University of Colorado **Denver**

CU Denver CEDC

University of Colorado Denver

College of Engineering, Design, and Computing

2021 Program Plan Amendment

ZGF

April 1, 2021

Acknowledgements

To those whose support and contributions greatly impacted this project.

University of Colorado
Mark Kennedy, President, University of Colorado

University of Colorado Board of Regents
Glen Gallegos, Chair
Lesley Smith, Vice Chair
Chance Hill
Heidi Ganahl
John Carson
John “Jack” Kroll
Linda Shoemaker
Sue Sharkey

University of Colorado Denver
Michelle Marks, PhD, Chancellor
Dorothy Horrell, PhD, Former Chancellor
Roderick Naim, PhD, Provost and Executive Vice Chancellor for Academic and Student Affairs
Jennifer Sobanet, Vice Chancellor for Administration and Finance

College of Engineering, Design and Computing
Martin Dunn, Dean
Keith Jones, PhD, Associate Dean
Cathy Bodine, PhD, Associate Professor—Bioengineering
Gita Alaghband, PhD, Professor and Chair—Computer Sciences and Engineering
Kevin Rens, PhD, PE, Professor, Chair and Director of Construction
Engineering and Management—Civil Engineering
Sam Welch, PhD, PE, Associate Professor and Chair—Mechanical Engineering
Stephen Gedney, PhD, Professor and Chair—Electrical Engineering
Petrina Morgan, College Administrator

Office of Institutional Planning
Cary Weatherford, Executive Director
Jered Minter, Campus Architect

Facilities Projects
Michael Barden, Director
Kyle Willcott, Project Manager

Consultant Team
ZGF Architects
AEI Engineering
Martin | Martin Engineering

View of North End of CEDC Building

Contents

01 Executive Summary

The University of Colorado Denver is taking the next steps to advance the College of Engineering, Design and Computing. The next phase of the College will enable adaptation and delivery of technological innovations that will impact Colorado and the World.

The College of Engineering, Design and Computing (CEDC) Project creates a new complex for engineering and innovation at The University of Colorado Denver and an enhanced gateway into the CU neighborhood. Located at the intersection of Speer Boulevard and Larimer Street, the CEDC project is comprised of a 94,200 GSF engineering laboratory building and approximately 46,000 SF of site improvements.

The site includes a public plaza that celebrates the entrance into the CU neighborhood, an engineering “alley” that includes outdoor laboratory work space, service area, and pedestrian connectors between the project and adjacent buildings, including a proposed pedestrian bridge connecting to North Classroom at the 2nd floor.

The CEDC building will be a cross-disciplinary teaching and research facility, drawing users from beyond the College. The new building will reflect a redesigning of engineering education that will prepare students for a world that is changing at an unprecedented pace. It will promote accelerated innovation and meaningful student-faculty interaction, as well as attract outside industry partners that are important to the success of student recruiting and retention.

The total project budget for the CEDC Project is $80,911,629. A request for state capital construction funding for 74% of the total project cost ($59,874,606) has been submitted for fiscal year 2022-2023. Additional sources of funding are being reviewed and explored.

View at Speer Boulevard and Larimer Street

02

Introduction & Background

North Classroom Building

Student Commons

Institutional Background

CU Denver originated in 1912 as an extension of the University of Colorado Boulder. In 1964, the extension division was renamed the University of Colorado Denver Center and granted the authority to offer undergraduate and graduate degree programs.

In 1973, the University Of Colorado Board Of Regents established the University of Colorado System to be led by a president and comprised of four distinct and independently accredited institutions—The University of Colorado Boulder, the University of Colorado at Denver, The University of Colorado Colorado Springs, and the University of Colorado Health Sciences Center. The CU System is now the state's largest public university system.

In 1977, the University of Colorado at Denver became part of an innovative multi-institutional campus known as the Auraria Higher Education Center (AHEC). The Auraria Campus, located on the edge of downtown Denver is shared by the University of Colorado Denver, Metropolitan State University of Denver, and the Community College of Denver and managed by AHEC.

In 2004, the University of Colorado Board of Regents approved the consolidation of the University of Colorado at Denver and the University of Colorado Health Sciences Center into a single institution. The consolidated university was initially named the University of Colorado at Denver and Health Sciences Center, and subsequently in 2007, was renamed the University of Colorado Denver—one institution with two campuses, CU Denver in downtown Denver and CU Anschutz Medical Campus in Aurora, CO. CU Denver and CU Anschutz are a legally consolidated university. Each campus operates independently, though several functions—including facilities, information technology, academic and student affairs, administration and finance, and human resources—are provided through consolidated units.

Beginning in 2006, CU Denver purchased several buildings in downtown Denver that lie outside the boundaries of the Auraria Campus. The CU Denver Building, purchased in 2006, is home to the College of Architecture and Planning and lies directly adjacent to Larimer Square, a popular historic district in Denver. The Lawrence Street Center, also purchased in 2006, houses the School of Public Affairs, the School of Education and Human Development, and many administrative units. The Business School, which reaches into the heart of downtown, was purchased in 2008 and renovated to accommodate and consolidate the school's various programs, departments and centers.

Also in 2006, the Lynx Crossing Residence Hall opened immediately adjacent to the Auraria Campus' western boundary. For the first time, CU Denver students could essentially live on campus and have a traditional, residential college experience.

In 2007, the Auraria Master Plan ushered in the concept of institutional neighborhoods - areas of the campus designated for each of the three AHEC institutions. The area of the campus along Speer Boulevard, directly adjacent to Denver's central business district, was established as the CU Denver Neighborhood. The concept allowed for a measure of institutional autonomy and identity not seen before on the campus. For CU Denver, it led to a period of significant change. Student Commons was built in 2014 and consolidated many student services into one location. As the first CU Denver-owned building constructed on the Auraria Campus, Student Commons established an urban design and architectural language that anchors the entry and defines a unique character for the CU Denver neighborhood.

In 2011, students voted to create a CU Denver-specific mascot and Milo the Lynx was introduced in 2013. In 2015, students initiated and led a referendum to construct the Lola and Rob Salazar Student Wellness Center, a facility devoted to enriching all dimensions of wellness for CU Denver students. It opened in August 2018 and is the first named building for CU Denver. This project continued to establish the character of the CU Denver neighborhood through further use of the standards established at Student Commons.

The second CU Denver housing facility will open in the fall of 2021. The City Heights Residence Hall and Learning Commons building is located between 11th and 12th on Larimer Street and its design will continue to solidify and ground the neighborhood in the established CU Denver design language. The residence hall will serve 555 students and will include a full-service dining facility. The Learning Commons is designed to enhance student and faculty development; this portion of the First-Year Student Housing Project will become the new center for academic support and co-curricular life for CU Denver students.

CU Denver serves a distinctive role as Colorado's public urban research university. It combines academic rigor with immersive real-world experiences to educate students through quality academics, relevant research, creative work, and civic engagement in the heart of Denver. More than 14,000 on-campus students thrive in a diverse cultural, professional, and experiential setting, benefiting from CU Denver's unparalleled internship, career, and networking opportunities. All of these opportunities are within easy reach of the central business district, lower downtown (LoDo), the State Capitol, and the global and regional headquarters of major companies, high-tech startups, non-profits, and cultural organizations. CU Denver offers more than 130 degree programs housed within several academic schools and colleges. CU Denver is also a major contributor to the Colorado economy, with a direct impact of $3.3 billion to the Colorado economy, including university expenses of payroll and operations plus indirect earnings and expenses.

The University of Colorado Denver (CU Denver) is submitting a program plan amendment for the College of Engineering, Design and Computing (CEDC) project to the CU Board of Regents (BOR) for approval. This program plan represents the current vision for the CEDC project, including a new site and program requirements.

PROJECT HISTORY

The CEDC project has gone through an evolution spanning over five years. The project has explored at least three different sites and has seen numerous program iterations and overall architectural concepts. All programming and conceptual efforts for CEDC aimed to consolidate and increase collaboration across the college. Currently, CEDC activities on the Denver Campus are distributed across eight buildings: North Classroom, Boulder Creek, 5th Street Hub, Administration Building, Lawrence Street Center (LSC), Inworks at the CU Denver Building, and St Cajetan's Center. Assignable square footage (ASF) areas are identified in the Currently Occupied Space Table.

A revised program has been submitted every year since 2015. Those submissions that include substantial changes are discussed here. The original program plan, approved in May 2015, addressed the space challenges by proposing a new building north of North Classroom. The program plan also proposed the renovation of vacated engineering space in North Classroom to create a "humanities hub" of interdisciplinary space. The site proposed in the 2015 program plan is shown at the right in figure 1.

The Spring 2018 Program Amendment retained the program identified in 2015 but proposed a new site, located south of the Science Building on Speer Boulevard. This site provided a more direct connection to the Science Building for students and faculty, while being situated on a more prominent site. The site proposed in the 2018 amendment is shown in figure 2.

In Spring 2019, the program was updated to emphasize the importance of first-year design and computing classes, as well as collaboration and maker spaces. The architectural concept took advantage of the prominent site and attempted to create an identity for CEDC. It also contemplated how the site might accomodate several building, allowing for future growth. This visionary exercise was not packaged and submitted as an offical program plan amendment.

The 2021 program plan utilizes a program similar to that identified in Spring 2019, while examining a new site between North Classroom and Speer Boulevard. This site provides visibility for CEDC in addition to taking advantage of increased efficiencies resulting from an adjacency to North Classroom. The 2021 site is shown in figure 3.

Figure 1: Site in the 2015 Program Plan Amendment

Currently Occupied Spaces

	ASF	ASF to be Vacated
North Classroom	44,992	
LSC 8th Floor	8,803	8,803
5th Street Hub	7,550	7,550
Boulder Creek	7,562	7,562
CU Building (Inworks)	5,000	5,000
Admin Building	1,832	1,832
St Cajetans	1,131	1,131
Total	**76,834**	**31,842**

Figure 2: Site in the 2018 Program and Concept Study

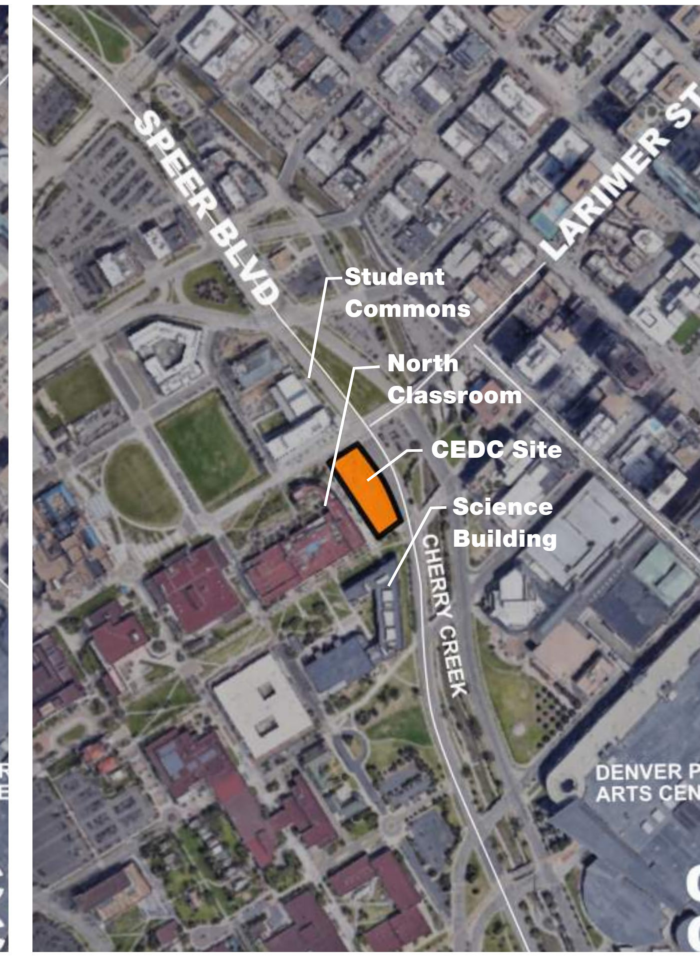


Figure 3: New Site for the 2021 Program and Concept Study

MISSION & VISION

CEDC has adopted IMPACT 2024 (IMPACT)—a strategic plan that was created by the college. IMPACT has bold plans to transform engineering education, emphasizing computing technology throughout, with interdisciplinary design-oriented teaching and learning. There will be a dynamic blend of hands-on and on-line pedagogy that can pivot in an agile manner, with an emphasis on cutting-edge technology, such as artificial intelligence and big data driven content delivery.

From this distinct platform, CEDC will focus its teaching and learning on two verticals: health and urban solutions. CEDC also realizes the need to be agile and adaptive to strategically differentiate in a rapidly changing world. This forward-leaning vision enables CEDC to leapfrog competitors and establish itself as the academic technological innovation engine of the Denver urban corridor. This vision is embodied in the conceptual programming and architecture of the new building.

KEY POINTS OF IMPACT 2024:

Transform Engineering Education

Emphasis on Computing Technology

Interdisciplinary Design-Oriented Teaching and Learning

Dynamic Blend of Hands-On and Online Pedagogy

Emphasis on Cutting-Edge Technology

Advising and Collaborative Convergence Research with a Focus on Innovation, Entrepreneurship, and Broad Impact

"At the CU Denver College of Engineering, Design and Computing, we focus on providing our students with a comprehensive engineering education at the undergraduate, graduate, and professional level."

