



# Program Plan for Tri-generation (Combined Cooling, Heat and Power) At CMU

August 5, 2013

## TABLE OF CONTENTS

<b>i. OVERVIEW.....</b>	<b>3</b>
<i>Executive Summary .....</i>	3
<i>Description of Academic Program .....</i>	3
<i>Relation to Facilities Master Plan .....</i>	4
<b>ii. JUSTIFICATION .....</b>	<b>6</b>
<i>Existing Conditions.....</i>	6
<i>Current program enrollment .....</i>	8
<i>Specific health/life safety deficiencies.....</i>	8
<i>Changes and Projections .....</i>	8
<i>Enrollment projections by program or department .....</i>	8
<i>Total Space Requirements.....</i>	9
<i>Alternative Analysis.....</i>	9
<b>iii. IMPLEMENTATION AND DESIGN CRITERIA .....</b>	<b>12</b>
<i>Spatial Relationships and Room Specifications.....</i>	12
<i>Site Requirements and Design Requirements .....</i>	12
<i>Project Schedule.....</i>	13
<i>Cost Estimate .....</i>	13
<i>Financial Analysis.....</i>	13
<i>Conclusion .....</i>	14

## i. OVERVIEW

### *Executive Summary*

Colorado Mesa University (CMU) is seeking approval from the Colorado Department of Higher Education to move forward with plans to construct and operate a tri-generation, combined cooling, heat and power facility (CCHP) on our main campus in Grand Junction, Colorado.

CMU's interest in CCHP systems stems from a continued effort to implement the broader vision of Governor Ritter's 2007 executive order that introduced the concept of "Greening ...State Government"<sup>1</sup>. Governor Ritter encouraged state governments to lead by example. That guiding principle has led to numerous, unique and highly successful energy savings measures that have been implemented by CMU.

Combined cooling, heat and power systems have been around for many years and have been employed by institutions of higher education, hospital facilities, commercial office buildings, large hotels, casinos, resorts, etc. Trigeneration systems combine cogeneration facilities with absorption chillers to provide power and both hot and cold water. The power that's produced is consumed on campus, while hot and cold water generated by the waste heat is used to modulate temperatures in CMU's campus wide geo exchange system.

The Department of Energy released a report in December, 1998 that concluded "... (CCHP) solutions represent a proven and effective near-term energy option to help the United States enhance energy efficiency, ensure environmental quality, promote economic growth, and foster a robust energy infrastructure"<sup>2</sup>. Said report identified CCHP as a key part of the United States energy future and alludes to the idea that through the use of CCHP systems an organization can help free itself from the reliance on traditional energy sources, the rising cost of energy prices and concerns about global climate change.

The four key components of CMU's interest in combined heat and power on our main campus in Grand Junction, CO are outlined below:

- Continued campus growth and expansion has identified the need for additional, reliable, clean sources of energy to power our campus in the near and long term
- CCHP will fit seamlessly into existing energy solutions on campus and will become a key component to a well-rounded campus energy portfolio that includes geo exchange, ground source heat pumps and solar electricity.
- CCHP will lower demand on the local energy delivery system, reduce CMU's reliance on traditional energy supplies, lead to significant savings and help CMU become more competitive in the business of higher education
- CCHP will provide a unique learning opportunity for CMU students and faculty.

### *Description of Academic Program*

The construction of a CCHP system at CMU doesn't directly relate to any one academic program being offered at our main campus. However, the project does have the potential to impact all programs by serving as an uninterrupted power source that has the potential to keep all buildings and programs up and running during a power outage and by reducing

