

Describe the project purpose.

- Michigan Tech has an opportunity to serve the state by supporting development of health-related/human-centered technological innovations, enhancing growth of one of the fastest maturing economic sectors in Michigan and the nation.
- Michigan Tech's enrollment is growing and many students are interested in pursuing degrees (including research experiences) in disciplines associated with health-related/human-centered technologies.
- Michigan Tech has outgrown occupancy capacity of existing research and education facilities as a result of substantial growth in health-related/human-centered education and research.
- In alignment with its strategic plan, the University is ready to invest in facilities and infrastructure to address deficiencies related to occupancy, safety, and innovation needs; this investment is key to recruiting and retaining high-caliber talent in Michigan.

From automobiles to artificial intelligence, Michigan Tech is known for its technological innovations. During the past two decades, Michigan Tech's faculty and students have become increasingly involved in developing technological innovations that improve the human condition. Our Five-Year Capital Outlay Plan will support ongoing efforts and contribute to future growth in our capacity to design, develop, and deliver human-centered innovations. The project requested for fiscal year 2018, *H-STEM Engineering and Health Technologies Complex – Phase 1*, will enable Michigan Tech to continue to grow its education, research, development and commercialization programs in areas that support workforce and economic development in the state of Michigan. Expected outcomes from the project include: social mobility for graduates, steady job creation, increase in federal research awards that directly put money back into regional and state economies, and development of innovative technology ready for commercialization. While one may not intuitively equate research with economic impact, the National Institutes of Health (NIH) report that every \$1 of externally sponsored program awards generates approximately \$2.21 in local, regional and state economic growth (National Institutes of Health. Impact: Our Economy. Accessed on 2015, January 14 from <http://www.nih.gov/about/impact/economy.html>). In the Upper Peninsula of Michigan, increased research expenditures are a local and regional economic game changer.

This project is needed because the University has experienced substantial growth in the number of faculty and students involved in health-related/human-centered STEM (science, technology, engineering, and mathematics). These faculty now comprise nearly 20% of the total number of faculty at Michigan Tech. They work within 17 different academic units and interact with students from 29 different undergraduate and 37 different graduate degree programs. Growth in the number of faculty with health-related research interests was driven primarily by the University's need to respond to students' interest in fields of study that have the potential to directly benefit humankind. Growth also reflects the natural maturation of several engineering and science industries. The growth experienced to date and expected for the future is placing unsustainable demands on current facilities.

Michigan Tech's FY18 capital outlay request is timed to strategically support the University's planned investments in facilities and infrastructure. Investment is needed to address deficiencies related to over-occupancy and safety; the investment will support continued innovation. This investment is also key to recruiting and retaining high-caliber talent in Michigan. As at any research university, lab facilities play a crucial role in recruiting and retaining research talent at Michigan Tech. Michigan Tech's health-related research spaces were classified as *satisfactory* in 2015

(<http://www.nsf.gov/statistics/facilities/>), meaning that the facilities are *suitable* for continued use over the next two years but will need repair or renovation during that time. Facilities classified as *satisfactory* do not provide adequate infrastructure support for researchers working in the most scientifically competitive fields. Michigan Tech's current net assignable square feet devoted to human-centered engineering and science laboratories is extremely low compared to other research institutions located within and outside of Michigan (<https://www.nsf.gov/statistics/srvyfacilities/>). The University has decided to make a request to upgrade some laboratories to *superior* status at this time because these upgrades will strategically benefit students and the state of Michigan. Addition of new laboratories will support future growth as well.

Describe the scope of the project.

- The single stand-alone project consists of renovation and addition to an existing building.
- Operational efficiency of the facility will be enhanced by its sustainable design.

More specifically, the *H-STEM Engineering and Health Technologies Complex – Phase 1* will include: (1) renovation of 45,000 gross square feet of existing space in the Chemical Sciences and Engineering Building and (2) a 63,000 gross square feet addition to the Chemical Sciences and Engineering Building. Renovated space will be used as classrooms and learning labs. The addition will house hi-tech, flexible laboratory spaces that will meet current industry standards for safe operation and the training of students.

The estimated investment of \$39,600,000 will allow Michigan Tech's engineers and scientists to continue to: (1) deliver high-quality, discovery-based educational degree programs to students, (2) prepare students to meet the state's future technological workforce needs, (3) contribute to the state's economic prosperity through development of innovative technologies, and (4) continually increase revenue derived from federal/industry research funding by at least 20% per year.

