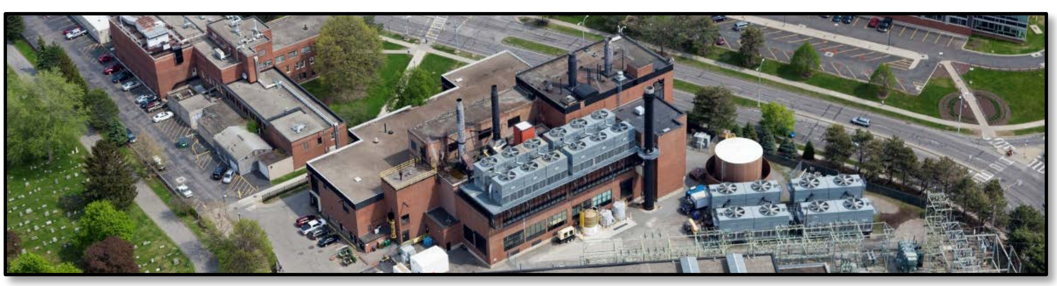
Utilities and Energy Management

Academic Collaboration Guide



Fall 2020 Edition

Table of Contents

Section 1: Introduction

Description of Initiative

The purpose of this document is to facilitate cooperation between Utilities and Energy Management (UEM) and Academic programs at University of Rochester. Utilities and Energy Management is a subset of UR facilities. They oversee energy purchasing, consumption, billing and related assets for all of UR.

UEM maintains and operates the cogeneration plant, Mid Campus Chiller Plant, River Pump house and all associated equipment which generates, transforms and distributes services to River Campus, Medical Center and Mid Campus.

Service	Annual Generation	Annual Distribution
Electricity	60 million kWh	170 million kWh
Steam	2 million mmBTU	500 thousand mmBTU
Hot Water	600 thousand mmBTU	600 thousand mmBTU
Chilled Water	1.75 million mmBTU	1.75 million mmBTU
Domestic Water	n/a	250 million gallons
Natural Gas	n/a	2.5 million deka-Therms
Sanitary	n/a	250 million gallons

UEM maintains the infrastructure for the building automation system which controls the HVAC equipment for all UR primary campuses. These systems and others not mentioned come together to form a complex web of people, processes, equipment and information which we believe can be leveraged for student projects, classroom examples, and academic research. UEM has been serving UR's energy needs for nearly 100 years. We believe it is time to start serving UR's academic needs as well. UEM intends to support students senior design projects, independent study programs and provide a setting for academic research and cooperation in fields such as Engineering, Environmental Science, Chemistry, Business, Computer Science, Data Science and others.

This document contains guidance for effective communication between students, faculty, and UEM staff to collaborate on projects or obtain data. The information gathered here is parsed from many interviews of both UEM staff and academic faculty. Information was obtained regarding: UEM: contacts, assets and systems; faculty: contacts, classes, research, and general interest. Our goal is to foster collaboration and opportunities for UEM, students, and faculty to engage in multidisciplinary projects and better the state of our campus. This document also contains suggested projects and research for students, faculty, and UEM staff. These suggestions will be updated as new ideas emerge. If someone has an idea that is not on the list, please bring it forward. A FAQ is available at the end of the document. This is meant to be a living document that is updated as information and situations change.

Benefit to UEM

If you are a member of the UEM staff, this document can serve as a conduit for you to bring faculty as well as their students into the fold. If you have projects that you are interested in and think that an academic program could be of use (whether that be a senior design project, research, or something else) then you can use this document to reach out to relevant people. In the contact information for academic faculty you can find multiple contacts for individual who may be able to help or connect you with students who can help on your project. If you believe that your project could be relevant for a senior design project for engineering students, multiple departments have specific contacts who oversee senior design in their respective programs.

Benefit to Academic Programs

Within this document you will find high-level descriptions of UEM systems that have potential for projects and research as well as instructions as to how to contact UEM to talk about your ideas. Additionally, section 3 contains additional ideas for potential projects.

Student Involvement

How can I as a student get involved and how will I benefit?

The first thing is to look through this document in detail to understand how UEM can play a role in academic endeavors for UR students. Start off by going through the list of the UEM suggested projects in Section 4 to get a sense of what is possible through this collaboration. This list is updated frequently, and projects may be added/removed over time. If a suggested project seems like something you would be interested in, contact Mike Whitmore, the director of UEM (contact information found in next section). He can connect you with the right person in UEM to serve as an advisor for the project. You should also have someone from your academic department in mind who can serve as a faculty advisor for the project, as it is helpful to have support from both UEM and an academic program for these projects. Once these connections are made, you would proceed with discussing the project and its logistics (time commitments, position type, financial details, etc.).

The list of suggested projects is not exhaustive. If you have another project idea in mind, UEM is certainly open to suggestions. It may help to view the sections on available UEM data and assets to see if what you would need is available. Contact Mike Whitmore, explain your idea, discuss with academic faculty, and go from there.

Finally, there are also opportunities to get involved through certain groups at the university. If you are a student in NROTC, some UEM aspects may be included in your coursework since it has been found that naval ship systems are close analogues to UEM systems. There is also opportunity for student organizations to participate in projects (see Section 8).

Overall, these projects and opportunities are meant to provide real-world experiences to students who wish to see how their academic studies can apply directly to the functioning of our campus. The central benefit of this initiative for students is the opportunity to learn from hands-on experience and have more options available to them when it comes to research or internships, which they can conveniently find right on campus through UEM.

Section 2: Contact Information

UEM Contacts

Anyone wishing to contact UEM staff or work on a project with UEM should contact Mike Whitmore, (UEM Director), he will direct you to the appropriate UEM staff member or resource.

Name	Email	Title	Role
Mike Whitmore	mwhitmo3@facilities.rochester.edu	Director	Everything UEM

Academic Program Contacts

Department	Name	Email	Title	Areas of Interest
Business	Rick Cardot	Richard.cardot @simon.rochester.edu	Faculty Director	
Chemical Engineering	Rachel Monfredo	Rachel.monfredo @rochester.edu	Primary Contact Senior Technical Associate, Lecturer	Senior Design
	Melodie Lawton	Melodie.lawton @rochester.edu	Primary Contact Assistant Professor	Senior Design
	Clair Cunnigham	Clair.cunnigham @rochester.edu	Laboratory Engineer	Senior Design
	David Foster	David.foster @rochester.edu	Associate Professor	Computational Fluid Dynamics (CFD), Heat and Mass Transfer, Separations. Can support students looking for internships and/or research.
	Eldred Chimowitz	eldred.chimowitz @rochester.edu	Professor	Advanced Process Control, techniques in LabView software.
Chemistry	Todd Krauss	Krauss @chem.rochester.edu	Chair, Professor	Materials chemistry and physics of colloidal nanoscale semiconductors
	Ellen Matson	Matson @chem.rochester.edu	Assistant Professor	Inorganic chemistry approach to energy storage and production
	Udo Schroeder	Schroeder @chem.rochester.edu	Professor of Chemistry and Physics	Nuclear physics; other energy issues
Computer Science	Michael Scott	Scott @cs.rochester.edu	Chair, Professor	Systems software for parallel and distributed computing
Data Science	Ajay Anand	Ajay.anand @rochester.edu	Deputy Director	Capstone projects

Department	Name	Email	Title	Areas of Interest
Earth and Environmental Science	John Kessler	John.kessler @rochester.edu	Chair, Professor	Chemical Oceanography, Analytical Chemistry
	Karen Berger	Karen.berger @rochester.edu	Associate Professor	Human use of and impacts on energy and water resources, metrics of sustainability, can connect students with independent research opportunities.
	Lee Murray	Lee.murray @rochester.edu	Assistant Professor	Atmospheric chemistry, climate modeling
Economics	George Alessandria	George.alessandria @rochester.edu	Chair, Professor	Macroeconomics
	Michael Rizzo	Michael.rizzo @rochester.edu	Lecturer	Environmental Economics, Economics of Higher Education
Mechanical Engineering	Doug Kelley	d.h.kelley @rochester.edu	Associate Professor Faculty Advisor Principal Investigator for the solar panel project in GAC.	Liquid metal batteries and grid-scale storage Liaison to MechE students interested in turbines and alternative energy
Optics	Wayne Knox	Wknox @optics.rochester.edu	Professor of Optics and Physics	Senior Design
Hajim School of Engineering Office	Wendi Heinzelman	Wendi.heinzelman @rochester.edu	Dean of Hajim School, Professor of Electrical and Computer Engineering	Wireless sensor networks, multimedia communication, cloud computing
	Paul Funkenbusch	Paul.funkenbusch @rochester.edu	Professor, Assoc. Dean of Hajim for Education and New Initiatives	In charge of the Senior Design in the Hajim School
	Nicholas Valentino	nicholas.valentino @rochester.edu	Academic Advisor	Point of Contact for the Hajim School
River Campus Libraries	Blair Tinker	Blair.tinker @rochester.edu	Research Specialist for GIS	GIS

Section 3: Available UEM Data

Brief overview

The information below is a compilation of data generally available for academic projects or research. There are many variations, nuances and exceptions which are not detailed here. Contact UEM to see if the specific data you are looking for is available.

