ENERGY MASTER PLANNING - FY07 ANNUAL STATUS REPORT

- **Central Power Plant Steam and Electric Generation**
- **Chilled Water Generation and Distribution**
- **Electrical Distribution**
- **Energy Economics**
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Utilities & Plant Engineering
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Central Power Plant Steam and Electric Generation

The Central Power Plant for 90 years has provided energy requirements to the Central and Medical campuses on a continuous basis. Maintaining a Master Plan is one tool used to insure that all energy demand requirements are met as the campus grows and mission changes. The installed equipment configuration presently at the Central Power Plant (CPP) is sufficient to meet thermal and electrical power demands into the future. Present Energy Master Plan focuses on maintaining reliability and energy efficiency of power production and distribution.

Thermal steam production is accomplished with a configuration of six boilers and two heat recovery steam generators which have an installed capacity of 1.1 million lbs of steam an hour generation. The age of these units span 50 to 7 years. A comprehensive study will be conducted in 2007 to formalize a plan of replacement and life extension for these units. Condition assessments of individual units have already identified component replacements to four steam generating units. FY09 will be the beginning of construction work for this plan. FY10 will involve the retirement and subsequent replacement of the oldest boiler.

Electrical production at the CPP relies on the Cogeneration principle where electricity is produced from the thermal steam demand of campus. Total electric demand is augmented by contracted purchase agreements (presently DTE). The CPP has three steam turbine generators with a total capacity of 37.5 MW. These three units are of sufficient capacity to utilize the campus thermal load in producing electricity. Electric production is also augmented by the operation of two gas turbine generator sets with a capacity of 7 MW. Energy Master Plan for electrical production equipment is directed at maintaining reliability and increasing efficiency by utilizing new technology in a life extension program. The CPP presently is in a steam turbine life extension program of all three units which involves replacing the internal components as they reach a service life of thirty years. These internal replacements will extend the life for another 30 years and utilize new technology in materials, design and manufacturing which will increase their efficiency by 10%. The cogeneration operation of the CPP will allow this increase efficiency to be utilized as an increase in electric production under most of the operating profile of the CPP. Completion of the steam turbine life extension will be in FY09. The two gas turbine generating units have just completed upgrades with new engines utilizing updated technology which will increase their generating capacity 0.5 MW each.

Energy production is dependant on many sub systems to insure the two main components fuel and water are properly and efficiently utilized and meet environmental requirements. Starting in FY07 through FY10 the water treatment and condition equipment and systems will be upgraded to maintain water condition and capacity requirements for future energy demands. The new technology and equipment installed will allow the CPP to maintain power production water quality requirements to a higher degree of purity. This will allow the steam production equipment to operate with a higher degree of efficiency and reduce fuel requirements and increase reliability and lower maintenance cost.

The many sub systems involved in energy production must be operated and controlled in exacting sequence and set parameters to insure efficiency of fuel utilization while continuously responding to the varying campus load demands. This is accomplished by a plant wide distributive control system (DCS). Starting in FY07 through FY09 the DCS will be upgraded with the latest technology in control and monitoring systems along with optimizing software, which will allow all sub systems to operate in a more efficient mode and enhance our conversion of fuel to energy production. In addition the CPP has a program started in FY05 through FY13 which will replace metering and control devices in all systems with the latest technology which will augment the new DCS to allow more accurate measuring and control of all the processes involved in producing energy.

The ongoing and future Energy Master Plan initiatives will insure that the CPP continues to provide reliable and efficient production and delivery of power services to the Central and Medical Campuses well into the future.

Richard Wickboldt, UPE Manager, Central Power Plant

Chilled Water Generation and Distribution

Objective
Update the Chilled Water Master Planning Study in order to assess the current CHW production and distribution systems, determine cooling load projections for existing, remodeled and new facilities, and develop options to consolidate existing distributed chilled water plants into a more regionalized approach. The results of the updated study will identify the preferred options to address equipment obsolescence, meet campus loads (for the next 10 years), minimize operating and maintenance costs and increase system redundancy and reliability.

Benefits
The following are the benefits to be realized by implementing a regionalized approach to the production and delivery of chilled water:

- Chilled water becomes a regionalized utility
- Allows for greater efficiency in production of chilled water
- Decrease amount of equipment to maintain, lowering maintenance costs
- Install less equipment than in a distributed system by taking advantage of building load diversity, minimizing first costs
- Mix of Steam Absorption and Electric Centrifugal chillers allows flexibility to reduce electrical demand costs
- Provides increased flexibility, redundancy and reliability
- All buildings have sufficient cooling even if one chiller is down
- Load additions to existing buildings and phasing of renovations is greatly simplified
- Equipment in designated regional locations allows for ease of maintenance, improving maintenance and reliability
- Allows for continued operation of the existing chilled water equipment for the remainder of its useful life, which fully depreciates the existing equipment
- Provides year round chilled water for Computer Server Rooms and other process loads, thus eliminating numerous split DX units
- Moves chilled water production out of buildings
- Does not require replacement of current building equipment that will ultimately be costly to replace
- Potential to return mechanical room space back to the University for other uses in the future
- Reduces load on existing building electrical systems, allowing for capacity to add building load in the future
- Consolidation of cooling tower equipment into a few regional locations improves campus aesthetics

Overall Scope of Work
The following tasks are required for updating the study:

1. Review the overall configuration and conditions of existing chilled water generation and distribution systems and compare it to other systems similar in size.

2. Identify the preferred manner for the integration of multiple existing systems for the purpose of improving capacity, increasing operating efficiency, through diversity and energy savings and reducing maintenance cost due to the overall reduction in pieces of operating equipment. This shall include but not limited to conceptual schematics showing plants' locations, plants' tonnage and the buildings served by each Plant.

3. Locate and identify areas on campus where centralized chiller plants should evolve based on projected future load growth, the need to replace aging chilled water plants and equipment, and redundancy benefits.