Program focus of occupants.

- Occupants will help address a unique workforce niche that *supports* and *compliments*, rather than duplicates, programs at other Michigan universities and community colleges.

The *H-STEM Engineering and Health Technologies Complex – Phase 1* will support STEM education and research in areas that directly benefit the human condition. Teams of researchers and students from Biomedical Engineering, Chemical Engineering, Mechanical Engineering, Electrical and Computer Engineering, Materials Science and Engineering, Biology, Chemistry, Cognitive and Learning Sciences, Computer Science, and Kinesiology and Integrative Physiology (all currently existing academic departments) will benefit by being able to work together in collaborative spaces using shared equipment. The interdisciplinary research community fostered by the H-STEM Complex will provide students with hands-on experiences that will prepare them for their future careers as leaders and innovators. Even though our alumni may leave the state to pursue additional education elsewhere, they often find their way back to help grow Michigan's Innovation Shore (<http://www.mtu.edu/research/administration/ie/>).

The Life Sciences Technology Institute (LSTI) (<http://lsti.mtu.edu/>), to be located in the H-STEM Complex, will connect faculty and student researchers from multiple disciplines. These faculty are active in interdisciplinary life-science research and education at the national and international level.

LSTI members are currently supported by over \$10 million in research funding awarded through 57 research grants and contracts (<http://lsti.mtu.edu/research/projects/>). LSTI promotes research and education in the areas of medical technologies, human health, molecular biology, biochemistry, genetics, genomics, bioinformatics, and biotechnology.

Faculty occupying the facility have a strong history of building educational programs and partnerships across the state of Michigan. Since 2009, a partnership between Michigan Tech and Michigan State University's College of Human Medicine has provided early assurance of medical school admission for Michigan Tech undergraduates interested in working as Michigan physicians in underserved regions or among underserved populations. Beginning in 2014, Michigan Tech's partnership with Central Michigan University and UP Health System established a doctorate of physical therapy program that will help address critical workforce and health needs in the Upper Peninsula. A partnership between Michigan Tech and the local philanthropic Portage Health Foundation, which was established in 2015, has resulted in an initial \$6.7 million investment in Michigan Tech to grow H-STEM talent and the local/regional economy. A partnership with the Herbert H. and Grace A. Dow Foundation has resulted in Mi-STAR, Michigan Science Teaching and Assessment Reform (<http://mi-star.mtu.edu/>), which is devoting \$5 million to improve pre-college education in Michigan. Mi-STAR involves several higher education and precollege schools and districts in Michigan, including Adams Township Schools, Bangor Township Schools, Central Michigan University, Eastern Michigan University, Eaton Rapids Public Schools, Grand Rapids Public Schools, Grand Valley State University, Grosse Pointe Public Schools, Hancock Public Schools, Houghton Middle School, Kalamazoo Public Schools, L'Anse Area Schools, Michigan State University, Midland Public Schools, Public Schools of Calumet-Laurium-Keweenaw, Saginaw Valley State University, and Western Michigan University.

Having high-quality facilities, particularly laboratories, is important at Michigan Tech because it helps the University retain experienced faculty. Faculty who leave the university often relocate out-of-state at benchmark universities with superior facilities (e.g., Massachusetts Institute of Technology, Virginia Tech, Purdue University, Penn State, Rensselaer Polytechnic). By retaining talent in the human-centered engineering and science disciplines, the state can continue to be a national leader in STEM education and technological innovation.

1. How does the project support Michigan's talent enhancement, job creation and economic growth initiatives on a local, regional and/or statewide basis?

Michigan Tech's enabling legislation calls on the University to provide the means for residents of Michigan to acquire knowledge that will contribute to industry (<https://www.mtu.edu/bot/governance/legislation/enabling-legislation.pdf>). Throughout its history, Michigan Tech has focused on application-oriented research and education in alignment with this charge from the legislature. The fact that Michigan Tech receives a greater proportion of its research funding from industry than any other university in the state makes it clear that Michigan Tech focuses on the needs of industry and is cognizant of the ways in which those needs change through time.