- **Electrical Metering**
    - Local Campuses (RC, MC, Mid Campus) Distribution System and UR substations
        - One or five minute interval data for most buildings.
            - All meters have energy and power (kWh and kW)
            - Most also have Power Factor and amperage
            - Some have voltage and reactive power.
    - Remote Campuses (Eastman, Mt Hope, South Campus) and Offsite Properties
        - Monthly electrical consumption only
- **Steam Turbine Generators**
    - Electrical Production (kW, kWh, PF, Amps, Volts, kVAR, kVARh) one minute intervals
    - Steam Consumption (mass, pressure, temperature and energy)
    - Operational data (valve position, speed, etc)
- **Thermal Energy Generation, Distribution and Consumption**
    - UEM generates hot water for building heating and chilled water for building cooling. These two energy carriers are pumped underground to RC, MC and Mid Campus to distribute heating and cooling energy to the buildings.
    - One to five-minute interval data for all thermal energy generating sources and all buildings consuming the energy including (power, energy, supply temperature, return temperature, differential temperature, flow rate and accumulated volume).
    - Some areas also have supply and return pressure.
- **Domestic Water Consumption**
    - Local Campuses: Most buildings have 5-minute interval data of water consumption.
    - Offsite Buildings: Most buildings have monthly water consumption data.
- **Natural Gas and Fuel Oil Consumption**
    - Utilities: Most natural gas and fuel oil purchased by UR is consumed in our central plant for producing steam, electricity and hot water. This natural gas and fuel oil consumption is tracked as it enters the plant and as it is used by each boiler. Data is available in one-minute intervals. (Fuel oil is only used as a backup source of energy)
    - Local Campuses: Very little natural gas is consumed by local buildings directly. At the building level NG is used mostly for kitchens and laboratories. This data is tracked in 5-minute intervals for the buildings that use it.
    - Offsite Buildings: Most buildings use NG as the heating energy source. This consumption is tracked in monthly billing data.
- **Utility Plant Operation**
    - All equipment in our Central Utility Plant and our Mid Campus Chiller Plant is controlled by our ABB Distributed Control System (DCS). The DCS has the ability to trend any control or operational parameters in the system. Most points are enabled for short term trends. Several hundred critical trends are transferred to our OSISoft PI system for permanent storage. Additional trends and permanent storage can be created as necessary for study or research.

  - We have operational data for our industrial scale equipment: 6 boilers, 9 chillers, two steam to electric and hot water co-generation turbines, 25+ pumps, 6+ heat exchangers, 2 water treatment systems and a host of support equipment.
- **Co-generation System (Subset of Utility Plant Operational Data)**
  - The co-generation system consumes steam which is produced by burning natural gas and produces electricity and hot water. Operational, energy consumption and energy production data are available for all aspects of this system.
- **Building HVAC operation - Building Automation Systems (BAS)**
  - Almost all of our HVAC equipment in our local and remote campus buildings is controlled by one of the three BAS platforms.
  - The BMS in each building may be between 30 years old and brand new. The different platforms and their various generations have different capabilities.
  - We can acquire operational data on nearly any aspect of these systems.
- **OSISoft PI system – Operational and Meter Data**
  - OSIsoft PI is an enterprise software and database suite for real-time data collection and analytics. PI has scalable architecture with more than 450 off-the-shelf interfaces to collect high-fidelity time-series data from many sources simultaneously. PI provides tools to perform rapid analysis and visualization on large volumes of diverse data in real-time.
  - PI serves as the core of Utilities and Energy Managements data collection and archival system. UEM's private instance of PI collects data from the ABB Plant Digital Control System, the electrical infrastructure, campus and building energy meters, and three different Building Automation Systems. In some cases PI is used to transfer data between some of our different systems and to send select data to our Energy Management Information System eSight. PI is the primary tool UEM uses to collect and store operational and energy data. UEM pays for our version of PI because we use it for operating our business, but OSIsoft offers a free version to use for research and education purposes.
  - Company Website: https://www.osisoft.com/
  - The PI system has been our system of record since 2005 for operational and energy data. Critical data from our DCS, BMS and meter systems enters PI in real-time and the value is stored permanently creating long term historical trend support of real-time data. Any of our control systems can be configured to send additional data to PI if we deem it necessary.
  - It is relatively easy to access the PI data using MS Excel, through the PI Vision website or using a Python or PowerShell script.
  - The data designated as critical and therefore stored in PI includes about 10% of the plant operational data (DCS), about 1% of the building operational data from the BMSs and nearly 100% of the local campus meter data.
- **Weather Data**
  - Various outside temperature and humidity sensors spread across campus in the BMS.
  - Hourly weather data from the ROC airport is used and recorded for most weather-related decisions.
  - While weather data is readily available from NOAA, our weather data is available for study or comparison if desired.
- **Utility Distribution (Local campuses)**
  - Schematics, details and maps of electrical, hot water, chilled water, steam, water, sanitary and storm water distribution for the local campuses.
  - These maps are in the process of being updated and incorporated into our GIS platform.
  - This data is sensitive and only available with proper approval.

- **Goergen Athletic Center (GAC) solar panels and grid battery storage**
  - In 2019 and 2020 an array of solar PV panels was installed on the GAC roof along with a set of grid scale Tesla batteries. The panels, battery, electrical meters are monitored by our OSIsoft PI system. Real-time and one-minute historical data are available.
  - The college of Arts Sciences and Engineering has a website available with a small portion of the available data
    - https://www.hajim.rochester.edu/solar-array/
    - The remaining data can be accessed by request through UEM's PI system.
- **Geospatial Information System (GIS)**
  - This system currently contains a 3D map and meta-data for some of our utilities. In the future it may also incorporate real-time data from other systems.
- **Energy Use Intensity (EUI) and building energy performance**
  - Relative and absolute energy use and carbon emission rankings of all campus buildings.
  - We are in the process of implementing a new system which will make this data available to the UR community through a website. Contact us if you need the data sooner or in more detail.
- **Distribution Pipe Material Data**
  - Pipeline classification
  - Expansion and contraction data

Section 4: UEM Suggested Projects

1. **Develop mathematical and operational models of the plant:**
   a. This project could be broken up into multiple projects due to the complexity of the plant.
      i. Sub-System models should be constructed in such a way as to integrate with each other as more models are constructed.
   b. The first project could be to develop the criteria and specifications for future models.
   c. These models could be used to simulate different operating scenarios and to compare live plant operation to a dynamic baseline.
      i. Steam System
         1. Boilers
         2. Condensate
         3. Towers
         4. Make-up Water
      ii. Hot Water System
         1. Heat Exchangers
         2. Distribution Pumps
      iii. Chilled Water System
         1. Steam Chillers
            a. Tower
            b. River Water System
            c. Distribution Pumps
         2. Electric Chillers
            a. Tower
            b. Distribution Pumps

            3. Economics of using one system or the other
        iv. Electrical Generation
            1. HP Steam Turbine Profile
            2. LP Steam Turbine Profile
            3. Heat Rejection
            4. Power Quality
            5. Economics of when to generate electricity
            6. Balance between the two turbines

