Modeling Energy Conservation Potential at Scale

MiAPPA 2025 Summer Conference

July 17, 2025 | 9:00 AM – 9:45 AM

Presented by:
Andrew Price, PE

UNIVERSITY OF MICHIGAN

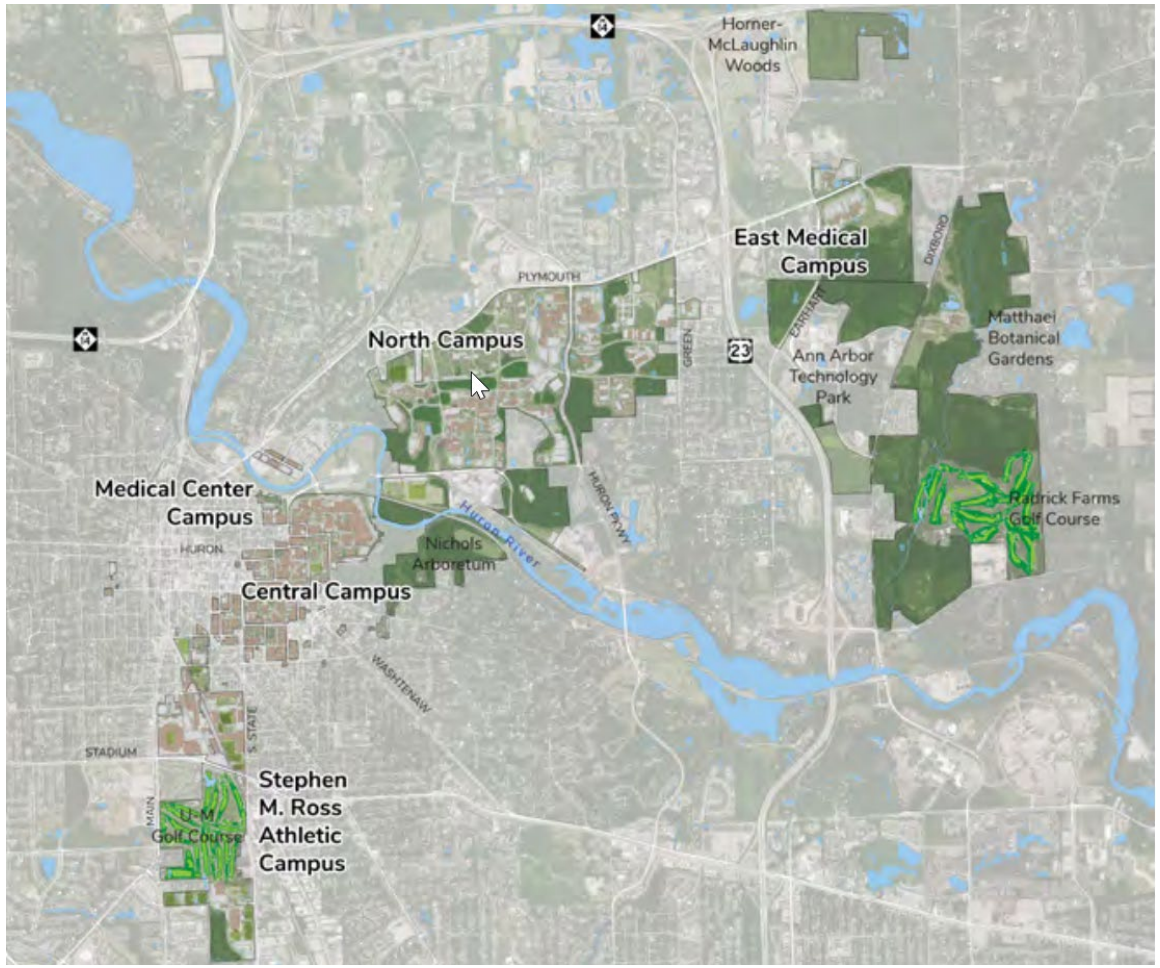
Affiliated Engineers®

Presenter

**David Conant Gilles, co-collaborator*

Andrew Price, PE
Project Manager
Affiliated Engineers, Inc.

University of Michigan



1817

year founded

Ann Arbor

Michigan

Public Research

University

University of Michigan North Campus

History & Statistics:

- Constructed: Early 1950s - 2022
- 8M square feet over 1,000 acres
- Various construction types & building uses
- Pfizer Complex, purchased in 2009
  - 1.2M square feet
  - 174 acres
  - 28 buildings
  - District heating and cooling only

President's Commission on Carbon Neutrality

Goal Recommendation

Prioritize direct emissions reductions for Scope 1 by setting a goal of eliminating them across all three campuses by 2040 and exceeding global science-based targets via direct emissions reductions along the way

Strategy Recommendation

Create and update campus- and district-level master plans to reflect that emissions mitigation is one of the university's top priorities, and update such plans at regular intervals with campus community input

Strategy Recommendation

Embark on a phased, district-level U-M's approach to converting heating and cooling infrastructure to be fossil fuel free, beginning with electrified systems centered on geo-exchange with heat recovery chiller technology and with the flexibility to pivot to other proven technological solutions as they emerge

Vision 2034

- 2023 Initiative to develop a 10-year vision for the university

Impact Areas

Life-Changing Education

Human Health & Well-Being

Democracy, Civic & Global Engagement

Climate Action, Sustainability & Environmental Justice

CampusPlan2050

- Strategic Planning to inform campus development in support of Vision2034 and beyond

Modernize existing academic and research facilities, and develop new ones	Thoughtful green spaces and mobility enhancements	Innovation district to nurture discovery, entrepreneurship, and private-public partnerships
Environmentally responsible transportation linking the five major campus areas	Environmentally responsible practices to help eliminate direct on-campus greenhouse gas emissions by 2040	Investment and renewal opportunities to foster a model of sustainability and decarbonization

Goals of NCUMP

Develop long term carbon neutrality strategy

Inform infrastructure replacement investments

Materials to communicate to campus stakeholders

Industry best practices & consultant creativity to:

- Optimize energy distribution, consumption, and generation
- Identify and locate utility corridors, facilities, and infrastructure
- Identify discrete and district energy systems in conjunction with the university's broader Integrated Master Plan
- Role of heat recovery, energy sharing, thermal storage, etc.
- Physical changes to buildings