Current economic indicators suggest that demand for technological innovations related to human health (e.g., wearable technologies, sensors, monitors, drug-delivery systems, adaptive mobility devices) is going to grow substantially during the 21st century. Projections indicate a 25% growth in the market for medical devices in the Americas between 2016-2020 and a 28% growth worldwide (<http://www.middevice.org/industry-profile/>; <http://michiganvca.org/wp-content/uploads/2015/04/MVCA-2015-Research-Report.pdf>;

https://www.bio.org/sites/default/files/SP_Michigan_o.pdf ;
https://www.bio.org/sites/default/files/files/v3battelle-bio_2012_industry_development.pdf).

Like other technological universities such as the Massachusetts Institute of Technology (M.I.T.), Michigan Tech is developing new technologies that support the work of health care providers. M.I.T.'s relatively recent investments in the area of health technologies have allowed it to be a leader in these emerging fields. Through investment in world-class facilities and people, M.I.T. has been among the most competitive universities in securing health-related research funding provided by federal agencies and industry. Michigan Tech is poised to make the same sort of leap forward; the faculty are in place on campus and are prepared to deliver rigorous education programs. Michigan Tech has a long history of providing students with an action-based, application-oriented education; this type of education requires faculty to integrate research experiences into degree programs and provide opportunities for students to conduct research on their own. These pursuits require safe and high-quality laboratory facilities in order to fully prepare students for the future.

An advantage of Michigan Tech's coupled education and research enterprise is that many discoveries have near-term practical applications, making it possible to transfer findings to both the classroom and society as quickly as possible. The synergies between Michigan Tech's research programs and curricula helps prepare students to be leaders and innovators in their chosen fields.

Michigan Tech's STEM programs produce graduates with the skills needed to design, develop, apply, manage and communicate information about engineering, science, and technology. These are the types of people who have a disproportionate effect on economic growth because what they do throughout their careers create jobs for others. Recognizing this, 331 groups (companies, government agencies, military branches and graduate schools) came to campus for the 2016 fall semester Career Fair. Over 1,200 recruiters spoke with students. In addition to Career Fair, over 70 companies participated in the four-week-long Career Fest Industry Days throughout fall semester. Prospective employers come to Michigan Tech because the University produces the talent they seek.

Students' interests in careers in industry is one reason why Money Magazine, the Wall Street Journal, PayScale, U.S. News and World Report, and others have recognized the opportunities that Michigan Tech offers to students. Earning an average of \$62,800 a year, early-career graduates enjoy the seventh highest salaries of graduates from any public institution in the nation. This is a strong motivator for degree completion. Michigan Tech students who are awarded an average financial aid and scholarship support package see a \$713,000 return on investment (ROI) over 20 years. That continues to attract attention throughout the state and nation, and has resulted in substantial increases in enrollment over the past decade as illustrated in the attachment. A Michigan Tech education is also an engine of social mobility, helping low-income students, who make up over 25% of our undergraduate population, rise from the lowest quartile of family income to the highest quartile in less than 20 years—by the time they are midway through their career. By responding to economic indicators and workforce demand related to health-related technological innovations, we anticipate the H-STEM Complex project will bolster this track record.

Michigan Tech is serious about growing the economy of the Upper Peninsula, which has an unemployment rate of 6%, well above the average for Michigan (4.3%) and the nation (4.7%) (<http://milmi.org/>; <http://www.npr.org/2009/09/27/113251646/u-p-county-tops-state-unemployment-rate>). Although the unemployment rate in the Upper Peninsula has declined in recent years, from a high of 12.3% in 2009, more needs to be done to revitalize and grow the region's economic base

(<http://www.uppermichiganssource.com/content/news/UP-unemployment-rate-drops-slightly--381032041.html>). Future efforts can be informed by prior successes—by responding to shortages among health professionals and growing H-STEM talent for example. According to the Bureau of Labor Statistics, future growth in employment in the western U.P. is expected to be greater than the statewide average).

The *H-STEM Engineering and Health Technologies Complex – Phase 1* will contribute to economic growth by developing the highly educated STEM workforce that is needed to sustain innovation in the future. The Michigan Translational Research and Commercialization (MTRAC) program (<http://www.mtu.edu/research/administration/iie/campus-inventors/mtrac/>), which accelerates commercialization of viable advanced applied material technologies, will help Michigan Tech's H-STEM researchers move their innovations from the laboratory into the commercial market. Start-up and small businesses resulting from research and development are nurtured by initiatives such as Innovation Shore (<http://www.mtu.edu/research/administration/iie/>), and organizations such as MTEC SmartZone (<http://mtecsz.com/>) and the Michigan Economic Development Corporation (<http://www.michiganbusiness.org>). Once successfully launched, these businesses will play an important role in future economic development in the Upper Peninsula.