---

1

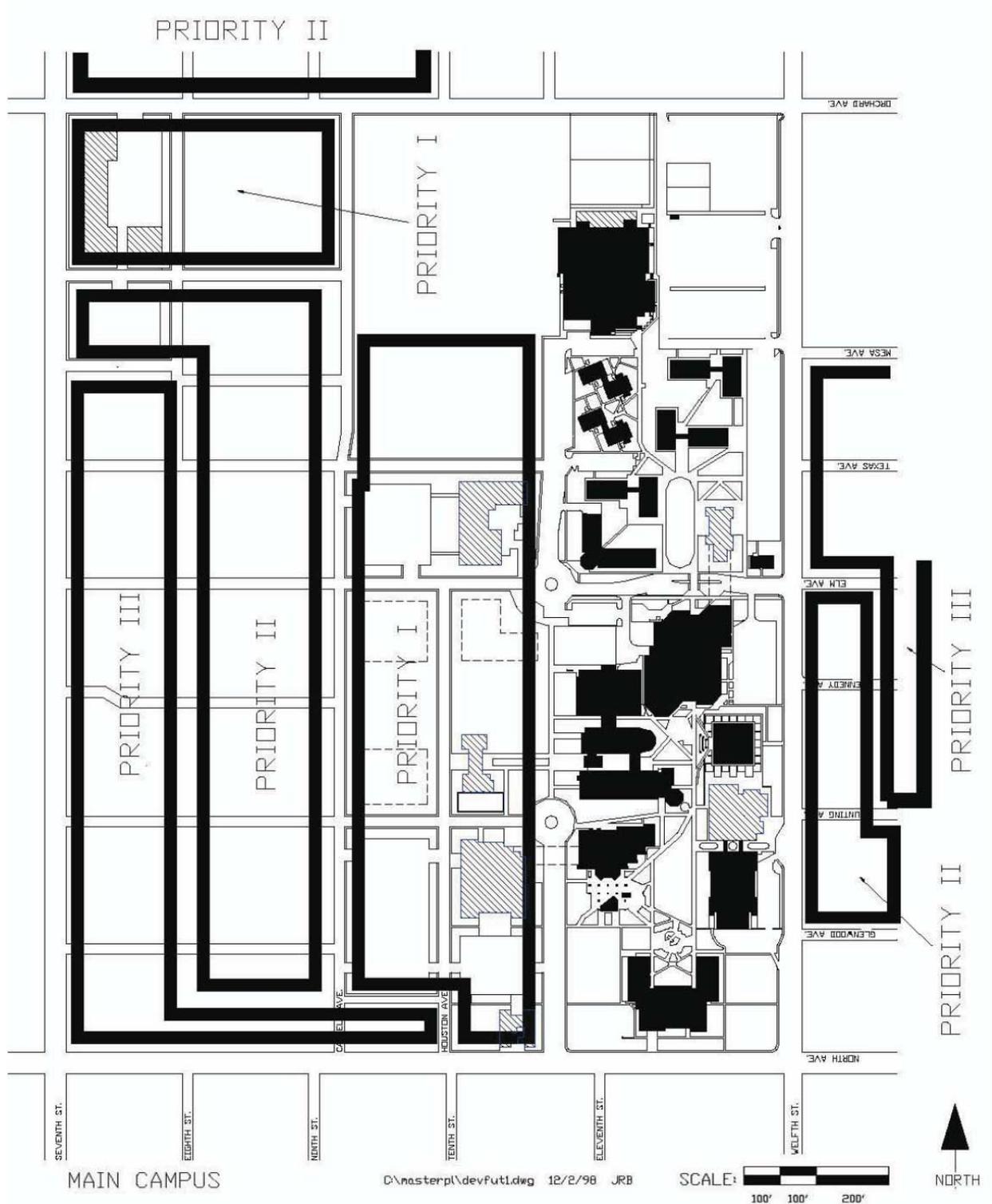
[http://www.allamericanpatriots.com/48721328\\_colorado\\_colorado\\_governor\\_ritter\\_issues\\_greening\\_government\\_order](http://www.allamericanpatriots.com/48721328_colorado_colorado_governor_ritter_issues_greening_government_order)

<sup>2</sup> [http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/CCHP\\_report\\_12-08.pdf](http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/CCHP_report_12-08.pdf)

the cost of utilities, thereby increasing CMU's competitive edge in the business of higher education.

*Relation to Facilities Master Plan*

Colorado Mesa Universities long range plan includes the expansion of the west boundary of campus from Cannell Ave., west another ¼ mile to 7<sup>th</sup> Street. The 1999 Facilities Master Plan identified several areas of potential expansion in accordance with the map shown below<sup>3</sup>.



