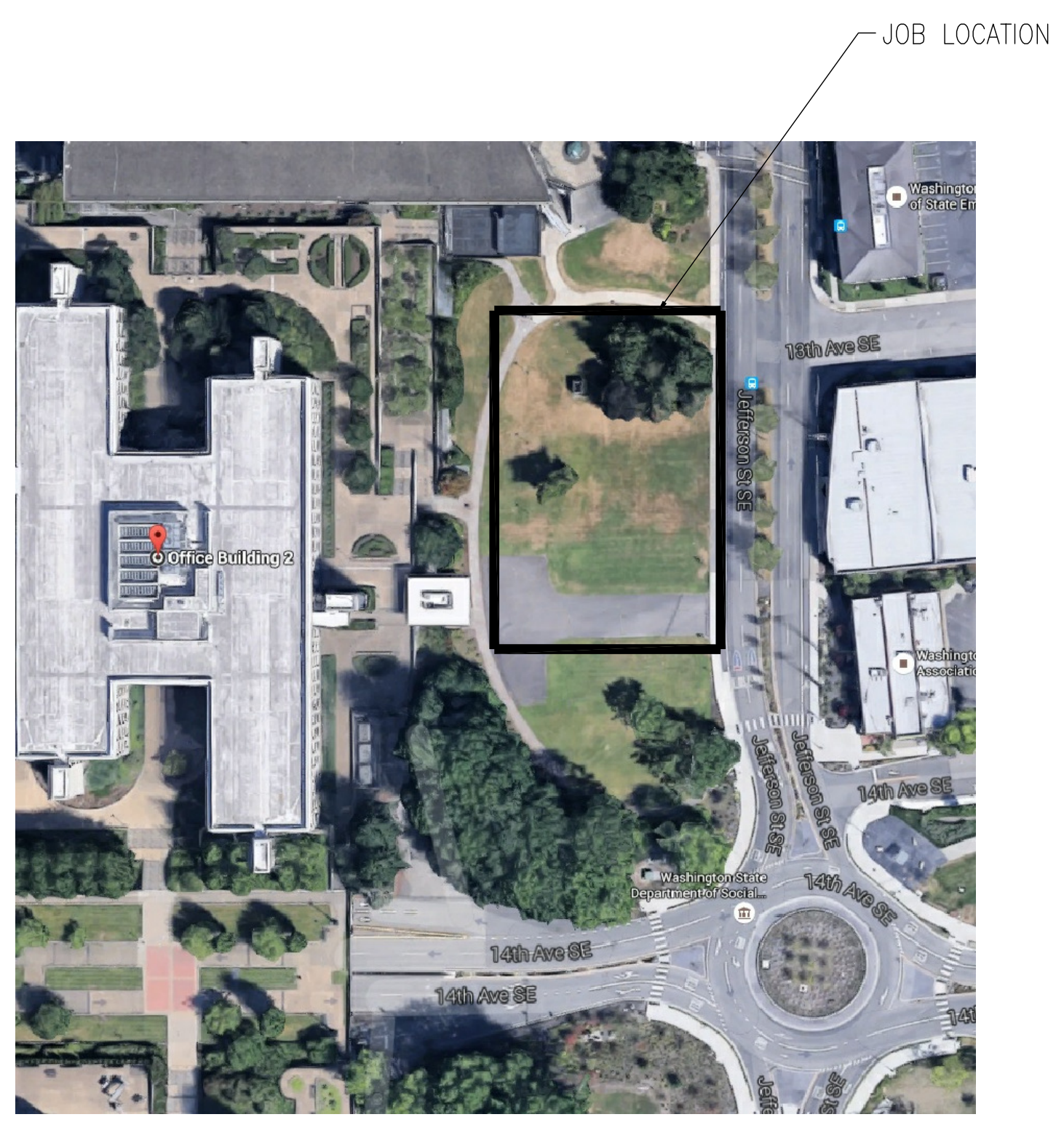
ABBREVIATIONS

EA	EXHAUST AIR
EAT	ENTERING AIR TEMPERATURE
ECONO	ECONOMIZER
EDH	ELECTRIC DUCT HEATER
EER	ENERGY EFFICIENCY RATIO
EF	EXHAUST FAN
EFF	EFFICIENCY
ELEC	ELECTRIC
ELEV	ELEVATION
EQUIV	EQUIVALENT
ESP	EXTERNAL STATIC PRESSURE
EVAP	EVAPORATOR / EVAPORATIVE
EWT	ENTERING WATER TEMPERATURE
EXH	EXHAUST
EXT	EXTERIOR / EXTERNAL
F	FAHRENHEIT
FC	FORWARD CURVE
FCU	FAN COIL UNIT
FD	FIRE DAMPER / FLOOR DRAIN
FLR	FLOOR
FLTR	FILTER
FOIC	FURNISHED BY OWNER INSTALLED BY CONTRACTOR
FPM	FEET PER MINUTE
FSD	FIRE SMOKE DAMPER
FT	FEET
FTU	FAN TERMINAL UNIT
FV	FACE VELOCITY
GA	GAUGE
GAL	GALLONS
GALV	GALVANIZED
GPM	GALLONS PER MINUTE
GWB	GYPSUM WALLBOARD
H	HUMIDIFIER
HC	HEATING COIL
HD	HEAD
HORIZ	HORIZONTAL
HP	HORSEPOWER
HT	HEAT TRACE
HVAC	HEATING, VENTILATING, AND AIR CONDITIONING
HVACDCS	HVAC DUCT CONSTRUCTION STANDARDS, METAL AND FLEXIBLE (SMACNA)
HX	HEAT EXCHANGER
ID	INDIRECT DRAIN / INSIDE DIAMETER
IN	INCH
KW	KILOWATT
L	LONG / LENGTH
LAT	LEAVING AIR TEMPERATURE
LB	POUND
LWT	LEAVING WATER TEMPERATURE
MBH	THOUSAND BTU PER HOUR
MECH	MECHANICAL
MOD	MOTOR OPERATED DAMPER
MTD	MOUNTED
MVD	MANUAL VOLUME DAMPER
NC	NORMALLY CLOSED / NOISE CRITERIA
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN / NUMBER
NTS	NOT TO SCALE
OBD	OPPOSED BLADE DAMPER
OC	ON CENTER
OD	OUTSIDE DIMENSION OR DIAMETER
OSA	OUTSIDE AIR
P	PUMP
PBD	PARALLEL BLADE DAMPER
PD	PRESSURE DROP / PUMPED DRAIN
PL	PLENUM
POC	POINT OF CONNECTION
PT	POST–TENSION SLAB
QD	QUICK DISCONNECT
RA	RETURN AIR
REF	REFERENCE
REV	REVISION
RF	RELIEF FAN
RH	RELATIVE HUMIDITY
RIO	ROUGH–IN ONLY
RPM	REVOLUTIONS PER MINUTE
SA	SUPPLY AIR
SCFM	STANDARD CUBIC FEET PER MINUTE
SCH	SCHEDULE
SECT	SECTION
SENS	SENSIBLE
SF	SUPPLY FAN / SQUARE FOOT
SL	SOUND LINE (INSIDE DUCT INSULATION)
SMACNA	SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION
SP	STATIC PRESSURE
SQ	SQUARE
SS	STAINLESS STEEL
ST	SOUND TRAP
TBV	TOWER BYPASS VALVE
TCV	TEMPERATURE CONTROL VALVE
TDH	TOTAL DYNAMIC HEAD
TOD	TOP OF DUCT
TOS	TOP OF STEEL
TP	TOTAL PRESSURE
TRNSN	TRANSITION
TSP	TOTAL STATIC PRESSURE
TYP	TYPICAL
UBD	UPBLAST DISCHARGE
UH	UNIT HEATER
UNO	UNLESS NOTED OTHERWISE
VA	VALVE
VAV	VARIABLE AIR VOLUME
VD	VOLUME DAMPER
VENT	VENTILATION / VENTILATOR
VEL	VELOCITY
VFO	VARIABLE FREQUENCY CONTROLLER
VI	VIBRATION ISOLATOR
VIV	VARIABLE INLET VANES
W	INSULATED DUCT / WATT / WIDE
WB	WET BULB (TEMPERATURE)
WG	WATER GAUGE
WT	WEIGHT

GENERAL NOTES

1. DRAWINGS ARE SCHEMATIC IN NATURE AND DO NOT SHOW EXACT ROUTING OR ALL TRANSITIONS/CONNECTIONS/OFFSETS REQUIRED.
2. COORDINATE ALL NEW WORK WITH EXISTING STRUCTURE AND HVAC. FIELD VERIFY EXISTING CONDITIONS.
3. PROVIDE CONNECTIONS AND TRANSITIONS AT EQUIPMENT AS REQUIRED.
4. INSTALLATION SHALL COMPLY TO ALL FEDERAL, STATE AND LOCAL CODES.
5. INSULATION OF DUCT WORK AND PIPING SHALL CONFORM TO THE WASHINGTON STATE ENERGY CODE.
6. USE UNISTRUT CONCRETE INSERTS, OR EQUAL, TO SUPPORT MECHANICAL EQUIPMENT OR DUCTWORK FROM THE P.T. SLAB.
7. ALL WORK SHOWN ON THIS PLAN SHALL CONFORM TO THE 2012 INTERNATIONAL MECHANICAL CODE, 2012 UNIFORM PLUMBING CODE, AND 2012 WASHINGTON STATE ENERGY CODE.

VICINITY MAP



MECHANICAL INDEX OF DRAWINGS

Issue:
No. Rev. Desc. Date

Project/Owner Information
CAPITOL CAMPUS - CONE CONFIGURATION
NEW DISTRICT ENERGY PLANT
Project Address:
OLYMPIA, WA.
Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

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Sheet No.	M0.01

DUCT INSULATION SCHEDULE

DUCT TYPE [7,8]	LOCATION	TEMP RANGE (DEGREES F)	INSULATION R-VALUE REQUIREMENT	INSULATION TYPE
OUTSIDE AIR [1,2,9]	UPSTREAM OF DAMPER [3]	ALL	R-18 [4]	FIBERGLASS
	DOWNSTREAM OF DAMPER, UNCONDITIONED SPACE	ALL	R-6	FIBERGLASS
	DOWNSTREAM OF DAMPER, CONDITIONED SPACE	ALL	R-8	FIBERGLASS
SUPPLY AIR [5,6,9]	UNCONDITIONED SPACE	ALL	R-6	FIBERGLASS
	OUTSIDE THE BUILDING	ALL	R-8	FIBERGLASS
	CONDITIONED SPACE	<55 OR >105	R-3.3	FIBERGLASS
	CONDITIONED SPACE	55-105	NONE	NA
RETURN AIR [5,6]	UNCONDITIONED SPACE	ALL	R-6 [6]	FIBERGLASS
	CONDITIONED SPACE	NA	NONE [10]	NA
	OUTSIDE THE BUILDING	ALL	R-8	FIBERGLASS
EXHAUST AIR	UPSTREAM OF DAMPER	ALL	NONE	NA
	DOWNSTREAM OF DAMPER [3]	ALL	R-18 [4]	FIBERGLASS

COMPLIANT WITH 2012 WA STATE ENERGY CODE, COMMERCIAL PROVISIONS (WSEC) AND 2012 SEATTLE COMMERCIAL ENERGY CODE (SCEC) WITH UPDATES THROUGH 2015.