IMPACT 2024:

A NEW MODEL OF ENGINEERING EDUCATION

A NEW GENERATION OF ENGINEERS

IMPLEMENTATION OF IMPACT 2024:

Student Success Record
1,740 enrollment in Fall 2020 – 35% increase since 2017, 17% increase in diversity – through new industry-responsive degree programs and pre-engineering retention program; Engineering Learning Community launched with NSF funding

Curriculum Modernization
Electrical Engineering curriculum and pedagogy redesign; Computer Science curriculum redesign; four new minors and two new certifcates

Computer Science + X
114 students in new CS+X program that connects CS to (X) disciplines across campus (anchored by new BA in CS degree); 36 CS+X major and minor choices across CU Denver

Design and Computing Integration
Flagship frst-year courses in Design and Computing; restructured Capstone Design Program; signifcantly upgraded Edtech and online pedagogy and capabilities across college

Transformational Partnerships
Trimble Technology Lab at CU Denver launched with generous gift from Trimble; Additive Manufacturing (3D Printing) lab launched with generous support from Lockheed Martin

Construction is Booming
Appointed Caroline Clevenger as Director of Construction Engineering and Management; launched BS degrees in Construction Mgmt/ Construction Engineering (Fall 2020); partnership with VERTEX and CU Denver Business School for online graduate programs

Skyrocketing Research
New research awards exceed $25M for 2020; >100% growth since 2017; launched Center for Inclusive Design and Engineering (Cathy Bodine, Director)

Re-brand as College of Engineering, Design and Computing (CEDC)
Launched in 2019

Leadership Recruits
Kris Wood (design), Keith Neeves (bioengineering), and Doug Sicker (computer science) join CEDC

Strengthen and Diversify Faculty
18 outstanding new faculty since 2018; increased overall faculty diversity (gender + racial) by 40%; cluster hire for new faculty in health systems and technology across Bioengineering, Mechanical Engineering, and Computer Science

Innovation and Entrepreneurship
Comcast Center for Media and Technology launched Design Horizons entrepreneurship program with College of Arts and Media and Jake Jabs Center, 24 students in frst cohort; integrated Inworks Innovation Initiative into college; strongest year ever for college startup companies

Earn-Learn Apprenticeship Program
New model for students to work on campus in jobs aligned with professional aspirations

Bioengineering Expansion at CU Anschutz
20,000 sf in new Biosciences 3 building (Fall 2020) to expand research and innovation in medical technologies; new Masters in Biomedical Device Design and Entrepreneurship

Relation to Strategic Plan

"By 2020, CU Denver will be a leading public university with a global reputation for improving the quality of life through excellence in learning, research and creativity, community engagement, and clinical care."

—2008–2020 Strategic Plan

The new CEDC project supports and advances goals and objectives from the Strategic Plan 2008-2020. The goal and objective numbers are taken directly from the strategic plan document and includes an explanation on how the CEDC project supports the goal.

Goal 1.1—Develop, strengthen, and sustain interdisciplinary and dual degree programs that maximize the strengths and bridge the disciplines of the Downtown and Anschutz campuses.

Objective 1.1.1—Develop, strengthen, and sustain new interdisciplinary academic degree programs at the undergraduate, graduate, and professional levels (including joint degrees) that are collaborative and connect the disciplines within and across the campuses.

Objective 1.1.2—Establish mechanisms to plan, pilot, and sustain joint interdisciplinary academic programs.

The new CEDC building will create a cross-college "Academy" to foster interdisciplinary design and computing innovation in education and research across the College. The new CEDC building is positioned to connect efforts across our campuses and facilitate external partnerships; with Inworks and the Comcast Center. The new building will also connect with the Anschutz Medical Campus programmatically by providing space for bioengineering and digitally to enable health technology and systems.

Goal 1.2—Strengthen and sustain existing and develop selected new areas of interdisciplinary research and/or creative work involving faculty across the schools and colleges of both campuses.

Objective 1.2.1—Develop criteria and processes to identify new research areas for investment.

Objective 1.2.2—Provide funding and other resources to support and develop areas of interdisciplinary research and/or creative work.

The new CEDC building will support the College's mission to build a culture of innovation, collaboration, and lifelong learning across the college, empowering students, faculty, and staff to be entrepreneurial. Makerspaces, interdisciplinary research labs, and student space will foster social and professional communities.

Goal 2.1—Deliver superior educational programs on multiple campuses and academic centers across the state, nation, and around the world.

Objective 2.1.4—Build capacity and increase delivery of educational programs aimed at lifelong learners, including returning students seeking degree completion, those seeking continuing and professional education, and those seeking to expand knowledge avocationally.

The conceptual programming of the new CEDC building is dictated by a balance of factors, including the CEDC education and research vision, growth potential, and distinctiveness. This program provides vacated space in other CU assets and the consolidation of spaces for a higher level of utilization and expansion for CU.

Goal 2.9—Broaden the educational experience for students to improve student success.

Objective 2.9.2—Create additional experiential learning opportunities for students.

The new CEDC building will integrate and amplify student success programs by strengthening and expanding teaching capabilities and capacity. The new building will allow the integration of design and computing throughout, connecting concepts, disciplines, and people through hands-on interdisciplinary experiences in authentic contexts in and out of the classroom. The design and programmatic layout will endow every student with exceptional human and social skills and experience, applying cutting-edge technology to enable value-creating solutions.

Goal 3.1—Be a global leader in the translation and application of discovery, innovation, and creativity for societal good.

Objective 3.1.1—Initiate and support community-based research and creative work that leads to the sharing and application of knowledge.

Objective 3.1.3—Fully invest in the signature areas identified for the Downtown Campus, including education research and policy and sustainability.

The new CEDC building will provide state-of-the-art spaces that are flexible, resilient, and generated with elements of the global leading edge. Engineering will be on display, whether that be through glass walls at research labs or through the exposing of building systems—both resulting in excitement for the new vision of the College.

Goal 3.6—Provide superior core research facilities to enhance the discovery, innovation, and creative activities of the university.

Objective 3.6.1—Build and sustain superior core research facilities and infrastructure.

Objective 3.6.2—Continually assess program needs and utilization to determine priorities for ongoing investment in core facilities.

Objective 3.6.3—Create and sustain research computing facilities that meet investigators' needs.

CEDC is redesigning engineering education to create agile and versatile engineers of the future with computation at the core. The program of the new building reflects the diversity of research, teaching, and social experiences the College is expecting for its students.

Goal 6.1—Promote partnerships and active engagement with business, industry, nonprofits, government, schools, and venture capitalists to optimize intellectual and cultural capital for societal use.

Objective 6.1.1—Leverage the capabilities of our centers and institutes to advance partnerships, engage venture capitalists, and provide incubators for businesses.

The visibility of the new CEDC building will offer excitement and opportunities for industries to get involved, or expand their involvement, with the College. There is an opportunity to co-create spaces with partners and deliver a customized solution to engagement.

Goal 7.2—Invest in providing the infrastructure (services and facilities) necessary for a world-class learning and discovery environment for the benefit of our students, faculty, staff, and communities.

Objective 7.2.1—Be recognized as an employer of choice through innovative employee-sensitive policies and practices to maximize productivity and competitiveness.

Objective 7.2.2—Implement the CU Denver facilities capital plan to provide cost-effective, adaptable, maintainable, sustainable, and accessible facilities.

Objective 7.2.3—Address all elements of the student experience at the university to improve the recruitment, graduation, and establishment of lasting connections to the university.

Objective 7.2.6—Facilitate interaction and collaboration solutions across various locations so that geographical separation is not a barrier.

Objective 7.2.8—Create a safe campus environment through implementing effective safety measures and campus safety training and technology.

The new CEDC building will unite disciplines that are currently spread across six buildings and establish a strong presence along a much-traveled urban corridor, better connecting the campus with the City. Flexible classrooms, labs, and collaboration space will support the continual adaptation and value-creating services that respond to the demands of the world, as it moves at an unprecedented scale and pace due to technology, globalization, and demographics.

Future of Engineering & Facilities

The College of Engineering, Design and Computing has adopted IMPACT 2024, which plans out the next phase of Engineering at CU Denver. The plan builds on the advances the College has made over the last decade and sets goals for the next five years. The plan recognizes the world is changing more rapidly than any time in history and that engineers of the future will have to respond to that change—it is the College's responsibility to prepare their students for that future.

Engineering Education

CU Denver's College of Engineering, Design and Computing is redesigning engineering education to create the agile and versatile engineers of the future. Through our pioneering curriculum and convergence research approach, we promote an inclusive culture of inquiry and innovation focused on making a broad impact with all we do.

We integrate the cutting edge of computing technology and design innovation across disciplines, blending this with authentic experiences that develop human and social skills, such as creativity, collaboration, entrepreneurship, and leadership. We embrace and leverage our setting, across urban and medical campuses, to enable social and economic growth of the Denver urban corridor through holistic public and private sector partnerships; we aspire to emerge as its technological innovation engine and significantly impact Colorado and the world.

Engineers of the Future

Engineers must be prepared to meet the rapidly evolving demands of the profession as well as new obligations and opportunities in our increasingly technology-based society. These skills will include:

- Deep and modern technical knowledge and capabilities
- Proficiency in contemporary design, systems, and computing-enabled technology to produce innovative, value-creating solutions that improve people and society
- Exceptional socio-emotional and entrepreneurial skills—critical thinking, creativity, teamwork, leadership, engagement with diversity, and the ability to continually reskill and learn throughout their lives

Engineering Education Must Be Different

Global leaders agree that engineering education must change significantly to deliver future engineers. Engineering Education must include:

- Integrative, active and authentic learning experiences that are interdisciplinary, global, societally-focused, and constantly refreshed
- Mass customized offerings that are increased in flexibility, choices, and diversification while exploiting technology
- Agile and responsive curricula underpinned by new value propositions and business models
- Increased emphasis on social skills and attitudes
- Highly connected research innovation enterprise that leverages and strengthens educational goals and approaches
- Strong alignment of goals between government, industry and academia, especially those that impact "place"

Students of the Future, City of the Future

CU Denver students are diverse urban learners and driven, purposeful doers. The student body will include:

- Widely varying demographics—socioeconomic, age, race, ethnicity, language, first-generational student status, commuter/resident—contributing wide-ranging and meaningful experiences
- Experientially motivated—seeking more from their education, e.g., purposeful opportunities aligned with career ambitions to increase relevance of education and meet fiscal challenges
- Drawn to Denver—seeking the vibrancy of city life with its economic and social opportunities and the development of professional networks

65% of children entering primary school today will end up working in jobs that currently don't exist.[1]

35% of today's core skills will change in next five years—increasing the need for creativity, emotional intelligence, and cognitive flexibility.[2]

Rapidly developing technological solutions require cross-functional collaboration and high-performance teams.

70% of the World's Population will live in Cities by 2050.

1. Dell Technologies, 2017
2. "The Future of Jobs - Employment, Skills, and workforce Strategy for the Fourth Industrial Revolution", World Economic Forum, 2016

Statement of Need and Benefit

The new CEDC building will be a single project, creating an Engineering Hub that promotes design-oriented engineering education that emphasizes deep computing and systems thinking, interdisciplinary and 21st Century skills at CU Denver

New Building Benefits

CONSOLIDATION

Consolidates CEDC downtown activity into two adjacent buildings; facilitated by additional internal moves

PROXIMITY

Close proximity to other CU Denver colleges and schools

VACATE

Vacates space in LSC, CU Building, and 5th Street Hub for growth of other CU Denver programs

CAMPUS GATEWAY

Enables campus gateway on Speer and Larimer; attractive location for fundraising

ENROLLMENT GROWTH

Allows enrollment growth of ~550 students from 1,618 currently (which is a 25% increase since 2018)

ENERGIZES

Energizes CU Denver and CEDC and rapidly supports realization of strategic plan for new engineering education for our diverse student body

Impact on Occupations with the Highest Projected Openings: In-Demand Engineering Jobs

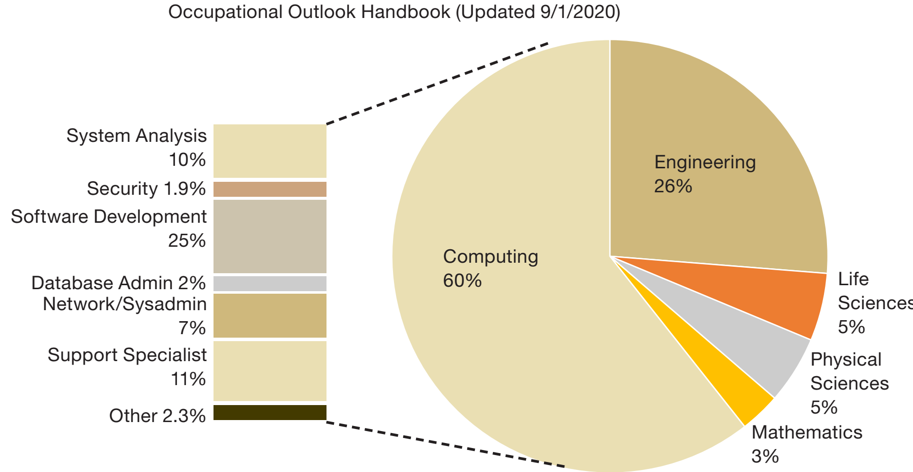
The Colorado Department of Higher Education (CDHE) 2016 Skills for Jobs Act listing of bachelor and graduate degree level jobs in Colorado identified 15 engineering and applied sciences occupations in the top 50, with three in the top 12.

The US Department of Labor Bureau of Labor Statistics ranked Bioengineering and Computer Science + Engineering related occupations among the top 50 fastest growing in the United States, with four of the Top Six In-Demand Engineering Jobs offered by CEDC. CU Denver hosts the only Bioengineering program in Colorado.