Master Plan Process

STEP 1

Mobilization and Goals Identification

STEP 2

Data Gathering and Condition Assessment Review, Establish Resilience Priorities

STEP 3

Load Analysis

STEP 4

Hydraulic Modeling

STEP 5

Preliminary Analysis and Options Screening

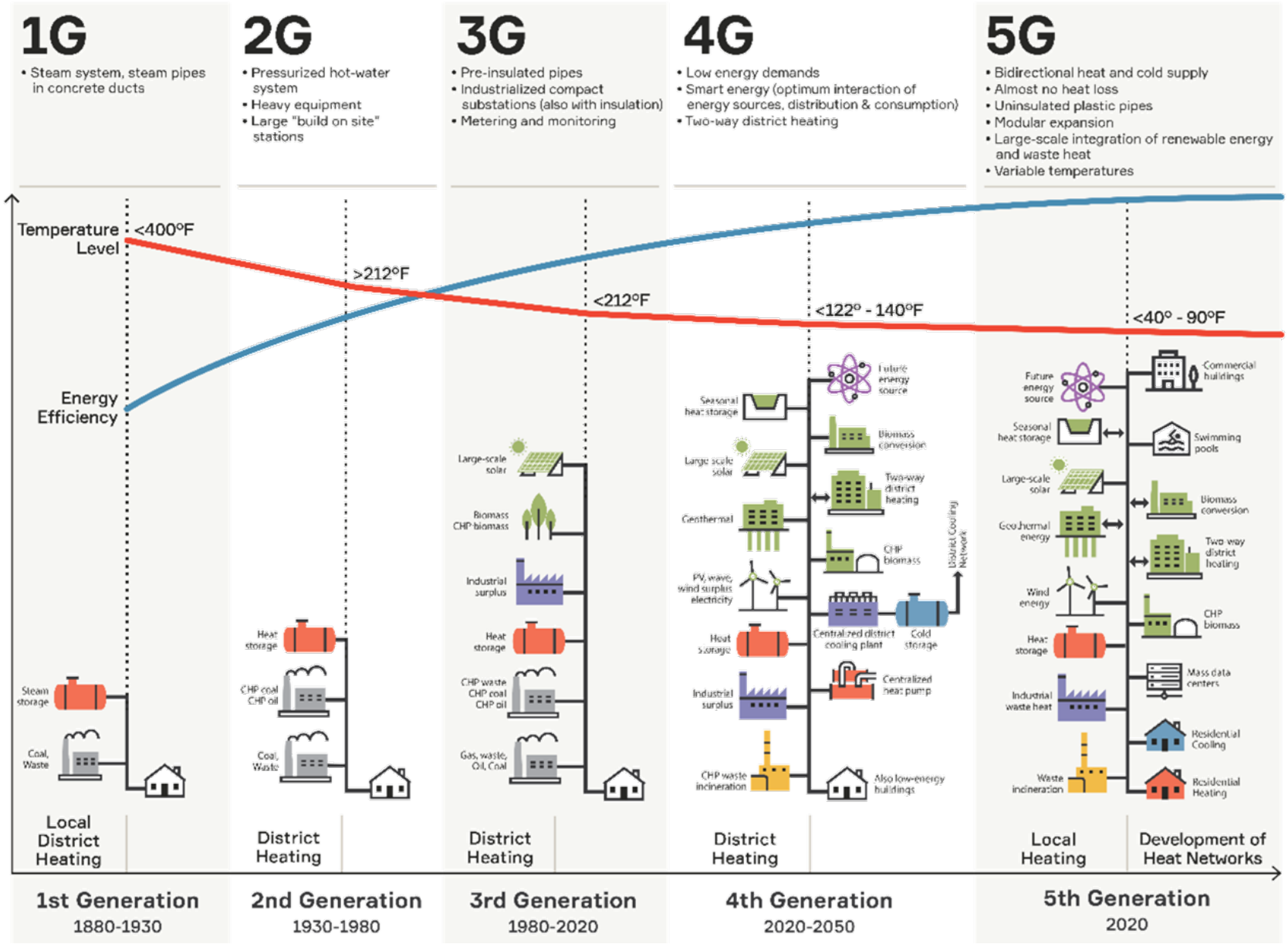
STEP 6

Detailed Analysis of Selected Options

STEP 7

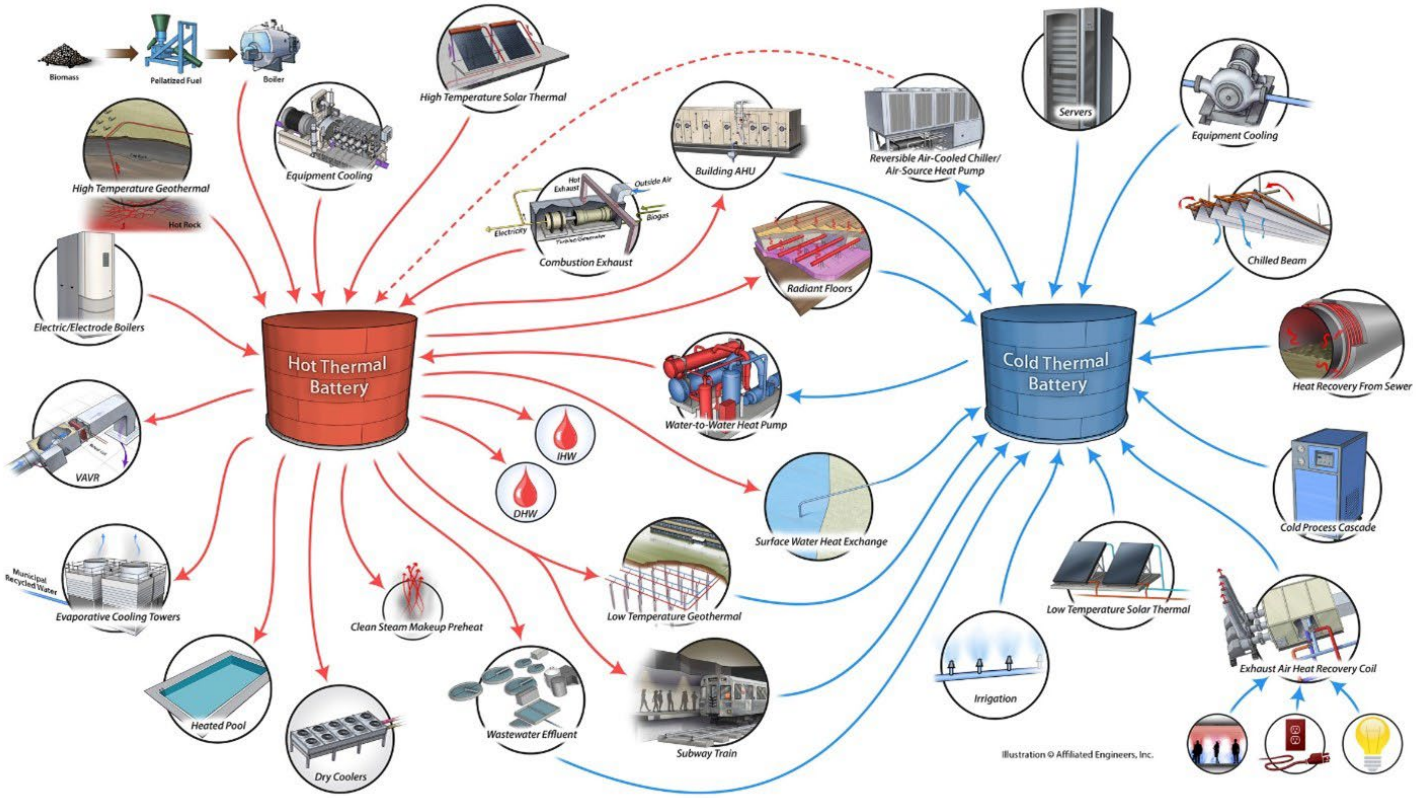
Final Report and Deliverables

Existing & Emerging Technologies



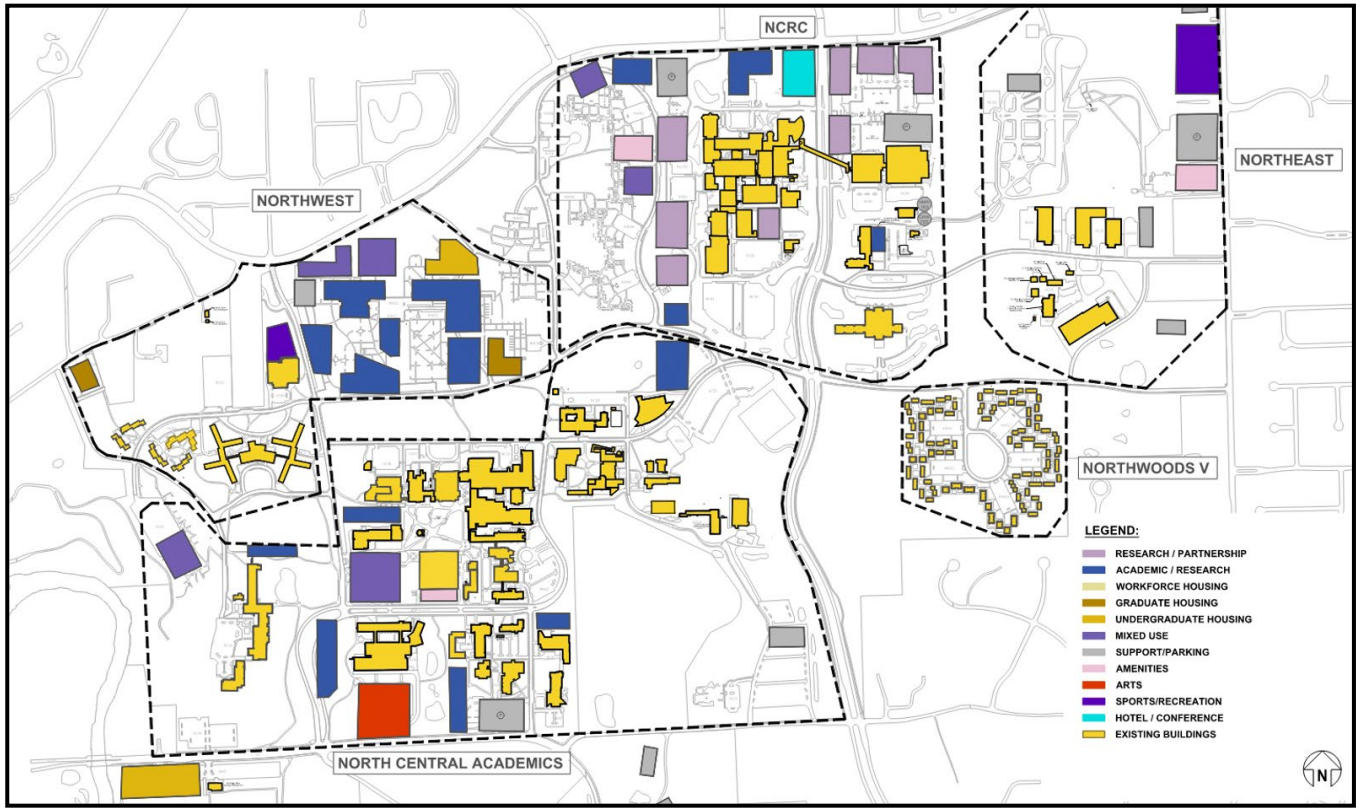
Existing & Emerging Technologies

- During the ideation phase, existing and emerging heating technologies and strategies were evaluated and screened to focus on technologies that are:
  - Viable
  - Significant in scale
  - Contribute meaningfully to U-M's energy, environmental, and operational goals



Future of North Campus

- The CP2050 Plan projects additional 4.15M GSF over first 10 years, and an additional 4.5M GSF at full build
- Convert existing buildings from steam to heating hot water, along with deep energy retrofits
- 4th generation combined heating and cooling plants with traditional chilled and heated water thermal distribution. Ambient piping distribution to multiple geothermal bore fields
- Additional utility import capacity



Step 1 to Decarbonization

Decarbonization Process

1. Perform Building Audits and System Survey and Background Data
2. Develop Energy Conservation Measure List
3. Representative Building Model Development
4. Building-by-Building Savings
5. Bundle Recommendations for Each of the 5 Campus Regions