NOTES:

1. OUTSIDE AIR DUCTS SERVING INDIVIDUAL SUPPLY AIR UNITS WITH LESS THAN 2,800 CFM TOTAL SUPPLY ONLY NEED R-7 INSULATION.
2. NOT REQUIRED IN UNHEATED EQUIPMENT ROOMS WITH COMBUSTION AIR LOUVERS PROVIDED THE ROOM IS ISOLATED FROM CONDITIONED SPACE WITH R-11 INSULATION.
3. INSULATE BETWEEN EXTERIOR ENVELOPE (WALL OR ROOF PENETRATION) AND ISOLATION DAMPER.
4. MINIMUM R-VALUE FOR OUTSIDE AIR DUCTS IS SAME AS FOR METAL FRAMED WALL PER TABLE C402.1.2. R-18 MEETS THIS EXTERIOR WALL REQUIREMENT FOR CLIMATE ZONES 4 AND 5. KING COUNTY IS ZONE 4C. USE R-21 FOR ZONE 6: FERRY, OKANOGAN, PEND OREILLE, AND STEVENS COUNTIES.
5. INSULATION NOT REQUIRED FOR DUCTWORK WITHIN EQUIPMENT.
6. FOR EXAMPLE, ABOVE CEILING PLENUMS WITH DUCTED RETURN ARE CONSIDERED UNCONDITIONED SPACE; HOWEVER, WHERE DESIGN TEMPERATURE DIFFERENCE BETWEEN THE INTERIOR AND EXTERIOR OF THE DUCT OR PLENUM DOES NOT EXCEED 15 F, NO INSULATION IS REQUIRED.
7. INSULATION FOR PLENUMS SHALL BE THE SAME AS ABOVE FOR DUCTS, DEPENDING ON SERVICE. REFER TO OUTSIDE AIR, SUPPLY, RETURN, OR EXHAUST SERVICE.
8. PROVIDE ALL SERVICE JACKET FOR ALL DUCTS, EXCEPT PROVIDE WEATHERPROOF ALUMINUM JACKET FOR DUCTS OUTSIDE THE BUILDING.
9. PROVIDE VAPOR-RETARDER MASTIC ON SUPPLY AIR AND OUTSIDE AIR DUCTS AND PLENUMS.
10. RETURN AIR PLENUMS WITH PERMANENT OPENINGS TO CONDITIONED SPACE ARE CONSIDERED CONDITIONED SPACE.

PIPE INSULATION SCHEDULE

INSULATION SPEC	PIPING SYSTEM	TEMP RANGE (DEGREES F)	CONDUCTIVITY BTU*IN/ (HR*FT^2*F)	MEAN RATING TEMP (DEGREES F)	INSULATION TYPE	VAPOR BARRIER REQUIRED?	PIPE INSERT NOTE	PIPE SIZE				
								<1"	1" TO <1 1/2"	1 1/2" TO <4"	4" TO <8"	8" & OVER
DOMESTIC COLD	DOMESTIC COLD NON-POTABLE COLD	ALL	0.21 - 0.27	75	FIBERGLASS	YES [11]	A	1/2" [6]	1/2" [6]	1"	1"	1-1/2"
DOMESTIC HOT [1]	DOMESTIC HOT NON-POTABLE HOT	105-140	0.21 - 0.28	100	FIBERGLASS	NO	B	1"	1"	1-1/2"	1-1/2"	1-1/2"
STORM DRAIN [2,3]	STORM DRAIN	ALL	0.21 - 0.27	75	FIBERGLASS	YES [11]	B	1"	1"	1"	1"	1"
HEATING WATER [4]	HEATING WATER - LOW TEMP	105-140	0.21 - 0.28	100	FIBERGLASS	NO	C	1"	1"	1-1/2"	1-1/2"	1-1/2"
	HEATING WATER - HIGH TEMP	141-200	0.25 - 0.29	125	FIBERGLASS	NO	C	1-1/2"	1-1/2"	2"	2"	2"
CHILLED WATER [4]	CHILLED WATER	40-60	0.21 - 0.27	75	FIBERGLASS	YES	D	1/2" [6]	1/2" [6]	1"	1"	1"
CONDENSER WATER [4,5]	CONDENSER WATER	40-60	0.21 - 0.27	75	FIBERGLASS	YES [7]	E	1/2" [6]	1/2" [6]	1"	1"	1"
GENERATOR EXHAUST [8]	GENERATOR EXHAUST	UP TO 1100	0.45	300	CAL-SIL	NO	G	3"	3"	3"	3"	3"
REFRIGERATION [9]	REFRIGERATION SUCTION	<40	0.20 - 0.26	75	ELASTOMERIC	YES	H	1/2" [6]	1"	1"	1"	1-1/2"
CONDENSATE DRAIN [10]	COIL CONDENSATE DRAIN	ALL	0.20 - 0.26	75	ELASTOMERIC	YES	H	1/2" [6]	1/2" [6]	1"	1"	1"

COMPLIANT WITH 2012 WA STATE ENERGY CODE, COMMERCIAL PROVISIONS (WSEC) AND 2012 SEATTLE COMMERCIAL ENERGY CODE (SCEC) WITH UPDATES THROUGH 2015.

NOTES:

1. INSULATE DOMESTIC HOT WATER RECIRCULATION PIPING. DO NOT USE INSERTS – INSULATE AROUND HANGER. (UMC STANDARD)
2. INSULATE ALL HORIZONTAL STORM DRAIN PIPING INSTALLED IN CONDITIONED SPACE, INCLUDING PIPING FROM LOWER ROOFS AND DECKS. INSULATE ROOF DRAIN BODIES. (UMC STANDARD)
3. INSULATE FIRST 20 FEET OF HORIZONTAL OVERFLOW STORM DRAIN PIPING INSTALLED IN CONDITIONED SPACE, INCLUDING PIPING FROM LOWER ROOFS AND DECKS. INSULATE ROOF DRAIN BODIES. (UMC STANDARD)
4. PIPING THAT IS PART OF A HEATING OR COOLING SYSTEM CONVEYING FLUIDS BETWEEN 60 F AND 105 F DOES NOT REQUIRE INSULATION. (WSEC 2012)
5. IF EXPOSED CONDENSER WATER PIPING IS USED FOR HEATING AND IS BETWEEN 60 F AND 105 F, INSULATE ALL GROOVED PIPE JOINTS BUT NOT THE PIPE RUN – IN OCCUPIED AREAS ONLY.
6. MINIMUM THICKNESS OF 1/2" IS REQUIRED BY CODE FOR THIS PIPE SIZE. 1" THICK INSULATION IS ALSO ACCEPTABLE AT NO ADDED COST IF PREFERRED BY SUBCONTRACTOR.
7. VAPOR BARRIER REQUIRED ONLY IF CONDENSER WATER IS 60 F OR BELOW.
8. GENERATOR EXHAUST INSULATION IS FOR PERSONNEL PROTECTION – THICKNESS IS NOT DRIVEN BY ENERGY CODE.
9. VERIFY REQUIREMENTS FOR REFRIGERANT SUCTION LINES FOR EACH APPLICATION.
10. INSULATE COIL CONDENSATE PIPING WHERE LOCATED IN CONDITIONED SPACE OR ABOVE CEILING OF CONDITIONED SPACE.
11. IT IS ACCEPTABLE FOR HANGER TO PENETRATE VAPOR BARRIER AT TOP OF PIPE FOR COLD WATER AND STORM DRAIN SYSTEMS.

OTHER GENERAL RULES:

- INSULATE ALL DIRECT BURIED PIPE UNLESS FLUID TEMPERATURE IS 60 F OR BELOW. (WSEC 2012)
- FIELD APPLIED JACKETS:
  - PROVIDE PVC JACKETS IN MECHANICAL ROOMS FROM FLOOR TO 8 FEET ABOVE FLOOR.
  - PROVIDE WEATHERPROOF ALUMINUM JACKETS FOR OUTDOOR INSTALLATIONS.
  - PROVIDE STAINLESS STEEL JACKETS FOR EXPOSED PIPING IN FOOD PREPARATION AREAS.
- FOR ELASTOMERIC PIPING OUTDOORS:
  - PROVIDE UV PROTECTION. PAINT INSULATION WITH 2 COATS OF "WB ARMAFLEX FINISH."
  - WHERE ADDITIONAL PHYSICAL PROTECTION IS REQUIRED, PROVIDE PVC COVER IN LIEU OF UV-RESISTANT PAINT. BASIS OF DESIGN: AIREX MANUFACTURING, INC., MODEL E-FLEX GUARD OR AS APPROVED.
- INSULATE AND HEAT TRACE ALL GREASE WASTE PIPING. POSITION HEAT TRACE EITHER ABOVE AND BELOW, ONE AT THE BOTTOM, OR TWO AT THE BOTTOM CENTERED ON LOWER QUARTER RADIUS.
- DO NOT INSULATE FUEL OIL PIPING.

THERMAL HANGER SHIELD INSERT NOTES:

A. PROVIDE THERMAL INSERTS FOR ALL DOMESTIC COLD WATER PIPING 3" AND LARGER. INSULATE AROUND HANGERS FOR CW PIPING 2-1/2" AND SMALLER.
B. THERMAL INSERTS NOT REQUIRED FOR THIS PIPING SYSTEM. INSULATE AROUND THE HANGERS WHERE INSULATION IS REQUIRED.
C. PROVIDE THERMAL INSERTS FOR HEATING WATER PIPING 2-1/2" AND LARGER. INSULATE AROUND THE HANGERS FOR PIPING SMALLER THAN 2-1/2".
D. PROVIDE THERMAL INSERTS FOR ALL CHILLED WATER PIPING.
E. PROVIDE THERMAL INSERTS FOR CONDENSER WATER PIPING ONLY WHERE INSULATED AND BELOW 60 F OR ABOVE 105 F.
F. PROVIDE THERMAL INSERTS FOR ALL STEAM AND STEAM CONDENSATE PIPING. USE POLYISOCYANURATE INSERT UP TO 292 F/ 45 PSIG. USE CALCIUM-SILICATE INSERT ABOVE 292 F/ 45 PSIG.
G. PROVIDE THERMAL INSERTS FOR ALL ENGINE EXHAUST PIPING, UNLESS PRE-MANUFACTURED DOUBLE-WALL CHIMNEY IS USED.
H. PROVIDE THERMAL SHIELD INSERTS FOR ELASTOMERIC INSULATION OR USE WOOD DOWEL INSERTS WHERE REQUIRED PER MANUFACTURER'S INSTRUCTIONS. FOR SMALL PIPING (<=1-1/4") WITH ELASTOMERIC INSULATION, INSERTS AND DOWELS MAY NOT BE REQUIRED, BUT DO NOT CRUSH INSULATION OR COMPROMISE THE VAPOR BARRIER.