In-Demand Engineering, Computer and Information Technology Jobs

	Job Growth Between 2019 and 2029	2019 Median Pay
Biomedical Engineering	5%	$91,410
Computer Hardware Engineering	2%	$117,220
Civil Engineering	2%	$87,060
Mechanical Engineering	4%	$88,430
Software Developers	22%	$107,510

Based on data from Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (Updated 9/1/2020)



US-BLS Total U.S. STEM Jobs through 2022 by STEM %. Based on data from U.S. Bureau of Labor Statistics Employment Projections, 2012-2022

Alignment with Colorado Rises Master Plan

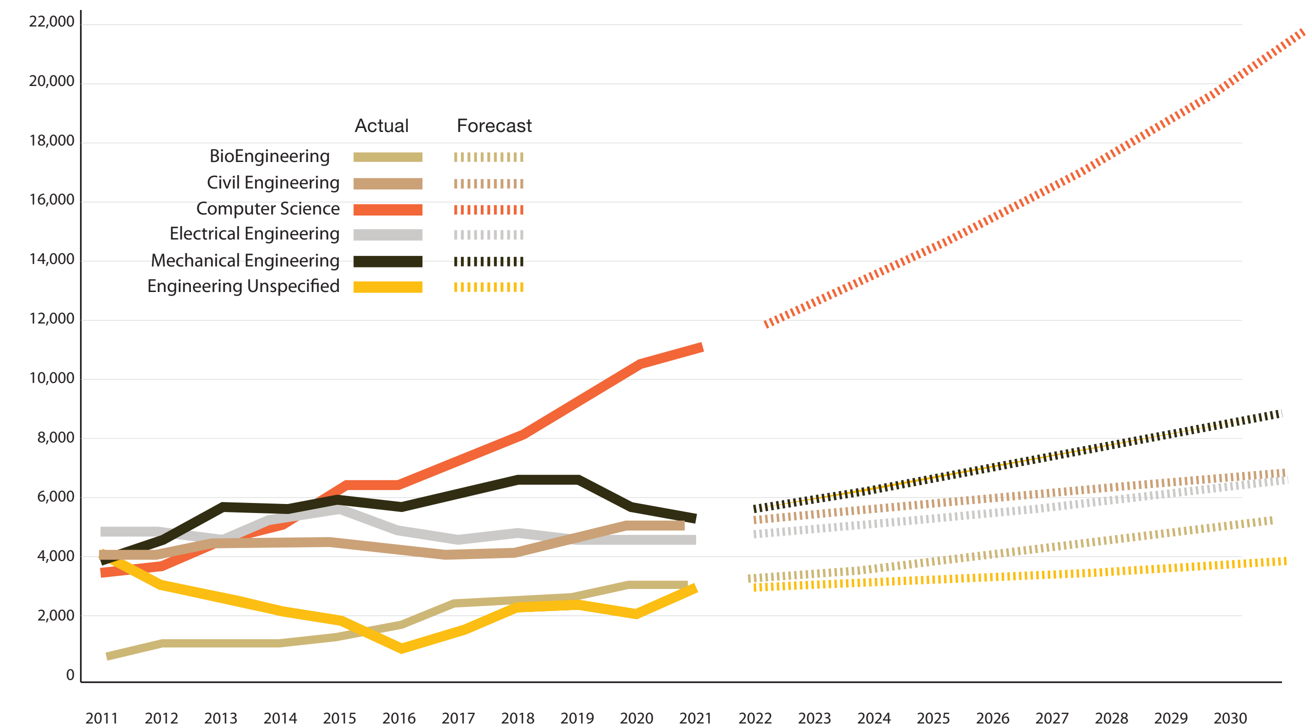
CU Denver has made significant strides to mitigate affordability and equity gaps for students. CU Denver's commitment to, and history of, serving diverse populations will help CU and the State reach their equity attainment goals. A new CEDC facility will increase credential attainment in "top jobs", as described in the CCHE Colorado Rises master plan.

Strategic Goal 1 and 3 of Colorado Rises urges institutions to focus on student outcomes, support, enrollment in STEM and increased persistence and retention.

By providing a modern, well equipped, and agile learning space for the College of Engineering, Design, and Computing, the program will attract and retain top tier faculty and researchers that represent innovative and interdisciplinary thinking.

A contemporary facility will inspire elevated curricula and innovative pedagogy which will attract and retain students.

The new CEDC facility will push the future of engineering and provide engaging opportunities to increase credentials for in-demand STEM education through amenities, cross-college engagement, and an increase in industry partnership.



CEDC Actual and Goal Enrollment History by Department.
UCD OIRE, February 17, 2021.
NOTES: Based on census of each term. Fiscal year is defined as summer, fall, spring with the year displayed being that of spring term.
CAVEATES: State reportable enrollment and credit hours only. Prior to fall 2020 construction management was a track under civil engineering.

Space Needs Alleviation Justification: Classroom and Class Laboratory Utilization

	Number of Rooms	Median ASF	Median Room Capacity	Median ASF per Station	Median Enrollment (Class Size)	Median Weekly Student Contact Hours	Median Weekly Hours Scheduled	Median Percent Occupancy
Classroom	52	970	40	24	26	997	36	67%
Lab / Studio	13	1,049	30	30	20	379	18	72%

NOTES:
From Fall 2018 classroom utilization study for CU Regents.
Includes rooms with any Engineering usage. Utilization includes all courses scheduled in those rooms.
Weekly measures are from the busiest week for each room.

Section

03 Project Description

This project will re-imagine the physical space for CU Denver's College of Engineering, Design and Computing. It will support an educational mission centered on a strong design sense, powerful computing skills, and a larger connection to changing global, economic, and societal needs.

Site — Surrounding relationships, neighbors, and future developments. 1. Nexus, Sliver and Firestation Site Development 2. Larimer Square Redevelopment 3. River Mile Development 4. Sun Valley Eco District Development 5. Denver Performing Arts Center Expansion 6. Pepsi Center Development

Site Selection & Master Plan Consistency

The site proposed for the engineering building, which sits at the intersection of Speer Boulevard and Larimer Street, was identified as a "future construction opportunity" site in the CU Denver 2017 Facilities Master Plan. The site would allow the CEDC project to act as a bookend to the Student Commons building and further define the Larimer Street gateway into the CU Neighborhood. The site also serves as a vibrant urban connector and a pedestrian landing zone for those arriving from LoDo and the Central Business District. Speer Boulevard will generate excitement for the CEDC by embracing the ethos of putting science on display. In return, the CEDC project has the potential to shift Speer Boulevard from a "parkway" to a City Street with enhanced pedestrian connections to downtown.

The site also offers proximity to North Classroom, which is critical because the new building will not accommodate the relocation of all of the CEDC departmental spaces. Some well-established and specialized laboratories will remain in North Classroom. Relocating these recently renovated spaces would significantly burden the project budget. The close proximity and physical connections to North Classroom will provide efficiency and interdisciplinary opportunities for faculty and staff.

Site from Speer Boulevard and Larimer Street

Site from Speer Boulevard and Lawrence Street

Site Highlights

NEIGHBORHOOD ENTRY GATEWAY

This site is the front door to the CU Neighborhood from the Central Business District.

CONNECTION TO DOWNTOWN

On Speer Boulevard and Larimer Street, the site reaches out to the urban fabric to the east. There is potential to respond and integrate future development into the programming and concept of the CEDC project.

PROXIMITY TO NORTH CLASSROOM

A majority of Engineering classes are held in North Classroom. Locating the new CEDC building to the east creates an efficient walking connection for faculty and students.

Site Challenges

EXISTING STORM WATER DETENTION

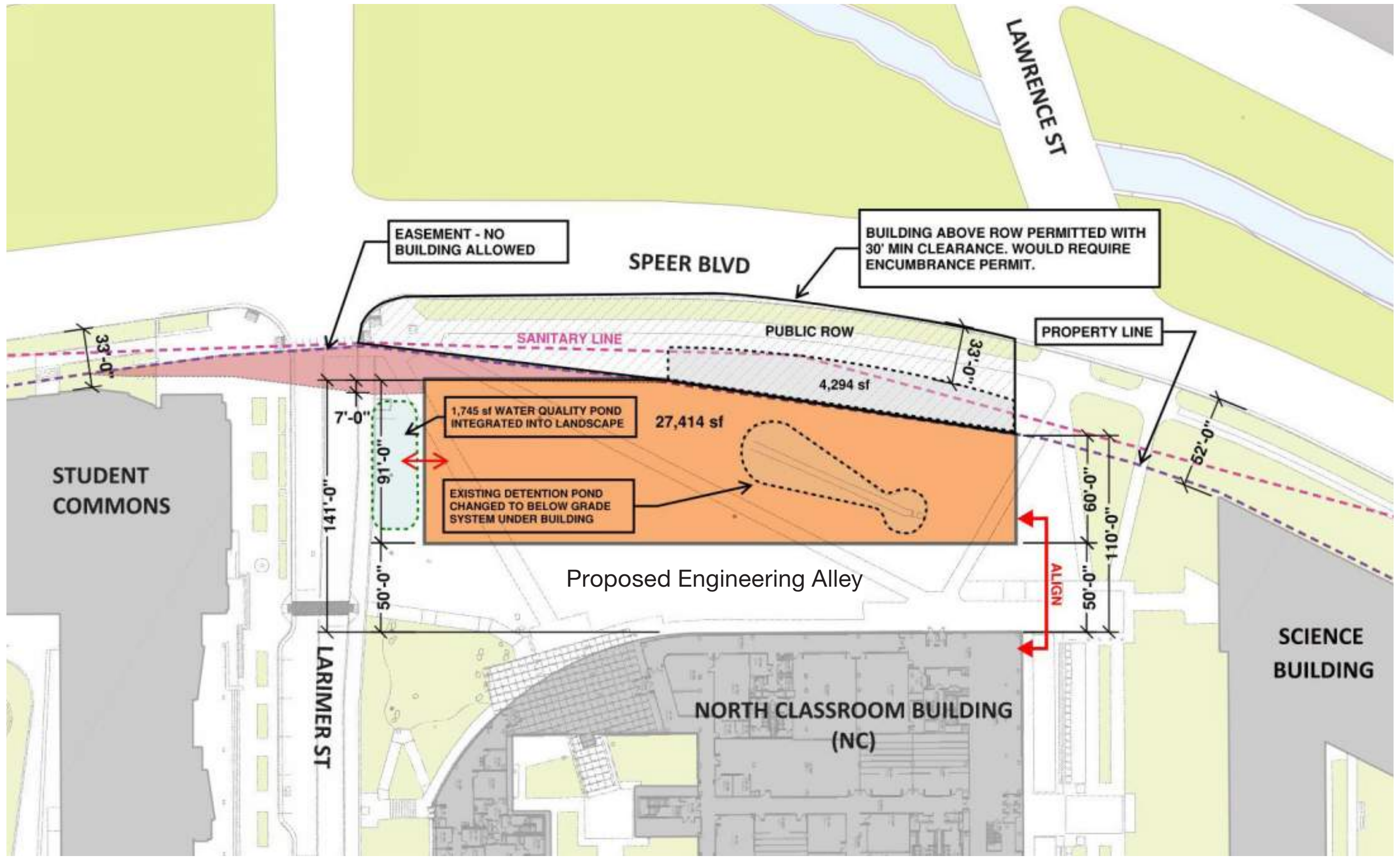
There is currently a storm water detenion pond occupying 0.25 acres of the site. A new strategy will need to be implemented to make up for displacing the existing pond. The proposed budget includes this scope of work.

LIMITED VEHICLE ACCESS

The only existing vehicle access to the site is from Larimer Street. Given the program desires for the main entrance to face Larimer Street, vehicle access will be complicated. The proposed site design offers several potential solutions to this challenge.

RIGHT OF WAY

There is currently a large right-of-way (ROW) bordering Speer Boulevard on the east side of the site. This ROW has pinched the buildable area of the site. The proposed building footprint and massing has taken this into consideration and a potential solution will be further developed during the next phase of design.



Site Boundaries

Site Conditions

Although the site provides opportunities relative to interconnection, gateway, and interdisciplinary collaboration, the site has several constraints. These include a storm water detention pond, limited vehicular access, a significant easement, and a right-of-way (ROW) that includes a 54” sanitary line running along the edge of Speer Boulevard. All of these factors have impacted the buildable area of the site and the resulting conceptual massing.

Easements and Right-of-Way

Along the southbound lanes of Speer Boulevard, there is a ROW extending approximately 52’ from the curb into the site. Within the ROW, there is a 54” sanitary pipe.

At the corner of Speer Boulevard and Larimer Street, there is an easement that extends into the north-east area of the site. The project cannot encroach into this easement. An encumberance permit would be required to build within the ROW, and the design of the building would need to provide vertical and horizontal clearance above the sanitary line.

Stormwater Detention

There is an existing stormwater pond, referred to as Pond 2 in the construction documents for the Science Building, that has a capacity of 10,562 cubic feet. Pond 2 provides both detention and water quality for a portion of the the Science Building site.

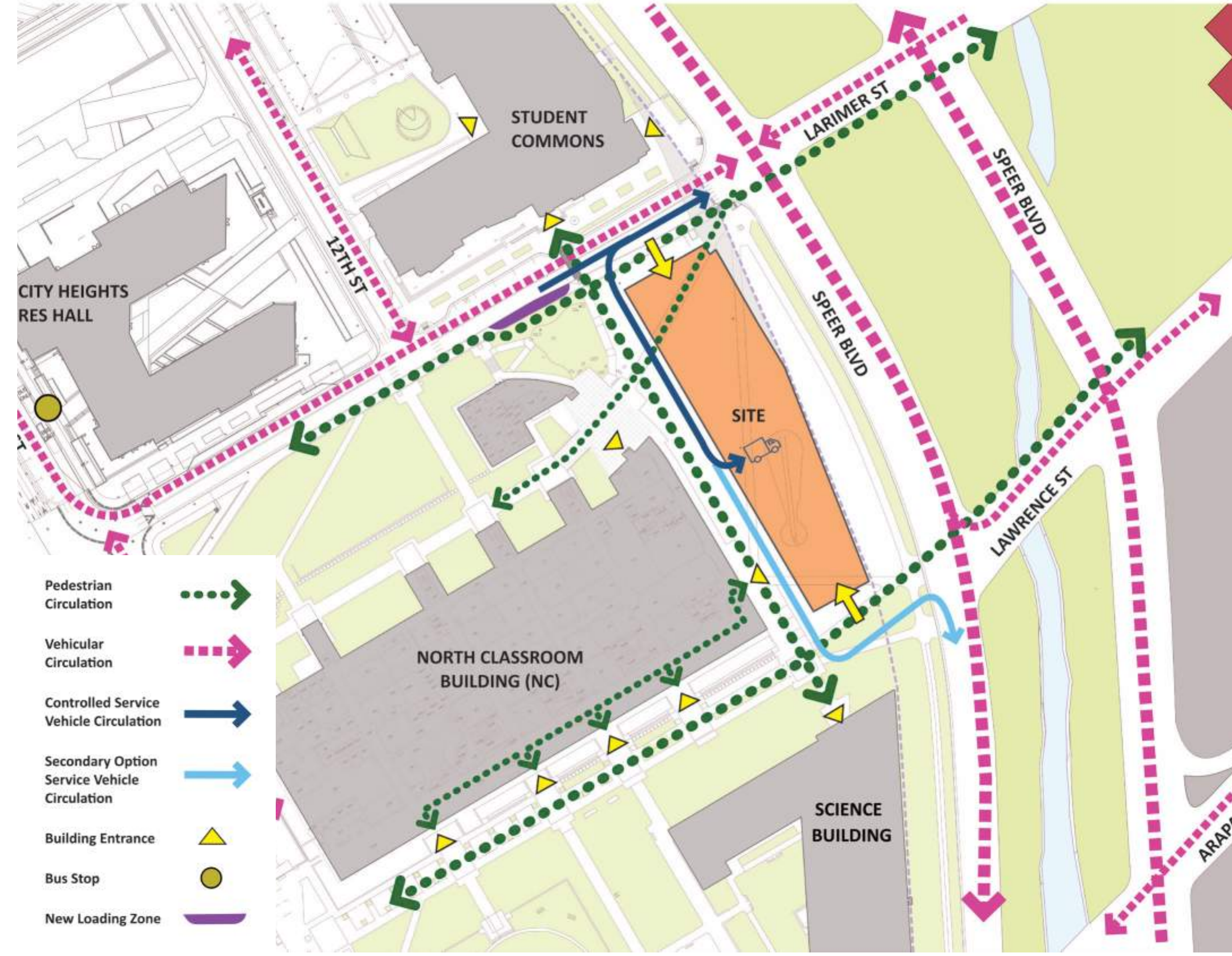
In order to accommodate a building on the site, it is recommended that an underground detention system and a surface water quality feature will be designed. These features accommodate flows from the proposed site as well as the areas tributary to the existing Pond B.