Proposed Audits

- Preliminary walk-through and data collection
- Building existing condition affects duration of survey
- Assume large laboratory will take up to 4 hours
- Assume small laboratory will take around 2 hours
- Non-laboratory buildings take 1 to 2 hours depending on complexity
- Assume up to 3 hours if a building includes a local heating/cooling plant

Draft

FACILITIES & OPERATIONS
ARCHITECTURE, ENGINEERING AND CONSTRUCTION
UNIVERSITY OF MICHIGAN

North Campus Utilities Masterplan DRAFT Field Visit Buildings - 1/4/2023

Number	Building Number	Building Name	Building Category	SQFT	kBTU's / sqft	Total BTU's
1	395	FRANCOIS-XAVIER BAGNOUD BUILDING (FXB)	LAB	101,812	231.66	23,586,127,784
2	396	DUDERSTADT CENTER	NON-LAB	240,256	186.69	44,853,621,884
3	399	NORTH CAMPUS ADMIN (NCAC)	ADMIN	129,114	150.83	19,474,364,851
4	406	ANN & ROBERT H LURIE BIOMEDICAL ENGINEERING	LAB	65,028	377.04	24,517,894,675
5	407	G G BROWN LABORATORY	LAB	290,501	206.10	59,871,889,319
6	415	NAVAL ARCH & MARINE ENGINEERING COMPLEX (NAME)	LAB	47,002	337.89	15,881,327,716
7	424	GORGUZE FAMILY LABORATORY COMPLEX	LAB	80,487	226.46	18,226,837,394
8	427	NORTH CAMPUS RECREATION BUILDING (NCRB)	NON-LAB	67,512	177.28	11,968,622,658
9	432	ART & ARCHITECTURE BUILDING	NON-LAB	264,134	140.87	37,207,909,191

Building Data Dashboard

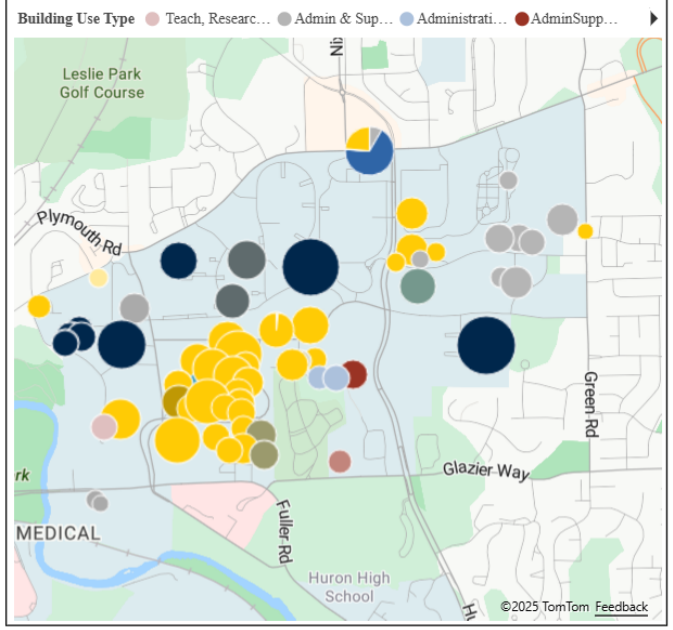
1.1 Building Information

NORTH CAMPUS UTILITY MASTER PLAN

What are the existing audited and additional buildings on North Campus and what are their relative energy usages?

