Awarded Project of the Year 2021
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Awarded Project of the Year 2021
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Dearborn HVAC Infrastructure and Energy Initiative

Vytau K. Virskus, principal Millenium Energy Company

Jim D. Larken, Larken Engineering

LARKIN ENGINEERING, LLC

Millenium ENERGY COMPANY

Executive Summary

The City of Dearborn, Michigan, launched an initiative for designing and installing comprehensive HVAC renovations in 2016. Actual construction began in 2018 following an intense planning and design period.

The objective was to transform the City's 80-acre building complex on Michigan Avenue across from the Ford World Headquarters into a world-class, energy-efficient, and sustainable municipal building campus. The City is investing significant amounts of capital and resources into upgrading HVAC and energy-consuming systems to the most current technology, as well as the thermal and electric infrastructure throughout the one-half million square-foot campus of six buildings, which include:

1. Dearborn Administrative Office Building (DAC)
2. Ford Community and Performing Arts Center
3. Henry Ford Centennial Library
4. Police Building and Jail
5. Courts Building
6. Central Cooling and Electrical Distribution Plant (the Powerhouse)

There are numerous elements of the City of Dearborn Mechanical and Electrical Renovation Initiative, that when taken together, make this project quite unique and innovative. When completed, the result of the City of Dearborn's initiative will bring it to the forefront of municipal energy management and efficiency. The Powerhouse and much of the energy infrastructure was built in the 1960s, and the energy costs had risen to over $1 million per year. This was due in part to the aging HVAC systems, along with the inefficient heating, cooling, and control technologies that lagged far behind that which was considered state-of-the-art in 2016 when the project was initiated. The resulting energy cost savings are estimated to be nearly 50% of the base year energy cost.

The breadth of this initiative is illustrated in the project scope that was developed with the leadership of Mayor John O'Reilly, Jr., and the City Council, together with the partnership and cooperation of the DPW, Powerhouse, Purchasing, Facilities, and other departmental staff. In addition to the design team, special recognition must be given to the Eric Witte, Deputy Director of the DPW, and Anthony Belzak, Superintendent of the Powerhouse and Facilities for their intimate roles as the City's primary representatives in support of the project implementation. Though there were many contractors involved in the construction of this project over three years, over 90% of the mechanical construction was provided by CSM Mechanical, LLC. CSM was responsible for replacement, or new installation of almost 500 pieces of major mechanical equipment, electrical equipment, as well as state-of-the-art temperature and environmental controls.

The primary objective was to replace all of the aging heating and cooling infrastructure with new equipment that would operate effectively for years to come without continuous parasitic maintenance costs. The second objective was to design the new system with the most current and energy-efficient technology to best serve the community in a sustainable manner, and to minimize the City's energy use and carbon footprint. The large majority of the project was completed in 2020. The remainder is expected to be complete in 2021, though the efforts for continuing energy efficiency and sustainability will be on-going.

- **Construction Schedule:** The construction schedule was developed to complete most of the project implementation by the End of Year 2020. However, due to the economic fluctuations following the election of 2016, both lead times for construction, as well as cost of materials increased significantly. This had an adverse impact on both the project budget and was well as the delivery of materials on site for installation. In addition, the COVID-19 pandemic, which had very high infection rates in early 2020 effectively delayed the project an additional six months to a year. Notwithstanding the impact of these momentous events on budget and schedule, the project moved forward as expeditiously as possible. It is a credit to the city officials, the Department of Public Works staff, the contractors, and to the designers, that the project persevered through all of these serious impediments.
- **Safety:** During the course of this entire project, there have been no injuries recorded, and the project maintains a 100% safety record to date. In addition, at the onset of the project, all contractors and subcontractors received training in recognizing hazardous materials, and its management.
- **Community Relations:** There were numerous communications with the community relating to the HVAC and infrastructure renovations. This was especially true for the library which had to be closed for several months due to the complete interior renovation of this historic building. The HVAC renewal and replacement was necessary in order to improve the functionality of the building and comfort of the patrons, but also to protect the books through much improved humidity control that will reduce the long-term degradation of important historical volumes.
- **Environmental considerations:** Though the project was focused on interior aspects of each building, along with the HVAC infrastructure renovations, it was anticipated that there would be a significant impact on the carbon footprint of the City of Dearborn and energy related aspects of the project. In replacing old and inefficient HVAC systems with new, ultraefficient heating and cooling systems, it was calculated that there would be approximately 50% savings in electricity and heating fuel. The old inefficient central steam heating system was replaced with 95% efficient thermal generation; the old chillers that provide chilled water for air-conditioning were replaced with ultraefficient, frictionless electromagnetic bearing chillers; the old heating and ventilation systems were replaced with occupancy-based HVAC units that operated at minimum capacity during low periods of occupancy; the old fluorescent lighting has been replaced with far more efficient LED lighting fixtures; all electric motors have been converted to variable speed, instead of the old constant speed motors which use far less electricity when full motor speed is not required. All of this is being controlled by a state-of-the-art building automation system that automatically optimizes energy efficiency and minimizes energy use.

- **Unusual Accomplishments:** Neither the Dearborn Administrative Center (DAC), the Police and Courts Buildings, nor the Community Center could be closed down during the course of the construction period. This required very close and intense coordination between the various city departments and the individuals whose offices occupied spaces in the parts of the buildings that were being renovated. This was especially true in the Police Building that operates 24 hours per day and has no down time. The collaboration, cooperation, and mutual efforts of the Police Department, city staff, and contractors was quite admirable. Many people and offices had to be moved periodically during the various phases of the contract, requiring strict scheduling to move people furniture and computers spaces that would allow uninterrupted law enforcement activities. This has been a great credit to not only the planners, but also to the personnel were displaced with minimal inconvenience.

It must be noted that all of the buildings on the City of Dearborn municipal campus had extensive renovations of the buildings. The HVAC systems in most of the buildings were substantially replaced. In addition, many of the buildings had architectural improvements on the interiors, as well as exteriors. Finally, the chilled water distribution systems housed in the underground tunnels of the campus were also greatly impacted by the renovations. The following is a summary of the work that was done in each building.

DAC Entrance Renovations

Dearborn Administration Center

The three front entrances at the Dearborn Administration Center (DAC) were renovated to improve accessibility for the constant flow of pedestrian traffic of both members of the community and City staff. All three entrance doors were replaced, and new electronic card access cameras were installed to improve building security. Safety barriers were also integrated into the new pedestrian approach and landscaping. On the inside of the main entrance way, heating and cooling was improved in the lobby areas to accommodate the ever-growing traffic of patrons visiting the building.