The underground detention system will accommodate approximately 0.36 acre-feet and the above water quality system will accommodate approximately 0.06 acre-feet. It is important to note that the water quality feature has been sized as a rain garden within the plaza and shall remain at a maximum depth of 18”, resulting in a footprint of 1,745 SF.

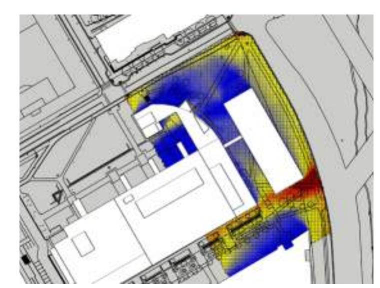
Engineering “Alley”

The space between North Classroom and the new building is critical to the success of this project as it will provide outdoor project space, social space, while creating an iconic urban design feature for the CU Denver campus.

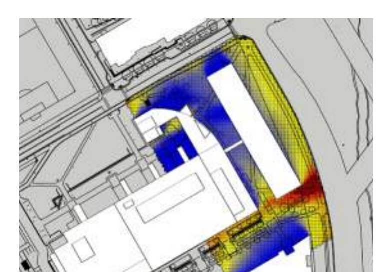
Several scenarios were explored to determine how close the new building could be to North Classroom while still providing ample solar exposure in the winter and an openness that fit the scale of the two buildings. Based on this study, it was determined that a 50’ setback from North Classroom provides



Site Circulation Study



Solar Study – Five-story building on Winter Solstice



Solar Study — Four-story building on Winter Solstice

the desired environment, while allowing for floorplate sizes that accommodated a lab module.

Pedestrian Flows

The site acts as a pedestrian connector between Student Commons, North Classroom, and the Science Building in addition to the pedestrian connection to LoDo and the Central Business District at both Larimer Street and Lawrence Street. The site and building will respond to all of these flows—creating enjoyable outdoor space, maintaining safety, and strengthening pedestrian connections with LoDo and the Central Business District.

The pedestrian flows on the site reinforces the importance of treating the Larimer Street and Lawrence Street sides of the building with equal consideration as both are significant to the pedestrian environment on campus and the City.

Vehicular Flows

Currently, there are no curb cuts onto the site nor are there nearby loading zones servicing the surrounding buildings that could be used by occupants of the new building. Based on the proposed program, delivery of materials to the building will be required. In addition, maintenance and service vehicles will need access to the building. Ideally, trash collection would occur at the Larimer Street curb in a manner similiar to Student Commons and Student Wellness.

Given the limited vehicle access to the site, the project will utilize the pedestrian alley between North Classroom and the building to provide delivery and maintenance access. That access could take the form of a dead end vehicular alley with a turnaround or a loop access road with a curb cut on Speer for right turn only. Various options will be analyzed further during the next phase of design.

Neighborhood & Downtown Connections

The University of Colorado Denver is Colorado's only public urban university. In the heart of one of America's fastest growing cities, it connects students with internships, jobs, and a thriving cultural scene.

The CEDC Project is in a key location on campus—directly adjacent to and visible from highly used street; highly visible from one of the primary approaches to the campus along Speer Boulevard; in proximity to multiple development opportunities between campus and downtown. The site has the potential to be both a gateway and a bridge to the CU Denver campus.

Neighborhood Connectivity

At the corner of Speer Boulevard and Larimer Street, the site welcomes pedestrians, bikes, and vehicles into the campus, while also closing the distance between the CU buildings across Speer Boulevard. The site acts as a crossroads between Student Commons, North Classroom, and the Science Building, connecting major circulation paths running between the three buildings.

Currently, the western edge of Speer Boulevard is lined by building facades, until you get to Larimer Street, where the site is located. The site-edge challenges the urban edge as a threshold—a welcoming gateway, while responding to the surrounding context.

Downtown Connection

The 2007 update to the Auraria Master Plan shifted the direction for the campus to prioritize continuity with the surrounding areas. It was no longer intended to be an isolated campus, but instead to create linkages to the adjoining neighborhoods. This is particularly true for LoDo and the Central Business District.

The CEDC site is the closest Auraria site to the CU facilities that are located across Speer Boulevard. For years, there has been talk about creating a physical connection between the Auraria Campus and the Central Business District to avoid pedestrian and vehicle interaction. This site has the potential to be a part of that connection by providing a landing, or a physical link to the building, that would allow pedestrian access to interact with Engineering on Display.

The CEDC site spans two major pedestrian paths, one at Larimer Street and one at Lawrence Street — both heavily trafficked with students commuting between Auraria and the Central Business District. The CEDC building's internal and external pedestrian flows will recognize these existing travel paths to ensure they remain efficient and safe, while using them to enhance student space throughout and around the building.

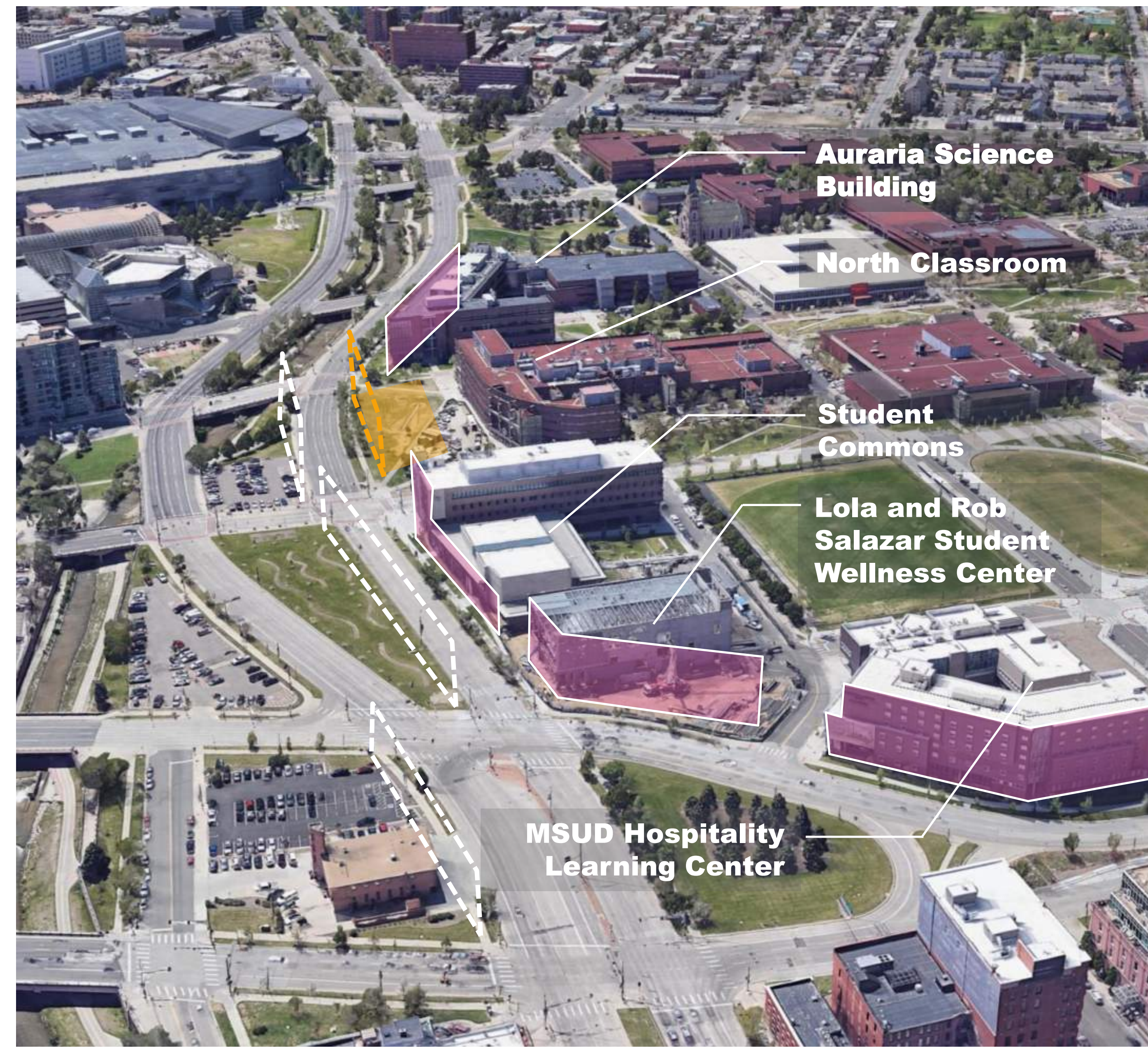
Connecting Park Space

The CEDC site offers the opportunity to provide a neighborhood gateway plaza to the north of the proposed building — one that welcomes guests onto campus, honors and celebrates North Classroom, and provide outdoor project space for CEDC.

The south side of the site has the responsibility to respond to the Lawrence Street Mall and continue the established pedestrian amenities and urban design language. With optimal daylight and southern exposure, this space can act as a continuation of the outdoor space at the south end of North Classroom.

The space between the new CEDC project and North Classroom (Engineering "Alley") will host performance events, include outdoor project space, and be a main pedestrian thoroughfare for the CU neighborhood. This space will be activated with a variety of outdoor environments, including seating, project work and storage, and vegetated areas—all with daylight and sun exposure being a consideration.

View from Larimer Square to new CEDC Building, new plaza, and North Classroom clock beyond



Aerial Image - Speer Boulevard Facades

Guiding Principles

FORWARD THINKING EXPRESSION

Represent CU Denver as an innovative model for public urban universities. Represent CEDC's vision of a state-of-the-art engineering hub.

ENHANCE THE GATEWAY

Acknowledge the campus and neighborhood gateway at Speer Boulevard and Larimer Street.

BEING A GOOD NEIGHBOR

Respond to the scale, materiality, and architectural aspects of the surrounding buildings and anticipate future development.

ENGINEERING ON DISPLAY

Create transparency into the building to showcase engineering activity. Expose and highlight building systems that can be used as a teaching tool.

RESPECT NORTH CLASSROOM

Acknowledge the existing conditions of North Classroom that could be affected by the new building and reduce the impact.

HIGH PERFORMANCE

Analyze and implement strategies that will reduce the environmental impact and increase the operational efficiency of the building.

Concept Design

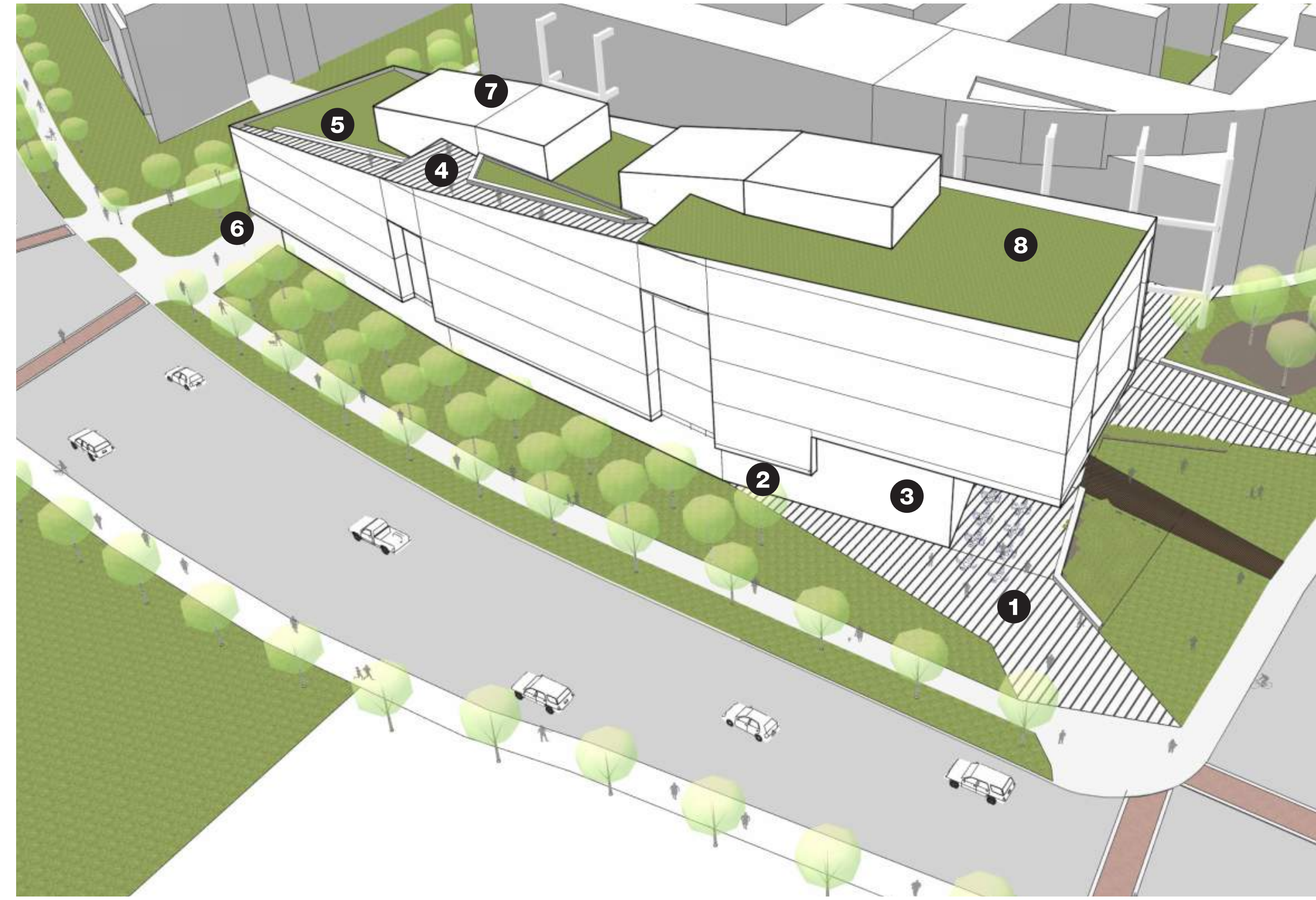
The University of Colorado Denver CEDC Project combines teaching, research, and clinical spaces to further expand and amplify the significance of the engineering profession across a broad range of applications.