Issue:

No.	Rev. Desc.	Date
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Project/Owner Information

CAPITOL CAMPUS - CONE CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:
OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

Legal

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We Build Value

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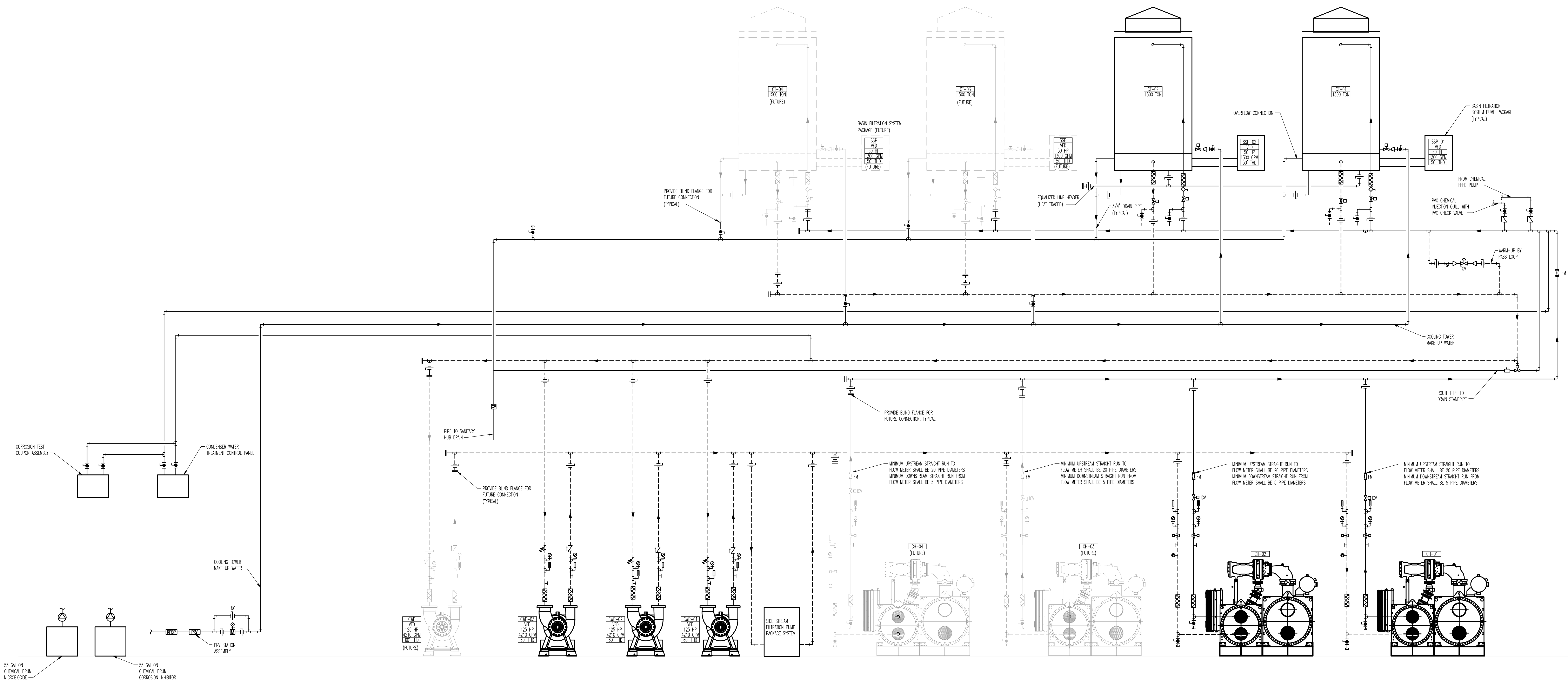

CENTRAL PLANT - CONDENSER WATER PIPING DIAGRAM

SCALE: NONE

Issue:

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Project/Owner Information

CAPITOL CAMPUS
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

Legal

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Title CENTRAL PLANT - CONDENSER WATER PIPING DIAGRAM

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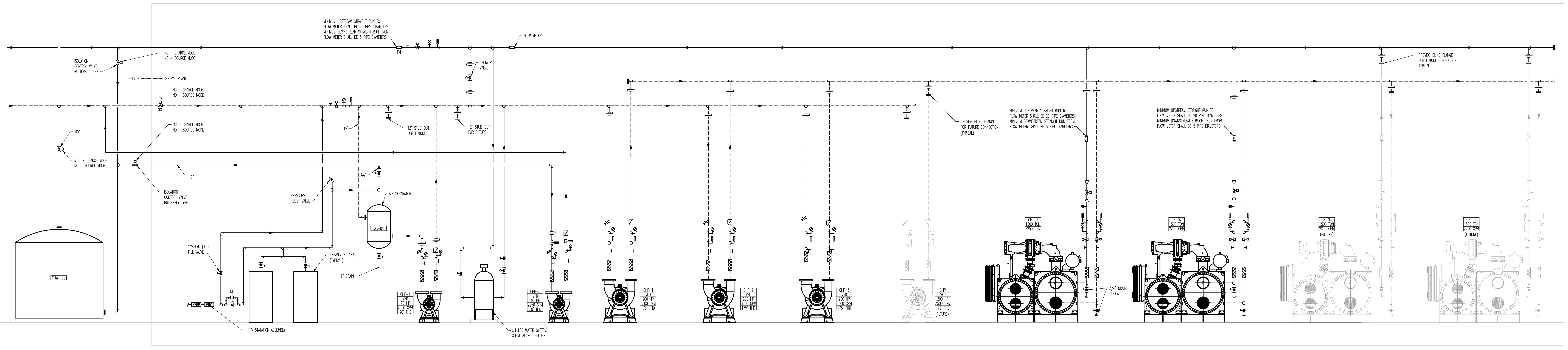

CENTRAL PLANT - CHILLED WATER PIPING DIAGRAM

SCALE: NONE

Issue:

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Project/Owner Information

CAPITOL CAMPUS
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: **DEPARTMENT OF ENTERPRISE SERVICES**

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Title CENTRAL PLANT - CHILLED WATER PIPING DIAGRAM

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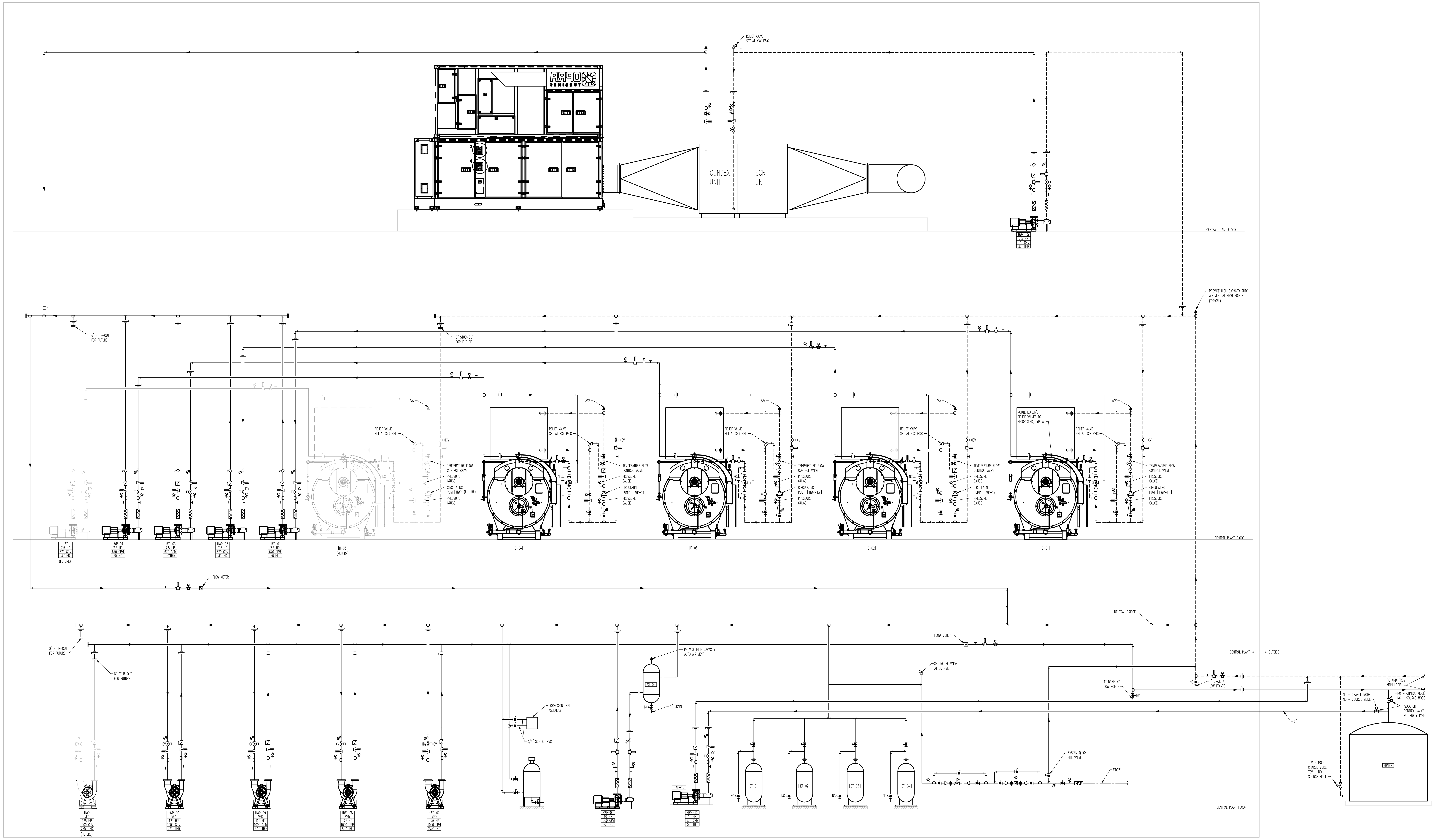