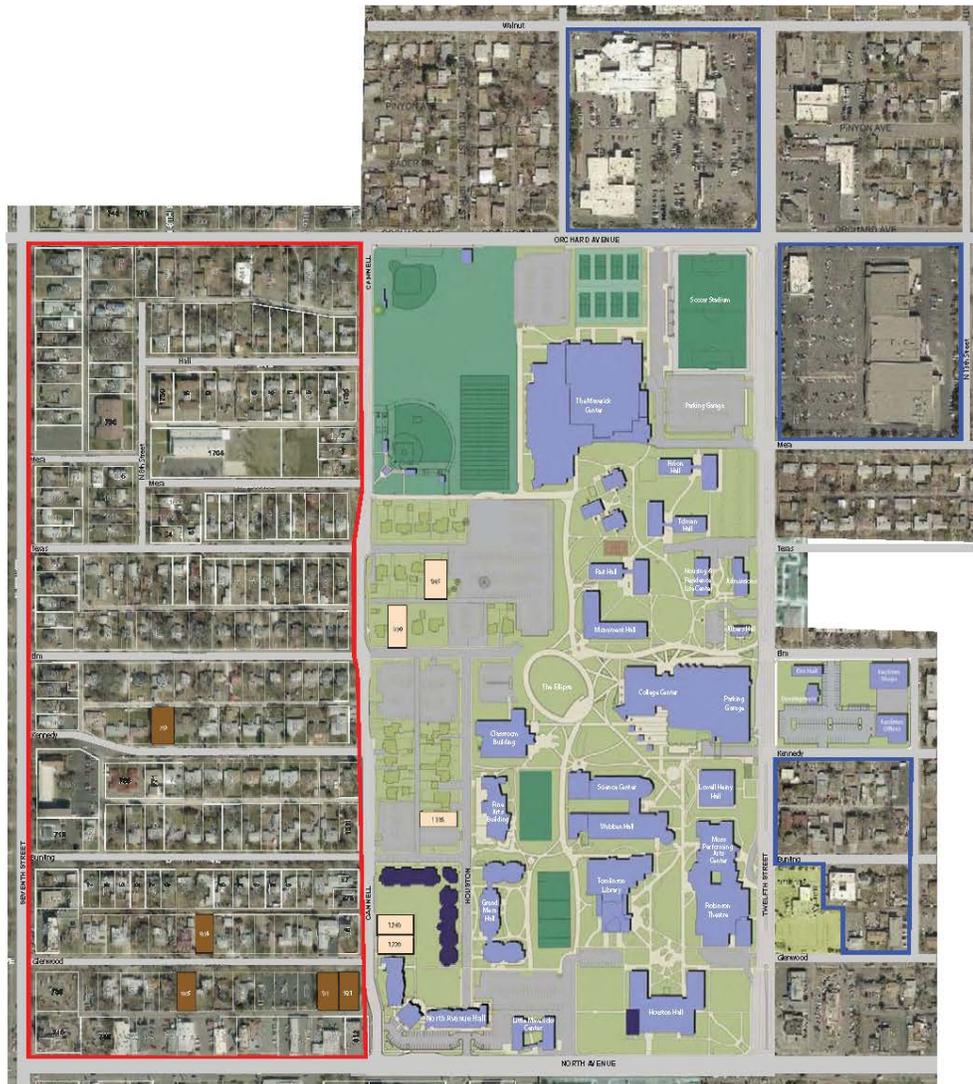
A more recent planning document adopted by the Board of Trustees for Colorado Mesa University, the West Expansion Property Acquisition Plan<sup>3</sup>, provides additional clarification regarding areas identified for future development while re-prioritizing areas of most significant need.



**MESA STATE COLLEGE**  
 CAMPUS FACILITIES MASTER PLAN  
 CAMPUS EXPANSION DRAFT  
 ACQUISITION PRIORITIES

CHAMBERLIN  
 ARCHITECTS

April 6, 2011



- Priority I (59 Acres)
- Priority II (27 Acres)
- Under contract April 12, 2011
- To be acquired w/in campus area

<sup>3</sup> The map above is a reprint of the map included in the 1999 Mesa State College Facilities Master Plan, Page 113.

CCHP is one of several options being considered to provide some portion of the additional power that will be required as our campus continues grow and represents an option to help lower the cost of electricity purchased over the next several decades. Other options being considered include petitioning our local public utilities company, Xcel Energy, to extend an additional electric feed to campus. A new feeder line will become a necessity in the near future if other sources or power aren't implemented on campus.

CCHP represents a technology that isn't new to higher education. The University of Colorado owns and maintains a combined heat and power facility at its main campus in Boulder, CO, but is a technology that's largely unheard of at smaller colleges and state universities.

The tri-generation project described in this program plan supports several of the University's goals as described in CMU's Institutional Vision and Values:

- "...facilities and technology that expand, expedite, and enhance learning for every student"<sup>4</sup>
- "An administration that uses human and natural resources wisely"<sup>4</sup>
- "Opportunities that engage students in applied learning"<sup>4</sup>

The use of tri-generation at CMU represents a major step forward in using our "... natural resources wisely". CMU has invested in other green technologies on campus (geo-exchange, ground source heat pumps, solar) and continues to identify other ways to lower its carbon footprint while keeping a watchful eye on the bottom line. "Much like wind power, solar energy, plug-in hybrid vehicles, compact fluorescent light bulbs, and biofuels, CCHP should be a key component of a well-rounded energy portfolio"<sup>4</sup>.