The building will promote a highly collaborative model by creating a series of interconnected classroom and research spaces anchored by a centralized maker space.

The "Plaza" seeks to celebrate the act of making, in the engineering and design curriculum, by centralizing key spaces, where activity is on display, within the project's spatial organization. The project team has identified a range of "activation" program spaces that highlight, celebrate and enhance the vision of the CEDC. These spaces include: the computing space, capstone space, and first year design space. The key attributes applied to the development of those spaces are connectedness, openness, and flexibility.

This project will serve to consolidate the engineering programs on the CU Denver campus, strengthen the expression of the CU neighborhood architectural language, and enhance the importance of engineering and design by representing a rethinking of the goals and strategies of the engineering school in a rapidly changing technological world.

This building is imagined as a stepping building form that climbs from the Lawrence Street Mall up to a five story mass at the Larimer Street gateway. The steps of the mass would provide exterior terrace opportunities — one being associated with a large conference room, which would look down on a "project space terrace" where engineering and making will be on display. The building is complimentary of campus scale and space making strategies, and implies a visual and physical connection between LoDo and the Central Business District and the CU Denver neighborhood.



Legend

1	GATEWAY PLAZA
2	MAKER SPACE — ENGINEERING ON DISPLAY
3	VISIBILITY INTO BUILDING - ENGINEERING ON DISPLAY
4	ROOF TERRACE — SOCIAL
5	ROOF TERRACE — PROJECT SPACE
6	ENTRY AT LAWRENCE STREET
7	MECHANICAL SYSTEMS ON DISPLAY
8	GREEN ROOF

Program

The relative proportions of different space types and their physical arrangement has a significant impact on how a building is experienced and how it functions. In the case of the CEDC Project, this mix is critical to achieving the collaborative and interdisciplinary environment that is its mission. Structural bay dimensions were based on a 30' x 21' module. This module is sized for best practice and flexibility of labs and classrooms.

To develop and evaluate the program, space types were grouped into three overarching categories: "Flex Instructional Modules", "Meeting / Social" and "Office". Within the "flex instructional modules", there are accommodations for research labs, classroom labs, and classrooms. Within "meeting / social" there are collaboration spaces (formal and informal), conference, and seminar rooms.

The areas dedicated to each of these space types are a result of relocated CEDC space from other buildings, precedents from other engineering facilities, and growth factors. A 60% efficiency grossing factor was applied to the assignable square footages. This grossing factor is in line with similar facilities across the region and allows for the infrastructure and back of house spaces required for this building type.

As the project proceeds further into the design phases, the team will work with the CEDC to develop the concept program into a detailed program. For this effort, the space types allows for a cost / SF association.

Program	ASF
FLEX INSTRUCTIONAL MODULE	43,700
Research Labs	
Classroom Labs	
Classrooms	
MEETING / SOCIAL	7,000
Conference and Seminar Space	
Collaboration Space	
OFFICE	5,800
TOTAL ASF	**56,500**
TOTAL GSF (60% EFFICIENCY GROSSING FACTOR)	**94,200**

Circulation

Several internal circulation patterns were reviewed and the desire for lab flexibility, chance interactions, and program efficiency resulted in both double loaded corridors and concourse circulation. The concourse circulation allows for back-to-back labs which offers flexibility for future growth or configuration. The double loaded corridors provide opportunities for chance interactions between students leaving or walking to class and reduces the square footage associated with circulation.

The circulation on the west side of the building includes the Grand Stair. The Grand Stair connects the northern lobby to the bridge that connects with North Classroom. The stair is meant to be an active, transparent space that engages with engineering "alley" below.

Service & Loading

As described previously, the service and loading access to the site is a challenge. Conceptually, the service and loading entrance into the building has been located under the Grand Stair, near the north end of the building. This location provides access to a service elevator within the bank of building elevators and limits the vehicle traffic within engineering "alley".

Student Center

A student center has been located on level 2, at the intersection of the Grand Stair and the bridge to North Classroom. This area will include student lounge space, study space, and tutoring space. The activities combined with the central location, will create a vibrant space with a focus on meeting student's needs - a primary goal of the project.

Office Suite

Office location, size and configuration will be explored more in design but the current concept has offices grouped together on levels three and four. Grouping the offices together into an office suite will support interdisciplinary interactions and provide flexibility for future configurations. The suite can be located near one of the interior stairs which will act as an interconnecting stair between the two suites promoting additional interactions and flexibility.

Outdoor Terraces

The "Plaza" scheme includes two outdoor terraces that face south. Given the Colorado climate, the southern exposure will allow these terraces to be used year round. The upper terrace (Social Terrace) is adjacent to a meeting space which will allow the meeting and activities to spill out onto the terrace. The social Terrace overlooks the lower terrace (Project Terrace) that is adjacent to flexible instructional space. Student projects and work will take place out on this terrace while having a connection back to the instructional space. Both terraces will be a combination of hard surfaces, green roof and vegetation and exposed mechanical systems - all supporting engineering on display.

Legend

1	INFORMAL MEETING SPACE
2	GRAND STAIR
3	STUDENT CENTER
4	FLEX INSTRUCTION MODULES
5	OFFICE SUITE
6	PROJECT TERRACE
7	SOCIAL TERRACE
8	SERVICE / LOADING AREA
9	MULTIPURPOSE / EVENT SPACE

- FLEX INSTRUCTIONAL MODULES
- MEETING / SOCIAL SPACE
- OFFICE
- SUPPORT

Exterior Spaces

The exterior spaces complement the rich and vibrant interior space, while serving as an extension of the program and mission of the CEDC.

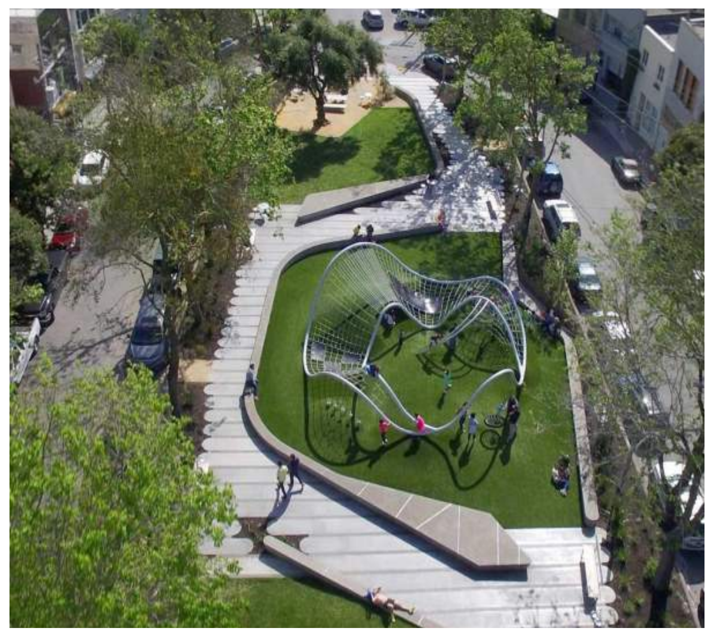
The gateway "welcome" plaza, located at the corner of Larimer Street and Speer Boulevard , provides identity and defines arrival—to the AHEC campus, the CU neighborhood, and the new CEDC building. This plaza will be critical in creating a first impression and giving visitors the first look at "engineering on display". Including a sculpture in this space will reinforce the significance of the gateway.

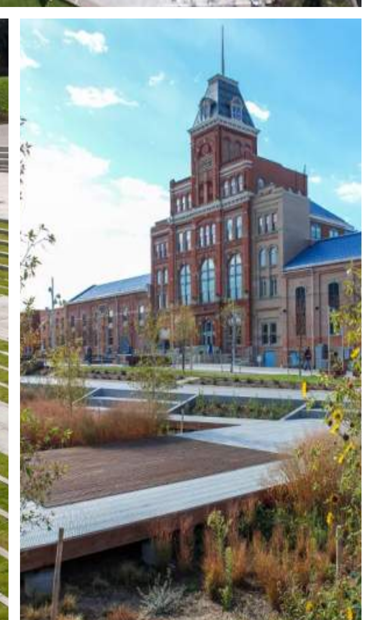
The plaza will lead into the engineering "Alley", which is the space between North Classroom and the new building. This space will act as a zipper between the new building and North Classroom by connecting engineering programs in both buildings, while enhancing a major campus circulation route. The space will be designed for walk-ability, service vehicles, and project space. The new building will include large overhead doors that will allow engineering to spill out into the alley. The University should consider renovating the ground floor circulation space, in the 1000 hallway of North Classroom, to compliment the ground level activation being provided by the new building. This scope is not included in the current renovation square footage in this program plan or the project budget.

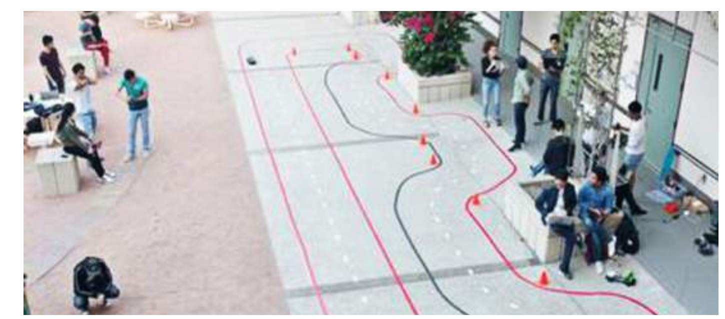
Engineering Alley will extend from the north of the building to the south, where it will tie into Lawrence Street Mall—a main pedestrian thoroughfare.

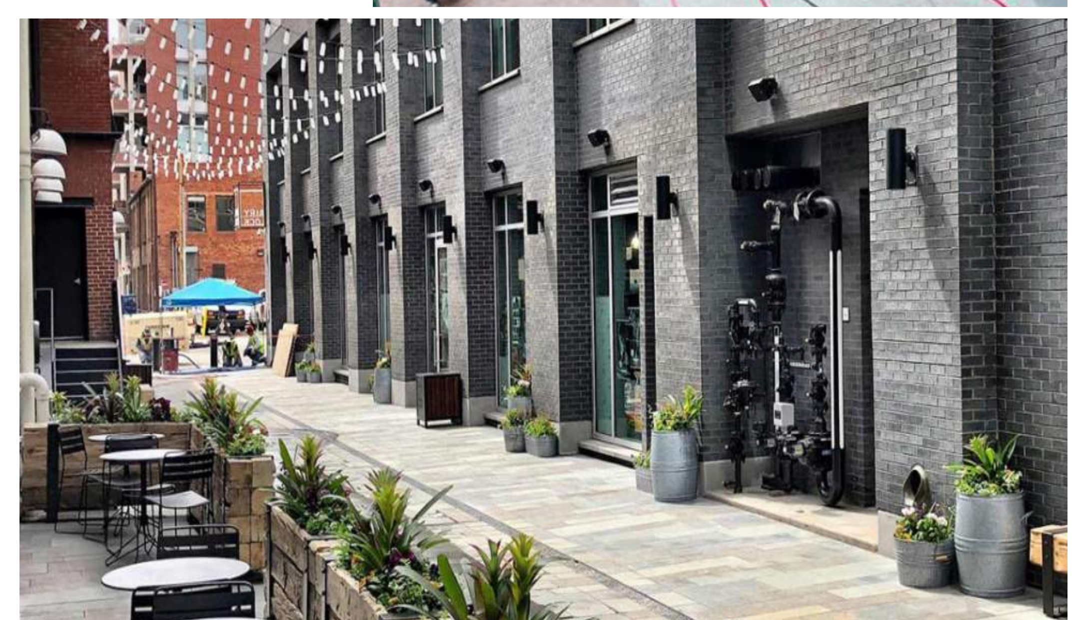
Both the Engineering Alley and the Gateway Plaza will incorporate aspects of water surface treatment to account for the existing detention pond, which this project will decommission. Those surface treatment zones can be in the form of landscaped or pervious paved areas. The project will require approximately 1,700 SF of treatment area.

The new building features two rooftop terraces. Both terraces face south for maximum sun exposure in the winter, which will allow the space to be utilized year-round. The lower terrace is seen as a project space, with the upper terrace being a social space that looks down on the project space and takes advantage of the downtown views.









High Performance

The CEDC Project aspires to be not only a model for innovative research, teaching, and learning, but also an instructional example of cutting-edge building performance and sustainability. These goals are especially relevant given that building systems are a key curricular component at the CEDC. In a building supporting engineering education, some consideration should be given to exposing the mechanical systems that would typically be concealed.