Two large rooftop HVAC systems were replaced with new natural gas heated units to maximize the use of natural gas to heat the building.

Ford Community and Performing Arts Center (FCPAC)

- Natatorium
    - Replaced dehumidification system.
    - Improved sound attenuation in the swimming pool area.
    - Replaced all pool lighting with new led fixtures.
    - Applied new high-grade coatings on pool area walls and structural steel.

- Converted the entire building from steam served from the Central Powerhouse boilers, and installed local, high efficiency thermal generation units to supply heat to the building.
- Replaced all old freon-cooled rooftop HVAC units with new high-efficiency water-cooled units served from the central chilled water plant. The rooftop units Are equipped with high tech variable speed fans and CO2 sensors that manage the building heating and ventilation based on. Occupancy.
- Replaced all obsolete HVAC controls with new state-of-the-art computerized control system to manage all heating and cooling in the building.
- Installed all new LED lighting fixtures to reduce lighting cost by one half.

Enhanced the lighting throughout the library interior

Library grand staircase (above) and new children's area (below)

Library Renovations

- Created a new maker space for children.
- Enhanced camera and security systems.
- Provided additional computer workstations and Internet access.
- Improved study and meeting spaces.
- Created a refreshment area for library patrons.
- Painted and replaced all ceilings along with the new LED lighting fixtures throughout the building.

Police and Courts Buildings

- Replaced all HVAC units in the courts building.
- Converted building steam heating from the Powerhouse to distributed hot water heating by installing high-efficiency boilers in the building.
- Replaced all old steam piping with new hot water piping throughout the building.
- Converted the entire building from constant air volume to the new variable volume (VAV) heating and ventilation systems converting the existing constant volume units to variable air volume control based on building occupancy. This will save a very significant amount of energy for the Police Building during the evening and night shifts when the building is occupied, but the occupancy is minimal.
- Converted all constant volume hot water and chilled water distribution systems in the building to variable volume flow utilizing a patented flow control system called E~flow.

- Replaced numerous suspended ceilings with new ceiling tile as a result of installing new ductwork in variable volume boxes in many of the ceilings throughout the building.
- Replace all remaining fluorescent fixtures with new LED lighting installed radiant gas heat in the Police Building garage Area.

Powerhouse

- Removed the two 22,000,000 BTU per hour boilers that comprised the central steam plant for the entire complex, which were sold to be used by an industrial concern for process steam because the boilers were not at the end of their useful life.
- Dismantled all the boiler feed water treatment, boiler feed water pumping, all condensate return systems and removed 10-inch steam piping from all over the underground tunnels on the campus.
- Replaced existing chillers with high-efficiency units.
- Replaced both older cooling towers with new efficient systems and added a sump tank that will allow the chiller system to operate in the event there was warm weather during the normal heating season. In addition, the entire campus chilled water distribution system on the campus was converted to freeze-less glycol so that the cooling system can be operated during unseasonably warm events in the wintertime to serve events at the Performing Arts Center.
- Replaced all existing pumps with premium efficiency motors and pumps.
- Installed new variable speed drives on all pumps to reduce electric consumption during periods of low cooling demand from the buildings on the campus. The entire campus chilled water distribution system, and flow control based on building cooling demand is made possible by the E~flow controls centralized and distributed throughout the campus.
- Installed radiant heating in the powerhouse to replace the old steam heating.
- Installed new high efficiency packaged rooftop units in the powerhouse to replace the old constant volume systems.
- Upgraded Powerhouse underground tunnel system for chilled water and electrical. distribution.
- Replaced all lighting with LED in the Powerhouse.

Dearborn Project Detail Description

Central Steam to Hot Water Heating Conversion

The entire campus of buildings is being converted from an old and inefficient central steam plant heating system to a distributed hot water heating system using high efficiency, low mass, condensing thermal generation units. The old steam boiler technology installed in the 1960s lost as much as 30% of the natural gas thermal heating capacity as unusable heat. The new, much smaller thermal generation units of today capture up to 95% of the heat. This alone will significantly increase the campus heating system efficiency and reduce natural gas heating fuel costs by as much as 25%.

Demand-Based Heating Controls and Boiler Optimization

Eliminating the two existing massive steam boilers that operated at only 70% efficiency compared to 95% efficient new boiler technology.

Seven (7) new hot water boilers were installed to supply heating to 4 of the campus buildings formerly heated with steam. These compact, high-efficiency, essentially instantaneous thermal energy generating units are rated at 95% efficiency. The new distributed heating systems in all four buildings are designed to supply heat based specifically on the ever-changing building heating demand that fluctuates due to both occupancy and weather.

Each new high-efficiency condensing boiler is fitted with a variable speed drive (VFD) or an electronically commutated motor (ECM) to vary the speed of the primary boiler pumps controlled by the onboard boiler controls based on the heating demand from the building's main heating loop. The secondary pumps are also fitted with VFDs, and the pump speed is varied through the patented differential energy controls to supply heating to each building system depending on how much heat is required as the occupancy and outside weather varies during each day.

Current hi-tech new hot water boiler units

Operating both the primary boiler pumps, and secondary pumps with variable volume control can reduce the electrical pumping costs by as much as 50%. Cascading the primary and secondary pump speeds with differential energy control also helps to optimize the new high-tech boilers in order to sustain the boiler efficiency well above 90% in almost all conditions.

Centralized Cooling Converted to Variable Volume Pumping

The cooling system has been centralized at the new central cooling plant, in which 1,200 tons of new high tech, high efficiency, electromagnetic bearing chillers will be installed. The two 600-ton Daikin Magnitude chillers are now operating at less than 50% of the electric power originally needed to provide cooling to the campus. These new chillers provide variable cooling water flow through the tunnel chilled water distribution system to the campus buildings depending on the cooling demand by using state-of-the-art differential energy control. Demand-based cooling greatly reduced chiller operating cost and electric pumping costs. Onboard chiller operating controls are being integrated directly into the new Tridium enterprise distributed building automation system (*d*BAS).

Reducing Campus Peak Demand

The Powerhouse HVAC Renovation is a seminal element of the HVAC renovation of the City of Dearborn Michigan Avenue campus. The original design strategy for the campus renovation was developed and approved in 2016 following a complete HVAC and energy Assessment. The broad view was to utilize the most efficient and current HVAC technologies and automated temperature controls. This started with reducing natural gas use by eliminating the central steam heating from the Powerhouse by converting to a new distributed high efficiency hot water system. Another key element of the new energy strategy was to greatly reduce electric costs by centralizing and optimizing cooling for all buildings from the central cooling plant. This was important because the old, diversified cooling system caused the collective peak electric demand for the campus to soar to as high as 2.3 megawatts during the summer months, which impacted the energy cost during the entire year.