2. **Using the plant and equipment models to improve efficiency**
    a. Analyze first single equipment, then subsystems, systems, and finally entire plant for efficiency using models developed above
3. **A student created video of what UEM has done and is going to do towards sustainability**
4. **A video of a virtual tour of the plant**
    a. A walk through with explanations of the equipment
5. **A 3D model of the plant for students to explore**
    a. The model could be improved over time
    b. Link data from subsystems and systems to the model
6. **Academic version of OSIsoft PI**
    a. See the Section 3 for a description of OSIsoft PI.
    b. An academic department could sponsor a PI system
    c. Utilities could share some of our data into this academic PI system for analysis and research
    d. There are then numerous projects to enhance, display, and analyze the data in this PI system
7. **Evaluate GIS system**
    a. Look for gaps and shortcomings
    b. Propose changes and enhancements
8. **Evaluate our PI Asset Framework (AF) structure**
9. **Energy analysis**
    a. How are energy and carbon related at UR?
    b. How is energy used inside buildings?
    c. How should energy usage be displayed to UR community to achieve the greatest impact to sustainability?
    d. Energy models of how energy moves through the plant and through the entire campus
10. **Carbon reduction through Electrification Analysis**
    a. Potential Evaluations (economic, environmental, mechanical, etc.)
        i. Conversion of steam to electric chilled water
        ii. Solar PV (parking lots, roofs, off-site field)
        iii. Ground source heat pumps
        iv. Air source heat pumps
        v. Heat recovery chillers
11. **Carbon reduction through alternate fuel sources**
    a. BIO-Gas sources for Utility Plant steam boiler system
12. **Chilled Water Load Forecasting**
    a. Use historical operational and weather data to build a mathematical model to predict future chilled water loads.
    b. The model should predict load for both short term (hours) and long term (days).
    c. The model must take into account the present weather conditions, weather forecast, present and predicted campus utilization.

   d. The load forecast will help determine how to better operate our chilled water system.
   e. The model can be incorporated into our plant control system to provide real-time predictions to the plant operators.

13. **Analyze electric chiller vs steam driven chiller performance for efficiency, cost and carbon.**
    a. UEM has two chiller plants. The MCCP plant is newer and uses electricity to generate electricity. The CUP plant uses steam generated by burning natural gas to power a turbine to generate chilled water.
    b. The project could examine and compare the operation of these two plants in regards to efficiency, fuel cost, operating cost and CO2 generation.
14. **Cooling Tower Replacement for River Water**
    a. Three of UEM's chillers reject heat to the Genesee River.
    b. There are several issues reducing the effectiveness or increasing the cost of this system which make continued use of the river water difficult.
        i. Increasingly strict regulatory issues and requirements
        ii. Zebra mussels have invaded the Genesee River and infiltrated the condenser circuit causing severe maintenance issues.
        iii. Often the river is not cold enough or deep enough to provide the amount of heat rejection desired.
    c. The current plan is to abandon the use of river water and construct a new cooling tower for heat rejection.
    d. There could be several different types of projects related to this topic.
        i. River water vs cooling tower.
            1. Chiller performance comparison. Will the chillers perform better or worse if a cooling tower is constructed?
            2. Energy analysis and comparison
            3. Carbon footprint analysis and comparison
            4. Economic analysis and comparison
            5. Operational analysis and comparison, including difference in maintenance
        ii. Engineering requirements and/or analysis of the new cooling tower.
        iii. Architecture: Designing the new cooling tower to fit into existing space and/or designing it to complement existing structures.
15. **Big Idea(s) to make UR carbon neutral**
    a. A group of students propose broad concept ideas about how to make UR carbon neutral.
    b. These ideas are then evaluated for engineering and/or economic feasibility.
    c. This could be setup as a class project, a collaboration between classes, a student organization project or a student body challenge.
16. **Analysis of campus energy and water usage before, during, and after the COVID-19 pandemic**
    a. Was there a change in consumption due to campus shutting down?
    b. How much energy/water do campus buildings consume when operating at limited to no occupancy? Is this significantly different than under normal circumstances? If so, how?

Section 5: UEM Assets

UEM Systems and Processes

1. **Steam Generation**
   a. Description
      i. Natural Gas fired Steam Boilers located in the Central Utility Plant that produce steam used to generate electricity, chilled water, hot water and distribute steam to campus for heating.
   b. Detail
      i. The boiler plant has 5 gas fired medium-pressure steam generating boilers capable of generating 500,000 lb/hr of steam at 165 PSIG plus an additional high-pressure boiler producing up to 168,000 lb/hr of steam at 900 PSIG.
      ii. The steam is consumed for multiple purposes including: Co-Generation of hot water and electricity, chilled water production, steam distribution to campus and heating hot water production. Steam pressure is reduced to 100 PSIG for all steam that leaves the Central Utilities Plant (CUP) building.
2. **Steam Distribution and Condensate Return**
   a. Description
      i. Responsible for the distribution of steam to local campus buildings and collecting and returning the condensed steam (water) to CUP.
   b. Detail
      i. Steam at 100 PSIG is carried from the CUP building to local buildings through about two miles of pipes in steam tunnels and buried underground. When steam enters the building, it condenses from gas to a liquid giving up most of its energy which is consumed by the buildings HVAC system. The condensed water is collected and transported back to the CUP building to be heated and turned back into steam. Some of the condensate return system is damaged and no longer is returns water to CUP, the condensate instead discharged to the sewers. The long-term plan is to convert the buildings with the damaged condensate return piping and others from steam to hot water service.
3. **Co-Generation (Electricity and Hot Water)**
   a. Description
      i. Steam powered generators that are responsible for generating electricity and heating water to local campus
   b. Detail
      i. The co-generation system consists of two steam driven generators theoretically capable of producing up to 25 MW of electricity and 170 million BTU of hot water simultaneously, plus the associated pumps, heat exchangers, cooling towers, etc.
      ii. The system is never run at full capacity and typically generates about 5-10 MW. The reduced production is mainly due to lack of hot water demand and the way in which the electrical circuiting is designed. The electrical circuiting will be corrected in the next couple of years and we are always looking for ways to utilize more hot water.
      iii. The larger generator is capable of producing up to 18 MW of electricity and is driven exclusively by the 900 PSIG super-heated steam boiler. This generator has two stages: 165 PSIG steam can be extracted between the first and second stage to feed into other processes or the steam can go through both stages emerging at

slightly below atmospheric pressure to produce hot water and/or rejected to a cooling tower.

   iv. The smaller generator is capable of producing 7 MW of electricity and is fed by the 165 PSIG steam header. The steam emerges from the generator in a vacuum and can then be used to heat hot water or rejected to a cooling tower.

4. **Chilled Water Generation**
   a. Description
      i. Responsible for generating the chilled water used to cool buildings on campus
   b. Detail
      i. UEM has two interconnected chiller plants with a total chilled water generating capacity of 34,000 tons.
      ii. There are four steam driven chillers in the CUP building located between the cemetery and Elmwood Avenue with a total capacity of 22,000 tons. Three of these chillers use the Genesee River for heat rejection and one has a dedicated open loop cooling tower.
      iii. The river water subsystem uses river water to reject heat from three of the steam driven chillers. It consists primarily of a pump house locate on the bank of the Genesee River and a pair of 36" diameter underground pipes running from the pump house to the CUP building. The system has numerous maintenances, environmental and regulatory issues and plans are in place to replace it in the next five years.
      iv. The five electric driven chillers in the MCCP building located South West of the Saunders Research Building on Kendrick Road have a total capacity of 12,000 tons. These chillers are newer and more efficient then the steam driven chillers and are generally used to near capacity before running the steam driven chillers. These chillers have a dedicated open loop cooling tower that consists of the top half of the building. The MCCP building is designed to be expandable when more capacity is needed.
5. **Chilled Water Distribution**
   a. Description
      i. Underground piping that distributes chilled water to campus buildings.
   b. Detail
      i. The chilled water generated by the electric and steam chillers is distributed to River Campus, the Medical Center and Mid Campus through about 5 miles of dedicated piping. Most of the chilled water pipe is directly buried in the ground with a minority located in basements or tunnels. The piping caries the chilled water from the two chiller plants to each building's internal chilled water system. The chilled water is used in the building primarily for comfort cooling, but some may be used for process cooling. Not all of the buildings on River Campus have comfort cooling but all the ones that have central air cooling are served by the chilled water distribution system.
6. **Electrical Distribution**
   a. Description
      i. Takes electricity from two electrical substations and CUP generators and distributes it to the local campuses
   b. Detail

   i. There are two electrical substations which serve the local campuses. UEM is responsible for maintaining the newer substation (substation 710) and all electrical equipment between these substations and each of our local buildings. This includes above-ground and underground electrical cabling, transformers, switch, etc. until it reaches the internal low voltage breakers of the building. Over the next two years we will be transitioning all electrical services from the old substation to the newer substation. Electricity is transmitted through the campus at either 11.5kV or 5kV until it reaches a building where it is transformed to 480V or 208V at which point it becomes the responsibility of the building facilities.