Number of Buildings*	Average Building Age (yrs)
110	45

Campus Map



Area (GSF) By Building Use Type

Building Name	Area (GSF)	Building Use Type	Year Built	Average EUI	Average Gas EUI	Average Electric EUI
Walgreen Drama Center	84,149	Teach, Research, Support	2007	162.8	123.10	39.67
University Hospital Child Care Center	14,850	Clinical Delivery	1991	115.1	92.43	22.63
U-M Transportation Research Testing Building	3,454	Teach, Research, Support	2012	0.0	0.00	0.00
U-M Transportation Research Institute	77,883	Teach, Research, Support	1969	125.0	86.50	38.54
Stamps Auditorium	13,488	Teach, Research, Support	2008	26.9	0.00	26.87

* Number of buildings is lower than actual building count on North Campus as "typical" has been used for residential units.

Buildings that do not have metered utility data show Average EUI, Average Gas EUI, and Average Electric EUI as zero.

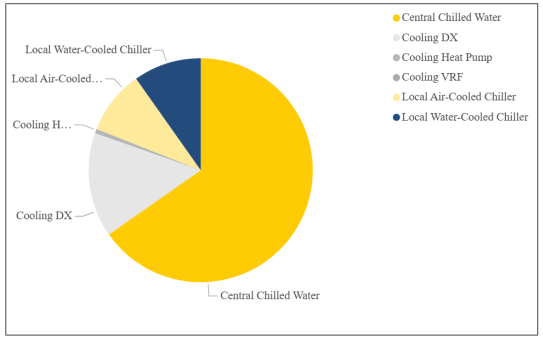
NORTH CAMPUS UTILITY MASTER PLAN

System Survey and Background Data

1.2 Building Cooling Systems

NORTH CAMPUS UTILITY MASTER PLAN

How is cooling provided to existing audited buildings on North Campus?



Main Cooling System: All

Buildings by Cooling System

Building Name	Area (GSF)	Main Cooling System
Aero and Gorguze	80,487	Central CHW;
Art & Architecture Building	264,419	Local Water-Cooled Chillers;
Beyster Building	104,132	Central CHW;
Bonisteel Interdisciplinary Research Building	21,993	Local Air-Cooled Chillers;
Bursely Hall	341,587	Local Air-Cooled Chillers;
Chrysler Center Continuing Engineering Education	45,310	Central CHW;
Climate & Space Research Building	105,521	Central CHW;
Duderstadt Center	240,256	Central CHW; Local Air-Cooled Chillers;
Electrical Engineering & Computer Science Building	305,021	Central CHW;
Engineering Research 1	36,033	Local Water-Cooled Chillers;
Engineering Research 2	28,332	Local Water-Cooled Chillers;
Total	**5,390,150**	

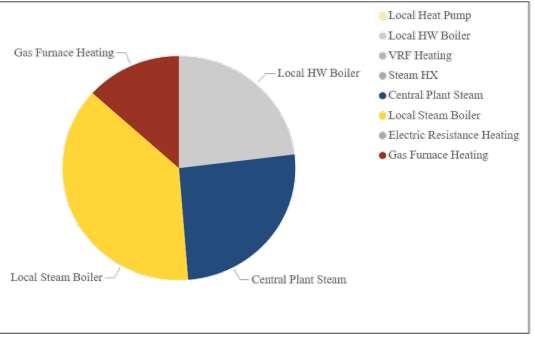
Groupings: All

43 Buildings audited

1.3 Building Heating Systems

NORTH CAMPUS UTILITY MASTER PLAN

How is heating provided to existing audited buildings on North Campus?



Main Heating System: All

Buildings by Cooling System

Building Name	Area (GSF)	Main Heating System
Aero and Gorguze	80,487	Local Steam Boiler;
Art & Architecture Building	264,419	Local Steam Boiler; Local HW Boiler;
Beyster Building	104,132	Local HW Boiler;
Bonisteel Interdisciplinary Research Building	21,993	Local HW Boiler;
Bursely Hall	341,587	Local Steam Boiler;
Chrysler Center Continuing Engineering Education	45,310	Local HW Boiler;
Climate & Space Research Building	105,521	Local Steam Boiler;
Duderstadt Center	240,256	Local Steam Boiler; Local HW Boiler;
Electrical Engineering & Computer Science Building	305,021	Local Steam Boiler;
Engineering Research 1	36,033	Local HW Boiler;
Engineering Research 2	28,332	Local HW Boiler;
Ford Motor Company Robotics Building	144,117	Local HW Boiler;
Total	**5,390,150**	

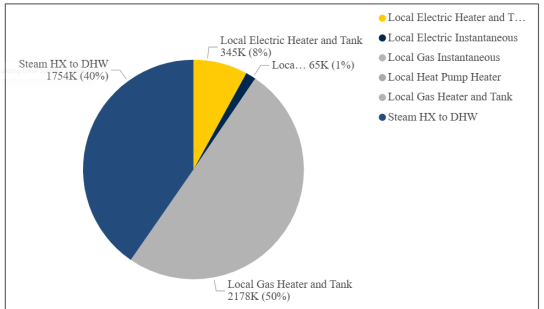
Groupings: All

43 Buildings audited

1.4 Building Domestic Hot Water Systems

NORTH CAMPUS UTILITY MASTER PLAN

What are the existing domestic hot water systems on North Campus in audited buildings?



Main DHW System: All

Buildings by Cooling System

Building Name	Area (GSF)	Main DHW System
Aero and Gorguze	80,487	DHW Gas Heater and Tank;
Art & Architecture Building	264,419	Unknown
Beyster Building	104,132	DHW Gas Heater and Tank;
Bonisteel Interdisciplinary Research Building	21,993	Unknown
Bursely Hall	341,587	DHW Gas Heater and Tank;
Chrysler Center Continuing Engineering Education	45,310	DHW Gas Heater and Tank;
Climate & Space Research Building	105,521	Unknown
Duderstadt Center	240,256	Unknown
Electrical Engineering & Computer Science Building	305,021	DHW Steam HX;
Engineering Research 1	36,033	DHW Gas Heater and Tank;
Total	**5,390,150**	

Groupings: All

43 Buildings audited

1.5 Metered Monthly Energy Consumption

NORTH CAMPUS UTILITY MASTER PLAN

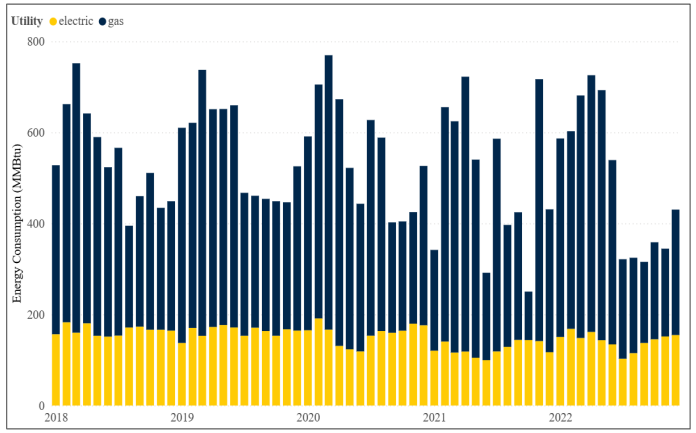
How does the energy consumption of audited buildings in North Campus vary during the year?