The renovations revolved around:

1. The installation of a new campus-wide building automation system,
2. Installing new state-of-the-art, variable speed, electromagnetic bearing oil-less chillers after central cooling plant,
3. Replacing the old inefficient cooling tower with variable speed cooling fans,
4. Shifting the cooling load from the outlying buildings, like the Community Center, which was cooled by old and inefficient electric compressors, to water cooling from the new central cooling plant, and
5. Converting the constant flow design of the old Powerhouse chilled water distribution system built in the 1960s into state-of-the-art variable flow distribution system.

Due to constraints on the types of variable flow control systems available on the market, the use of differential energy control (DEC), also known as E~flow (see diagram 1), was chosen as the most effective way of converting the campus central cooling plant into a very high efficiency operation. The central cooling plant conversion had to be re-controlled in this way because of the type of pumping systems that existed on the campus. All the campus buildings were going to rely on high efficiency, just-in-time cooling capability from the new electromagnetic bearing chillers at the central plant. The control system was essential for delivering the right amount of cooling water to a building, at the correct time, in order for all of the facilities to function properly and remain comfortable in all weather.

This chiller optimization and variable pumping system represents “the heart” of the new cooling strategy for the entire campus. It must function effectively in order to provide the kind of savings that were forecast as a result of the sum total of renovations throughout the nearly one half million square feet of campus building space.

Differential energy control is designed to supply cooling energy to a building based on cooling energy demand and is dependent on both volume flow and temperature of the cooling water that is delivered to the building or system. The primary cooling loop distribution system housed in underground tunnels was designed as a constant flow system so the 10-inch pipe mains were installed without any control or balancing valves that otherwise would be necessary to vary the flow.

The majority of buildings in the complex had also been designed and constructed with three-way bypass-type control valves which open partially to redirect water to a thermal load, or close off partially to bypass more water from the thermal load in order to send more water back to the return main. This, in technical terms, is defined as a constant volume system, in which the pressure also does not vary. So, in order to convert such a system to variable volume it is necessary to either modify or replace the original valves to two-way valves in order create a backpressure when the valve is closed. This “back-pressure” is much like a garden hose that pressurizes and inflates the hose somewhat when the hose’s water nozzle is turned off. The increase in back-pressure is due to the stoppage of flow from the nozzle, which has a similar effect to an automatic heating control valve closing. This increase in backpressure can then be used to generate a control signal to reduce the pipe pressure by slowing down the system pump in order to not over-pressurize the hydronic system.

The cost of replacing these types of valves in commercial buildings can be very expensive. The replacement of numerous 4-inch, 6-inch, and even 8-inch valves may be required in a building like the Ford Community and Performing Arts Center. These large valves are not only very expensive to purchase, but also expensive to install, to provide electric actuators and wiring, conduit, and require complicated programming and graphics—not to mention maintenance and upkeep.

Virtually all pumping control systems on the market are pressure-based and require both pressure sensors and modification/installation of new control valves. In contrast, differential energy control requires very little in the way of hardware replacement or modification, and therefore costs much less to install and maintain. In addition, since there is no direct relationship between pressure and building energy use, using a pressure-based control is only an estimate of what flow is required based on the positioning of control valves out in the system.

The differential energy control (E~flow) algorithm requires only inexpensive temperature inputs of supply and return water temperature, along with a number of system and building parameters, in order to operate the E~flow control algorithm. This programmed function then automatically slows down and speeds up pumps based on building energy demand. Also, because it is based on both temperature and flow, it provides a direct relationship to building energy consumption. This direct relational control is therefore the most accurate method of controlling the pumping system, which is directly based on the actual energy demand.

It is important to note that the City of Dearborn central cooling plant pumping system supplies chilled water to 4 buildings via several thousand feet of tunnel and buried line. This main chilled water loop that extends from the Powerhouse actually has no valves since it was simply designed to pump water around a continuous loop, though inefficiently, at a constant temperature and a constant volume to the outlying buildings.

This is the reason that the E~flow technology was specified as the required control system. E~flow is specifically designed to manage variable flow control in a hydronic system without valves, which is how the primary campus chilled water loop was originally. The patented E~flow is the only such control system capable of providing volume control of chilled water systems without depending on a differential pressure, or back-pressure from closing valves to control water flow.

Since the existing piping loop has no existing flow control valves, in order to utilize an alternative pressure-based control system to convert constant volume system to variable flow, very expensive new valves would have to be installed in all four of the outlying buildings. New two-way valves would be required to be installed, and piping redesigned, along with the attendant electric actuators and controls for a pressure-based to work. This would cost many thousands of dollars making the project very costly and making the control system very complex.

In contrast, differential energy control that was specified in the project mechanical drawings as an intrinsic part of the system design that does not require any replacement, modification, or installation of control valves, actuators, wiring, and other hardware installation.

The resulting E~flow system requires far less maintenance, much more reliability, and ease of operation. In addition, differential energy control has the capability of sequencing the high efficiency chillers, along with the variable flow capability, in order to optimize the chilled water plant operation for maximum efficiency in minimum cost. Chiller plant optimization, and chiller plant pump sequencing based on the variable volume, energy-on-demand chilled water distribution system will reduce pumping costs and enhance building comfort across the campus.

Shifting Cooling Load to New High-Efficiency Chillers

The high electrical load of existing inefficient 1.4 KW per ton DX air-cooled rooftop cooling units in outlying buildings have been replaced by water-cooled rooftop fan units now served by the new chillers at the Powerhouse central cooling plant. This will effectively eliminate the old inefficient electric-driven, direct- expansion (DX) cooling from the campus buildings.

This has thereby shifted the cooling load from the old inefficient rooftop units to the new high-efficiency electromagnetic bearing water-cooled chillers now operating at the much higher efficiency of the 0.33 KW per ton! It is estimated that the total campus electric demand reduction due to the innovative cooling load-shifting to the water-cooled chiller plant will exceed (-400) Kw of electric power demand.

New electromagnetic bearing chiller units

Chiller Plant Optimization

Dearborn central cooling plant

The chiller optimization and variable pumping system is now the heart of the cooling system for the entire campus. The entire system is optimized based on campus cooling demand instead of using predetermined setpoints that may not reflect the actual cooling needs of the diverse operating conditions in the various buildings on the campus. The needs of the buildings range from 24-hour operation of the Police Building and Jail, to the intermittent operation of the Performing Arts Center, which may have more than 1,000 attendees for a scheduled event.

