

De-Carbonizing the Campus: Planning, Tools & Technologies

CampusEnergy2023

February 27 – March 2, 2023

Gaylord Texan Resort & Convention Center | Grapevine, Texas



INTERNATIONAL
DISTRICT ENERGY
ASSOCIATION



Vanderbilt University: Central Utilities Initiative

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Background

- 110 Buildings over 330 Acres
- Total area $\approx$ 11 MSF
- Cooling ($\approx$ 14,200 T Load)
 - Powerhouse (3,600 T)
 - Peabody (5,400 T)
 - Building plants
- Heating ($\approx$ 290 KPPH Load)
 - NG: 460 KPPH / 360 KPPH firm
 - FO: 260 KPPH / 180 KPPH firm
- Power ($\approx$ 50 MW Load)
 - 13.6 MW Onsite generation



Goals for Campus Utility Infrastructure

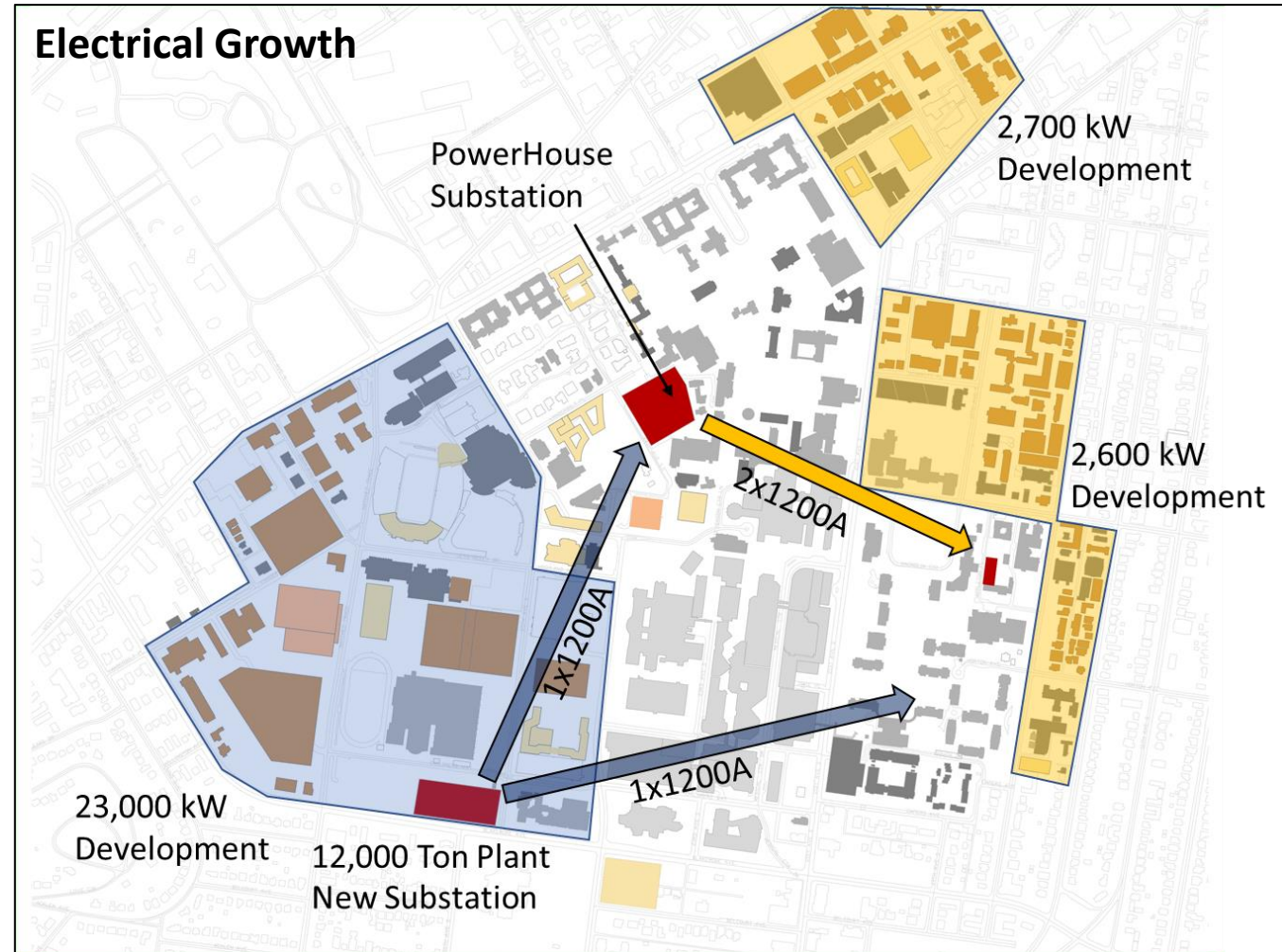
1. Supports Vanderbilt's Mission

- a) 99% Uptime
- b) Safe
- c) Comfortable
- d) Interesting/invigorating
- e) Park like setting
- f) Non-polluting
- g) Cost effective
- h) Energy efficient