The design and operation of the CCHP facility would also allow students in our Landman / Energy Management, Construction Management, Mechanical Engineering, Hospitality Management and Masters of Business Administration degree programs hands-on experience in an emerging technology that few other schools in Colorado, with the exception of CU-Boulder, could provide.

## ii. JUSTIFICATION

### *Existing Conditions*

Colorado Mesa University's primary power supply is provided by Xcel Energy at the north end of our main campus on Orchard Avenue. Said service provides 13.2 kV power across two separate electrical loops that function to provide redundancy in the way power is delivered across campus. One, or more than one building, as long as each building is located within the same reach of loop, can be taken off line while power is provided to all other buildings on the loop. Providing looped pathways for high voltage power delivery across campus helps to more evenly distribute loads as well.

The two existing loops and the main power supply from Xcel Energy, provide around 6 mW of power, which is sufficient to allow continued development within the current boundaries of the University campus (Orchard Avenue on the north, 12<sup>th</sup> Street on the east, North Avenue on the south, Cannell Avenue on the west).

The one line diagram on page 7 identifies the two main campus loops and provides information on the size of transformers and anticipated loads on both the east and west loops<sup>5</sup>.

---

<sup>4</sup> <http://www.coloradomesa.edu/about/values.html>

<sup>5</sup> The one line diagram has not been updated to include the addition of Bunting Avenue Student Housing, Garfield Hall or the new Academic Building II



Unfortunately, CMU's one and only power supply from Xcel Energy isn't large enough to allow the continued development anticipated on the campus master plan. Providing a CCHP facility on campus will help delay the point at which an additional power supply from Xcel Energy is needed by providing additional capacity during peak periods when the existing electrical system will struggle to keep up with demand.

The proposed combined cooling, heat and power facility will also function to provide backup power during power outages, but won't be used as a backup power source for any life, health and safety systems on campus. Functions that would be supplied from backup power delivered by the CCHP system include dormitories, food service facilities and portions of the University Center that include the police sub-station and dining hall.

#### *Current program enrollment*

Enrollment at CMU "for fall 2012 was 9,046 students..."<sup>6</sup> and represents an increase of 2.3 percent increase in student FTE.

#### *Specific health/life safety deficiencies*

CMU's current power delivery system meets all requirements for reliable, cost effective power delivery and will continue to function at or above accepted industry standards. The addition of tri-generation represents a significant step forward in leveraging the power delivery system by adding an emerging, green technology into the mix.

#### *Changes and Projections*

The physical size of CMU's main campus and the size of the power delivery system will continue to grow with concurrent growth in enrollment. The current power supply for CMU's main campus will reach its limit of 6.5 mW after construction of the new Academic Classroom Building II, the expansion of Tomlinson library and the second phase of student housing at Garfield Hall.

Further development of CMU's main campus, west of Cannell Ave. will require another source of power, either through the use of tri-generation or an additional electric feed from Xcel Energy. An additional electric feed from Xcel Energy comes with a yet-to-be-determined price tag. Earlier estimates showed the cost to be upwards of \$1,000,000. Recent improvements completed by Xcel Energy to provide a separate electric feed to St Mary's Hospital will likely decrease the cost of providing an additional power supply but nobody knows by how much at this juncture.

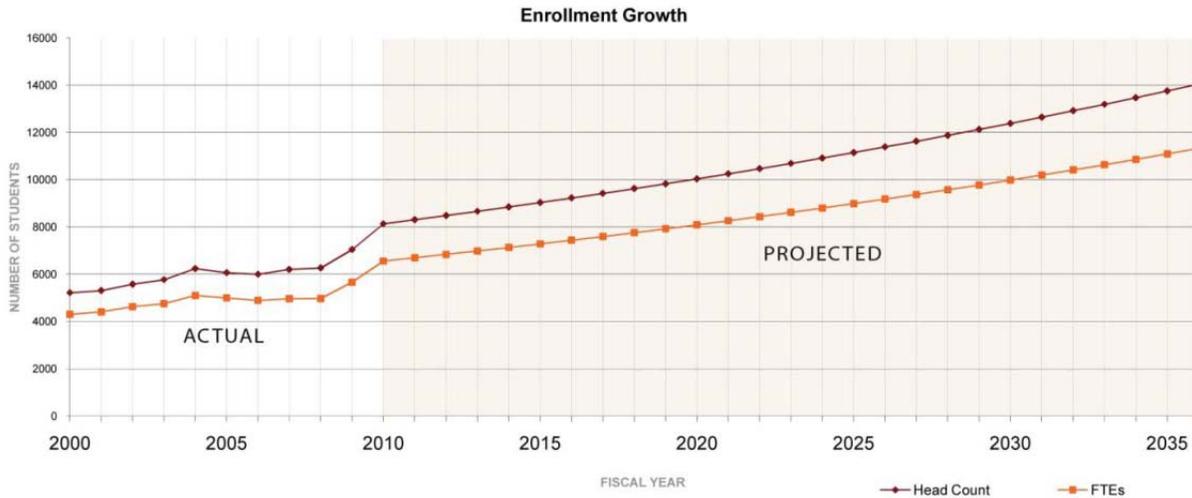
#### *Enrollment projections by program or department*