CENTRAL PLANT - HEATING WATER PIPING DIAGRAM

SCALE: NONE

Issue:

No.	Rev. Desc.	Date

Title CENTRAL PLANT - HEATING WATER PIPING DIAGRAM

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NEW DISTRICT ENERGY PLANT

Project Address:
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Owner: DEPARTMENT OF ENTERPRISE SERVICES

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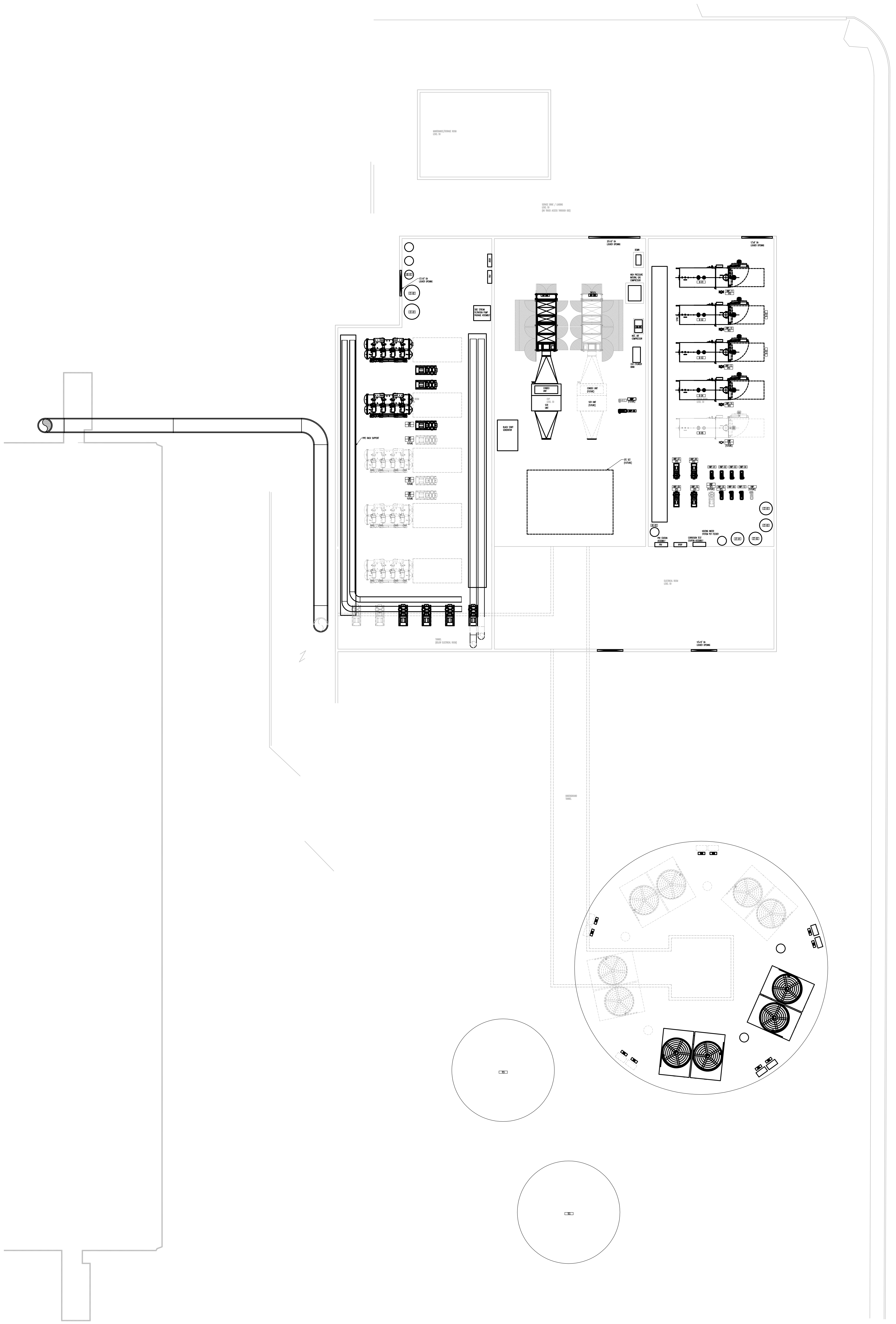
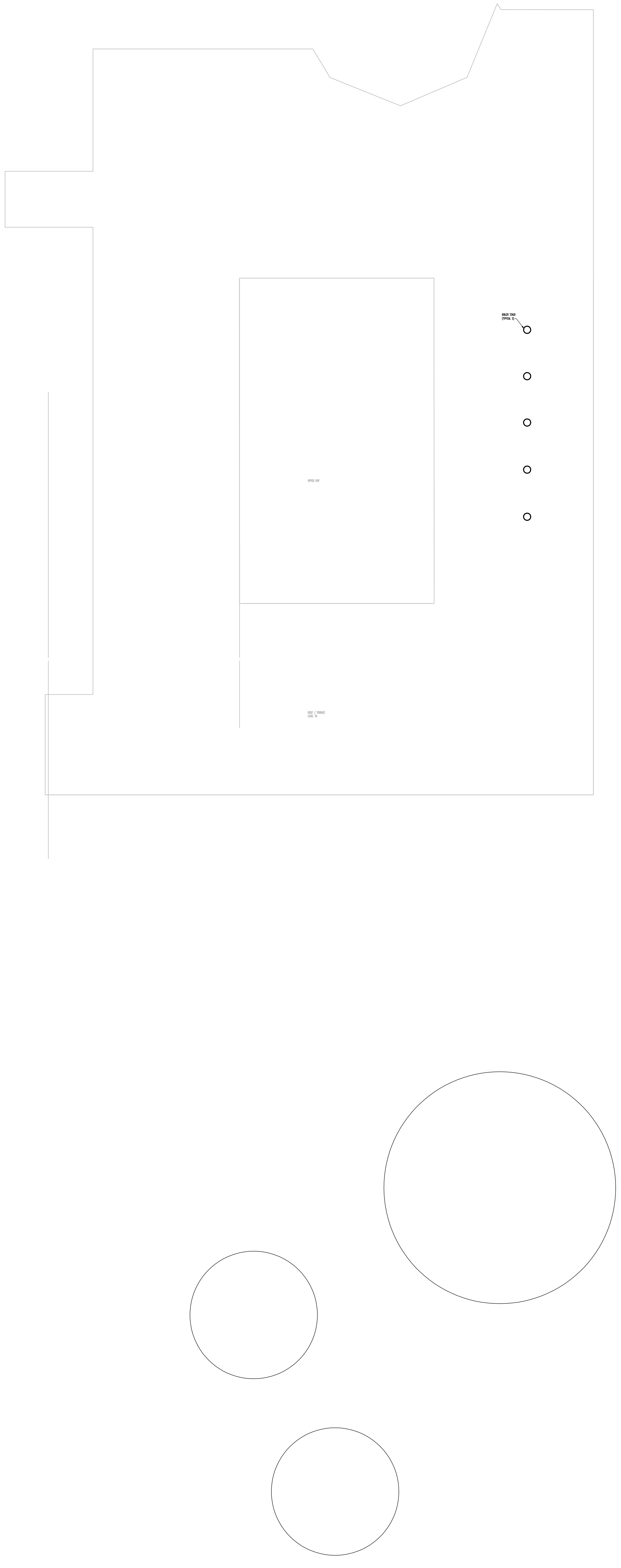


CENTRAL PLANT - LEVEL 50

SCALE: 1/16" = 1'-0"



CENTRAL PLANT - LEVEL 79

SCALE: 1/16" = 1'-0"

Issue: No.	Rev. Desc.	Date
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CAPITOL CAMPUS - CONE CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:
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Job No. 6693
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Sheet No.
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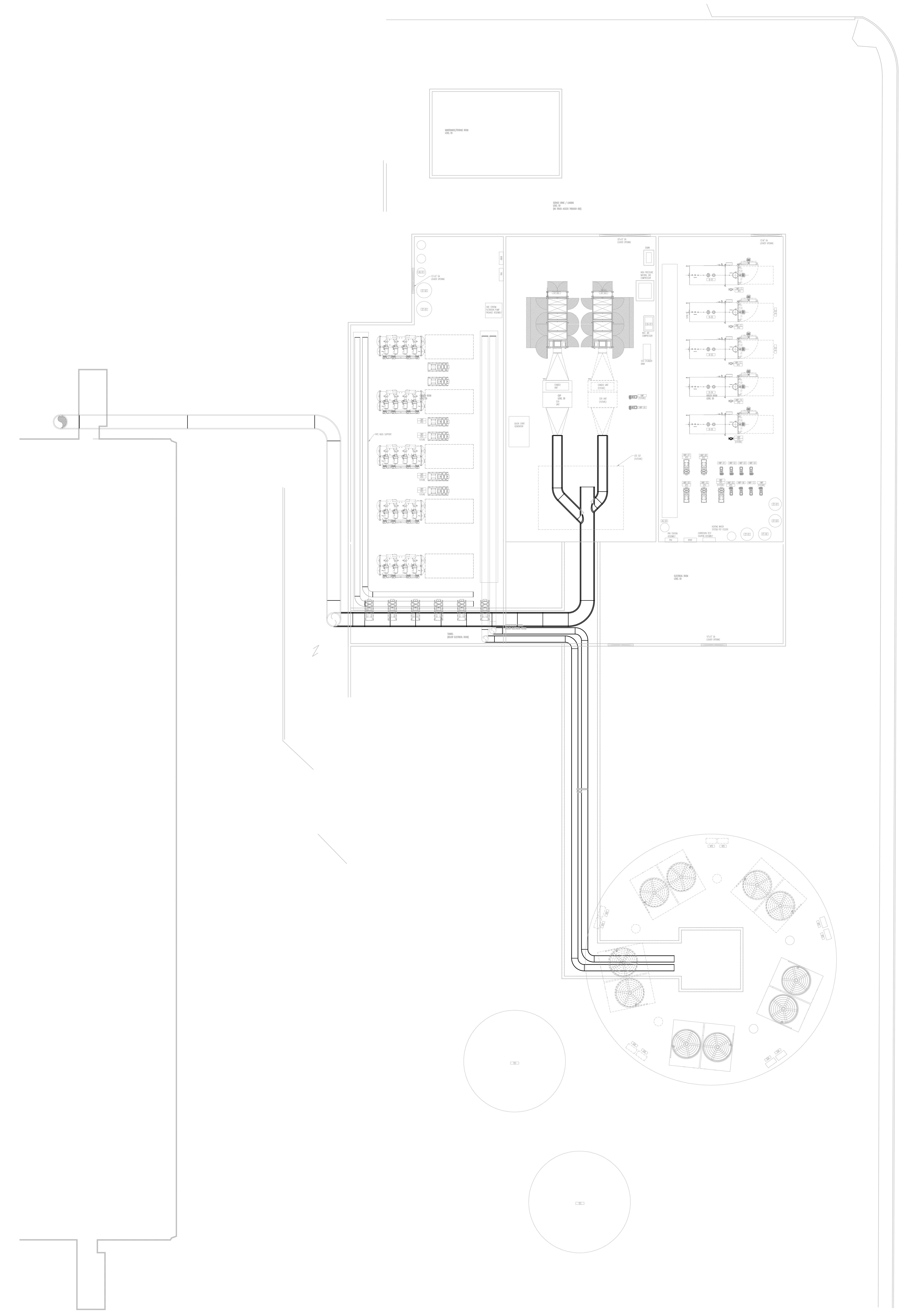