7. Hot Water Generation
   a. Description
      i. Creation of Hot Water from Co-Generation and Steam used for building heating.
   b. Detail
      i. All hot water for local campuses is generated in the CUP building by the co-generation system (co-gen) and supplemented by steam to hot water heat exchangers. The co-gen produces the base level of hot water and then if the quantity or temperature of the hot water is lower than desired, steam to hot water heat exchangers are used to boost the hot water to the appropriate temperature and energy content. The temperature of the hot water varies between 185°F and 235°F according to weather conditions.
8. Hot Water Distribution
   a. Description
      i. Responsible for the distribution of hot water to all local campus buildings
   b. Detail
      i. Hot water is carried from the CUP building to local campus buildings through about 3.3 miles of direct buried insulated underground piping. When the hot water piping enters a building, it transfers its energy through a heat exchanger to the building's local HVAC system and is used to heat the building and domestic hot water. Not all buildings have been converted from steam to hot water and some buildings have both steam and hot water service.

Section 6: Information Regarding Internships

<u>How many interns can be taken on by UEM in a semester?</u>

UEM can normally accommodate either one full time intern OR two part time interns in a given semester. These positions would be paid. There is also room for volunteer work with UEM or work as an unpaid intern.

Contact Mike Whitmore for intern opportunities. UEM may also periodically post intern positions on the UR Student Employment website JobLink.

Section 7: Information for NROTC Partnership

NROTC Contacts

Name	Email	Interests/Involvement
CAPT Nathan York	nyork2@ur.rochester.edu	Steam, energy distribution, chilled water systems, basic troubleshooting
LT Nathan Arnold	narnold2@UR.Rochester.edu	Ship systems engineering, thermodynamic concepts, nuclear power (see note below)
LT Dan Carlton	dancarlton5@gmail.com	Note: LT Carlton will transition into LT Arnold's position by the end of Fall 2020 semester.

NROTC Partnership

The NROTC department at the University of Rochester has indicated interest in collaborating with UEM. UEM systems and assets have several analogues in Naval engineering, and many students in NROTC may encounter these systems in their futures with the United States Navy.

Instructors of NROTC courses of all levels are encouraged to reach out to UEM for any assistance needed. Currently, there are plans for integrating tours of the UEM Central Utilities Plant near campus into the curriculum of an NROTC course (details in next section below). In addition, the NROTC department has indicated interest in UEM projects that could potentially fit into a single academic semester. Beyond these, interested students from NROTC may seek out UEM projects as potential research experiences or independent studies to perform outside of the requirements of the NROTC curriculum.

UEM Systems compared to Ship Systems

The Central Utilities Plant at the University of Rochester comprises multiple boilers, steam turbine driven equipment and steam turbine generators. We make steam for distributed services in the field, electrical production and heat primarily. Many of our systems are similar to shipboard equipment, however civilian work places have much more space to accomplish what is needed on a ship.

Though our processes may differ, the one thing that always remains the same is, a boiler is a boiler and a steam turbine is a steam turbine. An example would be our surface condensers for our turbine driven chillers that use river water to force condense our steam. The Navy uses sea water to accomplish this utilizing zinc anodes to combat salt corrosion. We purify our oil with a portable purifier vs. using a fixed purifier. We have De-aerators which are DFT's onboard and we also utilize auxiliary exhaust steam for lower pressure applications. Our systems have many similarities with and can give insight into shipboard systems. However to compare naval systems to a civilian plant would not do justice to what shipboard capabilities are.

– Richard Gardner, UEM Operations and Plant manager

Section 8: Student Organizations

Instructions for Student Organizations

If your student organization (i.e. engineering societies and other major professional clubs) is interested in taking on one of the projects listed above or another idea of your choosing, contact Mike Whitmore. It is possible, maybe even preferred, that projects roll over from year to year with new students working off the past students' progress.

Your organization should be able to get support for a project from both UEM staff and academic faculty within your department. Mike Whitmore can reach out to UEM staff on your behalf to see who would be the best advisor for a given project, and your organization should reach out to your home department to see if any faculty would be interested in supporting your project.

Although each project may be unique, there are some general considerations to keep in mind when planning one:

1. Create a project definition and scope.
2. Create a timeline for the project outlining a schedule for its completion.
3. Get support from both UEM staff and academic faculty as mentioned above.
4. Create a list of any information/data you would like to have in order to go through with your project.

Generally, student organizations are better equipped to take on less time intensive projects each semester. However, bigger projects can be broken up into smaller tasks to be completed on a semester by semester basis provided there is continual interest from your organization.

Section 9: FAQ

Instructions for UEM Staff

1. How do I submit projects to the Hajim School of Engineering?
    a. Go to the Sponsor Senior Design Page and Read the guide: https://www.hajim.rochester.edu/about/sponsor.html
    b. Fill the form: https://www.hajim.rochester.edu/about/sponsor-form.html
    c. You can only submit one project at a time.
    d. It is important to have clear deliverable that can either be completed in a semester or an academic year.
    e. When the form is submitted, it is received by Dean Funkenbusch who then forwards it to the necessary department based on the type of project and the expertise required.
2. What are Independent Studies?
    a. This is an opportunity where a student takes on a project during a semester. It is required that there is both an academic and UEM advisor for student. The academic advisor determines the number of course credits the study is worth. The UEM advisor will design the expectations of the study and then work with the academic advisor to finalize the credit equivalence. If a UEM staff cannot find an academic advisor then email Nicholas Valentino nicholas.valentino@rochester.edu of the Hajim School of Engineering for assistance.
3. Whom should I contact in the Hajim School of Engineering?
    a. Nicholas Valentino is the point of contact for any communication with the Hajim School of Engineering. He can facilitate with reaching out to engineering student groups regarding tours, independent study and internships. When reaching out to professors for any collaboration he should be cc'ed on emails so he could help follow up in case the professor is unresponsive. It will also demonstrate we are working with the Dean of Engineering's office.

NROTC Specific

4. Can NROTC students from RIT participate in the collaboration with UEM?
    a. Students from RIT who are enrolled in the NROTC courses at UR may participate in any activities held in conjunction with their courses (such as tours or class projects). However, UEM projects and opportunities offered outside of NROTC courses (such as research or independent study) are available ONLY for UR students. Students from RIT may still meet with UEM staff for any questions/advice

FAQ Continued

Academic Programs and Students:

5. Can UEM provide funding for projects?
    a. Likely not, as funding has been decreased during COVID-19.
    b. UEM may offer paid internships, as described in section 6.
6. What do I need to do to start a project?
    a. Contact Mike Whitmore and explain your interests. He will direct you to the appropriate UEM staff member who can help you get started.
7. What are the top priority projects?
    a. UEM is open to any project that it can support.
    b. Some projects are easier to support in the near term and these projects could be given priority.
        i. Develop a guideline about how to model plant operations so that each sub-system can be modeled independently and so all the models can work together.
        ii. Evaluation of UEM's GIS system
        iii. Carbon reduction through electrification study
        iv. Chilled Water Load Forecasting
        v. Cooling Tower Replacement for River Water Replacement
8. What is Central Utilities and how does it relate to UEM?
    a. The Central Utilities Plant is the building located between River Campus and the Medical Center that produces electricity, steam, hot water and chilled water for RC and MC. This building is one of several maintained by UEM to serve the utility needs of the campuses.
    b. Many people use the shortened name of the primary utility building "Central Utilities" to refer to the department of UEM.
    c. Although they are generally the same, UEM is more appropriate as Central Utilities or CU can confuse the building with the department.