The following graph presents enrollment growth, actual and projected, for the thirty-five year period from 2000-2035<sup>7</sup>.

---

<sup>6</sup> [http://www.coloradomesa.edu/mediarelations/documents/\(2012-09-06\)Census.pdf](http://www.coloradomesa.edu/mediarelations/documents/(2012-09-06)Census.pdf)

<sup>7</sup> [http://www.coloradomesa.edu/facilities/documents/WestExpansionPropertyAcquisition\\_4-12-11\\_.pdf](http://www.coloradomesa.edu/facilities/documents/WestExpansionPropertyAcquisition_4-12-11_.pdf)



The graph above predicts CMU will reach an enrollment of 10,000 students, an increase of just under 1,000 students above the fall enrollment of 2012 by the year 2020. Even a modest increase in students will require additional classroom buildings, dormitories, additional dining halls, recreation center space, etc., all of which will require the delivery of additional electricity to campus.

#### *Total Space Requirements*

This building is unique in that it is a relatively small structure that will contain an efficient power source that has the potential to keep all buildings and programs up and running during a power outage and by reducing the cost of utilities. Therefore, a GSF of 10,000 at \$460/GSF includes the building, the new turbine and steam generator, absorption chiller, heat exchanges, synchronization and control equipment, etc. The addition of tri-generation represents a significant step forward in leveraging the power delivery system of the University.

#### *Alternative Analysis*

CMU has investigated several alternative methods to reduce the amount of electricity consumed on campus and has implemented several green technologies that have proven cost effective.

- Solar
- Geo Exchange
- Additional electric feed from Xcel Energy

#### Solar

CMU currently owns and operates two small solar arrays on our main campus in Grand Junction, CO. The first array, a 12kW system installed on the roof of the Science building in 2003; the second, larger array, an 18 kW system was installed on North Avenue Residence Hall in 2008. Each provides power that's consumed on campus.

CMU has pursued other options for providing some portion of the University's current and projected demand by installing a combination of large and small areas arrays both on and off campus. CMU's long term goal is to provide 1 mW of solar electricity that can be consumed on campus or sold back to our local P.U.C.

The economics of installing several smaller arrays on multiple roofs across campus has proven to be a challenge, both due to the economics of providing multiple inverters, multiple connections into existing switch gear, metering, etc., and because of the amount of disruption required to install new arrays on buildings across campus.

CMU contracted with Davis Partnership Architects, who worked in collaboration with EMC Engineers, Inc., to prepare a report that examined the feasibility of adding solar on our main campus<sup>8</sup>. The report was prepared in 2009 and concluded that up to 414 kW of solar electricity could be provided via several small arrays on buildings across campus. Buildings were chosen based on the cost to upgrade the roof structure to accommodate solar arrays as well as any costs needed to update or retrofit existing switch gear and transformers to accept power from the new arrays. CMU requested funding from the State of Colorado in 2009 which would have allowed the project to move forward. Unfortunately, the project wasn't approved and has since been shelved.

CMU continues to pursue the implementation of a large monolith array at an off-site location as well. Doing so presents several hurdles that will have to be worked out with our local public utilities company to allow CMU to sell power back to Xcel Energy at a remote location.

### Geo Exchange

CMU currently owns and operates one of the largest community-type geo exchange systems in higher education. CMU's current geo exchange system is comprised of three existing drill fields and one new drill field currently under construction. Said drill fields contain just less than 304,000 lineal feet of 2" diameter high density polyethylene pipe (HDPE) and are connected together via 4,400 lineal feet of 18-inch diameter HDPE that's collectively used to exchange heat between the ground and campus buildings.