Year: 2018 – 2022

Building (Crtl+Click to select multiple): Chrysler Center Continuing Engineering E…

Energy Use Intensity (kBtu/GSF)

Year	Total EUI	Total EUI - Electric	Total EUI - Gas
2021	132.0	33.0	99.0
2022	130.8	37.9	92.9
2020	147.4	41.8	105.6
2019	148.6	43.2	105.5
2018	143.8	43.7	100.0



Develop Detailed Energy Saving Measure List

ESM

- Air sealing, insulation & weatherization
- Chilled Water (CHW) Reset
- Condenser Water (CW) Reset
- Cooking Hood Temperature_Smoke sensing turndown
- DDC Controls Upgrade
- Demand controlled ventilation (DCV) CO2 sensing
- Efficient ULT Freezers (-80) Stirling and others.
- EnergyStar appliances
- High Efficiency Fume Hood (~65 fpm)
- High efficiency replacement chillers
- High efficiency replacement DX
- High efficiency replacement NG Furnace
- Hot Water (HW) building loop Reset
- Increase IT/Electric rooms "cold" setpoints
- Kitchen exhaust fan (EF) variable air volume (VAV)
- Lab ACH Reduction
- LAB Exhaust Fan (EF) variable frequency drives (VFD)
- LED lighting upgrade
- Lighting controls
- Low flow DHW fixtures
- Occupancy based receptacle control
- Occupancy control HVAC setback
- Pump variable frequency drives (VFDs)
- Refrigerantion desuperheater-service water pre-heat
- Retro-Cx: airside economizer

Potential Energy Savings Measure Descriptions

frequency drives (VFDs)

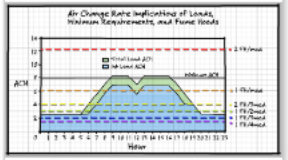
upgrade

Retrofit existng/old thermostats with digital

Retro-Cx: room T-stat & setbacks

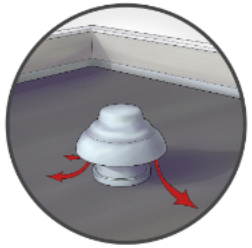
Zone temperature

High Efficiency Fume Hood (~65 fpm)

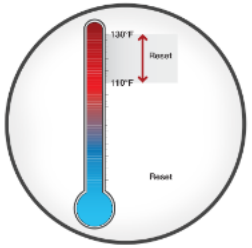


Lab ACH Reduction

This measure assumes a review of lab use and



Kitchen exhaust fan (EF) variable air volume (VAV)