CENTRAL PLANT - LOWER LEVEL- CONE LAYOUT

SCALE: 1/16" = 1'-0"

Issue:

No.	Rev. Desc.	Date

Title CENTRAL PLANT - LOWER LEVEL - CONE LAYOUT

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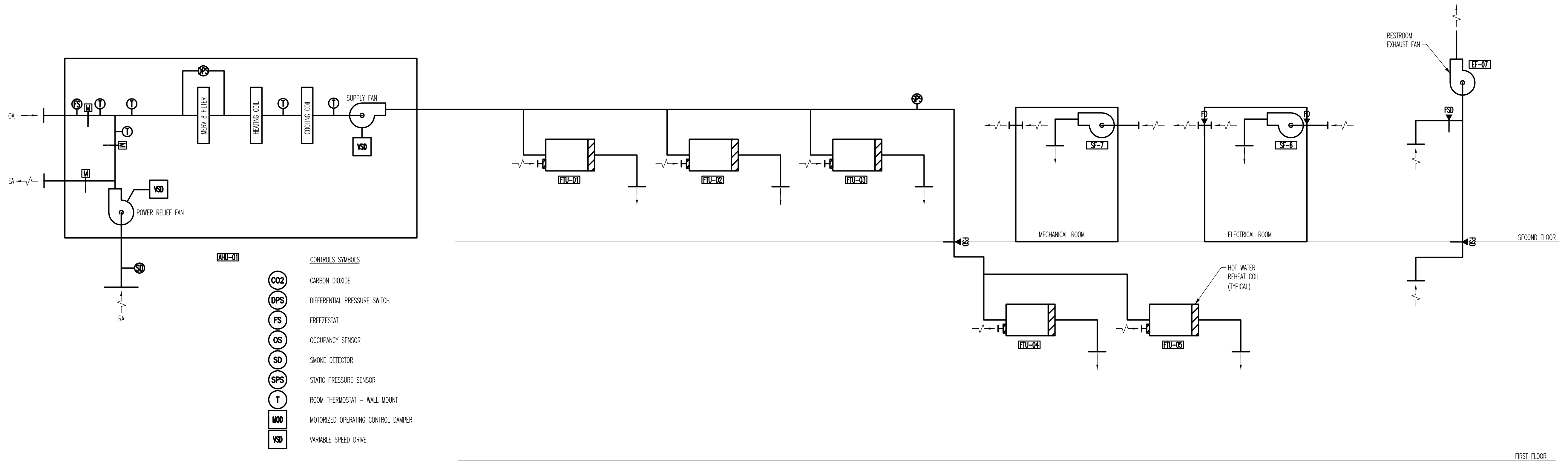


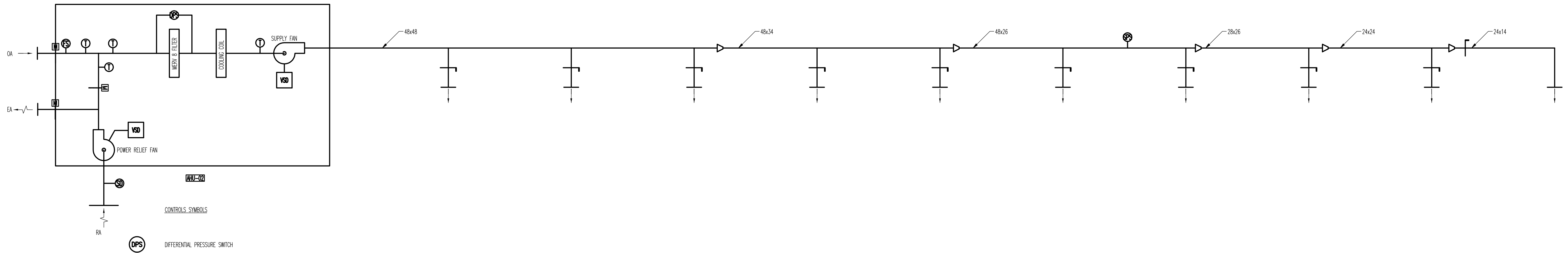
CONTROLS SYMBOLS

CO2	CARBON DIOXIDE
DPS	DIFFERENTIAL PRESSURE SWITCH
FS	FREEZESTAT
OS	OCCUPANCY SENSOR
SD	SMOKE DETECTOR
SPS	STATIC PRESSURE SENSOR
T	ROOM THERMOSTAT – WALL MOUNT
MOD	MOTORIZED OPERATING CONTROL DAMPER
VSD	VARIABLE SPEED DRIVE

1 OFFICE - AIRFLOW DIAGRAM

M8.01

SCALE: NONE



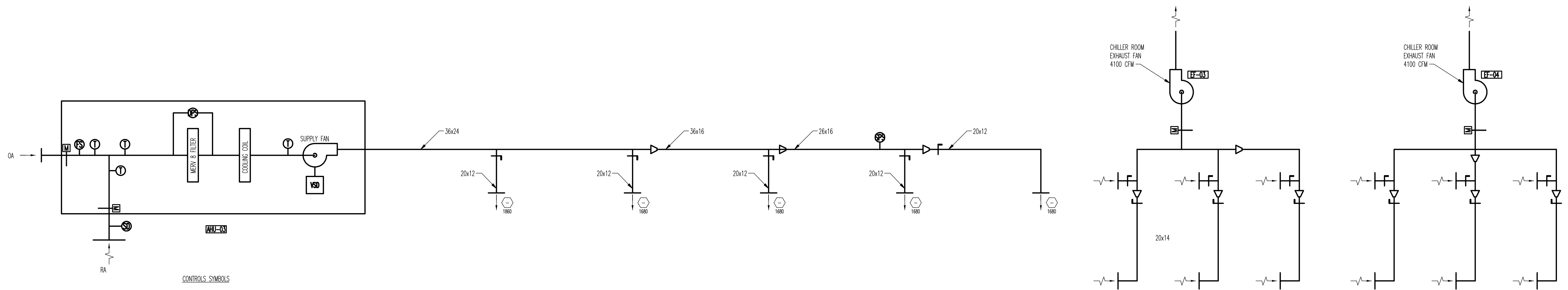
CONTROLS SYMBOLS

DPS	DIFFERENTIAL PRESSURE SWITCH
FS	FREEZESTAT
SD	SMOKE DETECTOR
SPS	STATIC PRESSURE SENSOR
T	ROOM THERMOSTAT – WALL MOUNT
MOD	MOTORIZED OPERATING CONTROL DAMPER
VSD	VARIABLE SPEED DRIVE

2 TRANSFORMER ROOM - AHU AIRFLOW DIAGRAM

M8.01

SCALE: NONE



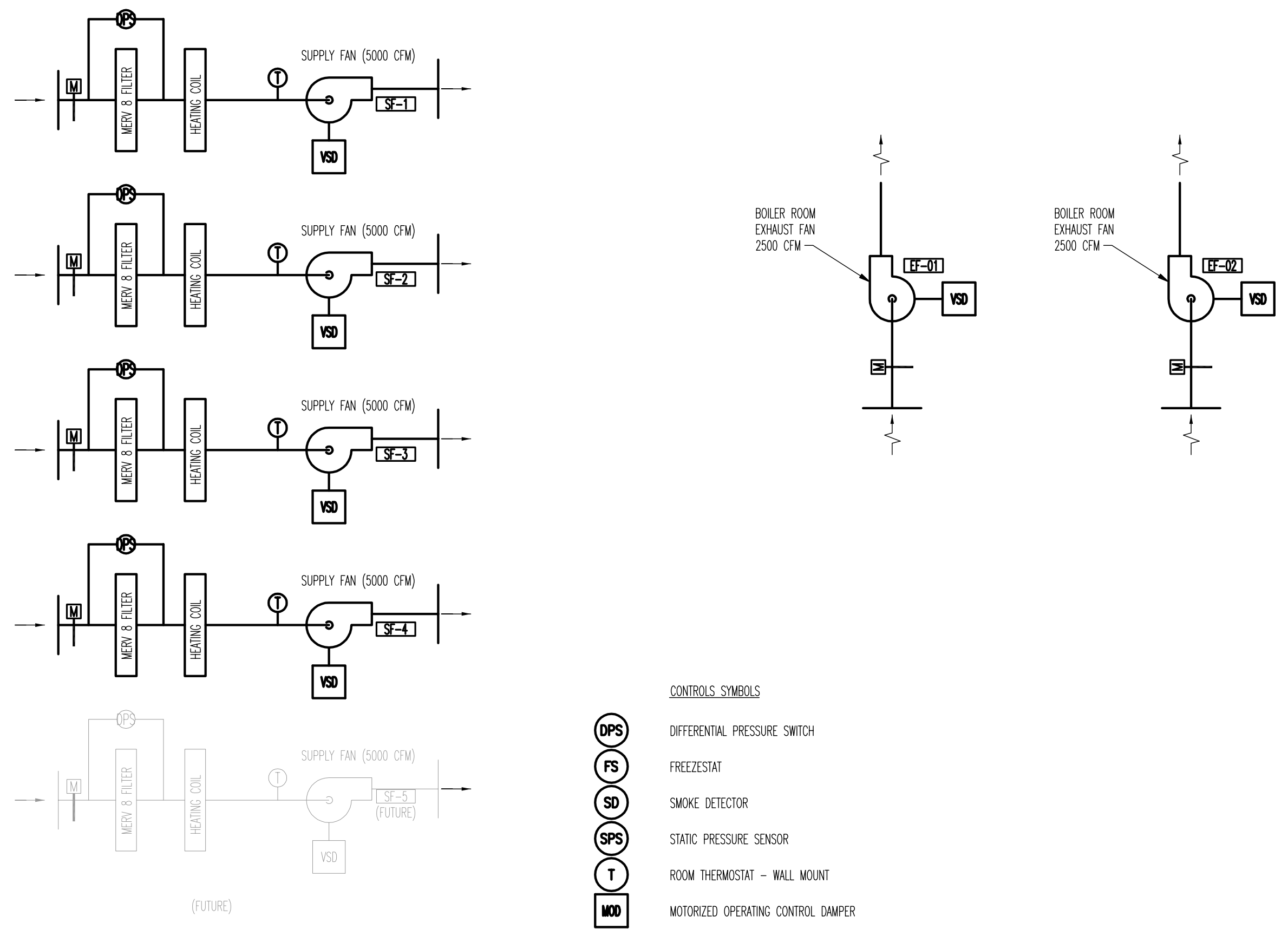
CONTROLS SYMBOLS

DPS	DIFFERENTIAL PRESSURE SWITCH
FS	FREEZESTAT
OS	OCCUPANCY SENSOR
SD	SMOKE DETECTOR
SPS	STATIC PRESSURE SENSOR
T	ROOM THERMOSTAT – WALL MOUNT
MOD	MOTORIZED OPERATING CONTROL DAMPER
VSD	VARIABLE SPEED DRIVE