The campus-wide geo exchange, or the "central loop" as it's now referred to, provides geo exchange to eight buildings across campus; Academic Classroom Building I (56k sf), North Avenue Residence Hall (110k sf), Bunting Residence Hall (73k sf), Garfield Hall (46k sf), Wubben Hall (44k sf) and the expansion of the Science Center (26k sf), Houston Hall (81k sf) and the University Center (100k sf). Plans for the central loop include connecting the new Academic Classroom Building II (75k sf), the remodel and expansion planned for Tomlinson Library (86k sf) and all new buildings or significant remodels planned for campus in the future.

The central loop and the continued use of geo exchange at CMU represents a significant investment by the University in what many consider to be the most economical and energy efficient HVAC system currently available. The central loop provides up to 89% of the energy needed to heat and cool connected buildings (696k sf) and saves the University as much as \$459,497/year<sup>9</sup>. Conservative estimates show our carbon footprint reducing by 8,188 metric tons through the use of geo exchange.

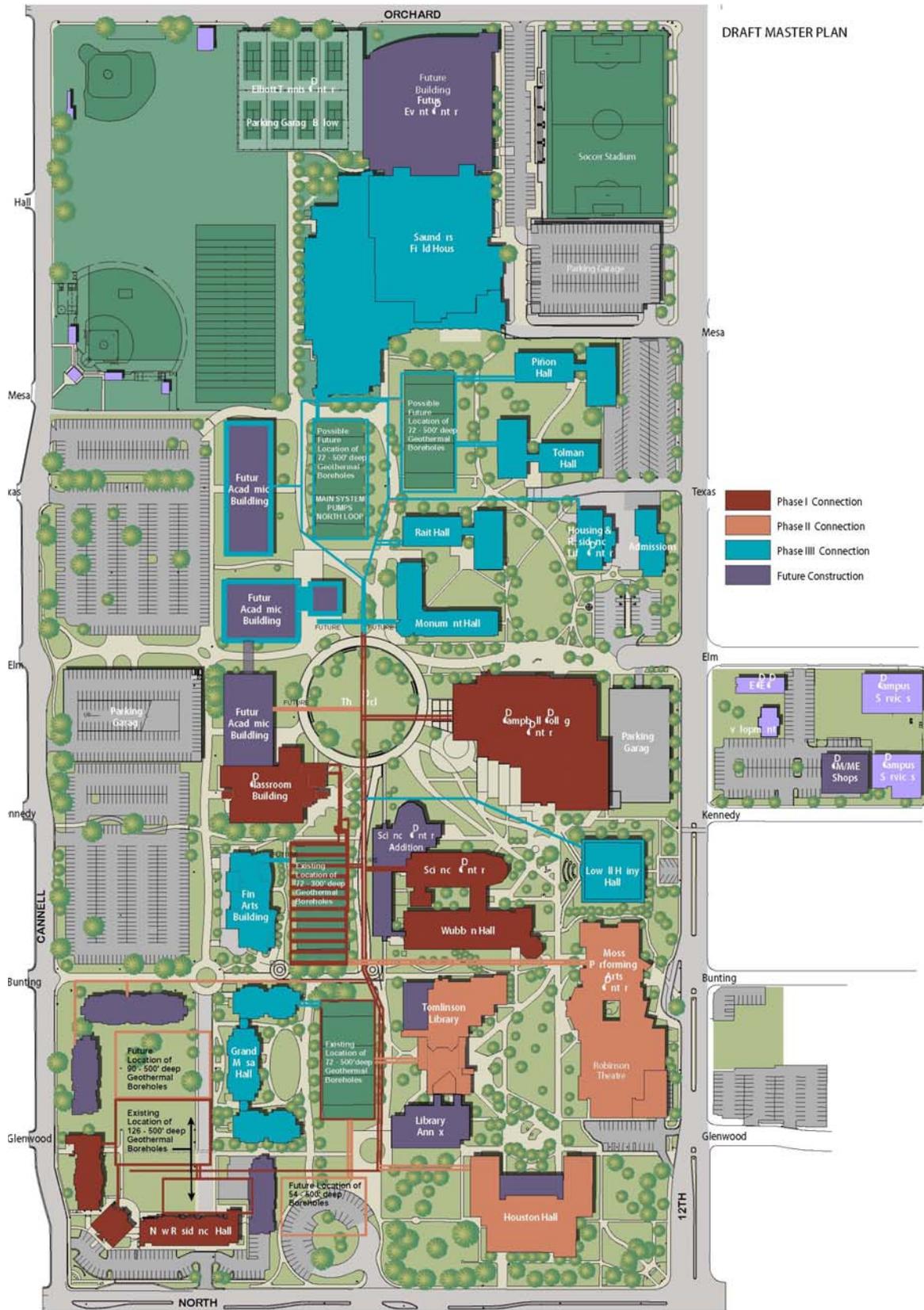
The exhibit included on the following page provides a graphic representation of CMU's current geo exchange central loop, associated bore fields and loop field piping<sup>10</sup>.