Section 10: Appendix

UR Campus Chilled Water Schematic

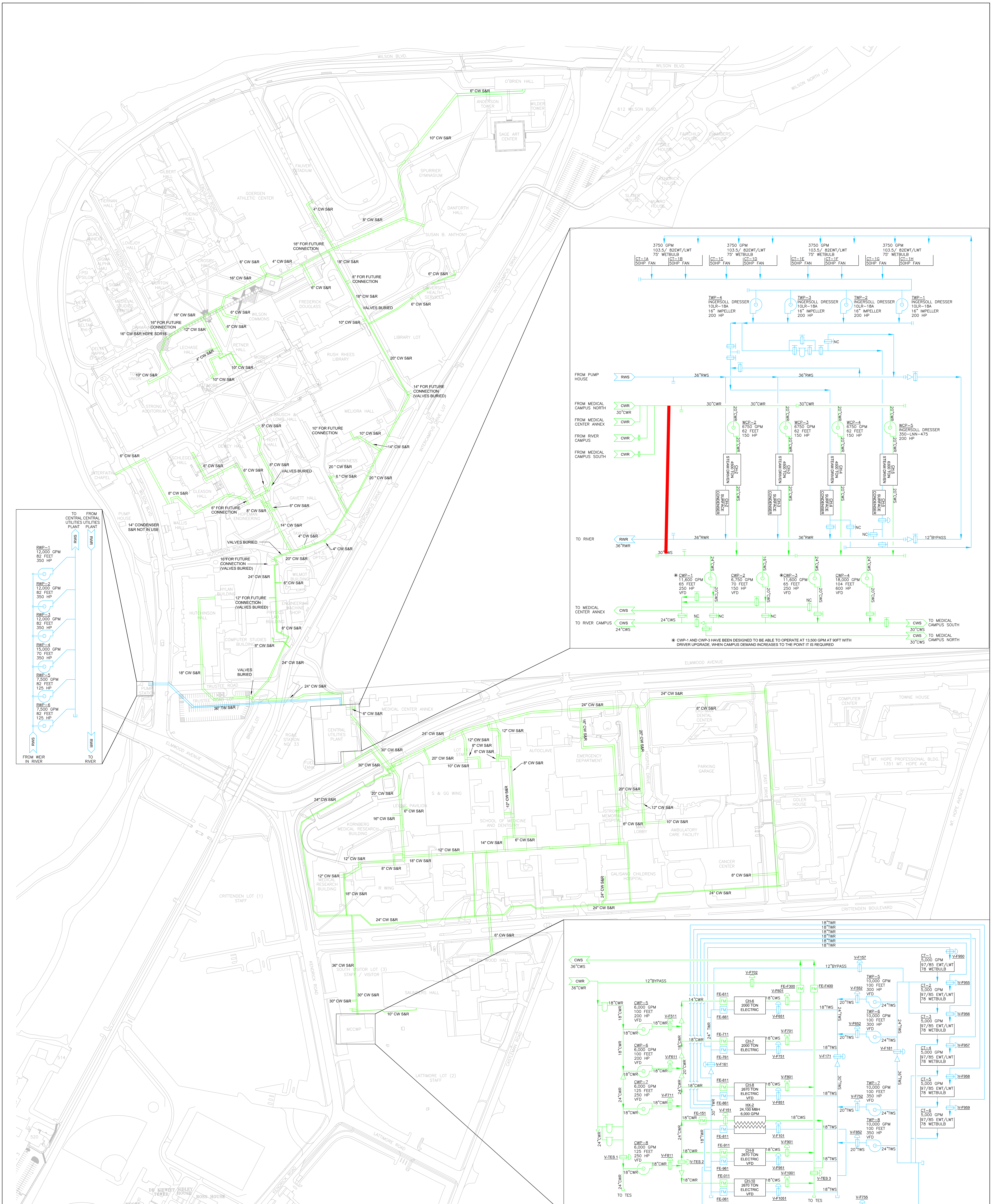
UEM Plant Chiller Simplified Diagram

UEM Plant Hot Water System Simplified Diagram

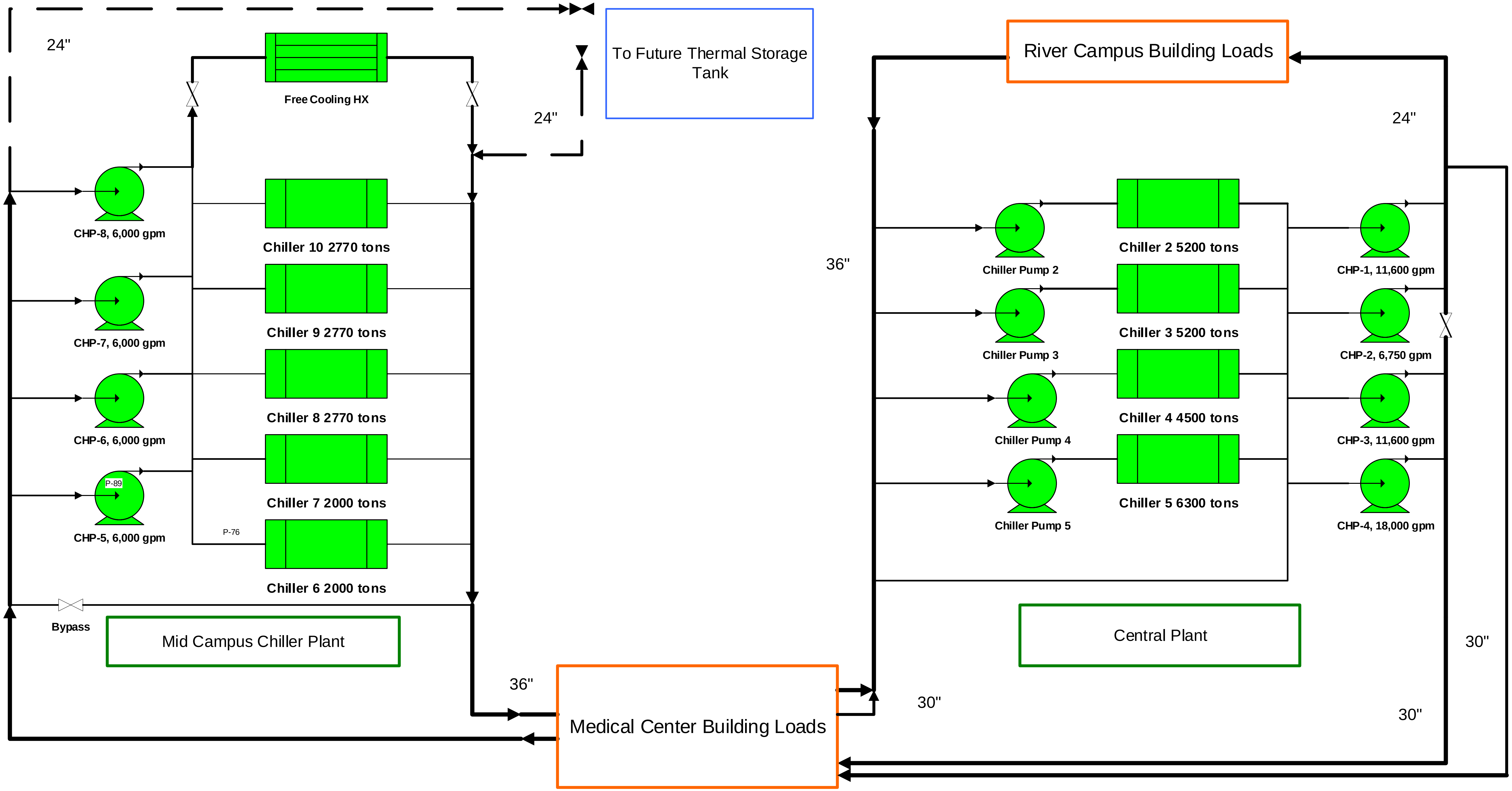
UEM Plant Steam Boilers Simplified Diagram