2. How does the project enhance the core academic and/or research mission of the institution?

The *H-STEM Engineering and Health Technologies Complex – Phase 1* project supports Michigan Tech's strategic goals to:

- deliver a distinctive and rigorous action-based learning experience grounded in science, engineering, technology, sustainability, business, and an understanding of the social and cultural contexts of our contemporary world;
- attract, retain and support talented faculty; and
- support research, scholarship, entrepreneurship, innovation, and creativity for a sustainable, just, and prosperous future.

Substantial increases in enrollment over the last decade coupled with growth in research and development activities are taxing our ability to provide appropriate space to those who need it. The Portrait of Michigan Tech 2045 (<http://www.mtu.edu/stratplan/2045/>), our long-term strategic planning framework, articulates plans for growth in the number of students at all levels (bachelor's, master's and PhD), and a change in the demographics of the University so that 40% of enrolled students are female and the University is in the top ten in the nation in terms of the percent of engineering degrees granted to women. We are on track to meet these goals. Fall 2016 enrollment at Michigan Tech is 7,268, the highest the school has seen since 1983. Female enrollment is at a record high, with 1,957 women making up 27% of the student body. If we continue to increase the number of female students each year at the same rate as we have during the last five years, we will meet our 2045 goal. By increasing gender balance at Michigan Tech, the University plans to prepare an overall greater number of individuals who will contribute their talent in support of Michigan's future. In 2015, over 70% of Michigan Tech students were enrolled in degree programs (bachelor's, master's, or PhD) involving faculty interested in human-health related research. These fields of study are clearly of interest to many students. There is particularly strong interest in these fields among female students; national-level data indicate that health-related fields are of great interest to women (<http://www.aauw.org/resource/why-so-few-women-in-science-technology-engineering-mathematics/>). Investment in the H-STEM Complex will help us achieve the Portrait of Michigan Tech 2045 goals to attract, retain, and graduate increasing numbers of students while simultaneously increasing the relative proportion of female students.

The H-STEM Complex will enhance Michigan Tech's core academic and research mission by providing a centrally located, flexible shared space for collaborative learning and research. Undergraduate and graduate students in human-centered fields of study, like Kinesiology and Integrative Physiology (KIP) and Biomedical Engineering (BME), regularly collaborate with faculty and students from other departments as they engage in interdisciplinary research, engineering-focused senior design projects, and community health projects. Research and teaching facilities in KIP are currently scattered across multiple buildings and located in spaces that were not designed for health-related research. Specifically, KIP faculty are located across three buildings designed for physical education (Student Development Complex), environmental and biological science (Dow Building), and cognitive and learning science (Meese Cognitive and Learning Building). Biomedical Engineering (BME) is located in a fourth building, the Minerals & Materials Building. All of the space currently used by BME is re-purposed space originally used in mining, mineral processing, and materials science education and research. BME teaching laboratory spaces for the Bioinstrumentation and Laboratory Techniques classes can serve only 10 students at a time. Both of these courses are required core courses for all BME students. This leads to significant scheduling issues and inefficiencies in delivering educational experiences, as BME currently enrolls approximately 315 undergraduate students.

Given the ongoing and growing research collaborations between KIP and BME, there is an urgent need to locate the two departments in close proximity to one another. KIP and BME research is conducive to the open lab model planned for the H-STEM Complex. The new construction associated with the H-STEM Complex addition will allow for creation of new shared research laboratory spaces. These spaces will allow faculty, graduate students, and undergraduates from multiple disciplines to work in collaborative settings. In contrast to the old model for research laboratories, in which a single research group was assigned to a single laboratory, new laboratories will be designed to address specific research needs and serve all research groups having those needs. Re-purposing and renovating of existing space in the Chemical Sciences and Engineering Building will provide additional space for classrooms and class laboratories.