---

<sup>8</sup> MSC\_Assessment One\_Final.pdf – Davis Partnership Architects

<sup>9</sup> Assumes cost of electricity to be \$0.06/kWh and rates of consumption equal to 22 kWh/sf/yr for traditional hvac systems and 10 kWh/sf/yr for buildings using geo exchange

<sup>10</sup> Campus-Wide Geo Exchange Central Loop



## Additional Electric Feed from Xcel Energy

CMU continues discussion with Xcel Energy to identify the most practical and cost effective means to provide an additional power supply from their main grid to our ever expanding campus. Recent improvements completed by Xcel Energy to provide a separate dedicated feed to one of our commercial neighbors along 7<sup>th</sup> Street, St Mary's Hospital, may allow a more economical solution than what was proposed several years ago.

The original cost to provide an additional feed to campus that would be capable of providing additional power to support campus expansion came with a price tag up to \$1,000,000 for construction costs along with demand and reserve capacity fees, the magnitude of which, were unknown at the time. The exact cost of providing another fee has yet to be determined; estimates vary from a low of \$250,000 to a high of \$1,000,000.

CCHP was chosen as an alternative energy supply for many different reasons, the most significant of which are listed below;

- CCHP systems provide an economical and environmentally sensitive alternative to traditional sources of electricity and conventional refrigeration systems<sup>11</sup>
- Tri-generation systems operate with heat, utilizing relatively inexpensive "excess energy"<sup>11</sup>
- Produced electricity can be fed into the public grid or used to cover electricity requirements of the plant<sup>11</sup>
- During cold seasons, heat can be utilized to cover heat requirements<sup>11</sup>
- System contains no moving parts, enabling low maintenance expenses
- Low operating costs and life-cycle costs<sup>11</sup>
- Using water as a refrigerant eliminates use of ozone-damaging substances<sup>11</sup>
- CCHP decrease the existing campus peak load by as much as 1,500 kW
- CCHP will serve as a back-up, uninterrupted power source for the entire campus
- CCHP will provide a unique hands on learning environment for CMU students

### **iii. IMPLEMENTATION AND DESIGN CRITERIA**

#### *Spatial Relationships and Room Specifications*

The structure will consist of one room containing the specialized equipment necessary to improve the energy usage at CMU.

#### *Site Requirements and Design Requirements*

CMU has several sites identified for the proposed CCHP project. A final decision won't be made on the precise location until details have been worked out with Xcel Energy, the City of Grand Junction and CMU's Board of Trustees. The site chosen for the new facility will likely be near the periphery of the future campus, as identified in the most recent version of the campus master plan. That master plan identifies 7<sup>th</sup> Street as the western campus boundary, Orchard Avenue as the northern boundary, 12<sup>th</sup> Street as the eastern boundary and North Avenue as the southern boundary.

The most likely location at this juncture will be along 7<sup>th</sup> Street. 7<sup>th</sup> Street is unique in the fact that Xcel Energy has an existing 5" diameter high pressure steel gas line in 7<sup>th</sup> Street. The gas line has the potential to deliver gas in appropriate volumes and at or very near the pressure needed for the proposed CCHP plant.

7<sup>th</sup> Street is identified as a Minor Arterial roadway on the Grand Valley Circulation Plan<sup>12</sup> and carries approximately 16,000 vehicle trips per day. 7<sup>th</sup> Street also serves as a boundary

---

<sup>11</sup> <http://www.ge-energy.com/solutions/trigeneration.jsp>

<sup>12</sup> [http://arcgis-fs.ci.grandjct.co.us/gis\\_map\\_external/index.html?map=citymap](http://arcgis-fs.ci.grandjct.co.us/gis_map_external/index.html?map=citymap)

between medium to high density housing and Colorado Mesa University's main campus east of 7<sup>th</sup> Street and commercial property and Grand Junction High School west of 7<sup>th</sup> Street. CMU currently owns two separate parcels on 7<sup>th</sup> Street, south of the intersection of 7<sup>th</sup> Street and Orchard Ave. and hopes to purchase one additional contiguous property. The properties in combination would provide sufficient room for the CCHP plant being proposed.