4. Item 2 and 3 above must be supported by a life-cycle analysis.

Scope Responsibilities:
The scope of work required is sufficient enough to warrant the hiring of a consultant to perform the majority of the tasks required to update the master plan. The breakdown of UM and consultant scope responsibilities is as follows:

<u>U-M Plant Engineering:</u>
- Gather information on current and project loads, historical trend data, chiller replacement requirements, existing campus master plans and utilities master plans.
- Coordinate consultant efforts.
- Integrate draft regional reports/plans w/ other university master plans

<u>Consultant:</u>
- Support information gathering by U-M
- Integrate information provided by U-M into comprehensive regional plans
- Develop options and alternatives for UM's selection for final analysis.
- Provide construction and life cycle cost analysis for selected options.
- Generate written regional plant descriptions
- Generate drawings/sketches/tables required to support regional plans
- Compile regional plans and other information resources into draft report
- Incorporate U-M comments into the final report

Study Approach
The initial phase of the study update will be to address the following regions in a broad fashion and then focus on the regions already identified as having priority due to future expansion. The consultant will submit draft reports in stages for each region, in order of priority, as they are completed. Then the report for each region will be further developed and finalized following review and comments by UM. The regions, in order of priority, and the preliminary study approach for each of them are as follows:

<u>Medical School Zone</u>
The University's near term plan to demolish the Kresge Buildings and erect new research buildings offers an opportunity to consolidate chilled water production in the Medical School zone. Also, the MSRB chillers (representing 3500 tons of capacity) are scheduled for replacement in 2018 when they will be 30 years old. The study update will include determining the feasibility and best approach to consolidating the existing chilled water production of nearby buildings into one of these new buildings. The study will also determine the best method for addressing the MSRB chiller replacements.

<u>North Campus Zone</u>
The existing North Campus regional chilled water system is designed for expansion to include all of the North Campus academic and research buildings. The study update will include determining the projected timing and cost of the system expansion based on the North Campus Master Plan being developed by the University Planners Office in 2007. The study will also include options for the installation of a thermal storage tank next to the existing chiller plant.

<u>East University Zone</u>
The existing East University regional chilled water system will be connected to the Hatcher regional chilled water system in 2007. The study update will include determining the best approach for using this connection in order to provide added system redundancy and reliability in the East University system. The study will also determine the best approach to realigning the existing capacity within the East University chiller plant by either replacement or addition of chillers.

<u>Thayer (MLB) Zone</u>

The existing chiller plant inside Modern Language building will be expanded in early 2009 to provide chilled water for the new North Quad building. The updated study will determine the feasibility of providing chilled water to the Rackham building.

<u>Fletcher (Dental) Zone</u>
The existing Fletcher Street regional chilled water system is relatively close to the new Palmer Drive chilled water system. The updated study will look at the feasibility of connecting the two systems together to provide added redundancy, reliability and operating efficiency.

<u>Chemistry-Kraus-Mason</u>
The existing chillers in Chemistry, Kraus and Mason (representing 5500 tons of capacity) are scheduled for replacement in 2018 when they will be 30 years old. The updated study will determine the best method for addressing these chiller replacements by either consolidation into an existing building(s) or into an underground chiller plant between the buildings.

<u>Thompson Street Zone</u>
The Thompson Street parking garage is to be expanded in the near term which offers the opportunity to site a regional chiller plant. The updated study will determine the feasibility of building the plant in order to provide chilled water to West & South Quad, the Law quad, the Union and buildings to the north.

Schedule:
<u>2006</u>
November: Start Thermal Energy Storage Tank (TES) study for NCCP
<u>2007</u>
February: Complete TES study for NCCP
February: Issue RFP for master plan study
March: Award PO to master plan consultant
November: Complete draft master plan report
December: Integrate chilled water plan w/ other master plans
<u>2008</u>
January: Issue final report for chilled water master plan

Eric Albert, UPE Manager, Mechanical Engineering

Electrical Distribution

The Electrical Master Plan for the University of Michigan is an overall design to insure that the University of Michigan electrical distribution infrastructure is able to provide adequate electric power to existing facilities and any planned renovations for these facilities as well as new buildings with planned construction within the five year window of this report.

The University of Michigan currently has 3 main interconnections with the local electric power utility company, Detroit Edison Company (DECO)/DTE Energy. These 3 main DTE Substations or U of M switching stations are DTE Campus Substation (UM name is North Campus Switching Station) serving North Campus, Ingalls Substation (UM name is Ingalls Switching Station) serving Central Campus, and University Substation (CPP) located at the Central Power Plant (CPP) and serving Central Campus. This report addresses the current and planned future electric loads at each of these locations up through year 2012 as known at this time.

DTE Ingalls Substation/UM Ingalls Switching Station

Ingalls Substation is the University of Michigan's newest electric power source. The first phase design of this substation provided for two 25 MVA* (mega volt ampere) transformers with a total capacity of 50 MVA. The redundancy criteria of the planning was that in the event there was failure of one transformer, the other would still be able to provide power to the total electric load of the substation. This is known as the N-1 scenario. The original planned loading of this substation is 25.3 MVA between the two transformers.

Construction on the substation structure with two transformers (Phase I) was completed in June of 2006. At this time, the Ann Street Parking Structure became the first load to be connected to the substation. With the completion of the interlocking scheme in December 2006, the Biomedical Science Research Building and Medical School feeders 20 and 43 will be connected to Ingalls. This will be followed by the addition of the Cardiovascular Center and the transfer of the Cancer Geriatric Center from the UM Hospital Academy substation to Ingalls. After the addition of the third transformer or Second Phase, the electric load of the new Children and Women's hospital will be added. Following is a table showing the planned electric loads for this substation through 20012.

***Note:** To convert MVA or Mega Volt Ampere to Mega Watts (MW), multiply the MVA figure by the power factor (PF). A PF of .9 can be used for estimation purposes.