Programming discussions and preliminary analysis of the anticipated spaces has identified a range of opportunities (further discussed below). Implementation of these goals will be explored in more detail in the next phase of design and reconciled with the overall project costs.

Factor 10 Engineering

In a high-performance integrated design, enhancing one building component or element should result in improvements to 10 other components. For example, enhancing the building envelope should result in needing little to no mechanical system, which results in improved indoor environment quality, ultimately resulting in higher productivity from the occupants. The design team will design the building and building systems while embracing this philosophy.

Electrification

In response to the Governor's Executive Order on Greening of State Government (D 2019 016), the project team studied the possibility of building electrification. Selecting building systems that rely on electricity rather than fossil fuels will increase electricity usage, but eliminate the use of on site fossil fuels such as natural gas. As the state power grid shifts away from the burning of fossil fuels to renewable sources, having an electrified building advances the sustainability goals of the university and the State of Colorado, which are supported by the electrical utility provider (XCEL). XCEL has a goal of providing 80% lower carbon emissions by 2030 and 100% carbon-free electricity by 2050. A life cycle cost analysis evaluating building electrification is provided after this section and in appendix A.

Renewable Energy

The orientation of the building on the site provides excellent exposure for the potential addition of photovoltaic panels. Photovoltaic panels are not included in the building budget, but could be installed on the roof or as canopies on the rooftop terraces. The amount of building energy that photovoltaic panels would offset and the potential ROI would be evaluated as the building design advances. If photovoltaics prove to be cost prohibitive, the building can be built with the necessary infrastructure as a minimal cost for future installation.

Transpired Walls

Given the orientation of the building and local climate, the new building could utilize a transpired wall to preheat the air entering the building. A transpired wall would be an integrated part of the building facade that passively heats the outdoor air to up to 40 degrees before it enters the building, significantly reducing the building heating load. A transpired wall is not broken out in the current budget, but can be integrated into the design for a nominal fee. The ROI and effects on energy reduction of a transpired wall would be analyzed before incorporating that into the building design.

Indoor Environment

Air quality strategies and healthy material selection are critical to the performance and health of the occupants. Given the current environment surrounding Covid-19 and respiratory diseases, various mechanical scenarios will need to be explored— will the desire for 100% outdoor air be requested at the cost of a larger energy load, or will a cascading air strategy provide the level of air quality that is desired? Materials will also play a large role in ensuring the health of the occupants. Ensuring that harmful chemicals and pollutant exposure is eliminated will optimize the health of the building occupants.

(Left) The J. Craig Venter Institute has two photovoltaic arrays comprising 26,124 SF of surface area that are predicted to exceed the building demand, pushing excess power generated back into the grid. These arrays are utilized as shading devices in most of the exterior spaces.

(Above) Rocky Mountain Institute Innovation Center utilized Factor 10 Engineering to further each sustainable strategy. The enhanced exterior envelope had a 4 year payback when considering it helped eliminate traditional mechanical systems and improved indoor environment quality resulting in increased productivity and engagement.

(Right) Montana State University, Norm Asbjornson Hall uses transpired walls to preheat outside air. Air passing through the transpired wall is preheated to 60 degrees in the middle of Montana's winter before entering the building. This effort is on track to save MSU millions of dollars in operating costs over the coming years.

View of CEDC building from Northbound Speer Boulevard

Building Electrification LCCA

As required by the Governor's Executive Order on Greening of State Government (D 2019 016), building electrification studies are included. The outcomes have been used to identify strong candidate projects for investment in electrification.

With the electric utility provider committed to zero carbon emissions for electricity generation by 2050 (1 – Xcel Energy), designing all electric buildings will reduce the University's carbon footprint as the utility grid's carbon impact improves. Program plans are the critical phase for major architectural massing decisions, HVAC system selection,and thermal utility analysis. All of these will shape the project's ability to meet carbon and sustainability goals.

The Life Cycle Cost Analysis (summarized in the adjacent charts and included in the Appendix) documents program plan life-cycle cost analysis for various building mechanical systems.

There are no campus thermal utilities for the proposed site, therefore all heating and cooling will be generated on site with either electricity or natural gas. Three all electrically sourced options with varying complexity were compared against a standard baseline option which includes gas and electric sources. Each option was analyzed over a 30-year life cycle. Quantitative values were considered for each option and included Rough Order of Magnitude (ROM) capital cost, operations cost, energy cost, water cost, total energy consumption, water consumption, and carbon emissions.

All electric laboratory designs are novel and there is not an abundance of historical cost data used for the life cycle analysis. As design progresses and more detailed cost estimates are available (using current labor rates, equipment costs, technology availability) , there is reason to believe that the cost between All-Electric Option 3 and the Baseline could be closer than the report predicts, and Option 3 would have a favorable life cycle cost.

The report recommends refining the Baseline and All-Electric Option 3 systems during Schematic Design to further detail initial costs and more accurately reflect the life cycle estimate.

Option	Description	Reason
Option 1: Base	• AHU DX cooling • VAV with HW reheat • Natural Gas Hot Water (condensing) Boilers • Code Heat Recovery (Wheel) 50% sensible and latent heat recovery effectiveness	Lowest Capital Cost
Option 2: Better	• AHU DX cooling • VAV with electric reheat • Code Heat Recovery (Wheel) 50% sensible and latent heat recovery effectiveness	Replace gas boilers with electric reheat. Lowest all-electric mechanical capital coStreet
Option 3: Better +	• AHU DX cooling with Direct Evaporative Cooling • VAV with HW reheat • Electric Heating (Air Source Heat Pump) • Maximized Heat Recovery (Wheel) 70% sensible and latent heat recovery effectiveness	Replace gas boilers with Electric Air-sourced Heat Pump. Load reduction on mechanical systems with improved heat recovery and reduced peak cooling demand with evaporative cooling. Improved electric heating efficiency over electric reheat.
Option 4: Best	• AHU/DOAS with Direct Evaporative Cooling (no hydronic coils) • Indirect Evaporative Cooling on Exhaust air before entering to the Wheel • VAV with HW reheat + chilled water (4-pipe) • Active Chilled Beams • Electric Heating/Cooling (Sewer Heat Pump) • Maximized Heat Recovery (Wheel) 75% sensible and 20% latent heat recovery effectiveness	Maximized load reducing techniques with indirect/direct evaporative cooling, improved heat recovery, and improved terminal unit design (4-pipe VAV/active chilled beams. Sewer-sourced Heat Pump provides all electric heating and cooling with improved efficiencies over air-sourced heat pump.

Costs	Opt 1: Base	Opt 2: Better	Opt 3: Better+	Opt 4: Best
Initial Capital Cost (Total Mechanical and Electrical Cost)	$16,821,000	$21,813,207	$21,299,159	$22,220,534
Total Energy Cost (Year 1)	$158,442	$196,113	$157,227	$126,094
Energy Savings Compared to Base Option Yyear 1)		-$37,671	$1,215	$32,348
Total Yearly Operation Costs (w/o Energy or Water)	$36,769	$35,846	$37,692	$36,769
Total Yearly Operations Cost Savings Compared to Baseline		$923	-$923	$0
Payback		Never	83 years	54 years
Direct & Indirect Carbon Emissions	**Opt 1: Base**	**Opt 2: Better**	**Opt 3: Better+**	**Opt 4: Best**
Carbon Emissions - Natural Gas (MTCE)	195	0	0	0
Carbon Emissions - Electricity (MTCE)	1,603	2,149	1,723	1,382
Total Carbon Emissions (MTCE)	1,798	2,149	1,723	1,382
Currently no Carbon tax in Colorado				

Financial Model & Assumptions

The total CEDC Project budget is $80,911,629. The initial concept level breakdown of project costs is below. The total project cost includes 5,000 SF of renovation in North Classroom to accommodate the Machine Shop being relocated from the 5th Street hub.

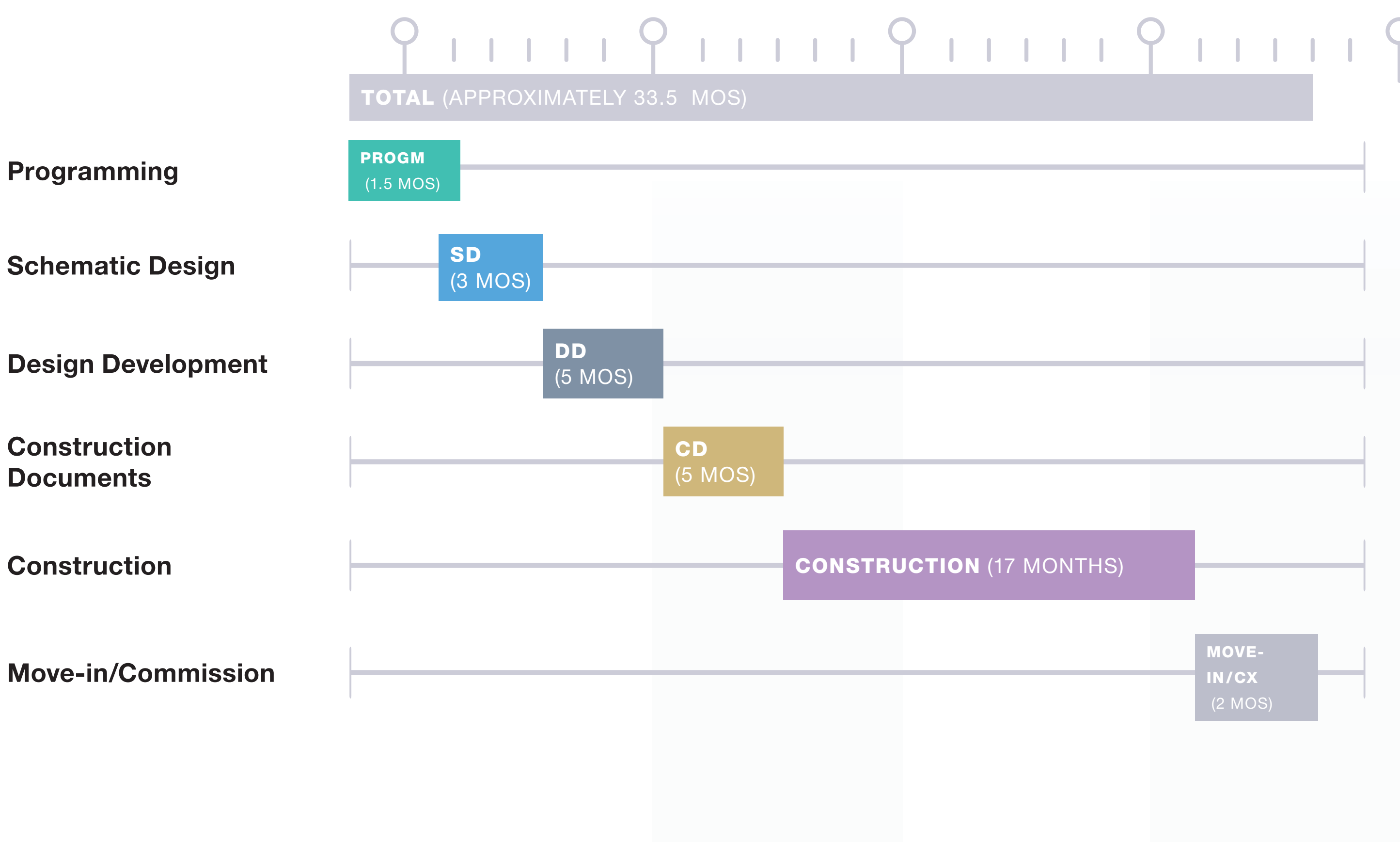
Project Cost		
A	Professional Services	$ 10,848,210
B	Construction - Building	$ 53,499,870
C	Equipment and Furnishings	$ 9,357,757
D	Miscellaneous	$ 1,499,787
E	Program Contingency	$ 4,572,005
	NEW BUILDING SUBTOTAL	**$79,777,629**
F	5,000 SF NC Renovation	$ 1,134,000
	PROJECT CONSTRUCTION BUDGET	**$ 80,911,629**

The construction cost for the CEDC project is $386/SF for classroom and office space and $632/SF for lab space. These costs are based on historical data from past projects on the Auraria Campus. Space types were then lumped into programmatic blocks to arrive at an estimated project cost. Further definition in the design phase will allow for more detailed cost reporting so that the project can be designed to and tracked against the budget. Some sustainability related design features, such as electrification, have the potential to push the project cost beyond the budget, but overall project goals, expected cost and budget will be further explored in the design phases.

View of south end of Engineering “Alley” and Lawrence Street Mall

Schedule

The below schedule is a preliminary schedule that will be reevaluated once Design begins, a delivery method is confirmed, and again when a contractor is added to the team. This schedule is based on similar projects within the region of a similar size and complexity.



04 Appendix

Electrification LCCA

1. Executive Summary

The new College of Engineering, Design, and Computing Project is envisioned to be five-story, 94,200 gross-square foot development to spur innovation in technology, manufacturing, and engineering, while providing opportunities for life-long learning and community connectivity through engineering on display and outdoor circulation zones. As required by the Governor's Executive Order on Greening of State Government (D 2019 016), building electrification studies are included to identify strong candidate projects for investment in electrification. With the electric utility provider committed to zero carbon emissions for electricity generation by 2050 (1 – Xcel Energy), designing all electric buildings will reduce the University's carbon footprint as the utility grid's carbon impact improves. Program plans are the critical phase for major architectural massing decisions, HVAC systems and thermal utility analysis which will shape the project's ability to meet carbon and sustainability goals.

This Life Cycle Cost Analysis documents program plan life-cycle cost analysis for various building mechanical systems. There are no campus thermal utilities for the proposed site, therefore all heating and cooling will be generated on site with either electricity or natural gas. Three all electrically sourced options with varying complexity were compared against a standard baseline option which includes gas and electric sources. Each option was analyzed over a 30-year life cycle. Quantitative values were considered for each option and included Rough Order of Magnitude (ROM) capital cost, operations cost, energy cost, water cost, total energy consumption, water consumption, and carbon emissions. First costs are estimated based on historical data, and it is assumed that the first cost for the electrification options are higher than the first cost for the baseline option due to the novelty of the design. As such, there is reason to believe that the cost between All-Electric Option 3 and the Baseline could be closer than the report predicts, and Option 3 would have a favorable life cycle cost.