Another Portrait of Michigan Tech 2045 goal articulates the need to ensure that our educational offerings are among the best in the world. To that end it is necessary for us to attract and retain faculty and staff who are internationally recognized for their education, research, development, and innovation activities. These faculty will benefit from the H-STEM Complex because it will allow them to work together with their students in state-of-the-art facilities that meet the expectations of industry and federal research sponsors in terms of safety, security, and capability. In the absence of state-of-the-art facilities, many faculty members find themselves at a disadvantage when pursuing external grants and contracts to support their educational and research activities. The external support they seek allows them to involve students in research, development, and commercialization. Without continued external support it will be difficult for them to continue to make the technological breakthroughs that are needed to ensure that Michigan's economy remains strong. The H-STEM Complex project will involve construction of shared laboratory spaces and updating/upgrading of existing space so that researchers and students can pursue funding and undertake projects that will allow Michigan Tech to retain its status as Michigan's high-tech STEM powerhouse.

The Portrait of Michigan Tech 2045 also identifies having an internationally competitive faculty, with 400 in tenured or tenure-track positions and 40% in endowed positions as a key goal. Endowed positions are critical to recruiting and retaining talent at any university because they are a recognition of outstanding achievements; they are extremely important to Michigan Tech because they can be a

strong incentive to keep faculty in the geographically remote Upper Peninsula. To have 400 faculty in place by 2045, the University needs to add approximately two tenured or tenure-track faculty each year between now and 2045. In addition, the University will need an approximately five-fold increase in the number of faculty in endowed positions between now and 2045. Growth in the number of faculty overall, as well as the number of faculty in endowed positions, will be facilitated by the research and educational activities that will be conducted in the H-STEM Complex. The number of faculty interested in health-technologies and related research has more than doubled in the last decade, so that faculty with research in these areas now comprise nearly one-fifth of the total number of Michigan Tech faculty. In 2015, through a partnership with the Portage Health Foundation, Michigan Tech established three new endowed faculty positions. The positions are in the areas of Medical Informatics, Community and Preventative Health, and Technological Innovations in Health. The individuals selected to fill these positions will work closely with the MTEC SmartZone (<http://mtecsz.com/>) to develop and enhance opportunities for local and regional economic growth.

The H-STEM Complex will provide necessary support to enhance health-related, human-centered education and research programs at Michigan Tech.

3. Is the requested project focused on a single, stand-alone facility? If no, please explain.

Yes. The project request is for a single, stand-alone facility, the *H-STEM Engineering and Health Technologies Complex – Phase I*. The project will include an addition to and re-purposing/renovation of a portion of the existing Chemical Sciences and Engineering Building.

4. How does the project support investment in or adaptive re-purposing of existing facilities and infrastructure?

The project will involve re-purposing of existing research lab space in the current Chemical Sciences and Engineering Building. This space will be re-purposed and as learning labs and classrooms. Re-purposing will provide significant cost savings for the project as a whole, the cost of renovating this space will be less than half the cost of building new classrooms and learning lab spaces. The addition to the Chemical Sciences and Engineering Building will focus on high-technology shared, flexible, research lab space. These hi-tech spaces could not feasibly be developed through renovation. New safety standards and research growth necessitate an addition.

Strategic investments toward adaptive re-purposing of the existing facility have been made based on Michigan Tech's Facilities Assessment and Deferred Maintenance Capital Planning Report, 2011 (<http://www.mtu.edu/facilities/engineering/pdfs/2011-mtu-facility-assessment-report-2011-10-13-update.pdf>). These include the following: (1) in FY 2016, the University renovated an undergraduate teaching lab, which will serve as a model for future H-STEM Engineering and Health Technologies Complex learning labs (see the last slide in the attachment); (2) in FY2017, the University is making a capital investment of \$2,000,000 to improve safety and compliance in the Chemical Stores, currently located in the Chemical Sciences and Engineering Building. The current space has serious access and egress deficiencies, temperature control and ventilation inadequacies that impact volatile chemical storage, and is undersized to serve current and future needs in a safe and efficient manner. Infrastructure investments, which will also be the framework for sustainable design plans for the H-STEM Complex, include replacing an outdated cooling tower, addressing safety concerns and ventilation inadequacies. Smaller investments are being made to update finishes and remove asbestos.

5. Does the project address or mitigate any current health/safety deficiencies relative to existing facilities? If yes, please explain.