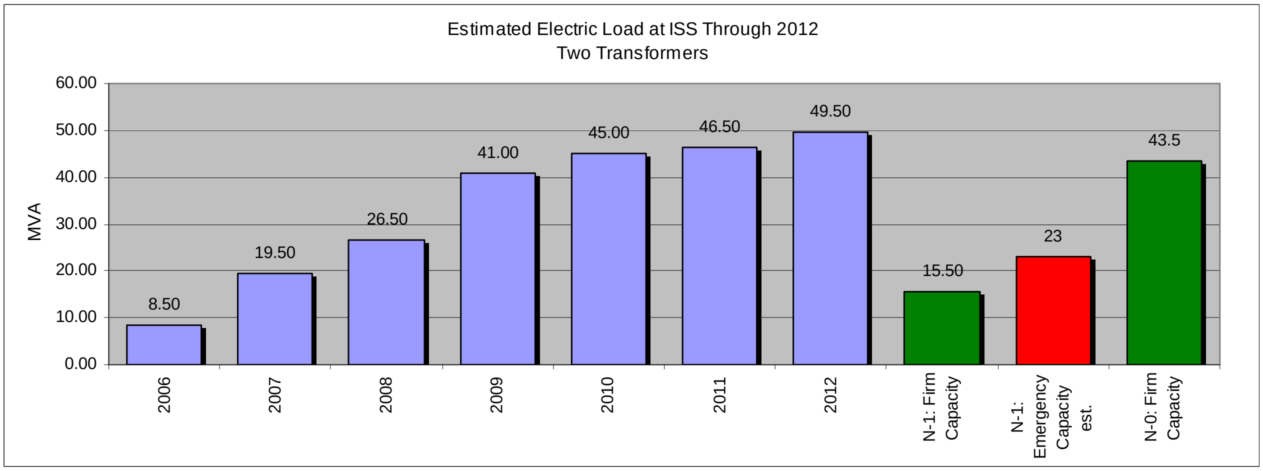
Table 1
Ingalls Substation Future Loads

	Accumulation of Loads for Ingalls Year in MVA						
Load	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Ann Street Parking	0.50						
Biomedical Science Research Building	4.00						
Cardiovascular Center		7.00					
Medical School Refeeds feeders 20 and 43 (option)	4.00						
CGC Refeed		4.00					
East Mechanical Building			3.00				
Women's & Children's Hospital				11.00			
Health Sciences Education Building (Kresge)					4.00		
North Ingalls Building Refeed							3.00
Kellogg Eye Center Addition			4.00				
Parking Structure(s)				0.50		0.50	.
Pathology Building				3.00			
Old KEC						1.00	
Total of Loads added to Ingalls Sub	**8.50**	**11.00**	**7.00**	**14.50**	**4.00**	**1.50**	**3.00**
Accumulated Total Load	**8.50**	**19.50**	**26.50**	**41.00**	**45.00**	**46.50**	**49.50**

Of the loads listed in Table 1, 33 MVA of the 49.50 are new loads.

The following graph shows the total electric load per year at Ingalls substation without the third transformer.

Estimated Electric Load at Ingalls Substation



This graph shows that this substation has adequate redundant (N-1) coverage of 15.5 MVA of firm electric load and an emergency coverage (N-1) of 23 MVA of load. The two transformer substation configuration can support 43.5 MVA of electric load with no redundant coverage (N-0).

DTE University Substation/UM CPP

University Substation located at the Central Power Plant was the first University interconnection with the local utility for Central Campus until the completion of Ingalls Substation in 2005. The following table shows the projected load growth for this facility as the information is known at this time.

Table 2 - University Substation Future Loads

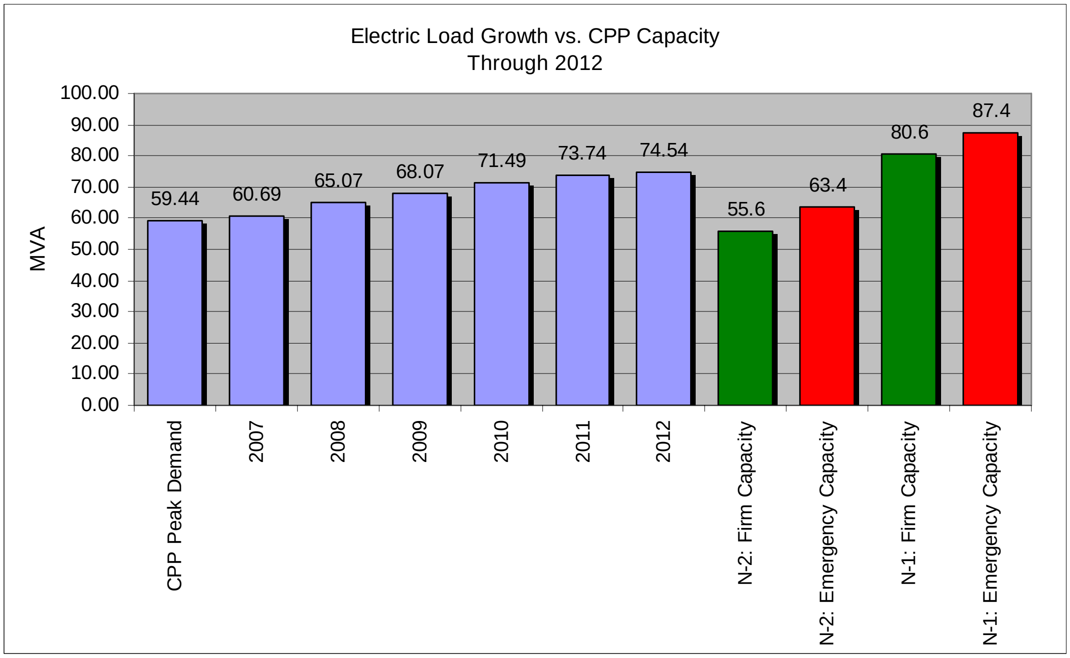
Accumulation of Loads for CPP

Year in MVA

Load	2006	2007	2008	2009	2010	2011	2012
Academic Center	1						
Ann St. Parking Structure	0.5						
Hatcher chiller plant and Substation replacement	1						
UMMA Renovation and Addition			0.5				
Division Street Parking					0.5		
Ross School of Business			1				
Law School Addition				1			
Ford School of Public Policy and Weill Hall	1.5						
Hill Area Dining Facilities			1				
School of Public Health I Revovation and Addition	0.8						
Thayer St. Building	0.75						
North Quad				1.5			
Dining Center							0.8
Kraus Renovation						0.5	
Ruthven Upgrades					0.5		
Mary Markley		1					
Molecular, Cellular, and Developmental Biology					1		
Michigan Stadium Addition and Renovation			1				
Crisler Projects					0.5		
Campus Safety Services Building			0.5				
Softball Stadium		0.25					
Stockwell Renovation						1	
New practice facility for football					0.5		
Medical School Refeeds feeders 20 and 43							
Med. Sci. I Chiller	1.02						
Modern Languages Building Chiller				0.50			
Taubman Medical Library Chiller			0.37				
Cook Legal Research Chiller					0.43		
Dennison Building Chiller						0.74	
Total of Loads added to the CPP	**5.07**	**1.25**	**4.37**	**3.00**	**3.43**	**2.24**	**0.80**
Accumulated Load at the CPP	**5.07**	**6.32**	**10.70**	**13.70**	**17.12**	**19.37**	**20.17**

The following graph shows the expected total load with yearly increases at University Substation/CPP, as known at this time, with redundancy capabilities for current equipment.

Impact of Load Growth at University Substation/CPP



With the current 3 transformers rated at 25 MVA at University Substation, this graph shows that the substation will be able to handle the increase in electric load adequately and also meet the redundancy criteria of N-1.