3 CHILLER ROOM - AHU AIRFLOW DIAGRAM

M8.01

SCALE: NONE



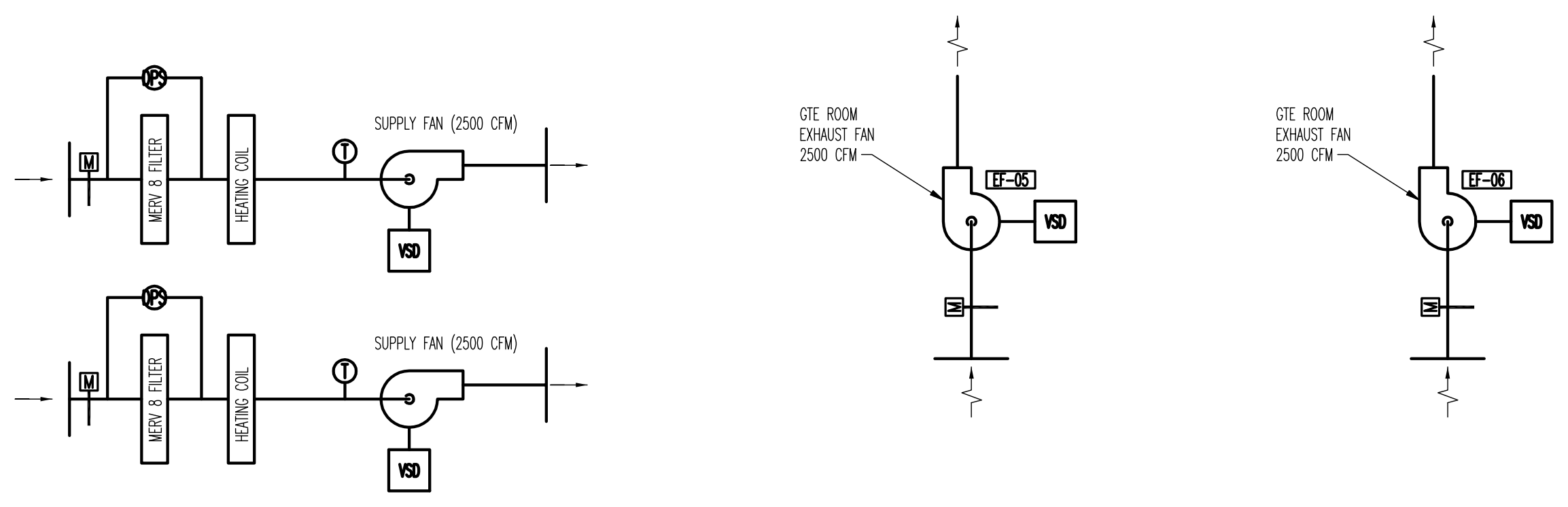
CONTROLS SYMBOLS

DPS	DIFFERENTIAL PRESSURE SWITCH
FS	FREEZESTAT
SD	SMOKE DETECTOR
SPS	STATIC PRESSURE SENSOR
T	ROOM THERMOSTAT – WALL MOUNT
MOD	MOTORIZED OPERATING CONTROL DAMPER
VSD	VARIABLE SPEED DRIVE

4 BOILER ROOM - AIRFLOW DIAGRAM

M8.01

SCALE: NONE



CONTROLS SYMBOLS

DPS	DIFFERENTIAL PRESSURE SWITCH
FS	FREEZESTAT
SD	SMOKE DETECTOR
SPS	STATIC PRESSURE SENSOR
T	ROOM THERMOSTAT – WALL MOUNT
MOD	MOTORIZED OPERATING CONTROL DAMPER
VSD	VARIABLE SPEED DRIVE

5 GTE - AIRFLOW DIAGRAM

M8.01

SCALE: NONE

Date

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Issue:

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Project/Owner Information

CAPITOL CAMPUS - CONE CONFIGURATION
NEW DISTRICT ENERGY PLANT

Project Address:

OLYMPIA, WA.

Owner: DEPARTMENT OF ENTERPRISE SERVICES

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Title AIRFLOW RISER DIAGRAMS

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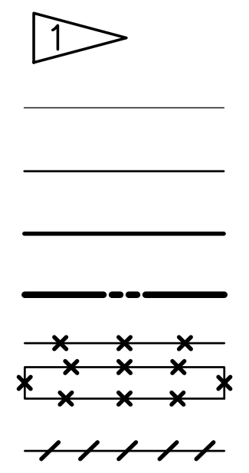
Drawn By	UMC
Checked By	TEB
Original Issue Date	XX-XX-XXXX
Job No.	6693
Scale	NONE
Sheet No.	M8.01

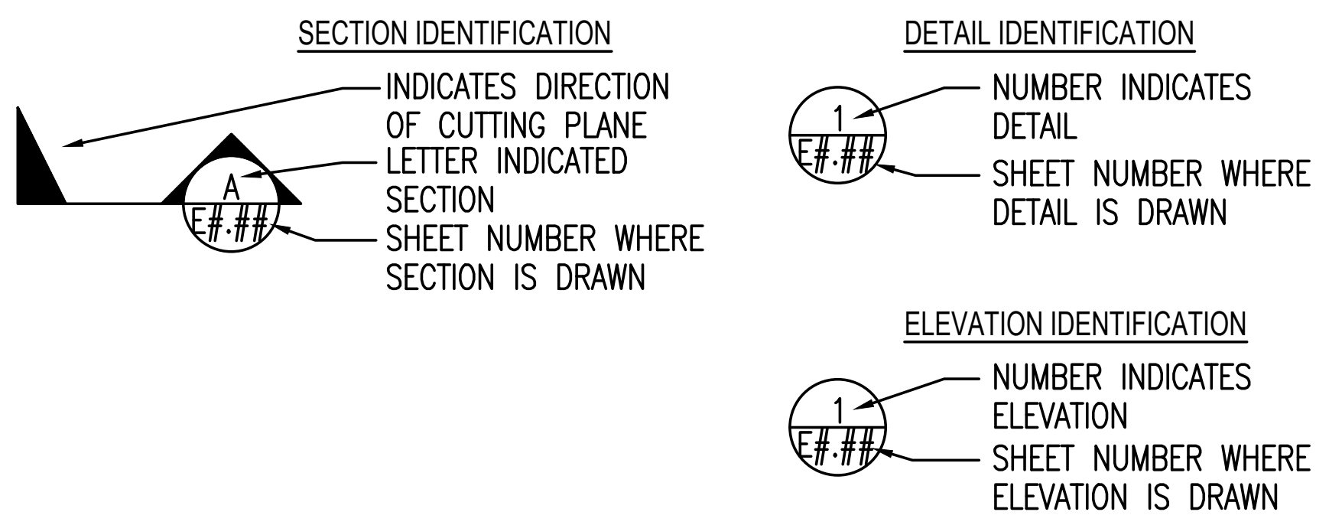
IF SHEET IS LESS THAN
30"x42"
IT IS A REDUCED PRINT
SCALE REDUCED ACCORDINGLY

GENERAL SYMBOLS



- SHEET NOTE
- LIGHT LINE INDICATES BACKGROUND
- LIGHT LINE INDICATES EXISTING WORK
- HEAVY LINE INDICATES NEW WORK
- MATCHLINE OR PROPERTY LINE
- LIGHT LINE WITH HEAVY X INDICATES EXISTING WORK TO BE REMOVED
- EXISTING WORK TO BE ABANDONED

DETAILS



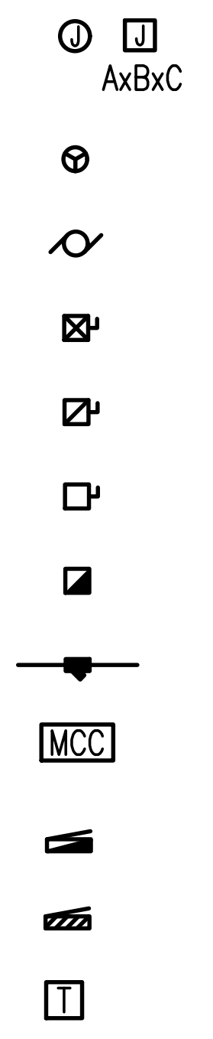
RACEWAYS

———————	CONDUITS CONCEALED IN CONSTRUCTION IN FINISHED AREAS, EXPOSED IN UNFINISHED AREAS
— — — — —	CONDUIT CONCEALED IN OR UNDER FLOOR SLAB

RACEWAYS - INDICATORS

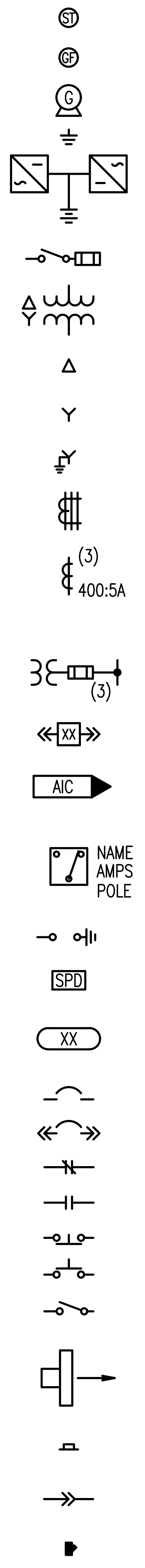
2"C 4#1 + 1#6 GND	INDICATES TRADE SIZE 2" CONDUIT WITH (4) #1 AWG AND (1) #6 AWG GROUND
(2) 2"C 4#1 + 1#6 GND	INDICATES (2) TRADE SIZE 2" CONDUITS WITH (4) #1 AWG AND (1) #6 AWG GROUND CONDUCTORS IN EACH CONDUIT