The differential energy flow control system provides continuous relational cooling demand response that begins out in the individual buildings whose pumping systems are also programmed to respond to the local instantaneous building demand. The chilled water flow in the building distribution system automatically increases as the occupancy and cooling requirements increase. This increase in local cooling demand is sensed by the primary campus loop controls, which automatically respond to increase the chilled water supply flow to the primary loop, as necessary. It should be noted that there are no valves in the primary campus loop which was designed as a constant volume distribution system.

Automatic Chiller Sequencing

When the chilled water pumps are operating at maximum capacity, the chillers automatically respond to increase their cooling capacity through their variable speed drives. When a single chiller is operating near its peak capacity, and the building cooling demand continues to increase due to occupancy and increase in temperature, i.e., on a very hot and humid summer day, a second chiller is indexed to come on automatically, based on actual cooling demand through the differential energy control volume flow management. This automatically provides sufficient continuous cooling to the primary campus loop, and therefore the entire district cooling system.

When the campus cooling demand starts to diminish as occupancy decreases and outside temperature starts to cool off, the entire cycle operates in reverse until all pumps in the district heating system are operating at the minimum speed and water volume, and only one chiller is operating until it is no longer needed, then it shuts off automatically.

Replacement of Old Cooling Towers and Conversion to Variable Speed Fans

The old central plant cooling towers were replaced with new Marley variable airflow cooling towers. The building automation system will control the variable speed fans on the two large cooling towers and will vary the airflow to optimize the condenser water for the chillers as part of the chilled water plant optimization. In addition, an indoor sump tank will store the cooling tower water in cold weather so that in the event there is unseasonably warm weather during the heating season, not uncommon in Michigan, the cooling tower will be ready to operate to provide condenser water for the chillers so that they can supply cooling for an event in unseasonably warm weather in the winter, such as at the Performing Arts Center.

Variable Flow Conversion of Cooling Water Distribution System

The existing campus constant volume chilled water distribution system was converted to a state-of-the-art variable volume flow. The entire campus central cooling system serving 4 buildings and almost half a million square feet has been converted to a variable flow system in order to satisfy changing cooling demand due to minute-by-minute occupancy requirements and weather conditions (see Diagram 1). The delivery of variable amounts of cooling water will be based on the specific instantaneous cooling demand in each building. This variable flow technology will reduce eclectic costs for water distribution pumping by delivering only the volume of cooling water needed for the conditions. The pumps will normally run at 50% lower electric consumption until building occupancy increases and/or rising outside air temperature increases the building cooling requirements.

The new variable flow system will allow the chilled water distribution system, much of it housed in several thousand feet of underground tunnels, to deliver cooling water to each building on a just-in- time basis. This greatly reduces the electrical pumping energy needed to supply cooling water to the buildings on the 80-acre campus during low load conditions.

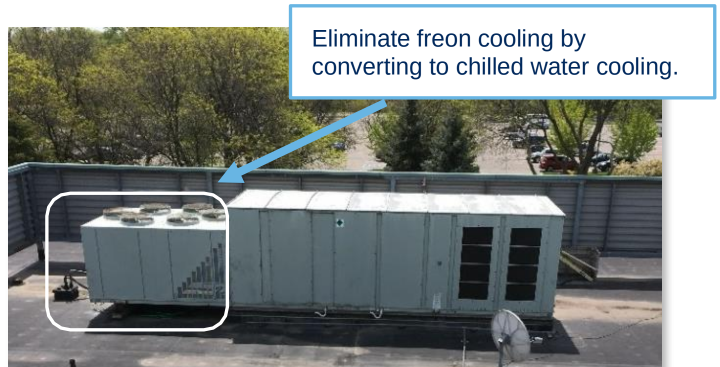
The patented differential energy flow control technology is also called E~flow. The resulting flow control system requires far less maintenance and offers much more reliability and ease of operation. Chiller plant optimization, and chiller plant pump sequencing based on the variable volume flow/energy-on-demand chilled water distribution system, will reduce pumping costs, and enhance building comfort across the campus.

Glycol Conversion

The central 1,200-ton cooling plant serving four buildings is being enhanced by converting the entire campus chilled water distribution system to a freeze-less, glycol-protected system. This is intended to reduce annual maintenance costs and provide more flexibility for the continuous operation of 24-hour buildings such as the Police Building. In addition, it will allow the operation of the Performing Arts Center with full cooling capability year-round. Cooling is now available even during extremely warm weather swings in the winter, which is not uncommon in the Dearborn climate zone.

HVAC Conversion from Steam to High-Efficiency Hot Water and Central Cooling

Most of the existing rooftop Sixteen of the old HVAC units are being replaced with new units that are now cooled from the high efficiency central cooling plant. The combination heating and cooling units are being converted from central steam heating to building-generated hot water heating. Each building will be heated with the new high efficiency condensing hot water boilers installed in each building. The new rooftop HVAC units are not simply being replaced on a one-for-one basis. The new units are being "right-sized" for current use, converted from steam to hot water heat, and specified with variable speed/direct-drive fan motors that are more efficient and require less maintenance. They are also being equipped with state-of-the-art energy controls that will optimize energy consumption, enhance air quality, and reduce energy cost.



Old rooftop HVAC unit with old inefficient air-cooled air conditioning replaced with high-efficiency water-cooled systems

Conversion to Variable Air Volume

All new rooftop HVAC units in 4 buildings have been equipped with the most advanced variable volume air handling and ventilation systems using direct-drive, beltless, ECM-driven (electronically commutated motor) fan array systems. In addition to reducing energy use by as much as 45%, these new Daikin packaged rooftop units will reduce maintenance costs because they will not require periodic belt and pulley replacements. The Henry Ford Centennial Library, the Police Building, and Community Center are being converted from the old and inefficient constant volume air conditioning systems to new high-efficiency variable volume systems.

State-of-the-Art Demand Control Ventilation

All HVAC systems have been converted to occupancy-based demand control ventilation (DCV) that supply heating, cooling, and ventilation air based on how heavily the building is being used. Carbon dioxide sensors will determine the need for ventilation air based on occupant-required ventilation demand. New variable-speed motors will automatically increase airflow and cooling capacity when needed, increasing efficiency by 35 to 40% by not operating the units at full capacity during low occupancy.

New High-Efficiency Filtration Technology Added to Improve Air Quality

The ductwork on the entire campus was either cleaned or replaced to improve air quality in the buildings. In addition, the City is now testing the use of new filtration and anti-contaminant technologies that can be installed to reduce various contaminants in a building in addition to particulates, such as bacteria, fungi, and possibly even viruses.