DTE Campus Substation/UM North Campus Switching Station

The DTE Campus Substation serves the University of Michigan North Campus. The following table lays out the expected electric load increase as known at this time:

Table 3 – North Campus Electric Load Increases

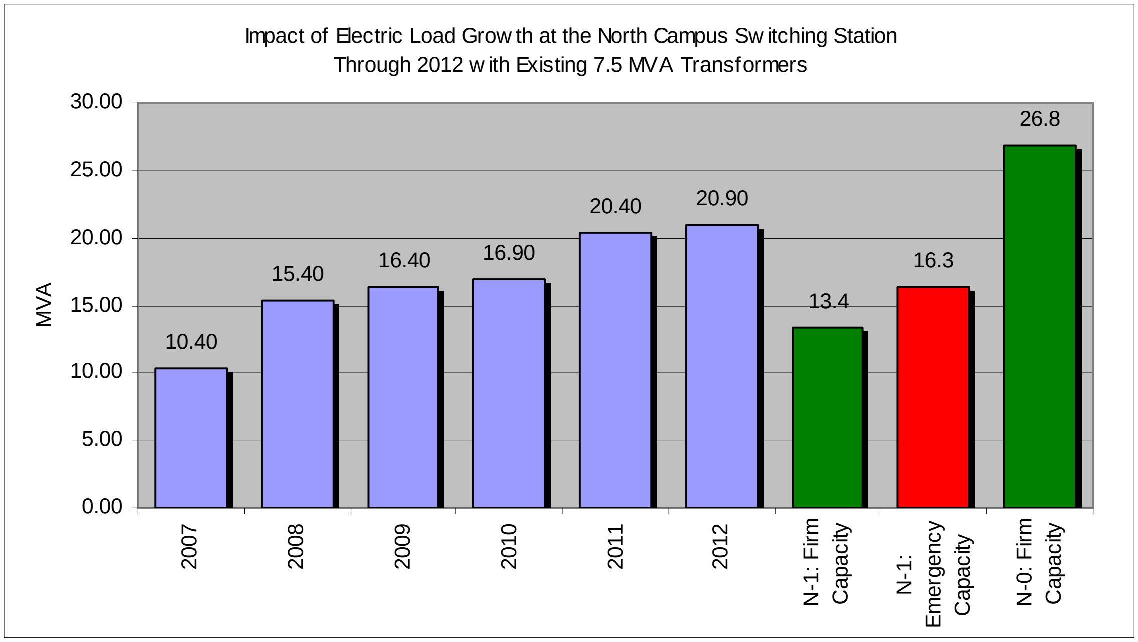
Additional Loads for North Campus

FY in MVA

Load	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Walgreen Drama Center and Auditorium	0.5					
Solidstate Electronics Lab	1.5					
North Campus Chiller Plant					3	
Parking Structure			0.5			
Machine Room		5				
GG Brown Addition				0.5		
Art & Architecture Addition					0.5	
Moore Renovation & Addition (School of Music)						0.5
Bursley Hall Renovation			0.5			
Total of Loads added to NCSS	**2.00**	**5.00**	**1.00**	**0.50**	**3.50**	**0.50**
Accumulated Load at the NCSS	**2.00**	**7.00**	**8.00**	**8.50**	**12.00**	**12.50**

The following graph shows the impact of the increased electric load on the existing two 7.5 MVA transformers at North Campus. This has necessitated an upgrade of the 7.5 MVA transformers in FY07.

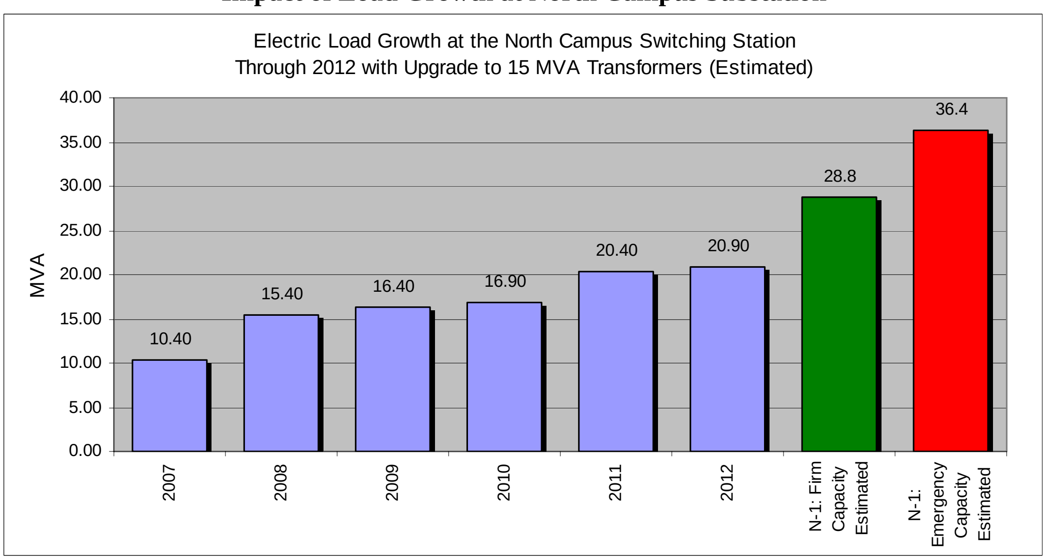
Impact of Load Growth at Campus Substation/North Campus



As can be seen by this graph, the redundancy capability of N-1 will be compromised in 2010 with the additional load unless the transformers are upgraded.

The next graph shows the North Campus load growth using two upgraded 15 MVA transformers.

Impact of Load Growth at North Campus Substation



The previous graph shows that with the two upgraded 15 MVA transformers at North Campus, the total estimated load of 20.90 MVA in 2012 can be supported with N-1 redundancy and the equipment will be able to provide power for further growth.

Summary
By FY 2012, this report has presented that the University of Michigan could potentially experience a load growth of about 65 MVA if all new loads reach the peak demands listed in Tables 1, 2, and 3.

Yoshiko Hill, Manager, Electrical Engineering & Energy Management

Energy Economics

Background

The University of Michigan Ann Arbor campus is a large and complex facility that consumes a great deal of energy from several different sources. The total utilities cost for Fiscal Year 2006 was over one hundred million dollars, in spite of a successful and on-going Energy Conservation Program that has reduced consumption in many buildings. The campus has experienced unprecedented growth in facilities through new buildings and additions and renovations to existing buildings. In addition, many buildings have seen increased energy consumption due to the normal growth of electronic equipment and increased utilization. At the same time, the cost of purchased utilities, especially natural gas, has grown at an historic rate. All of these factors combine to provide more incentive then ever before to reduce energy costs wherever possible.