The report recommends refining the Baseline and All-Electric Option 3 systems during Schematic Design to further detail first costs and more accurately reflect the life cycle estimate.

(1) https://www.xcelenergy.com/company/media_room/news_releases/xcel_energy_aims_for_zero-carbon_electricity_by_2050

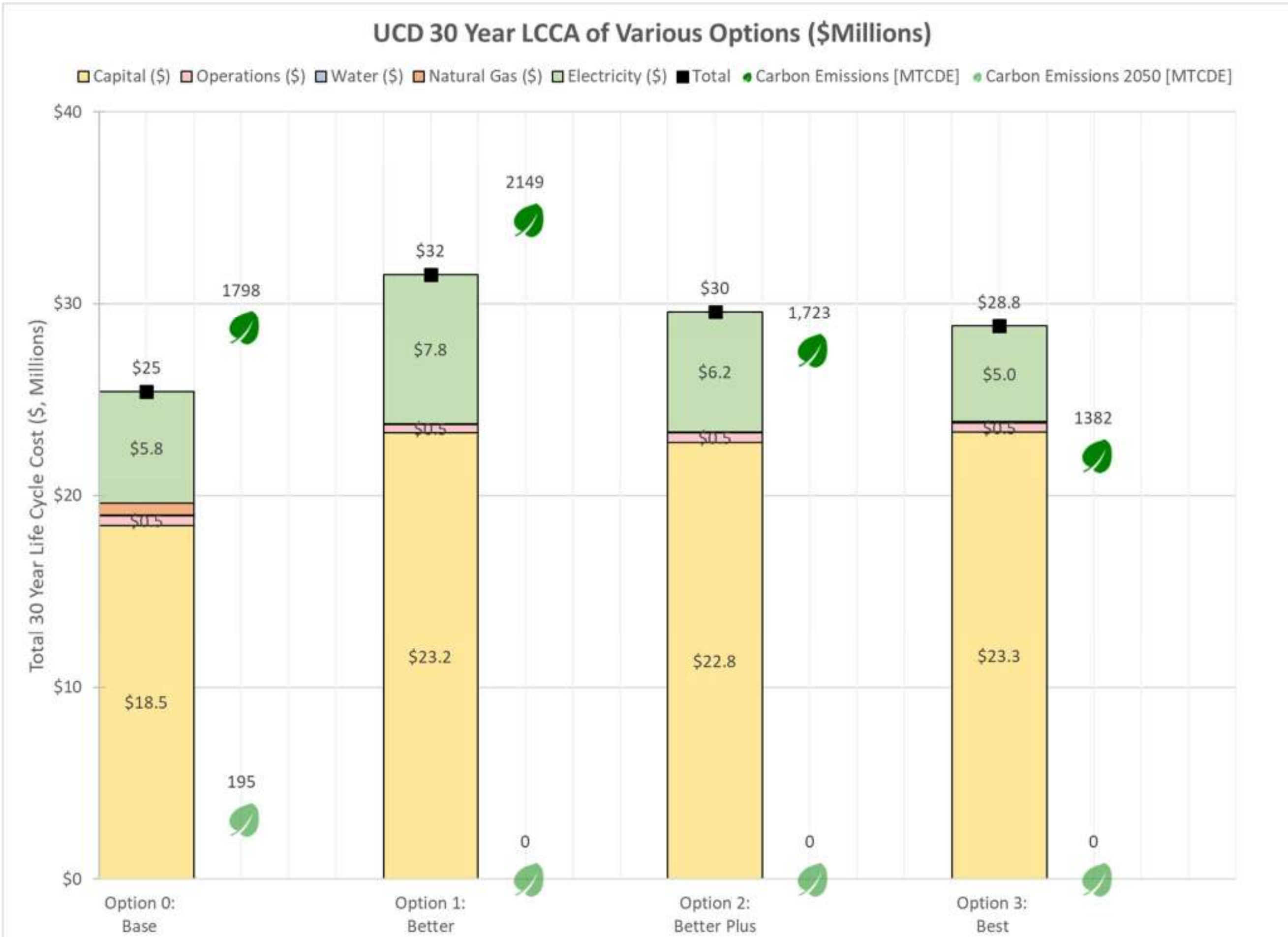


Figure 1– Summary of Life Cycle Cost Analysis
Note: metric ton carbon dioxide equivalent (MTCDE)

Based on the summary of the life cycle cost analysis shown above, AEI would recommend two options for further investigation to refine first costs and impact on a more detailed project program.

1. If a familiar system that uses best practices utilizing electric cooling/ventilation and natural gas heating is preferred, then Option 0 (baseline) should be pursued.
2. If carbon reduction/neutrality is a priority, then Option 3 (Best) should be pursued. The higher initial investment is not justified by life cycle cost savings by today's utility rates. AEI would recommend considering Option 3 based on university goals for carbon neutrality and future planning for an all-electric infrastructure. This option highlights:
   - Less energy consumption (EUI)
   - Zero on-site carbon emissions
   - Less grid carbon emissions dependent on electricity source
   - Longer equipment life
   - Future proof for State electrification requirements

   In addition, unique features of this option can provide educational opportunities to future engineers.

Certain benchmarked assumptions are made in the analysis which could significantly impact the results such as the escalation rate of electric, natural gas, and water costs, the availability of financial incentives and rebates, and the actual cooling and heating demands of the building. Variability in the energy and water costs and/or the implementation of a carbon tax would reduce the payback time for the electrified and more efficient central energy system. Financial incentives could reduce the additional capital investment required.

Electrification Options Considered

Four cases were considered for this study exploring the options of thermal utility sources and delivery systems. Equipment in the outlined systems would be in rooftop penthouses across the building with air-sourced equipment outside on the roof, and the sewer heat pump system or boilers located on the first floor. The options are summarized in table 1 below.

Table 1 - Summary of Options Considered

Options Considered	#	Description	Reason
Base	0	• AHU DX cooling • VAV with HW reheat • Natural Gas Hot Water (condensing) Boilers • Code Heat Recovery (Wheel) 50% sensible and latent heat recovery effectiveness	Lowest capital cost
Better	1	• AHU DX cooling • VAV with electric reheat • Code Heat Recovery (Wheel) 50% sensible and latent heat recovery effectiveness	Replace gas boilers with electric reheat. Lowest all-electric mechanical capital cost.
Better +	2	• AHU DX cooling with Direct Evaporative Cooling • VAV with HW reheat • Electric Heating (Air Source Heat Pump) • Maximized Heat Recovery (Wheel) 70% sensible and latent heat recovery effectiveness	Replace gas boilers with Electric Air-sourced Heat Pump. Load reduction on mechanical systems with improved heat recovery and reduced peak cooling demand with evaporative cooling. Improved electric heating efficiency over electric reheat.
Best	3	• AHU/DOAS with Direct Evaporative Cooling (no hydronic coils)	Maximized load reducing techniques with indirect/direct evaporative cooling, improved heat recovery, and improved

		• Indirect Evaporative Cooling on Exhaust air before entering to the Wheel • VAV with HW reheat + chilled water (4-pipe) • Active Chilled Beams • Electric Heating/Cooling (Sewer Heat Pump) • Maximized Heat Recovery (Wheel) 75% sensible and 20% latent heat recovery effectiveness	terminal unit design (4-pipe VAV /active chilled beams. Sewer-sourced Heat Pump provides all electric heating and cooling with improved efficiencies over air-sourced heat pump.

COVID-19 Considerations

Given the current climate, it is important to understand the implications of the ventilation system during a pandemic. All systems studied provide adequate ventilation air as required by local codes. Options 0 – 2 can allow for 100% of the total volume of air through the air handling unit to be outdoor air. In select spaces where active chilled beams are implemented in Option 3, recirculation air within the space and cannot be avoided. Oversizing equipment to meet the additional load of 100% outside air was not studied in this report and would add to the initial costs of the system. In all cases, operable windows are recommended to allow for user controlled natural ventilation.

Results

The key results of the 30-year lifecycle cost estimate are summarized in the table below:

Costs		**Option 0: Base**	**Option 1: Better**	**Option 2: Better Plus**	**Option 3: Best**	**Notes**
Initial Capital Cost						
	Total Mechanical and Electrical Cost (all phases)	$16,821,000	$21,813,207	$21,299,159	$22,220,534	
Water Cost (yr 1)	Total Water and Sewer Cost	$503	$503	$769	$722	
Natural Gas Cost (yr 1)	Total Natural Gas Cost	$12,171	$0	$0	$0	
Electricity Cost (yr 1)	Total Electricity Cost	$146,271	$196,113	$157,227	$126,094	
	Total Energy Cost [$]	$158,442	$196,113	$157,227	$126,094	
	Energy Cost Savings Compared to Option 0		-$37,671	$1,215	$32,348	
Operation Cost						
	Number of Full Time Employees	0.223	0.215	0.231	0.223	based on #hrs/year
	Cost of Labor	$26,769	$25,846	$27,692	$26,769	1 FTE per year /$120,000
	Cost of Maintenance	$10,000	$10,000	$10,000	$10,000	estimate for filters, broken dampers, valves, belts, etc
	Total Operations Cost (w/o Energy or Water)	$36,769	$35,846	$37,692	$36,769	
	Total Operations Cost Savings Compared to Base		$923	-$923	$0	
Payback	Payback	N/A	Never	83 years	54 years	
Direct and Indirect Carbon Emissions	Carbon Emission NG (MTCE)	195	0	0	0	
	Carbon Emission ELE (MTCE)	1,603	2,149	1,723	1,382	
	Total Carbon Emission (MTCE)	1,798	2,149	1,723	1,382	
	Carbon Offset Cost [$]	$0	$0	$0	$0	No carbon tax present for Colorado

Table 2 - Summary of Life Cycle Cost Analysis

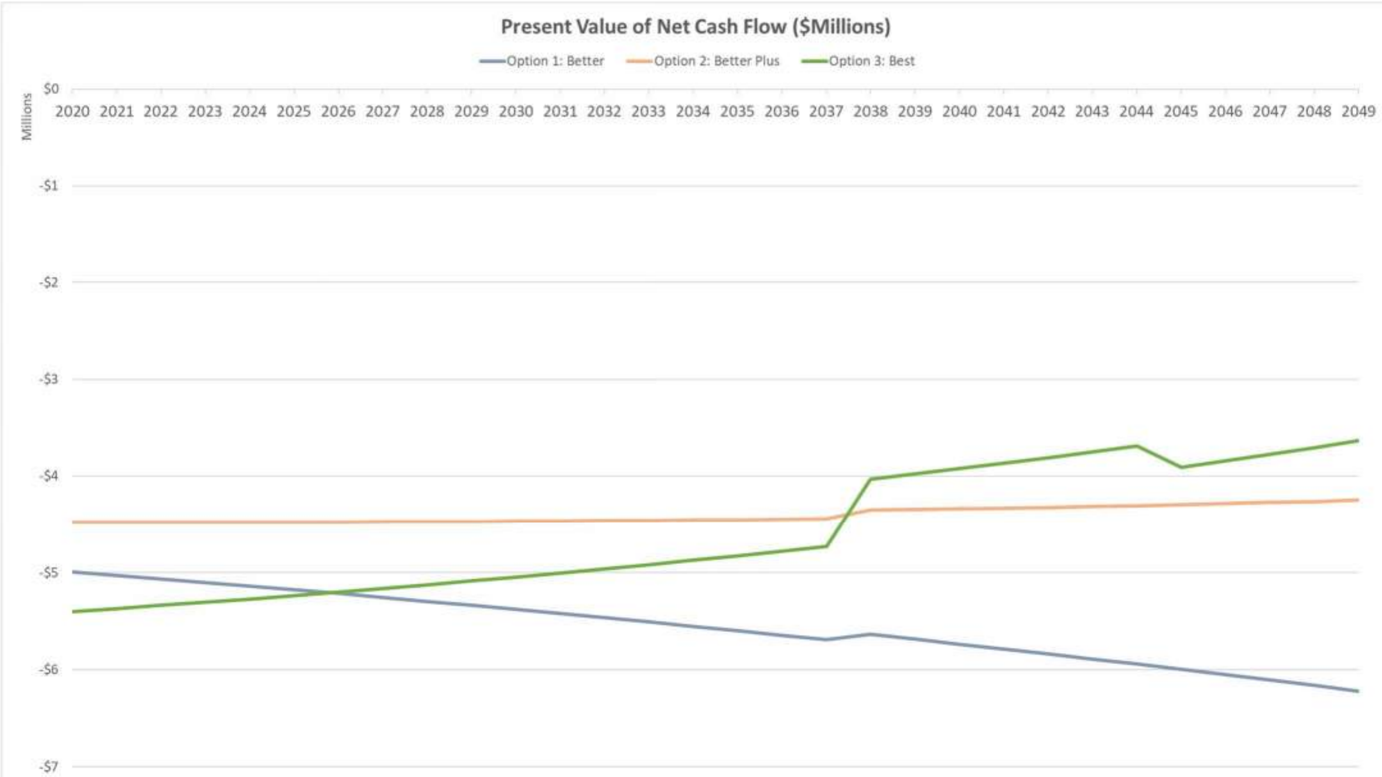


Figure 2 – Present Value of Net Cash Flow

AEI made several observations and conclusions from the Life Cycle Cost Analysis.

It is immediately apparent that Options 1, 2, 3 **DO** meet the all-electric goal but **DO NOT** payback within the 30 analysis when compared to the baseline option (x-axis) when using today's utility rates and considering no carbon neutrality incentives. Option 1 does not reduce energy costs over the baseline and therefore trends away from the x-axis which indicates it will never payback. Options 2 and 3 reduce energy costs and therefore trend upward toward the x-axis which indicates there will be a payback in the distant future. Option 3 trends upwards the quickest indicating that of the three all-electric options it will payback the soonest, but still outside of this 30-year analysis again based on today's utility rates.

Option 1 will generate the most carbon emissions initially but as the electric grid moves from carbon emitting sources to renewable sources, Option 1 will eventually release fewer emissions than the baseline solution. Options 2 and 3 emit fewer emissions from the baseline from the beginning and will continue to do so as the grid improves.