POWER



- JUNCTION BOX. "AxBxC" INDICATES DIMENSION OF JUNCTION BOX IN EITHER INCHES OR CENTIMETERS
- EQUIPMENT CONNECTION
- MOTOR CONNECTION, SIZE AND VOLTAGE AS INDICATED
- COMBINATION MOTOR STARTER AS SCHEDULED
- FUSED DISCONNECT SWITCH
- UNFUSED DISCONNECT SWITCH
- ENCLOSED CIRCUIT BREAKER CURRENT RATING AS NOTED, 30A–3P UNLESS NOTED
- CONDUIT SEAL
- MOTOR CONTROL CENTER (SIZED TO SCALE)
- PANELBOARD – 240V OR 208V LIGHTING OR POWER PANEL (SIZED TO SCALE)
- PANELBOARD – 480V LIGHTING OR POWER PANEL (SIZED TO SCALE)
- TRANSFORMER (SIZED TO SCALE)

DIAGRAM



- SHUNT TRIP
- GROUND FAULT ALARM
- GENERATOR
- GROUND
- UPS STATION BATTERY
- FUSED DISCONNECT SWITCH
- POWER TRANSFORMER
- DELTA CONNECTION
- WYE
- GROUNDED WYE
- ZERO SEQUENCE CT
- CT TRANSFORMER
  SUBSCRIPT INDICATES:
  3 = QUANTITY
  400:5A = RATIO
- PT TRANSFORMER
  SUBSCRIPT INDICATES: QUANTITY
- MEDIUM VOLTAGE DRAWOUT BREAKER
- AVAILABLE FAULT CURRENT
- AUTOMATIC TRANSFER SWITCH
- SURGE ARRESTOR
- SURGE PROTECTIVE DEVICE
- FEEDER CALLOUT
- CIRCUIT BREAKER
- CIRCUIT BREAKER DRAWOUT
- CONTACT, NORMALLY CLOSED (N.C.)
- CONTACT, NORMALLY OPEN (N.O.)
- PUSHBUTTON, NORMALLY CLOSED (N.C.)
- PUSHBUTTON, NORMALLY OPEN (N.O.)
- DISCONNECT SWITCH
- ELECTRICAL UNIT HEATER
- WALL CONNECTION
- SEPARABLE CONNECTOR
- CONDUIT SEAL

ABBREVIATIONS

A	AMPS
AC	ALTERNATING CURRENT
ADA	AMERICANS WITH DISABILITIES ACT
AHU	AIR HANDLING UNIT
AIC	AMPS INTERRUPTING CAPACITY
AFF	ABOVE FINISHED FLOOR TO ℄ OF DEVICE OR OUTLET BOX
AP	ACCESS PANEL
ARCH	ARCHITECTURAL
ATS	AUTOMATIC TRANSFER SWITCH
BLDG	BUILDING
BRKR	BREAKER
C	CONDUIT; CABLE; COIL
CB	CIRCUIT BREAKER
CKT	CIRCUIT
CLG.	CEILING
C.O.	CONDUIT ONLY
COL	COLUMN
CONC	CONCRETE
CONTR	CONTRACTOR
CR	CONTROL RELAY
CS	CONTROL SWITCH
CT	CURRENT TRANSFORMER
CTL	CONTROL
CU	COPPER
DC	DIRECT CURRENT
DDC	DIRECT DIGITAL CONTROL
DET	DETAIL
DIA	DIAMETER
DIAG	DIAGRAM
DISC.	DISCONNECT
DN	DOWN
DWG	DRAWING
EA	EACH
EF	EXHAUST FAN
EL	ELEVATION
ELEC	ELECTRICAL
EMERG	EMERGENCY
EMT	ELECTRICAL METALLIC TUBING
EOL	END OF LINE DEVICE
EWC	ELECTRIC WATER COOLER
EXP	EXPOSED
EXIST.	EXISTING
FA	FIRE ALARM
FACC	FIRE ALARM CONTROL CONSOLE
FACP	FIRE ALARM CONTROL PANEL
FDR	FEEDER
FIN	FINISHED
FIO	FURNISHED AND INSTALLED BY OWNER
FIXT	FIXTURE
FLEX	FLEXIBLE
FLR	FLOOR
FLUOR	FLUORESCENT
FOIC	FURNISHED BY OWNER AND INSTALLED BY CONTRACTOR
FT	FEET; FOOT
FU	FUSE
FUT	FUTURE
GALV	GALVANIZED
GEC	GROUND ELECTRODE CONDUCTOR
GEN	GENERATOR
GFI	GROUND FAULT INTERRUPTING
GND	GROUND
H	HIGH (DIM)
HH	HANDHOLE
HID	HIGH INTENSITY DISCHARGE
HOA	HAND–OFF–AUTOMATIC
HP	HORSEPOWER
HPS	HIGH PRESSURE SODIUM
HZ	HERTZ
I/O	INPUT/OUTPUT PANEL
IAC	INTERLOCKED ARMORED CABLE
IC	INTERRUPTING CAPACITY
ID	INSIDE DIAMETER
IN	INCH
INST	INSTANTANEOUS
J–BOX	JUNCTION BOX
KCMIL	THOUSAND CIRCULAR MILS
KVA	KILOVOLT AMPS
KW	KILOWATT
L	LONG
LAB	LABORATORY
LC	LIGHTING CONTACTOR
LT	LIGHT
LTG	LIGHTING
MCC	MOTOR CONTROL CENTER
MCP	MOTOR CIRCUIT PROTECTOR
MECH	MECHANICAL
MFR	MANUFACTURER
MH	MANHOLE; METAL HALIDE
MIN	MINIMUM
MLO	MAIN LUGS ONLY
MTD	MOUNTED
MTG	MOUNTING
MTR	MOTOR
MTS	MANUAL TRANSFER SWITCH
MVA	MEGAVOLT–AMPS
N.C.	NORMALLY CLOSED
NEUT	NEUTRAL
NIC	NOT IN CONTRACT
N.O.	NORMALLY OPEN
NO.	NUMBER
NTS	NOT TO SCALE
OD	OUTSIDE DIAMETER
PA	PUBLIC ADDRESS
PAR	PARALLEL
PC	PHOTO–ELECTRIC CELL; PULL CHAIN; PERSONAL COMPUTER
PF	POWER FACTOR
PH	PHASE
PL	PROPERTY LINE
PNL	PANEL; PANELBOARD
POC	POINT OF CONNECTION
PT	POTENTIAL TRANSFORMER
PVC	POLYVINYL CHLORIDE
PWR	POWER
QTY	QUANTITY
R	RADIUS; RISER
REC	RECEPTACLE
RECEP	RECEPTACLE
RGS	RIGID GALVANIZED STEEL CONDUIT
RM	ROOM
RQMTS	REQUIREMENTS
SECT	SECTION
SFD	SMOKE FIRE DAMPER
SHLD	SHIELDED
SHT	SHEET
SPEC	SPECIFICATION
SQ	SQUARE
STD	STANDARD
STL	STEEL
STR	STRANDED
SUBST	SUBSTATION
SURF	SURFACE
SW	SWITCH
SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
T	TRANSFORMER
TB	TERMINAL BLOCK
TC	TERMINAL CABINET
TEL	TELEPHONE
TEMP	TEMPORARY; TEMPERATURE
TP	TWISTED PAIR
TSP	TWISTED SHIELDED PAIR
TYP	TYPICAL
UG	UNDERGROUND
UON	UNLESS OTHERWISE NOTED
UH	UNIT HEATER
UV	UNIT VENTILATOR
V	VOLT(S)
VA	VOLT–AMPERES
VS	VERTICAL SCALE
W	WATT(S), WIRE(DIM)
W/	WITH
W/O	WITHOUT
WF	WATER FLOW ALARM
WP	WEATHERPROOF
WT	WATER–TIGHT
XFER	TRANSFER
XFMR	TRANSFORMER
XMTR	TRANSMITTER
Z	ZONE; IMPEDENCE
#	NUMBER
ø	PHASE

SCHEMATIC DESIGN

REVISION	BY

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Bellevue WA 98004
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woodharbinger.com

COMBINED HEAT AND POWER/HOT WATER DISTRICT HEATING
CAPITOL CAMPUS
OLYMPIA, WA

SHEET TITLE
ELECTRICAL LEGEND AND ABBREVIATIONS

DATE	05/17/16
SCALE	1:1
ENGR	DCB
DRWN	BCP
CHKD	DCB
APPR	DCB
JOB	16003

E0.01

SHEET 1 OF 4

6/15/98, MAC TB.DWG, 1:1

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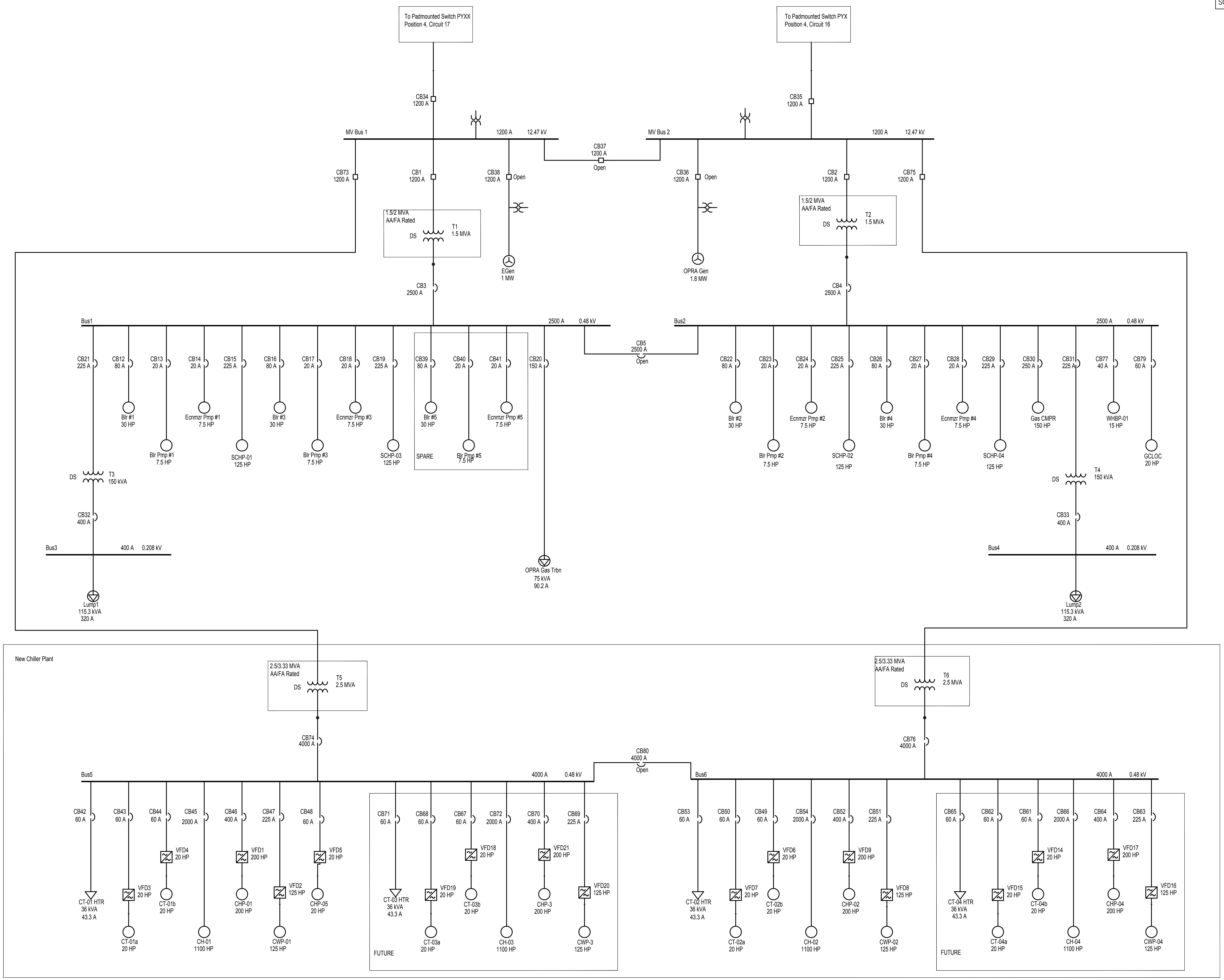