Campus Layout

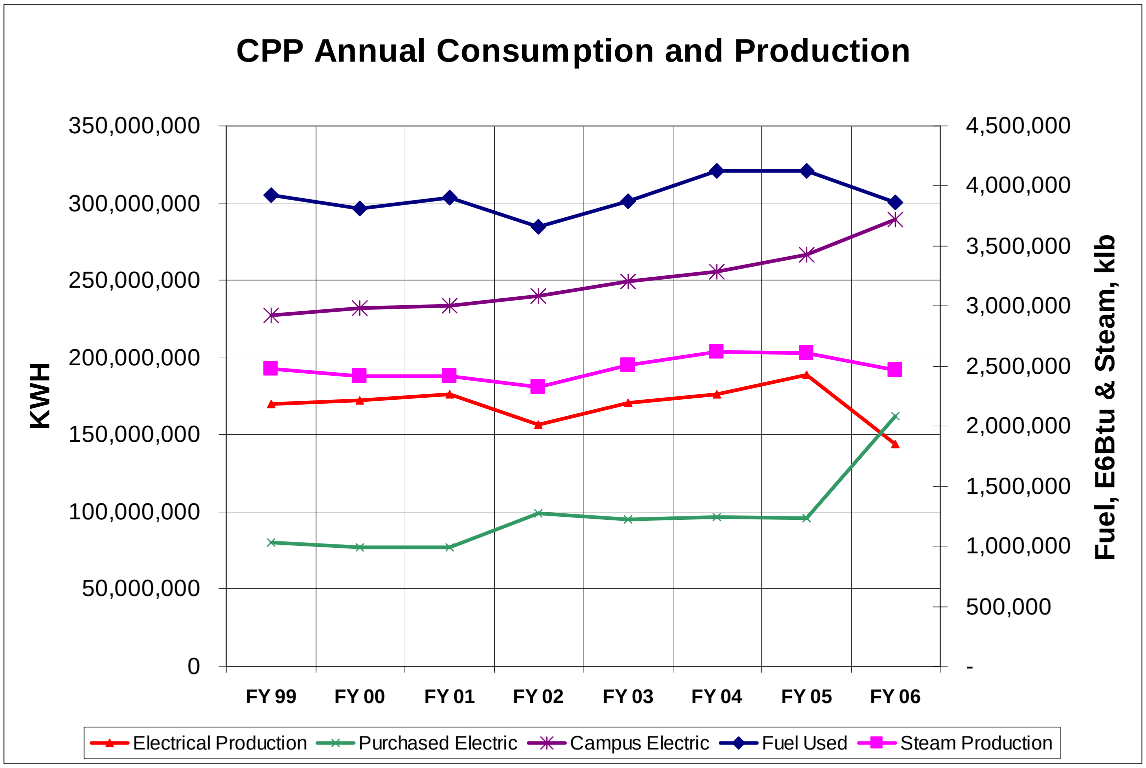
The Ann Arbor campus can be thought of as two main campuses, Central and North, with two outlying areas, East Ann Arbor Medical Center and Wall Street, plus numerous smaller off-campus facilities. Most of the Central campus is served by the Central Power Plant for steam, electricity, domestic hot water (DHW) and compressed air. The hospital complex receives steam, DHW and compressed air from the CPP but not electricity, which is fed directly from DTE Energy. To the south, the athletic complex receives electricity from the CPP but not steam or DHW. There is no central chiller plant on Central Campus. Instead, buildings are served by individual chillers or direct expansion air conditioners, except in a few cases where a few buildings share a single chiller plant.

The North Campus does not have a central heating or power plant but does have a central chiller plant which will gradually be expanded to serve most of the area. A few buildings share heating plants, but otherwise, each building has its own boilers and hot water heaters. Buildings off the two main campuses have individual heating and cooling equipment.

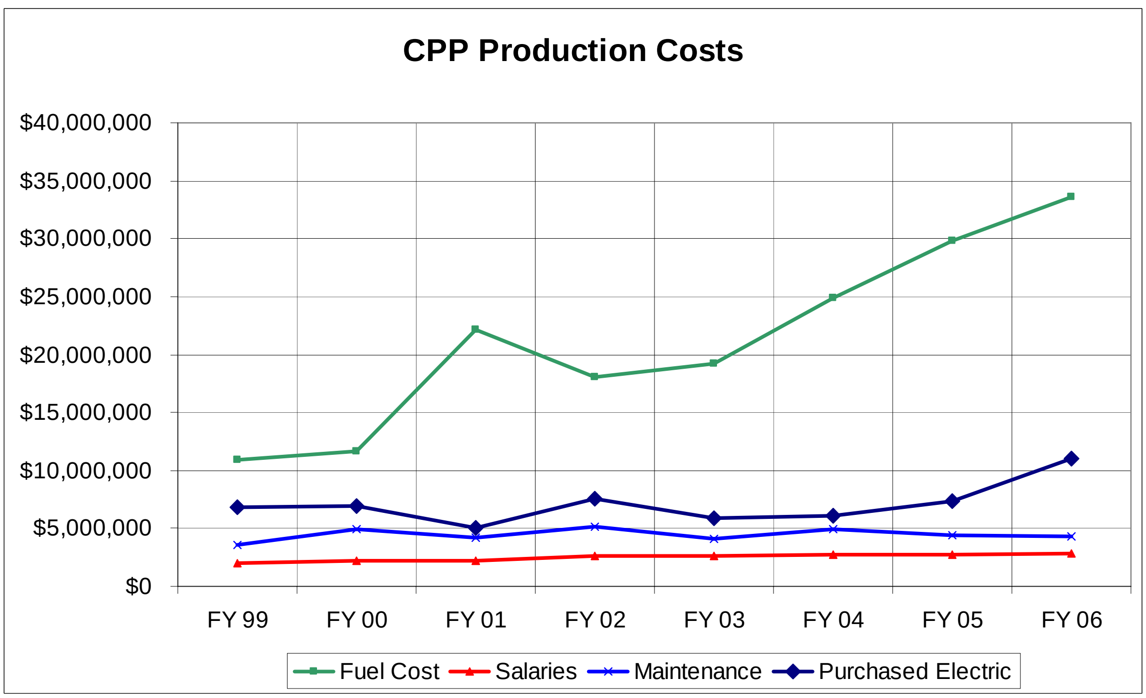
The Central Power Plant is a combined-cycle, cogeneration plant, meaning that it uses gas turbine and steam turbines in tandem to generate electricity and uses the low-grade energy in the form of steam to heat the Central Campus. This provides one of the most energy efficient systems available and reduces pollution compared to separate heating and generation plants. The CPP is the only source of steam for most of the Central Campus but can supplement generated electricity with that purchased from DTE. In the event of a complete CPP plant outage, which has never happened, the DTE connection is sufficient to supply the entire connected load on Central Campus. Steam is used in absorption chillers to provide cooling in the summer, which allows the CPP to generate more electricity in the summer when demand is highest.