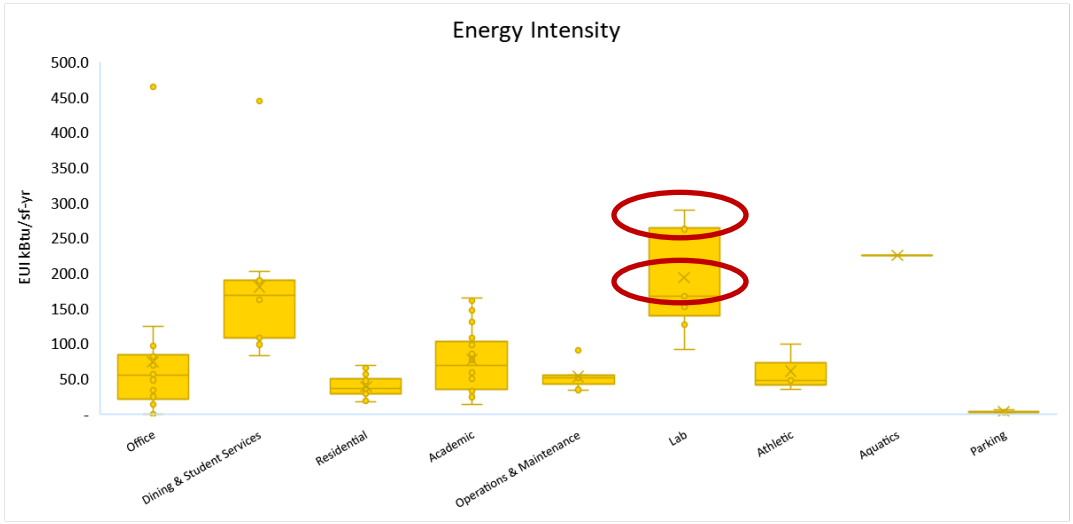
Hot Water (HW) building loop Reset

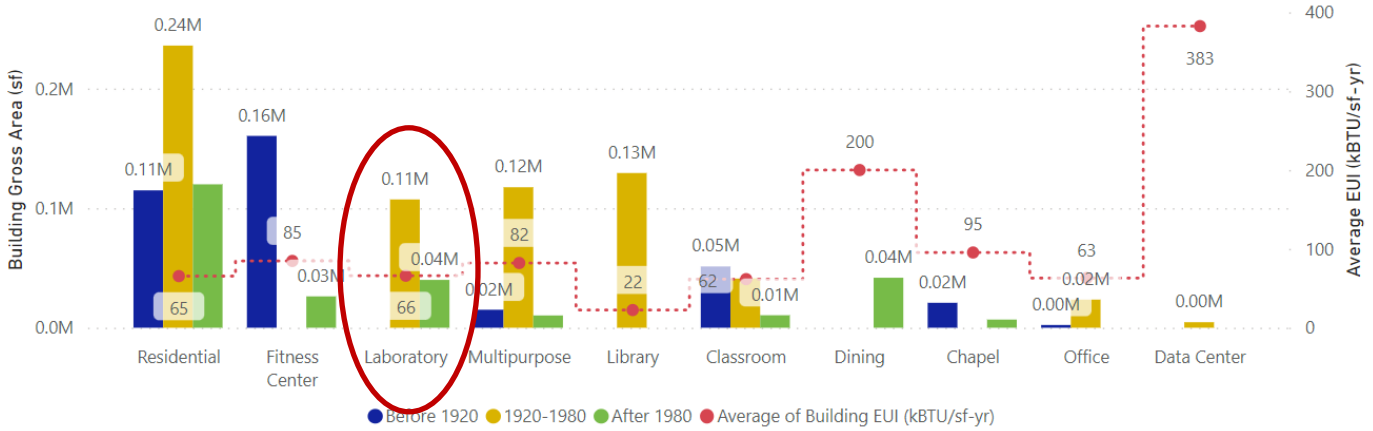
Supply water

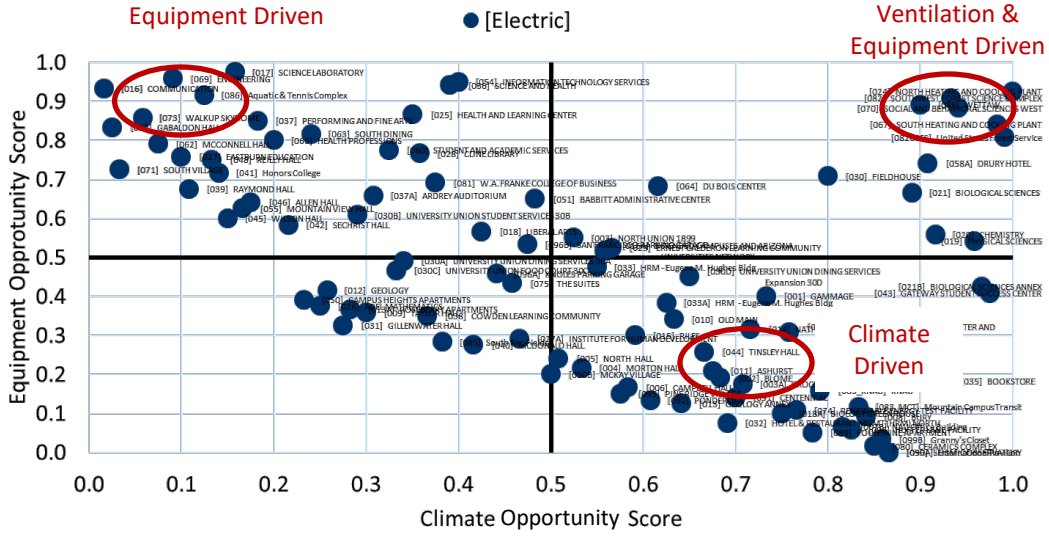
EnergyStar appliances

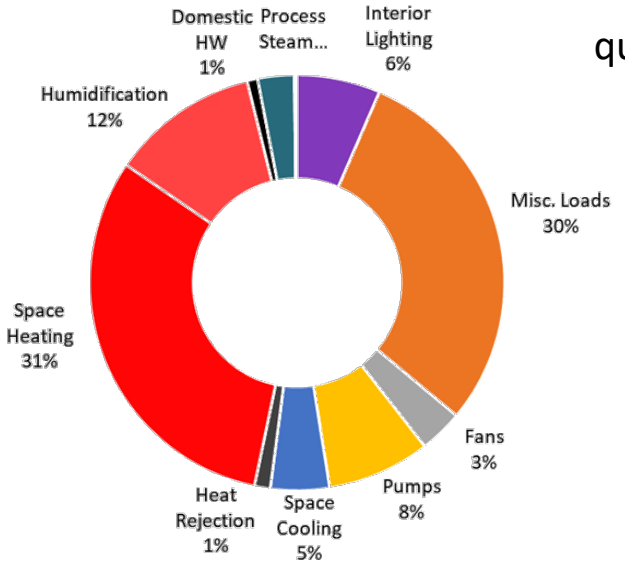
Replace existing

Generate Representative Building Models

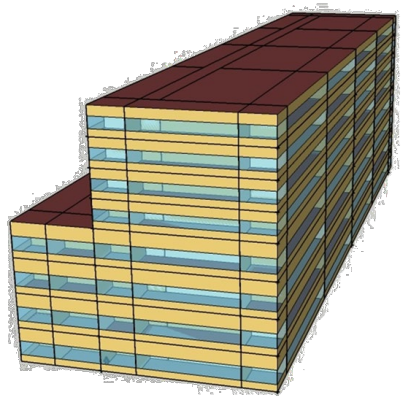








Building Energy Models for use in quantifying Energy Savings Measures



Develop Building-by-Building Demand Reduction Calc

4.2 Energy Saving Measures by Building

Building Type, Name

- Academic
- Athletics
- Campus support
  - Central plant
  - Custodial House
  - Evans Campus Safety & ...
  - Facilities Service Center
  - Hampden Center
  - Health & Conseling Cent...
  - IT Building
  - Mail Building
  - Mary Reed Building
  - Project Management Bu...
- Greek
- Laboratory
- Office
  - Administrative Office Bui...
  - International House
  - John Moye Hall
- Other
- Student Housing

Energy Model
Energy End-Use Breakout

Building Characteristics — **Mary Reed Building**

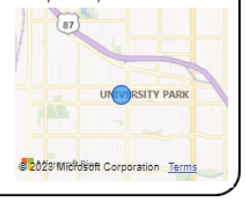
Primary Space Type: Campus support

Area (GSF):	Age (yrs.):
77K	91

Cooling System: Local Chilled Water-Ai...
Heating System: Central Plant Steam

DU-2019 metered EUI (kbtu/sf-yr):	Energize Denver 2030 Target EUI (kbtu/sf-yr):	EUI with ESM applied (kbtu/sf-yr):
60.6	60.6	52.2

Campus Map



Energy Savings Measures (ESMs)

Potential Energy Savings Measure Descriptions

First Cost Category: High | Low | Med

Potential Energy Savings Measures

ESM	First Cost Category
Air sealing, insulation & weatherization	Low
DDC Controls Upgrade	Med
Demand controlled ventilation (DCV) CO2 sensing	Low
Energy Recovery Wheel	High
High efficiency replacement chillers	Med

Base Year: 2019

ESM Implementation Cost ($): $3M

Degree of ESM Overlap: 20%

Base Yr. Gas & Electric EUI (kbtu/sf-yr):	Post ESM Gas & Electric EUI (kbtu/sf-yr):
60.6	52.2

ESM Savings MTCDE: 59
Annual Gas Savings (therms): 1,881
Annual Elec. Savings (kWh/yr): 97K

% Gas Savings: 9.3% (0.0% – 100.0%)
% Elec Savings: 19.1% (0.0% – 100.0%)

Savings to Investment Ratio (SIR): 0.08
Return on Investment (ROI): 8%
Discounted payback period (years): 18
* Assuming a fixed 3% discount rate

ECM Bundles

- Physical audit of 43 buildings extrapolated and combined with university recorded data
- Three Energy Conservation Measures (ECM) bundles recommended for each five regions

Bundle 1

*Looks at **$ value reduction** per lb CO2e*

Bundle 2

*Looks at simple payback in **<6 years***

Bundle 3

*Looks at simple payback in **<30 years***

- Discounted paybacks further evaluated in Total Cost of Ownership model

ECM Bundles

9.1 ECMs Bundled by Simple Payback for NCA Buildings

What if the energy reduction measures are bundled by anticipated simple payback?

Buildings

Labs - High EUI - Internal Loads Driven (Group 3....

Current Grouping:

Multiple selections

ECM Carbon vs Exist CO2 (kg/sf)

18.5

EUI (kBtu/sf-yr

144.2 278.3

4

Approximate Bores S...