Replace High-Cost Electric Heating

New library LED lighting

In the DAC Building, high-cost electric heating has been converted to primary natural gas heating. The oversized rooftop units were replaced with state-of- the-art units that deliver optimized heating and cooling while the use of the residual electric components will be minimized.

New Enterprise-wide Distributed Building Automation System – *d*BAS

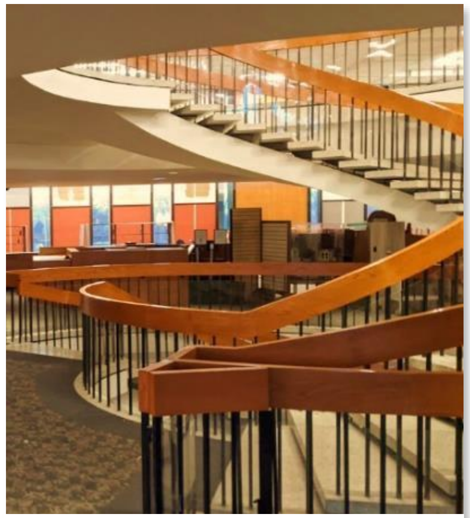
A new state-of-the-art distributed building automation system (*d*BAS) is being installed utilizing onboard intelligent controls of the new chillers, new boilers, new rooftop HVAC units, and new variable speed pump controls. The new onboard equipment controls have been integrated with a new Tridium N4 platform reducing expensive on-site control installation costs. The *d*BAS concept with the new Trane HVAC units reduces cost for programming by utilizing manufacturer's control hardware, software, and sequence of operations.

Henry Ford Centennial Library Renovation

The Henry Ford Centennial Library received the most extensive renovation. Along with the HVAC equipment replacements which required major ceiling modifications, the infrastructure construction project was used as an opportunity to upgrade the building interior as well. In addition to the upgrade of the heating and ventilation systems, several building spaces were reconfigured for incorporating the advancement of technology in libraries, along with new ceilings, carpeting, and security systems.

New Lighting with LED and Occupancy-Based Controls

All lighting in the beautiful Henry Ford Centennial Library, and the Ford Community and Performing Arts Center has been replaced with new high-efficiency LED lighting fixtures and panels. The new LED lighting is controlled by a state-of-the-art lighting control system that provides occupancy-based lighting control and automatic dimming capability for much of the building lighting based on occupancy. A lighting cost savings of 43% is expected by converting fluorescent lighting to LED. In addition to reducing the lighting electrical costs, the lighting levels in the iconic white marble library, and the community center, have been increased dramatically. Lighting will also be replaced in parts of the Police and Courts buildings. Residual non-LED lighting will also be replaced throughout the campus, including the Powerhouse.



Library central staircase

Other Improvements

Centralized Power Supply and Power Security

There is currently only one electrical feed to the FCPAC. This means that if there is a power failure due to storms or other unexpected events, the building would be without electricity until it is restored by the utility, which could be hours, or days. This would be especially problematic for scheduled events at the Performing Arts Center theater. The FCPAC power is being re-fed from the Powerhouse electric feed, which has two independent and secure sources of power This will reduce the possibility of the FCPAC losing power and greatly reduce the risk of an unexpected power outage interrupting the operation of the building. The new FCPAC generator would also be a second source of short-term emergency power for critical lighting and equipment, making the building power far more secure.

Renewable Energy – Net Zero Electric Demand (?)

A new thermal storage system has been under consideration to eliminate the use of high electric demand chiller operation in the summer months. A new photovoltaic (PV) solar plant is also under consideration. This would use the electricity generated from a PV electric power generating system to offset the now greatly diminished campus electric power needs. Both PV and thermal storage may prove economically feasible due to the focused efforts to improve campus energy efficiency. A PV system potentially could further reduce the electric demand during summer daytime cooling operations. After further study following a full thermal year of the new heating - cooling system operation, applications of PV and other energy technologies will be reviewed.

Equipment and Energy Use Database

At the start of the project, we created an equipment and energy use database that included 467 major pieces of equipment totaling 2,687 horsepower of pumps and fan units, and 690,464 cubic feet per minute of building ventilation air. The database will be continuously updated during the course of the construction period to include all new equipment replacements. In addition, we will keep a detailed list of mechanical and energy efficiency improvements for each building, as well as the cost reduction impact of the newly renovated heating/cooling plant. The energy baseline that was established will be used to calculate the total energy and cost savings for the initiative. The final results and savings for the entire project, of course, will not be available until the entire project has been completed, which is anticipated to be in 2021.

High-Security Remote Internet Access

The new building automation system will include new high-security remote communications technology for high integrity IoT data transfer on a secure layer of the existing wide area campus network (WAN). This will facilitate remote system analysis, troubleshooting, access to cloud services, and will save service costs by reducing technician travel time.

Innovative and Comprehensive Design Strategy for Energy and Maintenance Cost Savings

The entire project is expected to save approximately 4,000,000 kilowatt-hours of electricity, and nearly $500,000 annually in natural gas and electric energy costs compared to the baseline use. The cost savings will be derived from an innovative strategy developed by Millenium Energy and Larkin Engineering, working closely with the Powerhouse staff to minimize both energy and maintenance costs for all mechanical systems. The electric peak demand has been reduced to less than 1.0 MW, and natural gas use for heating will be reduced by over 50%.

The strategies utilized to accomplish these results include:

- Eliminating the outdated and inefficient central steam plant and converting all buildings to distributed hot water heating utilizing high-efficiency condensing boilers with long-life stainless steel heat exchangers.
- Reduction in energy use by installing new state-of-the-art and energy-efficient equipment such as fans, pumps, chillers, cooling towers, lighting, etc.
- Installation of a new state-of-the-art distributed building automation system (dBAS) for comfort control and energy management.
- Applying energy-efficient operations strategies for high-efficiency centralized cooling, distributed heating, and building ventilation focused on building occupancy.
- Load-shifting the cooling load from inefficient air-cooled R-22 rooftop units to the new high efficiency central cooling plant.

- Converting the campus cooling water distribution system from constant volume to high efficiency, demand-based variable volume control.
- Utilizing solar electric generation technology to offset electric use during peak electric cost hours reduces electric demand and shift purchase of electricity to low-cost nighttime hours. This technology is currently under consideration and will be reviewed in more detail once the new electric usage and new peak demand are determined following full implementation.
- Create Energy Dashboard for all campus buildings with real-time, on-line metering to track energy usage and costs.