Energy Cost Trends

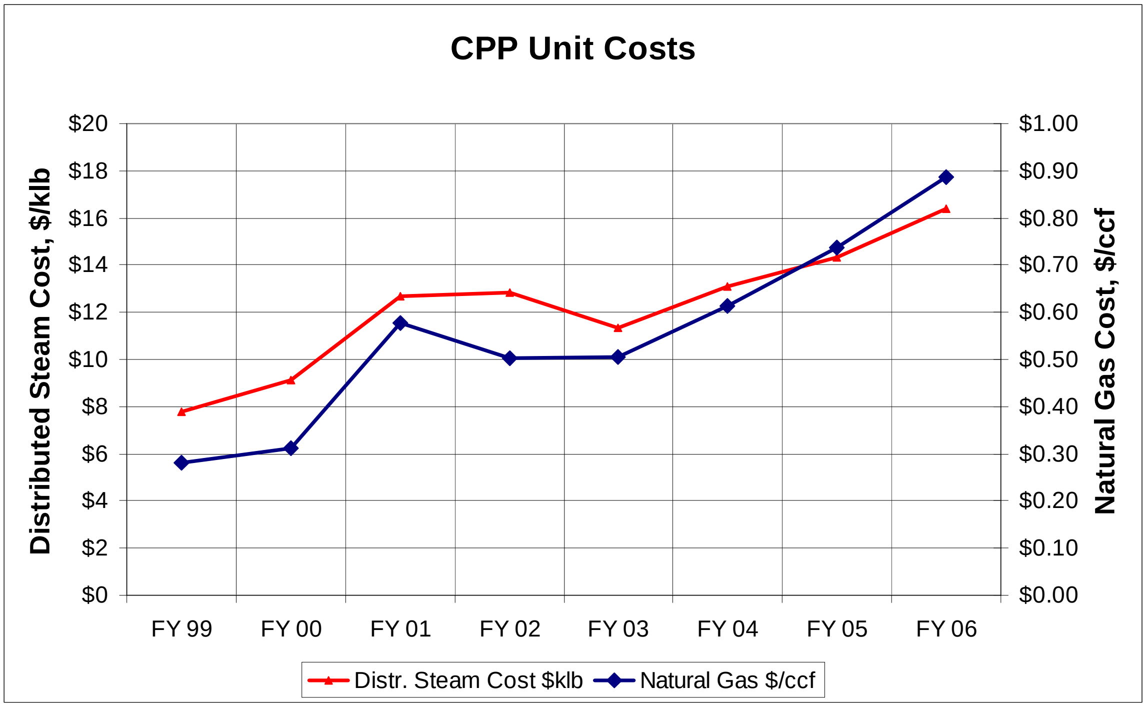
The following graphs show costs for Central Campus and the Central Power Plant. The first shows the trend in energy consumption and production. While steam consumption and production has been relatively flat over the eight-year period, electrical consumption has grown steadily. Electrical consumption comprises electricity purchased and that generated. In FY06, a program of reducing generation during off-peak hours was instituted to take advantage of DTE’s rate structure, increasing annual purchases and decreasing generation.



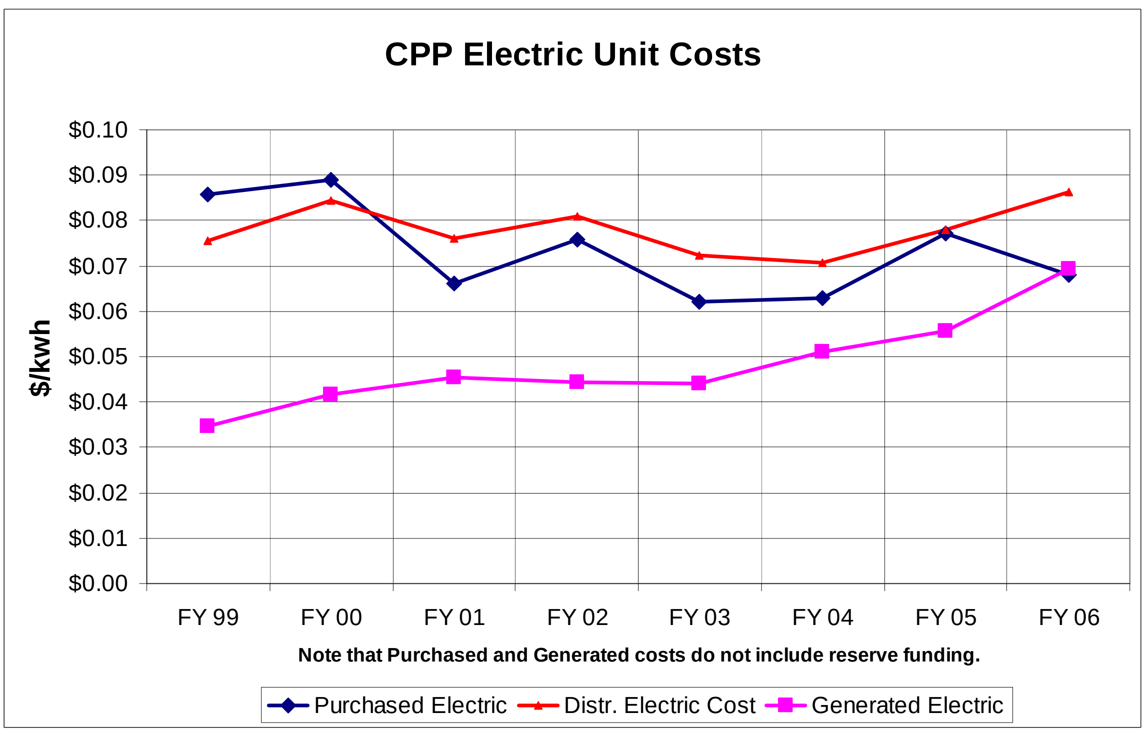
The second graph shows the main components of production costs at the CPP. While the overhead costs and purchased electricity have stayed relatively flat, the cost of natural gas has tripled.