UEM Plant Co-Generation Simplified Diagram

UEM Plant Equipment Data



UNIVERSITY OF ROCHESTER CHILLED WATER SYSTEM MAP



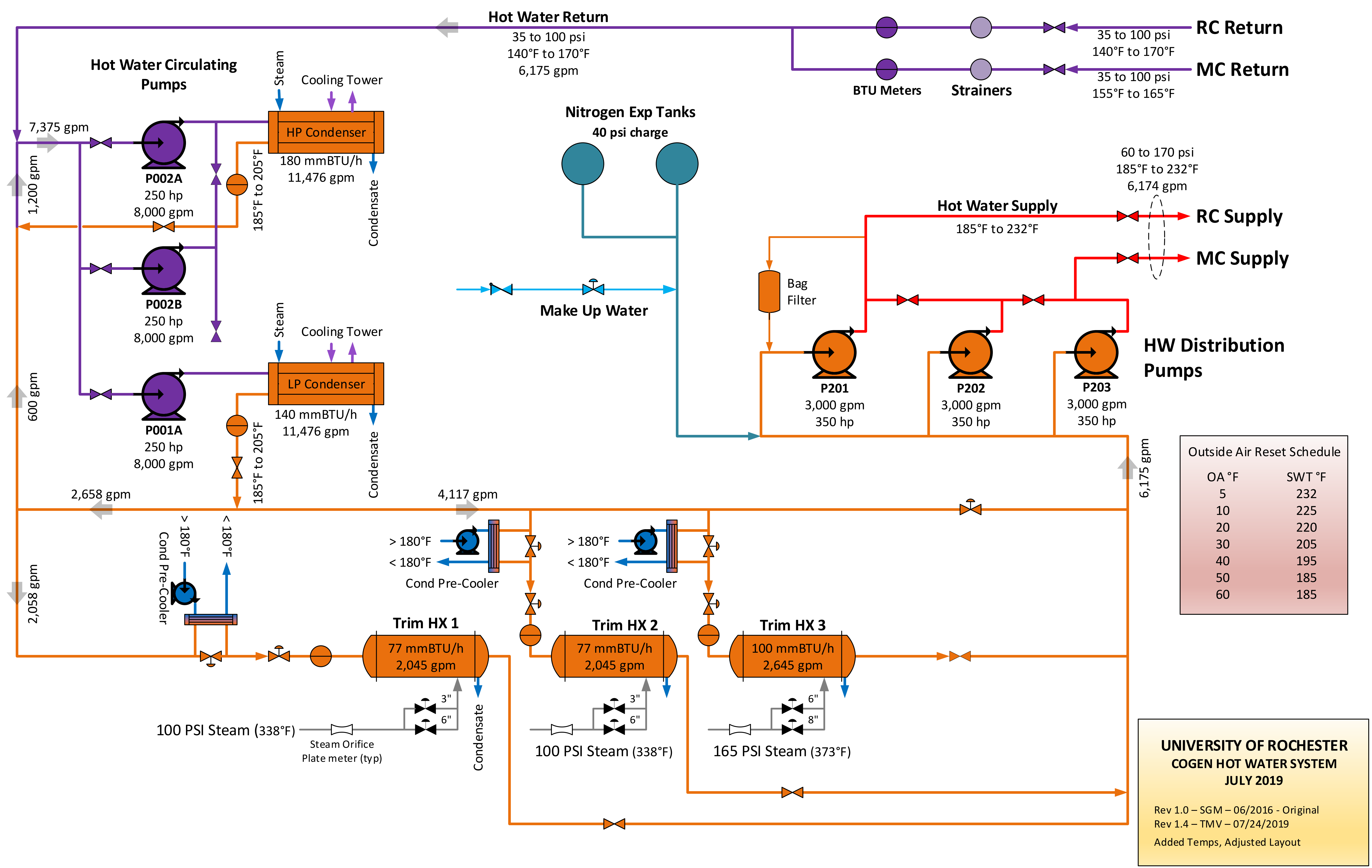
Chillers 2 through 4 are Carrier steam turbine driven chillers, R134 A , 4500 tons, condenser water is from river

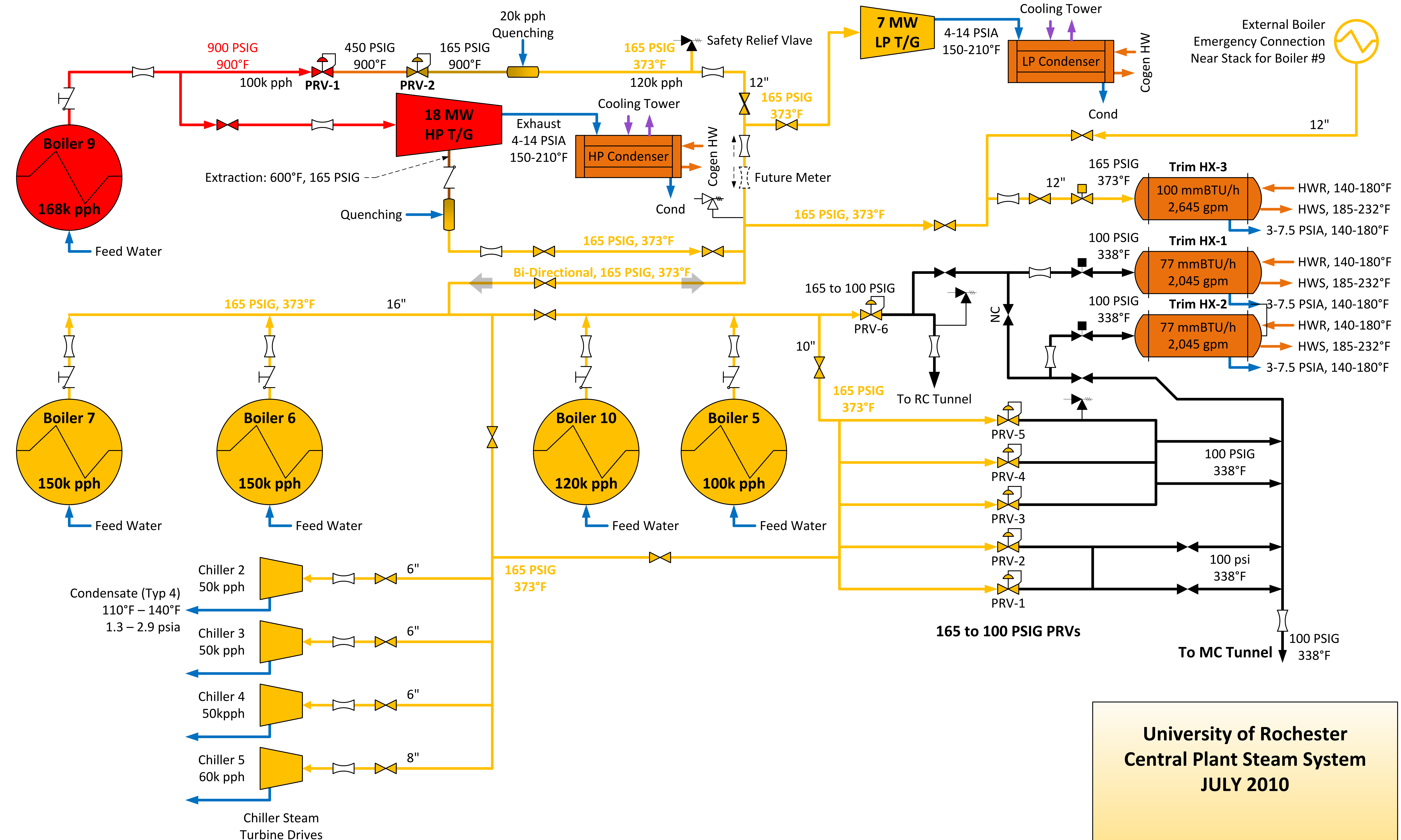
Chiller 5 is a two stage York steam driven chiller, R134 A, 6300 tons, with hot gas bypass, served by Cooling Tower 1

Chillers 7, 8 and 10 are JCI/York motor driven chillers with variable speed compressor drives, R 134A, 2000 tons (7) and 2770 tons (8 and 10)

Chillers 6 and 9 are JCI/York motor driven chillers, R 134 A, 2000 tons (6) and 2770 tons (9)