Yes. In addition to what is mentioned above, the following mitigate current health/safety deficiencies relative to the existing facility:

- Moving research labs to the new construction portion of the H-STEM Complex will help mitigate ventilation and air flow concerns, which could not be feasibly addressed in the current facility.
- Renovated undergraduate teaching labs will include new, safer technologies. Current deficiencies include outdated and oversized fume hoods that create a visual and physical obstruction in the learning labs. Plumbing and pipes for cold, hot, and reverse osmosis water as well as compressed air and natural gas do not have any vacuum piping, and instead rely on a venturi connection on the water supply fixtures. Renovations will include vacuum pumps and vacuum piping.
- Elevator upgrades have been identified and replacements will increase safety.
- A heating and ventilation system recommissioning will take place as part of the process, which will increase safety, address system deficiencies, improve energy usage, and lower operating costs.
- Additional renovations will correct several current code deficiencies related to restrooms and accessibility issues.

6. How does the institution measure utilization of its existing facilities, and how does it compare to relative established benchmarks for educational facilities? How does the project help to improve the utilization of existing space and infrastructure, or conversely how does current utilization support the need for additional space and infrastructure?

Michigan Tech's space/facilities management is a continuous process maintained through our Accounting for Space, People, Indexes, Research, and Equipment (ASPIRE) database. The University does an annual snapshot to strategically determine funding priorities, as well as prioritize equipment purchases and space utilization. For example, this fiscal year (FY17) the Vice President for Research office has introduced a formal process for departments to delist space at the department level in exchange for a positive budget adjustment. This process is being driven, in part, by the lack of space for expanding life science and engineering research, which has more than tripled over the past 10 years.

Each unit administrator ensures that all space assigned to the unit is used efficiently and effectively per Michigan Tech's Space and Equipment Management Guidelines

(<http://www.admin.mtu.edu/admin/Space/SpaceEquipmentManagementGuidelines.pdf>).

In support of this effort, the ASPIRE database provides: space descriptions, functional use, and metrics for instructional and research space utilization. For instructional space, the number of hours a classroom is scheduled per week and the percentage of seats occupied when the room is scheduled are available in ASPIRE along with graphical displays, allowing quick comparisons. For research space, every research project is assigned to one or more rooms, and room utilization metrics include the total research expenditures per square foot of assigned space, which was \$170 for fiscal year 2015 was \$170. Students supported per square foot is often reviewed as well. Administrators can compare information to assign or reassign laboratory space when new faculty are hired or when multi-million dollar research

projects are initiated.

ASPIRE datasets help to identify spaces with low utilization. This allows for space utilization to be maximized as determined by occupant use or research expenditures. ASPIRE informs the University's flex lab approach in the Great Lakes Research Center and will inform how research space is assigned and reassigned in the H-STEM Complex.

Every two years the University completes the National Science Foundation (NSF) Survey of Science and Engineering Research Facilities survey (<https://www.nsf.gov/statistics/srvyfacilities/>), which allows for comparison relative to established benchmarks. According to the most recent published NSF data (<https://www.nsf.gov/statistics/2015/nsf15320/pdf/nsf15320.pdf>), the three top research spaces at Science & Engineering research institutes are: 1) biological and biomedical sciences, 2) health and clinical sciences, and 3) engineering. For Biological and Biomedical Sciences, Michigan Tech has 25,374 net assignable square feet (NASF) of research space at the end of FY 2015. Note that out of the total, 3,651 NASF was categorized as research animal research space. Health Sciences was assigned only 2,823 NASF. Michigan Tech's combined NASF is extremely low compared to in-state and out-of-state benchmarks. To continue growing Michigan's state economy related to health and human-centered technological innovation, more facility space is required. The project, *H-STEM Engineering and Health Technologies Complex – Phase 1* addresses the need to increase NASF.

7. How does the institution intend to integrate sustainable design principles to enhance the efficiency and operations of the facility?

Michigan Tech has an established practice of designing new construction and major renovations to achieve LEED certification, with two campus buildings currently certified. A student residential building, Hillside Place, is LEED certified at the Gold level and an administrative building, Lakeshore Center, holds LEED certification. The University intends to design the *H-STEM Engineering and Health Technologies Complex – Phase 1* to meet LEED Gold certification.

A number of sustainable design principles are being studied for the project, listed below. All are entirely feasible; many have been incorporated into current buildings during new construction or renovations.