Sensitivity

With the relatively high constructions costs in the Denver area and relatively low utility rates, there is no near-term paybacks. Should utility rates, especially natural gas rates, rise due to political climate around using natural gas or the addition of a carbon tax, the payback for all electric options would reduce. For instance, with a 10% natural gas escalation rate and a $25 per MTCDE carbon tax, Option 3 would have a payback of 38 years. Also, if Option 3 initial costs are within 10% of baseline cost, Option 3 would have a payback within 30 years.

Recommendations

The best performing option to achieve energy and carbon reduction is to invest in Option 3, however this study shows the payback greater than 30 years given the assumed high initial capital cost and the low costs of both electricity and natural gas based on today's utility rates and no carbon neutrality financial incentive mechanisms. If reducing carbon emissions and demonstrating sustainable practices are a priority regardless of payback time-frame, Option 3 best displays these priorities.

The first costs used for the life cycle analysis are based on historical system data. While AEI has significant experience designing all-electric systems, they are novel and there is not an abundance of historical cost data. As such, there is reason to believe that the cost between Option 3 and the Baseline could be closer than our benchmarks predict and Option 3 would have a favorable life cycle cost.

AEI recommends refining the Baseline and Option 3 systems during schematic design to further detail first costs and more accurately reflect the life cycle estimate. If the Baseline Option is selected, the building can be future-proofed for all-electric infrastructure with thoughtful design that does not impact project budget.

APPENDIX

Methodology and Assumptions

Building Load Profile

AEI developed an energy model for the building using EnergyPlus, with a high-performance envelope to determine the annual cooling and heating demand and operational profile based on historical design data.

Table 4 is a high-level summary of inputs assumed for these early massing energy models. The energy model load profiles are calculated using code ASHRAE 90.1 characteristics, and estimated typical internal loads, without any allowances for climate change, construction deviations or occupancy variances. The real operating peak cooling demand is expected to be between 500 and 700 square feet per cooling ton at the LLL tower and residence facility, and between 350 and 500 for the LSTE buildings, which is slightly lower than loads used in this analysis.

The cooling and heating demand calculated by the energy model is summarized below.

Table 3 – Loads Summary

	LSTE (East)
Square Feet	94,200
Peak Cooling (Tons)	200
Cooling (Ton-hours)	420,166
Peak Heating (MBH)	1,317
Heating (MMBtu)	2,876

Table 4 - Energy Model Inputs

General	Weather Data	Denver, CO
	ASHRAE Climate Zone	5B
	Energy Code	ASHRAE 90.1 2013
	Simulation weather file	USA_CO_Denver.Intl.AP.725650_TMY3.epw
	Modeled total floor area	94,200 sf
Building Envelope	Roof constructions	U-factor = 0.050
	Window constructions	U-factor = 0.55, SHGC=0.28
	Exterior wall constructions	U-factor = 0.064
	Window to Wall Area Ratio	40%
System Assumptions	HVAC	See Table 1
	Lighting	LED throughout
	Kitchen	Excluded process gas/steam
	Labs	Excluded process gas/steam
	Equipment (Labs)	8W/sf
	Equipment (Offices)	2W/sf

Lab Air Change Rates per Hour (ACH)	Labs	6ACH occ./4 ACH unocc.
	Other spaces	Compliant with min ventilation per ASHRAE 62.1
Utility Cost	Natural Gas	$3.7/MMBtu (virtual rate calculated based on local utility tariff)
	Electricity	$0.055/kWh (virtual rate calculated based on local utility tariff)
	Water	$2.67 per 1,000 gallons
Economic Factors	Electricity Cost Escalation Rate	3%
	Natural Gas Cost Escalation Rate	4.7%
	Water and Sewer Cost Escalation Rate	3%
	Interest Rate	3%
	Inflation Rate	3.5%

Additional Modelling Results

From the AEI energy model, the results of the different mechanical options are summarized below.

Figure 3. EUI Comparison by End-use Category

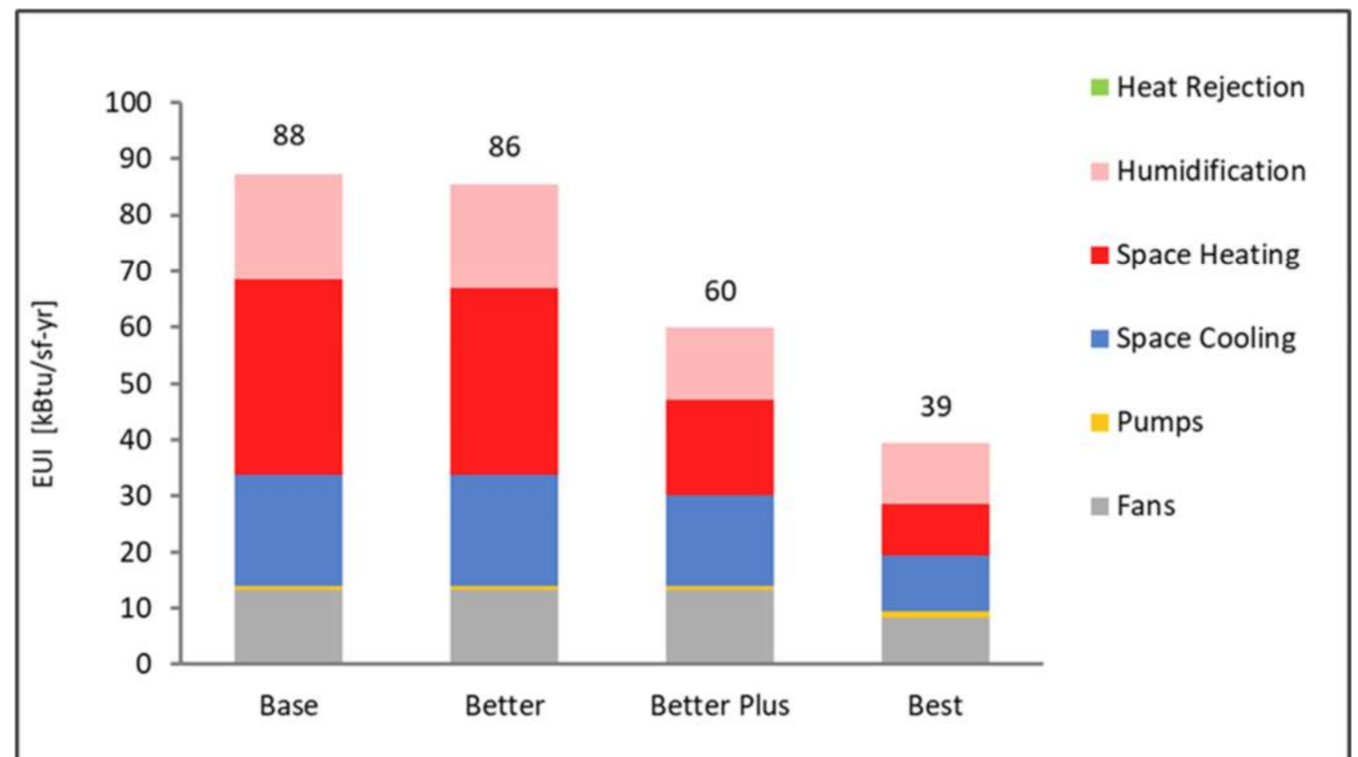
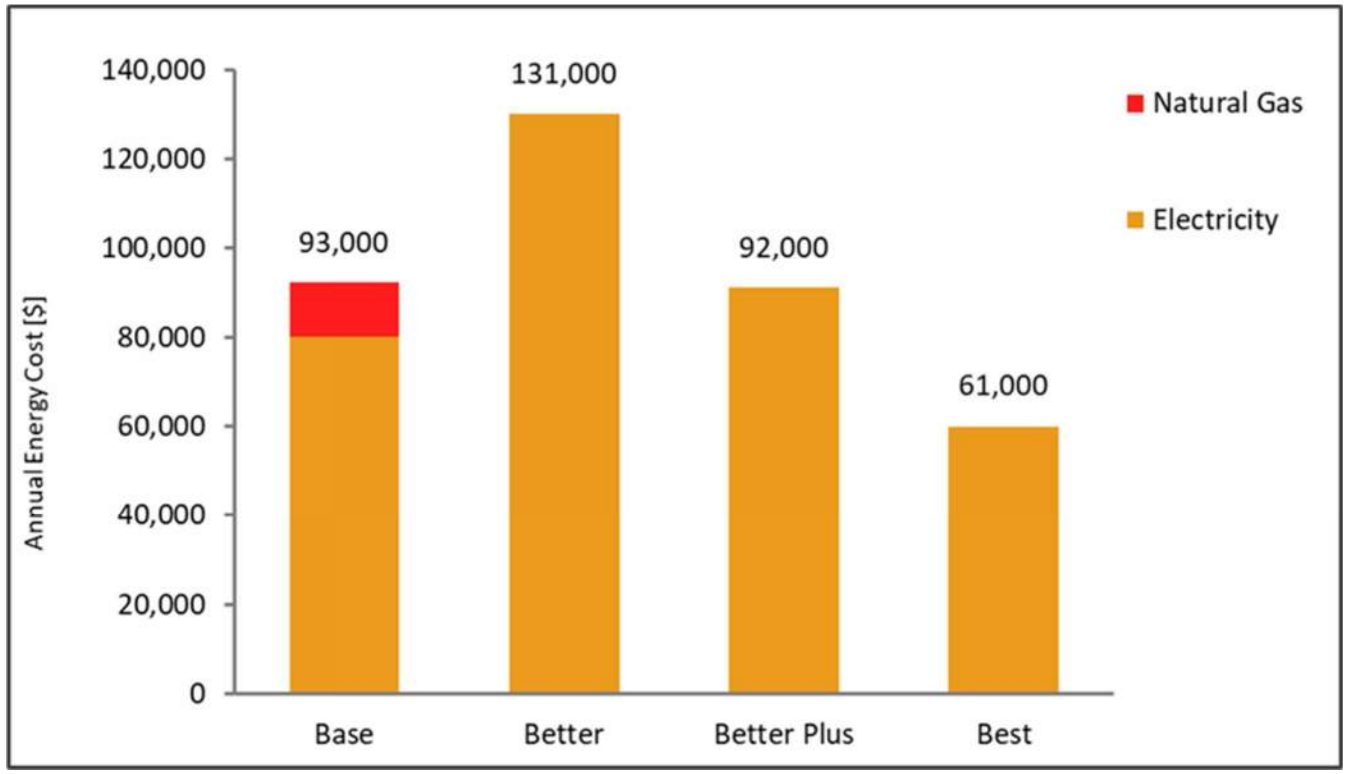


Figure 2. Annual Energy Cost Summary



Third-Party Independent Review

3198 Speer Boulevard
Denver Colorado 80211
303 294 9448
Fax 303 294 0762
www.amdarchitects.com

AndersonMasonDale
Architects

23 March 2021

Cary Weatherford, Director of institutional Planning
Jered Minter, Campus Architect
Kyle Willcott, Project Manager
University of Colorado Denver

RE: Third-Party Independent Review
CU Denver College of Engineering, Design, and Computing (CEDC)
2021 Program Plan Amendment

To the CU Denver Team,

We have reviewed the referenced Program Plan Amendment addressing updates to the CU Denver CEDC. We offer the following comments:

Executive Summary:

1. *Executive Summary* is consistent with the findings in the previous program plan exercises conducted since 2015, which articulate the evolving landscape of contemporary engineering education and specifically its cross-disciplinary complexion. The summary identifies the proposed new site for the building, identified as a development site by the CU Denver 2017 Facilities Master Plan, to enhance the gateway into the CU Denver Neighborhood at the Auraria Higher Education Center (AHEC).

Introduction & Background:

2. *Institutional Background* provides a succinct overview of the CU Denver historical evolution within AHEC and downtown Denver, and its role as a public urban research university in the city and the state;
3. *Project History* provides overview of the evolving program plan for the CEDC project since the original 2015 Program Plan, including the exploration of different sites for the project and program iterations focused on consolidation of physical space to reinforce collaborations across colleges.
4. *Mission & Vision* clearly articulates the trending attributes of today's engineering education, and CU Denver's focus with the CEDC project towards establishing itself as a leader of innovation within the Denver urban corridor.
5. *Relation to Strategic Plan* pointedly connects the vision of the CEDC with specific goals and objectives as articulated in the 2008-2020 University of Colorado Denver Strategic Plan.
6. *Future of Engineering & Facilities* reinforces the overarching mission of the CEDC as it relates to the educating and delivering the future generation of engineers.
7. *Statement of Need and Benefit* reflects alignments of the CEDC with current U.S. labor analysis of engineering careers and with Colorado Commission on Higher Education (CCHE) restated goals per its 2017 Master Plan Update; the section also provides a clear summary of classroom and lab spaces needs.

Project Description:

8. The new site proposed is identified as a development site by the CU Denver 2017 Facilities Master Plan.
9. The proposed site is concentrated at what is considered to be the gateway to the CU Denver Neighborhood at AHEC.
10. The CEDC program will maintain a strong affinity with the North Classroom Building (NCB), where current programming resides, and with some programming slated to remain, having been recently renovated during improvements to the NCB.
11. The site conditions – physical patterns, constraints and opportunities - are clearly communicated in the description of the proposed site.
12. The program description articulates a building efficiency factor that is consistent with this building type.
13. The High Performance agenda for the project is briefly described and is consistent with concepts typically explored for State of Colorado projects required to secure LEED-certification; and a specific analysis has been conducted to initially address alignment with State of Colorado steps toward more sustainable state facilities.
14. The Financial Model & Assumptions analysis is consistent and appropriate for construction of a project of this building type and scale, based on our familiarity with projects at AHEC, and with projects of this building type delivered in the Denver-metro region.

In summary, the 2021 Program Plan Amendment for the CU Denver College of Engineering, Design, and Computing (CEDC) puts forth reasonable recommendations that evolve the goals, objectives and findings of the previous program plan efforts since 2015.

Respectfully Submitted,

Joey Carrasquillo AIA LEEP AP
Principal
Anderson Mason Dale Architects
Architect, State of Colorado, License No. 20-3349

ZGF