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COMBINED HEAT AND POWER/HOT WATER DISTRICT HEATING
CAPITOL CAMPUS
OLYMPIA, WA

SHEET TITLE
NEW CHP - ONE-LINE

DATE	05/17/16
SCALE	1:1
ENGR	DCB
DRWN	BCP
CHKD	DCB
APPR	DCB
JOB	16003

E0.02

SHEET 2 OF 4

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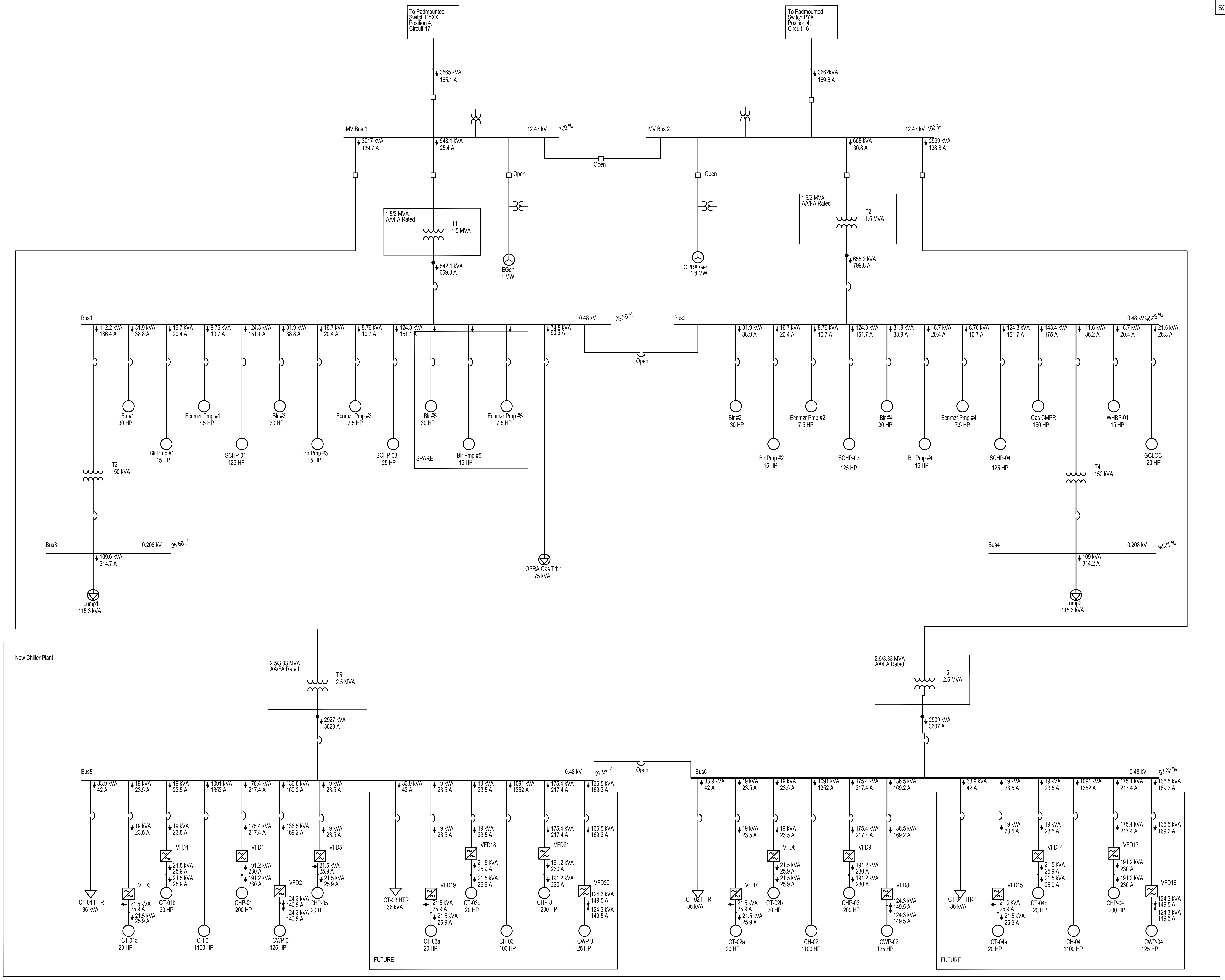

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COMBINED HEAT AND POWER/HOT WATER DISTRICT HEATING
CAPITOL CAMPUS
OLYMPIA, WA

SHEET TITLE
NEW CHP - LOAD FLOW

DATE	05/17/16
SCALE	1:1
ENGR	DCB
DRWN	BCP
CHKD	DCB
APPR	DCB
JOB	16003

SCHEMATIC DESIGN

E0.03

SHEET 3 OF 4

IF SHEET IS LESS THAN 30"x42"
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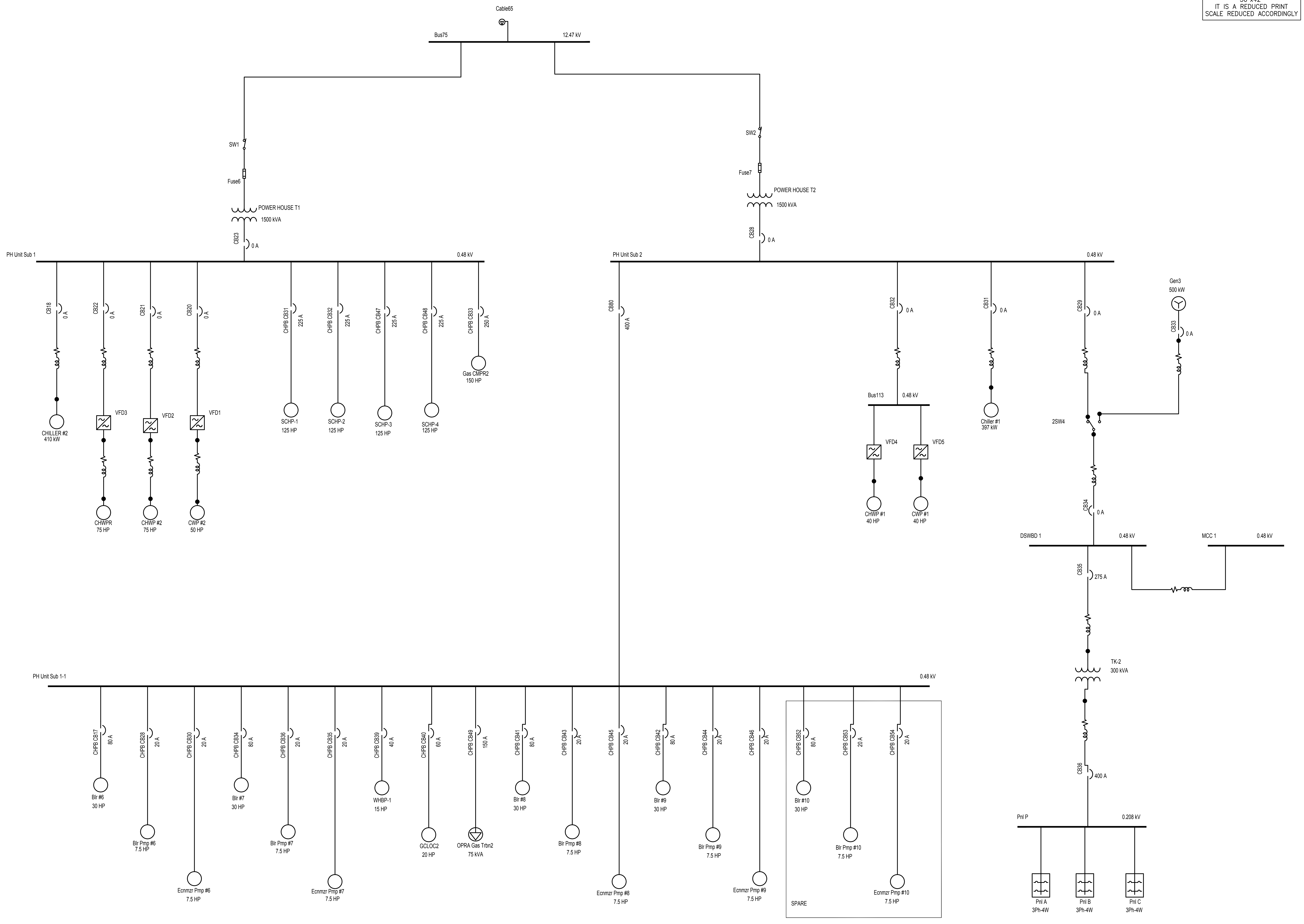
SCALE REDUCED ACCORDINGLY



SCHEMATIC DESIGN

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COMBINED HEAT AND POWER/HOT WATER DISTRICT HEATING
CAPITOL CAMPUS
OLYMPIA, WA

SHEET TITLE

EXISTING POWER PLANT ONE-LINE

DATE	05/17/16
SCALE	1:1
ENGR	DCB
DRWN	BCP
CHKD	DCB
APPR	DCB
JOB	16003

E0.04

SHEET 4 OF 4

6/15/98, MAC
TBDWG, 1:1