- Utilize waste heat stream from the Central Heating Plant boilers to provide heat for facilities in close proximity.
- Utilize low-temp waste heat from heating plant for chillers.
- Utilize any other waste heat sources in the building appropriately.
- Use lake water for cooling the air conditioner condenser water.
- Use dry coolers instead of cooling towers to reduce water usage.
- Use variable frequency drives on fans and pumps.
- Oversize ductwork to reduce required fan energy.
- Place central fan systems inside of the building envelope.
- Utilize low lifecycle cost lighting and lighting controls.
- Use automatic lighting controls in public and general areas of the building.
- Install individual room and space lighting and comfort controls.
- Maximize the use of natural light.
- Use high-efficiency window systems.
- Utilize occupancy-controlled, high-efficiency fume hood and lab exhaust systems.

- Install heat recovery on exhaust systems.
- Utilize thermal solar panels to preheat domestic hot water.
- Incorporate passive solar design concepts.
- Design the building with flexible spaces that readily adapt to changing needs.
- Plan for recycling areas and bins in the building design.

8. Are match resources currently available for the project? If yes, what is the source of the match resources? If no, identify the intended source and the estimated timeline for securing said resources.

Yes. Michigan Tech has match resources available using a combination of capital financing and capital reserves. Furthermore, interest from industry partners and community foundations has been expressed, and the University plans to secure any funding commitments from outside partners within a year of an approved capital outlay to supplement existing resources.

9. If authorized for construction, the state typically provides a maximum of 75% of the total cost for university projects and 50% of the total cost for community college projects. Does the , institution intend to commit additional resources that would reduce the state share from the amounts indicated? If so, by what amount?

Michigan Tech intends to fund the project at the required 25% match, with the maximum 75% requested from the state. Michigan Tech will additionally make investments in adjacent spaces not currently included in the project scope.

10. Will the completed project increase operating costs to the institution? If yes, please provide an estimated cost (annually, and over a five-year period) and indicate whether the institution has identified available funds to support the additional cost.

No, the completed project will not increase net operating costs to the institution. The University has been preparing for many years to absorb the operating and maintenance expenses of the new addition. Significant efforts have been made to consolidate custodial and maintenance services to more efficiently cover additional square feet; the effectiveness of these efforts has already been demonstrated when we brought other new spaces online without additional staffing. Michigan Tech's practice of continuous improvement using Lean principles guides these efforts and offers a framework for additional problem-solving to expand the capacity of our existing resources. In 2013, a new tier of lower entry-level wages was negotiated with the ASFCME labor union, which has reduced labor costs and will continue to produce savings as new employees are on-boarded (<http://www.mtu.edu/hr/current/docs/afscme-contract.pdf>). Energy efficiencies, excellent purchasing practices, and favorable negotiated rate structures have resulted in University-wide energy savings. Furthermore, Facilities and Administrative (F&A) cost recovery from anticipated increases in federal research awards will additionally offset operating costs.

11. What impact, if any, will the project have on tuition costs?

The project will not impact student tuition.

13. What alternatives to this project were considered? Why is the requested project preferable to those alternatives?

A complete renovation of the existing Chemical Sciences and Engineering Building was considered but was not selected for several reasons. The cost to renovate existing small, inflexible labs into modern research facilities was prohibitive. Available space in the building was also insufficient to allow for the addition of modern research facilities that meet new safety standards.

Renovation of a different facility was also considered but was not selected because the Chemical Sciences and Engineering Building was identified in a facility maintenance review as the academic building on campus most in need of renovation. No other building was in need of such extensive renovation to address teaching needs.

An entire newly constructed facility was also considered but was not selected because it would not allow for renovation of existing teaching laboratory space. Because new construction makes building classrooms, classroom labs, and office space cost-prohibitive, new construction was not considered further.

The combination of an addition to and renovation of the existing Chemical Sciences and Engineering Building addresses all needs. The new addition will provide hi-tech, flexible lab space that meets modern safety standards and the needs of students and researchers. Labs in the existing building, which have exceeded their useful lifespan, will be re-purposed to provide modern classroom and learning spaces for students.

The H-STEM Engineering and Health Technologies Complex – Phase 1 will enhance Michigan Tech's mission to "deliver action-based undergraduate and graduate education and discover new knowledge through research and innovation." The success of the project will be measured by increased enrollment, career placements, research expenditures, and the "accomplishments and reputation of our graduates, national and international impact of our research and scholarly activities, and investment in our University" (https://www.banweb.mtu.edu/pls/owa/strategic_plan.p_display).