242

Total MTCO2 Reduction

% CO2 Savings

29.8%

$2.24M

Project Cost

Discounted Payback Period (Years)

60.8

Annual Electric Saved kWh

274K

% Elec Savings:

25.3%

Annual Heating Saved (kBtu)

2M

% Heating Savings:

Annual Cooling Saved (kBtu)

278K

% Cooling Savings:

Building Name	GSF	Main Heating System	Main Cooling System

Selected ECMs

Building Name	ECM	Project Cost $	Simple Payback yrs.	MTCDE Reduction	Approximate Bores Saved
School of Information North	Air sealing, insulation & weatherization	$247	1.9	0.35	0
School of Information North	Chilled Water (CHW) Reset	$2,413	18.7	0.44	0
School of Information North	CV to VAV Air Systems	$109,442	23.2	13.81	0
School of Information North	DDC Controls Upgrade	$85,932	27.3	9.29	0
School of Information North	Demand controlled ventilation (DCV) CO2	$84,377	26.9	9.88	0

* Assumes a fixed 3% discount rate

* Assumes efficiency of chiller and boiler included

UMP Modeling

Campus Region	ECM Bundle	MTCO2 Reduction	% Reduction Electricity	% Reduction Heating Energy	% Reduction Cooling Energy	Est. # of Avoided Geo-bores	Project Cost	Discounted Payment Period (Years)
NCRC	ECM Bundle 1	16,979	13.2%	20.6%	4.5%	115	$33.1M	11.6
	ECM Bundle 2	12,980	8.3%	17.4%	2.1%	50	$5.16M	2.3
	ECM Bundle 3	16,923	12.9%	20.7%	4.5%	115	$32.68M	11.5
NWR	ECM Bundle 1	898	0.7%	8.1%	0.1%	3	$845K	5.0
	ECM Bundle 2	937	0.8%	8.4%	0.1%	3	$1M	5.9
NW V	ECM Bundle 1	56	N/A	4.1%	N/A	N/A	$294K	27.7
NCA	ECM Bundle 1	13,817	13.2%	5.6%	1.0%	40	$11.01M	6.1
	ECM Bundle 2	11,081	11.0%	3.2%	0.4%	19	$2.18M	1.5
	ECM Bundle 3	14,899	13.7%	7.8%	1.3%	52	$17.85M	8.9
NE	ECM Bundle 1	34	0.1%	4.9%	2.6%	1	$81K	13.7
	ECM Bundle 2	19	-1.9%	4.6%	1.6%	1	$33K	8.6
	ECM Bundle 3	34	-1.3%	6.3%	2.9%	1	$86K	13.6

Next Steps

Recommendation 1

- The University should move forward with the next level (design) of geothermal systems

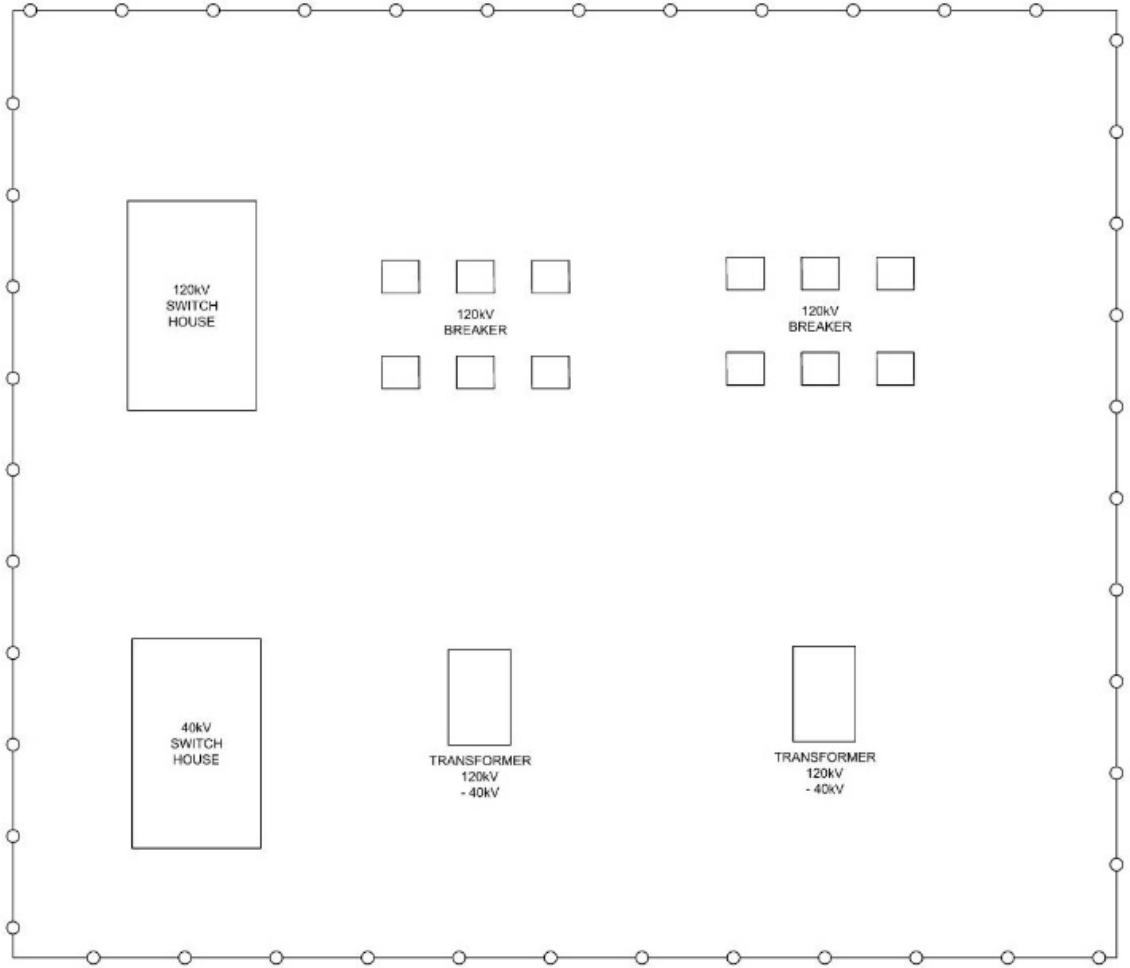
Recommendation 2

- As an immediate step, the University should develop a series of projects to convert existing building heating systems from steam to hot water