Implementation of Comprehensive Maintenance Cost Reduction Strategy

The entire project is also expected to significantly impact maintenance costs for the 0.5 million sq. ft. of campus buildings and the extensive amount of HVAC equipment needed for heating, cooling, and ventilating them. The replacement of the equipment that had depreciated far beyond its expected operating lifetime will have a lasting effect over the next 20 years with regards to annual maintenance costs, as well as energy and efficiency savings.

The maintenance cost reduction measures that were implemented across the campus include:

- Eliminating the old, high maintenance, central steam heating plant, including the two massive 22 million BTUH steam boilers, which were disconnected and removed as a result of implementing a "distributed hot water heating" strategy. The buildings are now locally heated with high-efficiency, hot water condensing boilers with long-life, low maintenance stainless steel heat exchangers.

  This newest building heating technology reduces the natural gas use by 25-30% but does not require the original large steel chimney stacks for venting large amounts of combustion products. The new boilers use small, dedicated plastic combustion air intakes, as well as much smaller, stainless steel combustion air exhaust. Also, these new boiler units are far smaller, and do not require a complex boiler water feed system, nor thousands of feet of steam condensate return pumping and piping from buildings served by steam from central plant.
- Removal of the campus steam distribution system: Several thousand feet of aging steam piping was removed from the underground tunnels throughout the campus. The old steel piping had long exceeded its useful life and had a growing potential for extensive repairs, and even periodic failure. A major steam leak in the tunnels in the coldest part of the winter could have caused a catastrophic loss of heating to the entire Dearborn campus served by the Powerhouse. Prospective annual repair and/or replacement of steam line infrastructure posed a significant maintenance cost in the coming years if the campus district heating system was to remain in use. This is because the water that condenses from steam is highly corrosive. The condensate piping that had also long exceeded its useful life and was subject to continuing repairs and high annual maintenance costs.

- Removal of building steam piping and steam heating equipment: Many thousands of feet of aging, high maintenance, condensate return piping and condensate return pumping systems were removed from the buildings. Also, many depreciated steam-to-hot water heat exchangers and their controls were disconnected and removed from each of the buildings originally served by steam, after being disconnected from the steam distribution piping in the underground tunnels.
- Most of the aging HVAC units on the campus were replaced with new units having direct-drive fans requiring far less maintenance. Some HVAC units were refitted with state-of-the-art controls, replacing obsolete pneumatic and electronic controls for more efficient operation and to eliminate continuing and chronic temperature control issues and maintenance costs. In the Library the old dual duct, constant volume systems were converted to more efficient variable air volume, and fan units were replaced with low maintenance, direct drive fan systems.
- All existing pumps and pump motors were far past the useful life expectancy. All pump systems were replaced throughout the campus with premium efficiency motors and high-efficiency pumps. These pumps will not require replacement or significant maintenance for many years to come.
- Most of the campus lighting was replaced with LED fixtures, whose lamps can last 100,000 hours compared to the much shorter life span of the old fluorescent fixtures.
- The aging centrifugal chillers in the Powerhouse were both inefficient and were in need of significant and costly repairs. They also required a high degree of annual maintenance. The old chillers were replaced with new 600-ton electromagnetic bearing chillers with oilless compressor bearings which do not require any periodic oil changes. These new chillers will require less maintenance over the coming years.
- The aging cooling towers at the Powerhouse, which required a significant level of maintenance upgrade and repair, were replaced with new long-life towers designed for minimal maintenance. These units now have stainless steel distribution and collection pans which will eliminate the potential for leaks over the life of the towers.
- The obsolete campus building automation and temperature control system was replaced with a new Tridium system that will help to reduce maintenance, improve temperature control, allow quick identification of malfunctions, improve campus energy efficiency, and reduce maintenance costs from control system failures for years to come.

All new equipment and system replacements were designed to significantly reduce the amount of annual maintenance. Each of the replacements was chosen carefully for efficiency of operation along with extended equipment life and reliability. The collective maintenance savings for the entire campus is estimated to be +$75,000 per year to maintain and repair 467 pieces of HVAC equipment identified on the Equipment Database that was developed for the campus of buildings.

Rebates from the DTE, the Local Utility

The project will also be eligible for significant energy rebates from DTE who has been helpful and cooperative in the City’s energy efficiency and electric demand reduction efforts which is expected to reduce electrical use by as much as 4,000,000 kilowatt-hours, and more that 1.3 megawatts of electric demand from the DTE grid. The project could qualify for as much as $200,000 in energy incentives from DTE under Michigan’s PA 295 of 2008, the Clean and Renewable Energy and Energy Waste Reduction Act.

A Word About the COVID-19 World Pandemic

The Project was almost half-completed when the COVID-19 pandemic struck the Detroit and Dearborn areas of the United States. It was to the great credit of the city’s staff, the various departments within the City of Dearborn, and all of the contractors working on multiple projects concurrently, that the essential infrastructure work could continue during the most difficult periods. All of the contractors were provided training to minimize any exposure and were very compliant with wearing masks and social distancing wherever the work was being done.

In addition, on-site project progress meetings often have to give way to conference calls and video meetings in order to minimize exposure to city staff and other contractors. All contractors and any necessary building personnel continue wearing masks at all times and maintaining proper social distance while using mobile phones in lieu of face-to-face communications whenever possible. Also, taking temperatures and disinfecting surfaces continues in essential areas that must be open to the public.

Summary

The new energy infrastructure will also increase occupant comfort in all buildings while greatly reducing energy use, reducing the carbon footprint, enhancing campus sustainability, and maximizing energy efficiency throughout the entire campus. The ultimate objective is to maximize efficiency, minimize cost, while achieving as close to Net Zero Electric Demand as possible.