University of Rochester
Chilled Water System Schematic
August 20, 2014
sgm


Hot Water Return
35 to 100 psi
140°F to 170°F
6,175 gpm
RC Return
35 to 100 psi
140°F to 170°F
MC Return
35 to 100 psi
155°F to 165°F
BTU Meters
Strainers
Hot Water Circulating Pumps
Steam
Cooling Tower
HP Condenser
180 mmBTU/h
11,476 gpm
Condensate
185°F to 205°F
7,375 gpm
1,200 gpm
P002A
250 hp
8,000 gpm
P002B
250 hp
8,000 gpm
P001A
250 hp
8,000 gpm
LP Condenser
140 mmBTU/h
11,476 gpm
600 gpm
Nitrogen Exp Tanks
40 psi charge
Make Up Water
60 to 170 psi
185°F to 232°F
6,174 gpm
Hot Water Supply
185°F to 232°F
RC Supply
MC Supply
Bag Filter
P201
3,000 gpm
350 hp
P202
3,000 gpm
350 hp
P203
3,000 gpm
350 hp
HW Distribution Pumps
6,175 gpm
2,658 gpm
4,117 gpm
2,058 gpm
Cond Pre-Cooler
> 180°F
< 180°F
Trim HX 1
77 mmBTU/h
2,045 gpm
Trim HX 2
77 mmBTU/h
2,045 gpm
Trim HX 3
100 mmBTU/h
2,645 gpm
3"
6"
8"
100 PSI Steam (338°F)
165 PSI Steam (373°F)
Steam Orifice
Plate meter (typ)
Outside Air Reset Schedule
OA °F SWT °F
5 232
10 225
20 220
30 205
40 195
50 185
60 185
UNIVERSITY OF ROCHESTER
COGEN HOT WATER SYSTEM
JULY 2019
Rev 1.0 – SGM – 06/2016 - Original
Rev 1.4 – TMV – 07/24/2019
Added Temps, Adjusted Layout



University of Rochester
Central Plant Steam System
JULY 2010

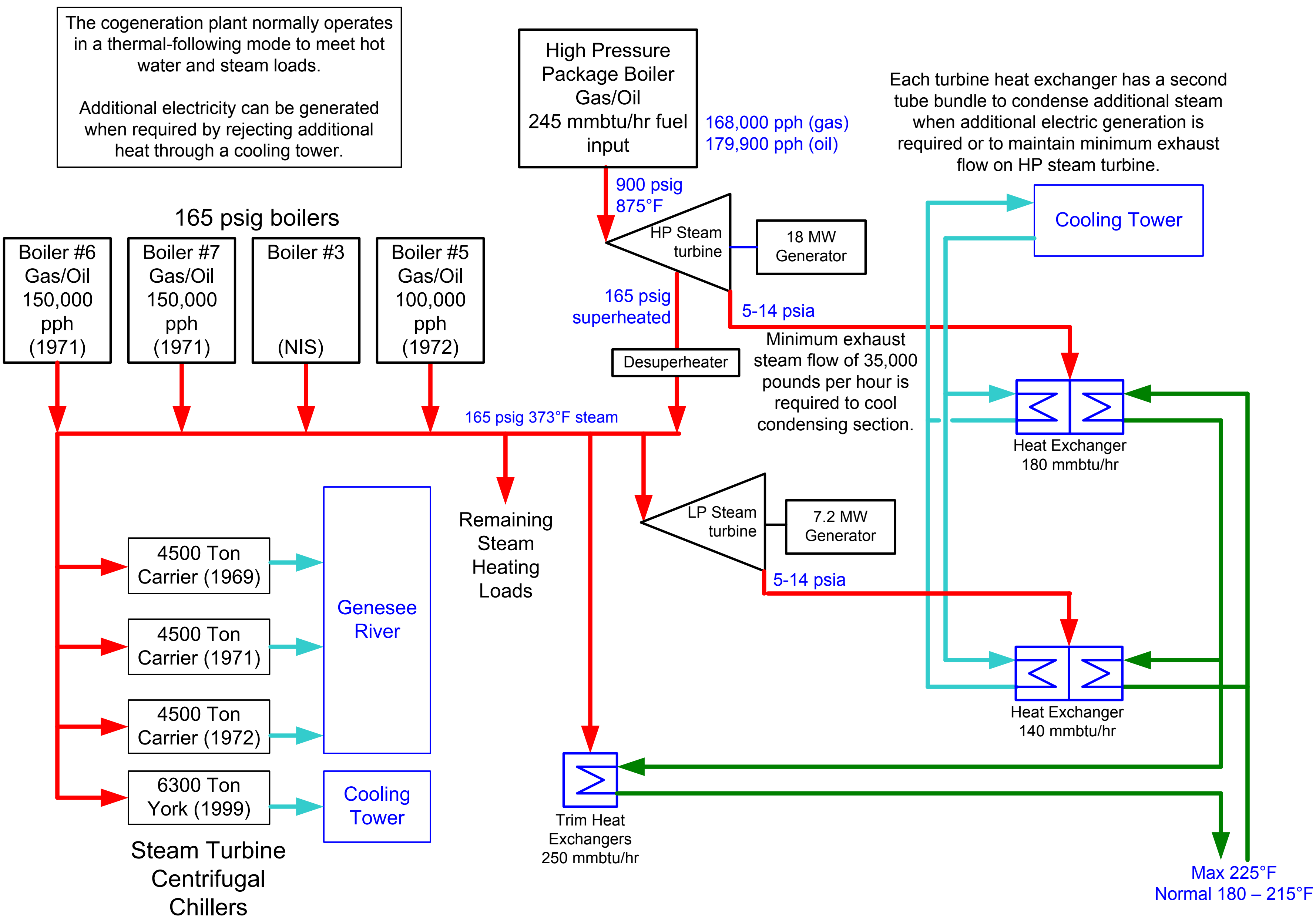
Rev 1.0 – 06/2016 – SGM – original drawing

Rev 1.3 - 07/24/2019 – TMV - add Temps, adjust layout

Boilers, 5 ,6, 7 and 10 are 165# saturated steam boilers, gas/oil
Boiler 9 is 900 psig, 900 F superheated steam boiler, gas/oil

Boilers 6 and 7 are converted B+W coal boilers, 4 low NOx burners
Boiler 5 is B+W D type package boiler, single low NOx burner
Boiler 10 is a Rentech O type package boiler, single low NOx burner

University of Rochester
Cogeneration Plant Schematic



S Mischissin 28 Apr 2015

University of Rochester CUP-Boiler and Chiller Data

Boilers	Firm Capacity, pph	Pressure, psig	Temperature, F	Year Built	Manufacturer	Fuel	# Burners	Comments
#3	0	165	373	1956	B&W	No. 2 oil	2	Removed 2015.
#5	80,000	165	373	1971	B&W	oil/gas	1	package boiler
#6	150,000	165	373	1967	B&W	oil/gas	4	converted coal boiler
#7	150,000	165	373	1971	B&W	oil/gas	4	converted coal boiler
#9	168,000	900	875	2005	B&W	oil/gas	1	Cogen boiler
#10	120,000	165	373	2016	Rentech	oil/gas	1	New 2016
Total	668,000							

Chillers	Nameplate Capacity, Tons	Refrigerant	Type	Year Built	Manufacturer	Drive	Condenser Water	Comments
#1	0	R-11	Centrifugal, 17 CA	1967	Carrier	steam turbine	river water	Removed 3/15
#2	5,225	R-134a	Centrifugal, 17 DA	1969	Carrier	steam turbine	river water	Converted to R134A, new turbine rotor 2014
#3	5,225	R-134a	Centrifugal, 17 DA	1971	Carrier	steam turbine	river water	Converted to R134A, new turbine rotor 2012
#4	5,225	R-134a	Centrifugal, 17 DA	1972	Carrier	steam turbine	river water/ct	Rebuilt and retubed and new turbine rotor in 2017
#5	6,300	R-134a	Centrifugal, OM	1999	York	steam turbine	cooling tower	cooling tower limited to approx. 5600 tons
#6	2,000	R-134a	Centrifugal, Millennium	2008	York	4160 v motor	cooling tower	MCCP
#7	2,000	R-134a	Centrifugal, Millennium	2008	York	4160 v motor w/ VSD	cooling tower	MCCP
#8	2,670	R-134a	Centrifugal, Millennium	2013	York	4160 v motor w/ VSD	cooling tower	MCCP
#9	2,670	R-134a	Centrifugal, Millennium	2013	York	4160 v motor	cooling tower	MCCP
#10	2,670	R-134a	Centrifugal, Millennium	2013	York	4160 v motor w/ VSD	cooling tower	MCCP
Total	33,985							

Turbines	Rating, MW	Inlet Pressure, psig	Temperature, F	Year Built	Manufacturer	Hot Water HX Capacity, BTU/h	Reduction Gear	
HP	18	900	875	2005	Dresser-Rand	180 ,000,000	Lufkin	Has 165# steam extraction
LP	7	165	373	2005	Dresser-Rand	140,000,000	Lufkin	
	25							