This program plan describes a 10,000 square foot masonry building that will house the new gas turbine and generator located on a one acre parcel of land within the bounds of CMU's adopted campus master plan. The masonry structure will be built above a 12' deep concrete foundation where the gas turbine and new generator will be placed. The main floor of the building will allow room for equipment storage, a control room and offices. The gas turbine and generator will be placed below ground to decrease noise levels and to provide a water tight concrete enclosure that would contain any fluid leaks.

Heat recovery systems and an absorption chiller(s) will be placed above grade, adjacent to the new generator enclosure. Said ancillary systems will work in concert with heat exchangers between the campus-wide geo exchange system and the CCHP system to regulate temperatures in the central loop. Regulating temperatures in the central loop increases the efficiency of heat pumps and allows CMU to continue to add new buildings without having to drill additional fields.

### *Project Schedule*

The program plan for this project will be submitted to the Colorado Department of Higher Education in July, 2013. CMU anticipates receiving approval for spending authority and appropriate state funding in the upcoming Long Bill that's published near the end of the current fiscal year (May -June, 2014). Construction on the CCHP plant would begin in August or September, 2014 and would extend through August, 2015.

### *Cost Estimate*

Colorado Mesa University is requesting spending authority of \$6,814,092 from the State of Colorado to construct a 1.5 mW CCHP facility on campus. The total project budget for the CCHP project includes the following:

- \$1,043,386 for professional fees included A.E. design fees, construction management fees, code review and code inspection, site surveys, investigations and reports
- \$5,343,787 for construction of the CCHP, a new building to house the plant, new electric feed from CMU's main electrical gear at Orchard Ave. to new CCHP facility and new telecommunication and fiber lines to connect into the main campus "backbone".
- \$49,000 for furnishings, equipment and communications
- \$53,438 (1% of construction costs) for art in public places
- \$324,481 for required project contingencies
- Total project costs \$6,814,092

### *Financial Analysis*

CMU consumes approximately 23,500,000 kWh of electricity each year; current peak demand at CMU varies from a low of 3,055 kW in the winter months (October through May) to a high of 4,298 kW during the summer months (June through September). Peak demand charges for the low of 3,055 kW in December, 2012 amounted to just over \$41,000. Peak demand charges associated with the high of 4,298 kW in September, 2012 resulted in fees in excess of \$69,000. Peak demand charges for fiscal year 11-12 amounted to \$634,721.

Clearly, a 1.5 mW CCHP facility won't provide enough power to completely eliminate demand charges nor will CMU save the equivalent of 1.5mW per month times the cost of peak power provided by Xcel Energy (\$16.640 per kW during the summer months versus

\$13.63/kW during the winter months). The cost to generate power at the new CCHP must be calculated and factored into any costs savings. Additional costs associated with annual maintenance, new employees to run the plant and the costs savings associated with dumping waste heat into CMU's central loop must all be considered.

Another key assumption made while compiling data used in the financial analysis of CCHP at CMU, involves the cost of purchasing bulk gas for the new facility. CMU is currently paying an average of \$5.84/Dth for natural gas and pays a blended rate of \$0.059/kWh for electricity purchased from Xcel Energy. Xcel Energy owns and maintains a 5" diameter, steel, high pressure gas main along the west side of 7<sup>th</sup> Street, very near one of the sites proposed for the new CCHP facility. The high pressure line would allow delivery of bulk gas, which ought to result in significant cost savings per Dth.

### *Conclusion*

Colorado Mesa University is one of Colorado's premier institutions of higher education, with a tripartite mission in providing baccalaureate and graduate programs as a state-wide institution, as a regional community college and as a county provider of vocational programs<sup>13</sup>.

The new CCHP facility, if funded, will represent a significant step forward in the way power is provided to higher educational facilities across the state and represents a significant opportunity to for CMU to work together with other community partners, such as St Mary's Hospital, to provide ways to both conserve energy and lower the costs of doing business. This project is fully consistent with Colorado Mesa's five-year Capital Improvement Plan.

---

<sup>13</sup> [http://www.coloradomesa.edu/facilities/documents/ProgramPlanAcademicBuildingII\\_April2012.pdf](http://www.coloradomesa.edu/facilities/documents/ProgramPlanAcademicBuildingII_April2012.pdf)