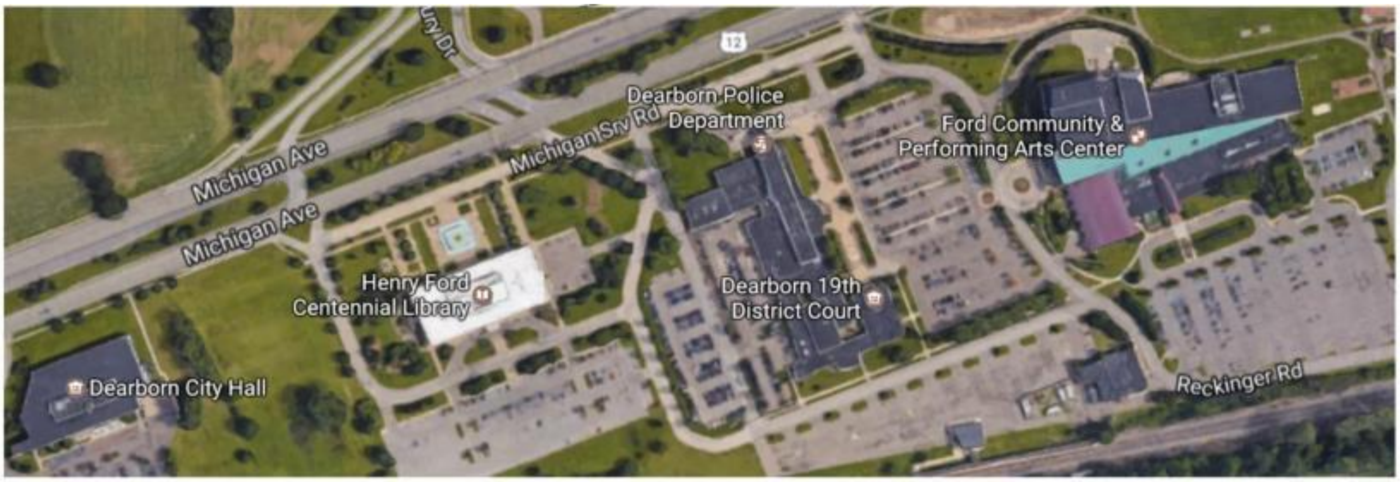
This extensive mechanical renovation and energy initiative has resulted in wide recognition concerning the innovative and successful energy efficiency measures that have been implemented, at times under difficult conditions due the COVID – 19 pandemic. This Initiative places the City of Dearborn building complex at the forefront of energy efficiency and sustainability with the integration of diverse energy-efficient technologies to improve comfort and reduce energy use, while providing significant savings on operating and maintenance costs.

Construction is substantially complete and is nearing final completion for all the retrofits of the Ford Community and Performing Arts Center, the Henry Ford Centennial Library, the DAC, and the Central Cooling Plant. The Police Building, Municipal Courts Building, and the Powerhouse renovations are expected to be fully completed in early 2021.

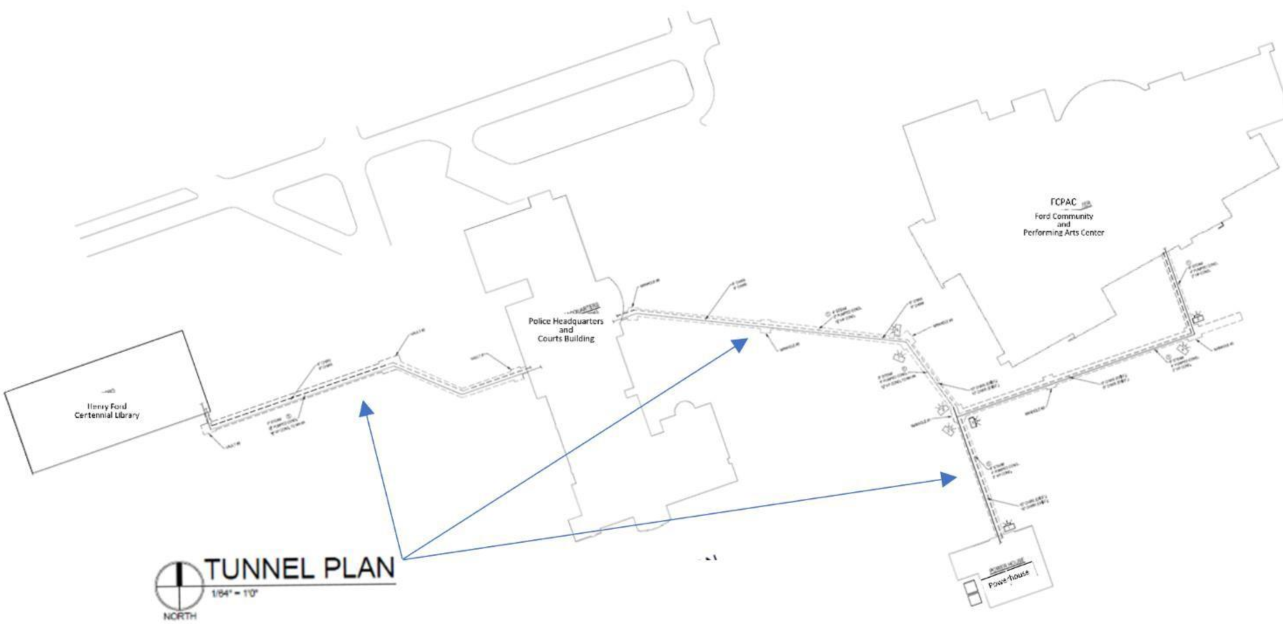
Vytau K. Virskus M.E., JD
Millenium Energy Company
Energy, Building Automation Sytem, and Variable Fow Distribution Design

cc: **Jim Larkin**, P.E., MEP Design
Eric Witte, Deputy Director DPW
Anthony Belzak, Powerhouse Superintendent
David Norwood, Sustainability Coordinator Mayor’s Office
Craig Mortz, CEO, CSM Mechanical, HVAC Installation Contractor