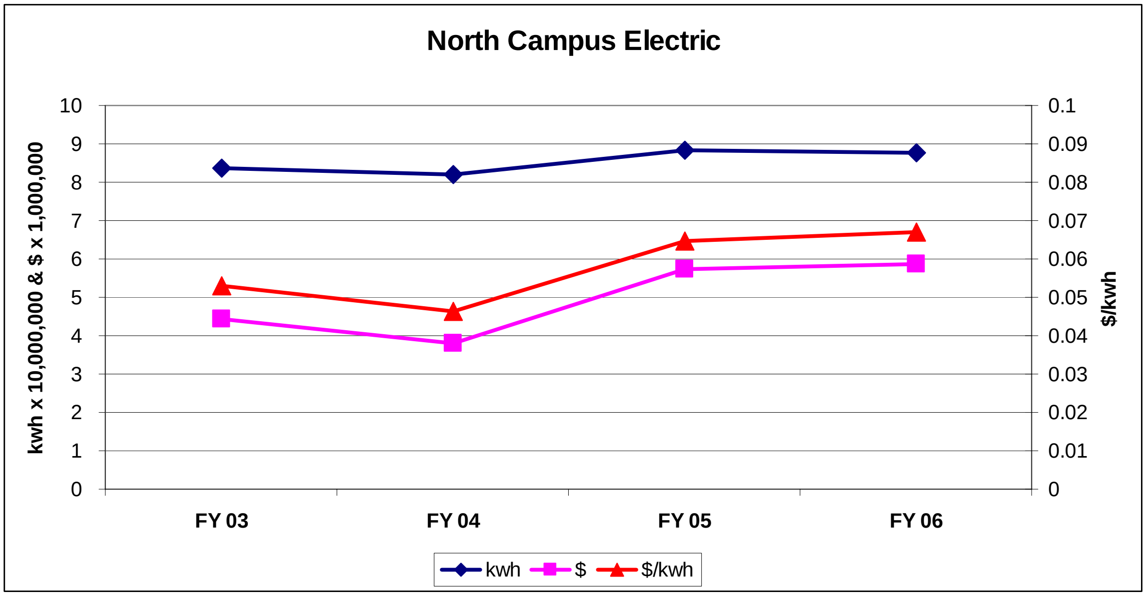
The third graph shows unit costs for natural gas and for steam distributed to the campus. This shows that distributed steam costs have risen slower than that of natural gas.



The fourth graph compares unit prices for purchased electricity, generated electricity and the final cost of electricity distributed to Central Campus customers. The final distributed unit cost has not changed much, while the cost of purchased electricity has decreased slightly as a result of competitive purchasing, while the cost of generated electricity has nearly doubled due to natural gas price increases.



The last graph shows the changes in electric consumption and cost on North Campus for the last four years. While consumption has only grown a small amount during this period, there are several large buildings under construction that will add to the existing load in the next two years.



Energy Cost Control Strategies

Following are some of the methods that can be used to manage energy costs.

1. Reduce energy consumption
2. Improve efficiency of energy usage
3. Utilize the CPP to provide lower cost energy than can be purchased
4. Utilize the Building Automation System (BAS) to manage demands
5. Find new sources of energy to reduce costs
6. Reduce cost of purchased fuels and electricity

The simplest and most straightforward way to reduce energy costs is to use less. This is addressed by the ongoing Energy Conservation program through projects to improve the energy efficiency of buildings and through outreach programs that encourage building occupants to reduce energy consumption.

The CPP provides a tool for managing some of the campus utility costs. Since its construction in 1914 until the last couple years, the cost of steam and electricity produced by the CPP was considered to be less than available through any other means. The plant was converted from coal to natural gas in the 1960s when natural gas was inexpensive and price-controlled. In the last couple years, the sky-rocketing price of natural gas has made the picture much less clear. While coal now provides a much lower cost per million Btu, there is no practical way for the plant to go back to burning coal. Both the physical conversion and environmental permitting issues would be huge obstacles. Other alternative fuels may be more practical in terms of conversion and permitting, but finding sufficiently reliable sources at competitive costs will be challenging.

One way that the CPP is presently helping reduce costs is through managing purchased electricity demand. The present contract with DTE breaks up the costs into three basic components: energy, demand and standby charges. The energy is essentially the cost of fuel to produce the electricity. Since most of DTE's electricity is produced by coal-burning plants, this cost is less than the cost of the natural gas used by the CPP to produce electricity, even though the CPP overall plant efficiency is about double that of DTE's plants. However, demand charges, which are based on the highest demand in each month and in a 12 month period, make up approximately half of each month's bill. By using all available CPP generation during these peak times, the demand charge can be minimized. Then when generation can be reduced without setting a higher demand, cheaper electricity can be purchased from DTE. Since the present DTE contract began, this method has been practiced by the CPP, saving several hundred thousand dollars a year. In the future, the electrical market in the Midwest may adopt a "Time-of-Day" pricing system where the cost of electricity will change by the minute. In that case, having a flexible in-house generation system will be even more valuable to take maximum advantage of price swings.

The Building Automation System can control major HVAC equipment in most buildings on campus. This could be used to cycle major electricity using equipment on a rotating basis to minimize peak electrical demands with little or no effect on occupant comfort. This would have an effect on demand charges similar to that of managed generation in the CPP. This and other demand management techniques could provide significant savings, especially in a time-of-day pricing market.

Alternative types of fuel and sources of electricity may offer the potential for reducing overall fuel costs. As previously stated, reliability of supply and price are critical factors in deciding to make long-term commitments to alternate energy sources. For instance, constructing a wood chip fired heating or cogeneration plant for North Campus could provide a cost savings over natural gas, if the availability and cost of acceptable wood fuel can be reasonably predicted over the life of the plant. One way to reduce the risk would be to have a boiler plant that could burn a variety of fuels, so that fuel sources could be switched to take advantage of price swings. It is unlikely that any one fuel will have the supply reliability or price stability of natural gas.

Utilities department personnel responsible for purchasing natural gas and electricity have been using a variety of techniques to minimize those costs. Purchases are made on a competitive basis to the extent allowed by regulations. Whether selecting an electricity provider or purchasing natural gas on long-term contracts, the most difficult task is predicting what future prices will be. After many years of slow and predictable movements in these prices, we seem to have entered an era where prices can fluctuate rapidly with no historical basis. In any period of volatility, methods such as long term contracts can minimize risk and allow better fiscal planning.

Energy Economics Committee Charter
The committee will investigate any of the areas above that have a potential to reduce overall costs to the University. It will also interface with other Energy Master Plan committees to coordinate efforts.