Next Steps

Recommendation 3

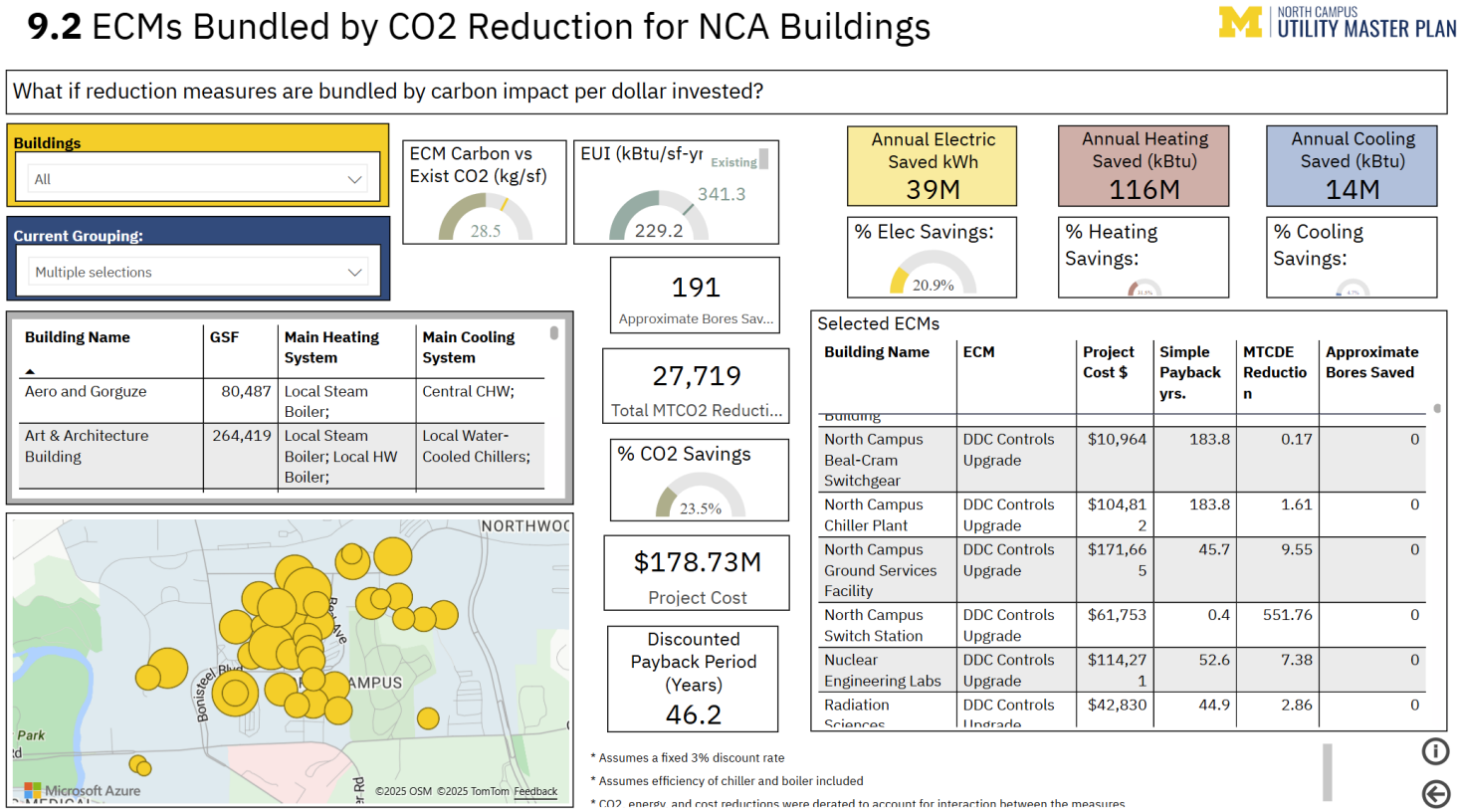
- Maintain engagement with ITC/DTE, the electricity utility that serves the campus, to deliver the additional electrical capacity



Next Steps

Recommendation 4

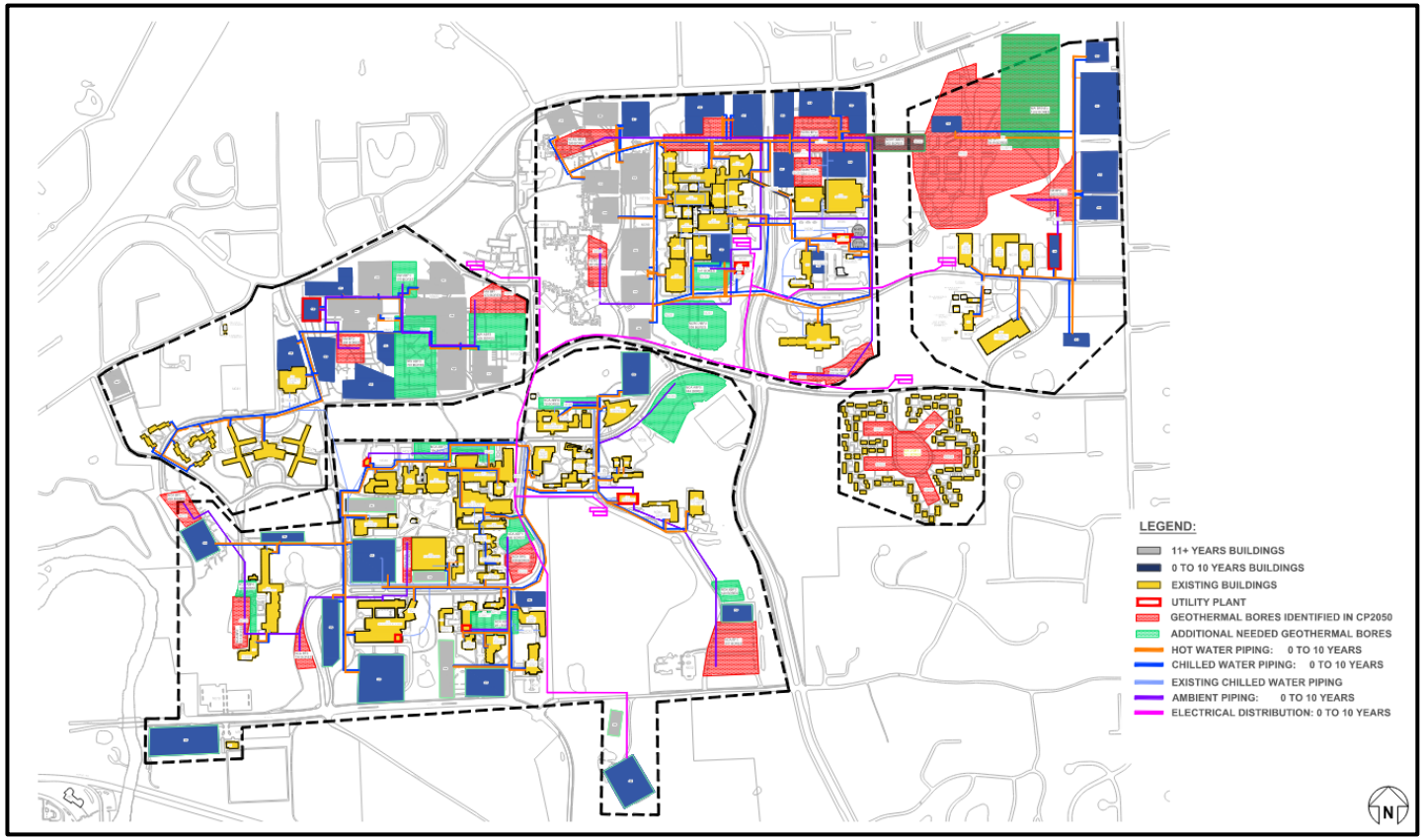
- Invest extensively in reducing building energy demand over the next decade. Strategically, this should be executed in combination with converting buildings to receive low-temperature hot water rather than steam



Next Steps

Recommendation 5

- Further identify and reserve the significant footprint associated with utility distribution and geothermal bore fields



Questions

MiAPPA 2025 Summer Conference
July 17, 2025 | 9:00 AM – 9:45 AM

Modeling Energy Conservation Potential at Scale

UNIVERSITY OF MICHIGAN

Affiliated Engineers®