Dearborn City Campus – Aerial View

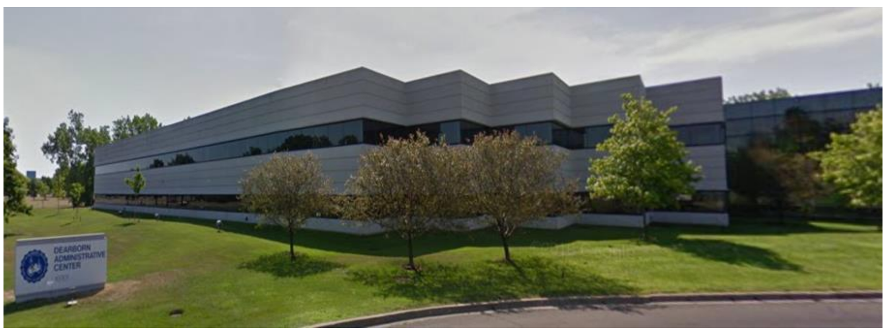


Dearborn Building and Tunnel Distribution Map

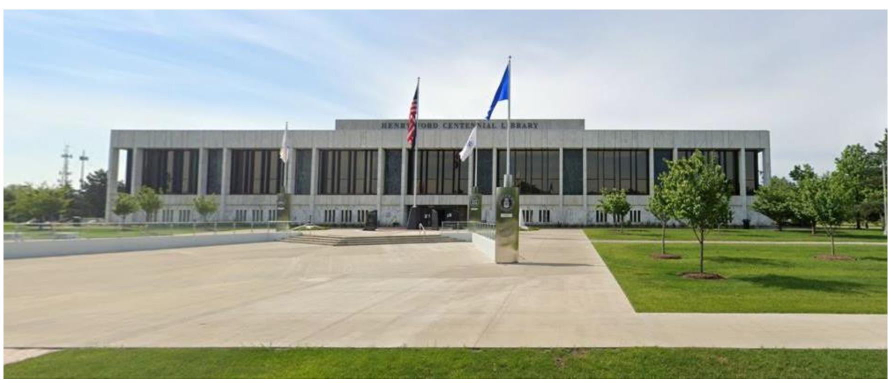


City of Dearborn Michigan Avenue Campus Buildings

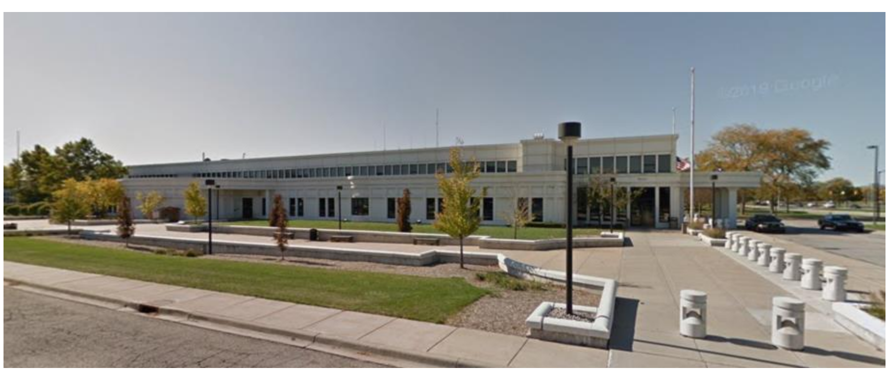
Ford Community and Performing Arts Center



Dearborn Administrative Center

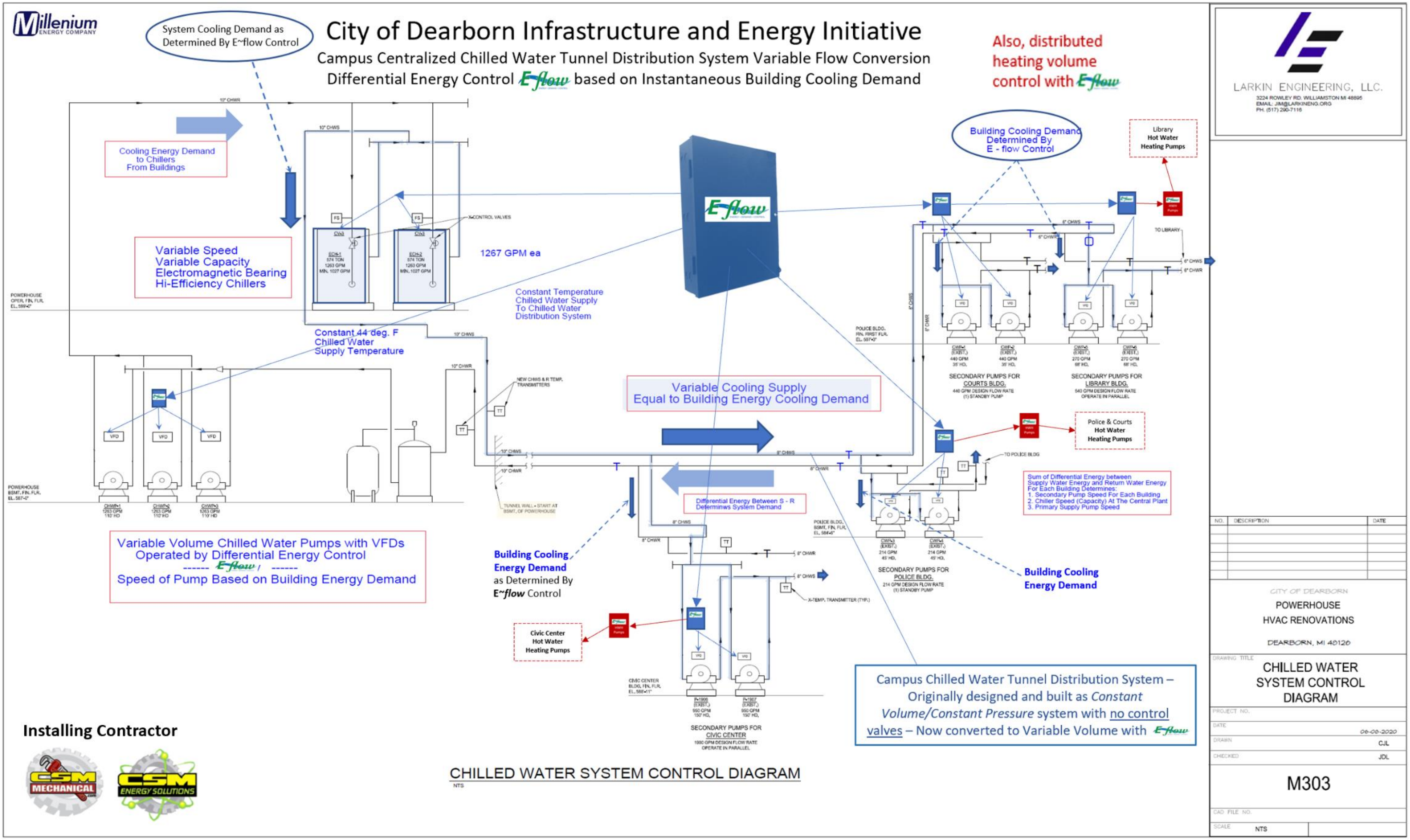


Henry Ford Centennial Library



Police Building and Courts Building

Diagram 1: Dearborn Campus Chilled Water Tunnel Distribution System – Variable Flow Conversion



This is a diagram of the E~flow control system that converts all cooling and heating systems on the Dearborn city campus of buildings from constant volume to variable flow based on building system cooling or heating demand. The central variable capacity chillers respond to the volume of cooling water needed to maintain the necessary temperature and humidity in each individual building. Though the individual building cooling demand may vary due to function and occupancy, the collective energy demand is manifested in the energy difference (ΔE) between the cooling energy supplied to the main distribution loop, and the residual cooling energy returning from the campus system to the chillers for re-cooling. E~flow manages the volume flow to maintain the desired ΔE setpoint for the system segment or sub-system being controlled. E~flow also automatically stages the chillers to optimize the system when additional cooling demand is experienced by the system.