CUP Variable Primary/ Distribution Chilled water Pumps	Capacity, GPM	Total Dynamic Head	Drive	Year Built	Manufacturer	Horse Power	Voltage	
CWP-1	11,600	65	VSD	2013	Flowserve	400	480	New 2013
CWP-2	6,750	70	VSD	1971	Canada Pump	150	480	Constant Speed, low TDH
CWP-3	11,600	65	VSD	2013	Flowserve	300	480	New 2013
CWP-4	18,000	104	VSD	1999	Ingersol-Dresser	600	480	New Eaton VSD and WEG Motor in 2012
CWP-5 (MCCP)	6,000	100	VSD	2008	FlowServe	200	480	Variable Speed Drive
CWP-6 (MCCP)	6,000	100	VSD	2008	FlowServe	200	480	Variable Speed Drive
CWP-7 (MCCP)	6,000	125	VSD	2013	Goulds	250	480	Variable Speed Drive
CWP-8 (MCCP)	6,000	125	VSD	2013	Goulds	250	480	Variable Speed Drive

CUP Chiiler Pumps	Capacity, GPM	Total Dynamic Head	Drive	Year Built	Manufacturer	Horse Power	Voltage	
Chiller 2	6750	62	Motor			150	480	
Chiller 3	6750	62	Motor			150	480	
Chiller 4	6750	62	Motor			150	480	
Chiller 5			Motor	1999		200	480	
Cooling Towers	**Rating, GPM**	**Design Wet Bulb, F**	**Inlet/Outlet Temps, F**	**Year Built**	**Manufacturer**	**Type**	**# Fans & HP Each**	
#1 (Chiiler 5)	3750 per cell	75	103.5/82	1999	Evapco	Counter Flow	8 @ 50 HP	Located on grade, west of plant -serves Chiller 5
#2 (Cogen)	5000 per cell	75	123/90	2005	Evapco	Counter Flow	12 @ 30 HP	On Plant Roof, serves Cogen condensers
MCCP #3A	5,000	78	97/85	2008	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant
MCCP #3B	5,000	78	97/85	2008	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant
MCCP #3C	5,000	78	97/85	2014	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant
MCCP #3D	5,000	78	97/85	2014	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant
MCCP #3E	5,000	78	97/85	2014	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant
MCCP #3F	5,000	78	97/85	2014	CCS	Counter Flow	1 @ 75 HP	Mid Campus Chiller Plant

Tower Water Pumps	Capacity, GPM	Total Dynamic Head	Drive	Year Built	Manufacturer	Horse Power	Voltage	
MCCP #5	10,000	100	VSD	2008	Flowserve	300	480	New in 2008
MCCP #6	10,000	100	VSD	2008	Flowserve	300	480	New in 2008
MCCP #7	10,000	100	VSD	2014	Goulds	350	480	New in 2014
MCCP #8	10,000	100	VSD	2014	Goulds	350	480	New in 2014
Chiller 5, CT 1-A	5,000		Motor	1999	Iingersol-Dresser	200	480	CT #1
Chiller 5, CT 1-B	5,000		Motor	1999	Iingersol-Dresser	200	480	CT #1
Chiller 5, CT 1-C	5,000		Motor	1999	Iingersol-Dresser	200	480	CT #1
Chiller 5, CT 1-D	5,000		Motor	1999	Iingersol-Dresser	200	480	CT #1
Hot Water Heat Exchangers	**Rating,BTU/hr**	**Type**	**Tube material**	**Year Built**	**Manufacturer**	**GPM Rating & Inlet/Outlet Temp**		
HP Condenser	180 ,000,000		SS	2005	Graham	11,476 GPM (157F-127F)		Serves HP Turbine Exhaust
LP Condenser	140,000,000		SS	2005	Graham	11,476 GPM (157F-127F)		Serves LP Turbine Exhaust
Trim HX 1	77,000,000	Shell and Tube	CS	2005	ITT Standard	2045 GPM (240F-162F)		50 psig steam feed from CUP
Trim HX 2	77,000,000	Shell and Tube	CS	2005	ITT Standard	2045 GPM (240F-162F)		50 psig steam feed from CUP
Trim HX 3	100,000,000	Shell and Tube	CS	2013	ITT Standard	2645 GPM (240F-162F)		50 psig steam feed from CUP
Total	394,000,000							
Hot Water Dist. Pumps	**Rating, GPM**	**Total Dynamic Head**	**Drive**	**Year Built**	**Manufacturer**	**Horsepower**		
HWP-001	3,000	300 '	Motor	2008	Flowserve	350		
HWP-002	3,000	300 '	Motor	2008	Flowserve	350		
HWP-003	3,000	300 '	Motor	2008	Flowserve	350		
River Water Pumps	**Capacity, GPM**	**Total Dynamic Head**	**Drive**	**Year Built**	**Manufacturer**	**Horse Power**	**Voltage**	
#1	4,000		Motor			125		At Intake on River
#2	4,000		Motor			125		At Intake on River
#3	12,000		Motor			350		At Intake on River
#4	12,000		Motor			350		At Intake on River
#5	12,000		Motor			350		At Intake on River
#6	12,000		Motor			350		At Intake on River
River Water Screens				**Year built**	**Manufacturer**			
#1				2012	Atlas			At river pump house
#2				2012	Atlas			At river pump house
#3				2012	Atlas			At river pump house
Boiler Feed Pumps	**Capacity**	**Total Dynamic Head**		**Year built**	**Manufacturer**	**Horsepower**	**Voltage**	
#4			Motor		Goulds	100	480	LP Feedwater System
#5			Motor		Goulds	100	480	LP Feedwater System
#6			Motor		Goulds	100	480	LP Feedwater System
#7			Motor		Goulds	100	480	LP Feedwater System
#8	500 gpm	1300 psi	Motor	2005	SIHI/Goulds	500	4160	HP feedwater System
#9	500 gpm	1300 psi	Motor	2005	SIHI/Goulds	400	480	HP feedwater System, VSD
Deaerators	**Capacity lbs/hr**			**Year Built**	**Manufacturer**			
#1	225,000							LP deaerator
#2	400,000							LP deaerator
#3	250,000			2005				HP deaerator
Switchgear	**Type**	**Relays**		**Year built**	**Manufacturer**			
4160 North	Metal Clad vacuum breakers	SEL		2015	ABB			
4160 South	Metal Clad vacuum breakers	SEL		2016	ABB			
11.5 kV North	Metal Clad vacuum breakers	SEL			Westinghouse			Retrofit with Eaton Vacuum breakers 2013
11.5 kV South	Metal Clad vacuum breakers	SEL			Westinghouse			Retrofit with Eaton Vacuum breakers 2013

MCCs-CUP	Rating			Year built	Manufacturer		Transformer Rating	
Sub 1	480 volt			1967	Westinghouse		11500:480	oil filled transformer
Sub 2	480 volt			1967	Westinghouse		11500:480	oil filled transformer
Sub 3	480 volt			1967	Westinghouse		11500:480	oil filled transformer
Cogen substation	480 volt			2005	Siemens		11500:480	2 air cooled transformers
Black Start Generators	**Type**	**Nameplate Rating**		**Year built**	**Manufacturer**		**Transformer Rating**	
Set #1	Diesel	700 kW		2005	Generac			
Set #2	Diesel	700 kW		2005	Generac			
Set #3	Diesel	700 kW		2005	Generac			
Step Up Transformer	Oil Filled						480:11500v	
Mid Campus Substation	**Type**	**Rating**	**Secondary Voltage**	**Year built**	**Manufacturer**		**Transformer Rating**	
North 11.5 kV switchgear	Metal Clad vacuum breakers	15 kV		2008	Square D			
South 11.5 kV switchgear	Metal Clad vacuum breakers	15 kV		2014	Powercon			
Transformer 1	Oil filled	5 MVA	4160				11500:4160	
Transformer 2	Oil filled	10 MVA	4160		Howard		11500:480	
Transformer 3	Oil filled	3 MVA	480				11500:4160	
Trabsformer 4	Oil filled	3 MVA	480		Howard		11500:480	
Station 710								
Switchgear Line Up	Metal Clad vacuum breakers	15 kV		2014	Powercon			