The Utilities Billing group distributes costs to various departments on campus based on actual measurements of usage in most cases. Every effort is made to fairly distribute costs. However, changing markets can skew this distribution. For instance, electrical supply contracts prior to the present DTE contract billed electricity on an energy only basis ($/kwh) or with a small demand charge ($/kw/month). With the DTE contract, demand charges make up about half of the bill. The University's internal billing for electricity is based solely on energy ($/kwh). Therefore, some clients with large demands at peak times cost more per kwh to serve than customers with more steady loads. These potential inequities of cost distribution will also be considered by the committee when examining proposed changes.

The first two cost containment methods listed above are more directly addressed by the Energy Conservation Committee, while number six is an ongoing responsibility of Utilities Department personnel. Therefore, the efforts of this committee will be concentrated on areas 3, 4 and 5, as well as any other ideas with potential for savings.

Summary
Escalating and fluctuating energy prices present challenges but also offer opportunities for managing University energy costs. The Energy Economics Master Plan Committee will address those challenges and pursue opportunities for reducing overall utility costs.

William Weakley, CPP Results Engineer & Manager, Outlying Boilers

Mechanical Piping Distribution Systems

The University's Mechanical Piping System Master Planning committee was formed over 10 years ago to actively address a range of issues that ensure that the distribution systems remain viable well into the future. Members of the committee include – Bill Verge, Mike Swanson, Bill Fink, Tom Girard, and Ven Manian. The committee was commissioned to address concerns that impact growth, reliability, and emergency preparedness planning. Current planning efforts address the following areas:

- Campus growth
- Limits on capacity
- Emergency Preparedness Planning
- Aging infrastructure
- Long term maintenance projects
- Upgrading steam systems to handle 600 degrees F.
- North Campus opportunities

Components of the planning effort include periodic review and updates as necessary of the low pressure steam (LPS), medium pressure steam (MPS), and condensate models to address any issues that affect their accuracy. It wasn't until fiscal year 2006 that the MPS and condensate models were completed but have since proven to be invaluable in our planning efforts. By adjusting the model for projects such as phase one of the Brick Tunnel Replacement Project, the Art Museum expansion, Ross School of Business and the new Woman's and Children's Hospital, we can determine what changes will be necessary in the distribution system to accommodate these projects. For example, the condensate model revealed the exact cause for why condensate could only flow in one direction in our looped Medical/Hospital piping system. We were able to determine what changes needed to be made and are able to plan for them so that these changes will be implemented before the new Women's and Children's Hospital comes on line.

The Utilities and Plant Engineering Department currently has a 10-year capital plan in place that helps secure funding for most of the projects that comes out of our master planning efforts. This plan currently has 32 projects identified within the thermal distribution system and all of which came out of our master planning efforts. Listed below are brief descriptions of a few of these projects:

- Five phases of projects that will replace all remaining brick tunnels.
- New 60# to 9# pressure reducing stations located in the Business School and Law School areas of campus which will provide a reliable back-up should the low pressure steam piping need shutting off for an emergency or scheduled maintenance.
- Several tunnel structural repair and replacement projects that are needed because salt that has been used for de-icing sidewalks and roads over the years have seeped into cracks in the tunnels and corroded the reinforcement steel in the roofs and walls causing the concrete to crumble and loose strength.
- A study and phased construction of permanent hard piped connection points into the medium pressure steam system which will be located strategically so that if an event were to occur and the CPP could not deliver steam or there was a tunnel collapse or similar event, a truck mounted boiler could be brought in and connected into the distribution system within hours which would prevent a major loss in research and disruption to the hospital system.
- Phased approach to upgrading the steam distribution system so that it is able to handle a 600 deg temperature excursion if a mechanical failure were to occur with the CPP.

The current boundary of the master planning committee is that is does not address any issue that will be specifically addressed by the other Energy Master Planning committees: CPP, Electric Distribution, and Chilled Water Plants & Distribution. The committee access any and all available information sources, including other departments on campus, other universities, government agencies, trade organizations, etc. The committee participates in forums, seminars, etc inside and outside the University in order to gather information that can help achieve the stated objectives.

The reliability of the mechanical distribution systems on campus is extremely important and our goal is that our systems will some day be free of all unplanned outages. Our customers expect this type of service and the master planning committee is dedicated to providing leadership and direction in planning future expansion and renovation projects that will keep the distribution services operational and available for future campus growth. The management of the underground mechanical distribution system and its staff are completely committed to providing world class service.

Listed below is a listing of current Central Campus – Thermal Distribution projects:

Asbestos Abatement Program for Tunnel System
Brick Tunnel Replacement Phase I (POR 608-612)
Brick Tunnel Replacement Phase II (POR 804-807)
Brick Tunnel Replacement Phase III (POR 800-804)
Brick Tunnel Replacement Phase IV
Brick Tunnel Replacement Phase V
Business School PRV's for Tunnel System
Condensate System Upgrade for Tunnels to Support Women's and Children's Hospital Expansion
Couzens Hall Tunnel Chamber Replacement
DHW System Improvements, SS Upgrades for Tunnels
Emergency Plan - Permanent Steam Connections for Portable Boilers (Phase I)
Emergency Plan - Permanent Steam Connections for Portable Boilers (Phase II)
Emergency Plan - Permanent Steam Connections for Portable Boilers (Phase III)
Emergency Plan - Permanent Steam Connections for Portable Boilers (Phase IV)
Emergency Plan - Permanent Steam Connections for Portable Boilers (Phase V)
Expansion Joint Replacement for Tunnels for 600 °F Design (Phase I)
Expansion Joint Replacement for Tunnels for 600 °F Design (Phase II)
Expansion Joint Replacement for Tunnels for 600 °F Design (Phase III)
Expansion Joint Replacement for Tunnels for 600 °F Design (Phase IV)
Expansion Joint Replacement for Tunnels for 600 °F Design (Phase V)
Last Remaining Areas to be Converted to Copper in Tunnels
Lorch Hall Tunnel Structure & Piping Replacement
LPS Expansion Joint Replacement in Tunnels (POR 222-230)
LSA/Kelsey - Replacement of Underground Steam Line
North Quad Utility Services
School of Education Crawl Tunnel Replacement Including Piping
South Quad and 900 Tunnel PRV System
Structural Chamber Replacement at POR 402
Structural POR 834-835 State Street Alumni Memorial

Structural Replace Tunnel Under South U. Serving - Law School and Others
Structural Systems Improvements Within Tunnels
Ventilation Improvements for Tunnel System

Mike Swanson, Manager, Piping Systems & Utilities Services