2. Provide heat, cooling & electricity

3. Maximize interconnections

4. Minimize number of plants



Flexibility for FutureVU

1. Supports FutureVU Goals

- ☑ 99.999% Uptime
- ☑ Safe
- ☑ Comfortable
- ☑ Interesting/invigorating
- ☑ Park like setting
- ☑ Non-polluting
- ☑ Cost effective
- ☑ Energy efficient
- ☑ Research / Educational Opportunities

2. First Cost: Centralized ≈ Decentralized

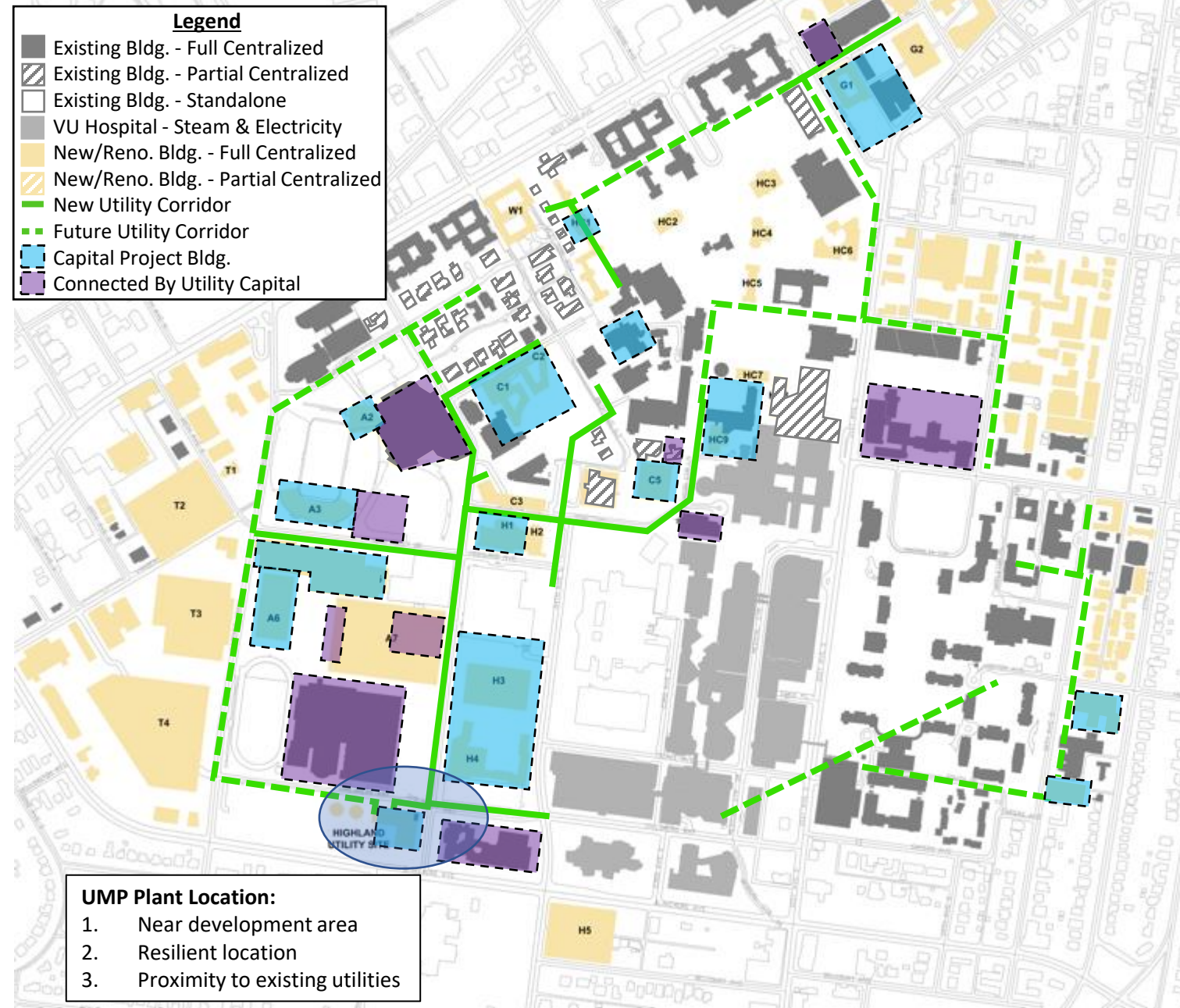
- + Less equipment required
- + Larger equipment = installation savings
- + Consolidate redundancy = less equipment
- + Less space required at buildings
- More distribution piping required

3. Annual costs: Centralized < Decentralized

- + Higher efficiency = energy & GHG savings
- + Lower electric rate
- + Less equipment = Lower O&M

4. Renewal cost: Centralized < Decentralized

- + Longer economic life
- + Less to renew
- + Less impactful to users
- + Easier to pivot to plug / play new technologies



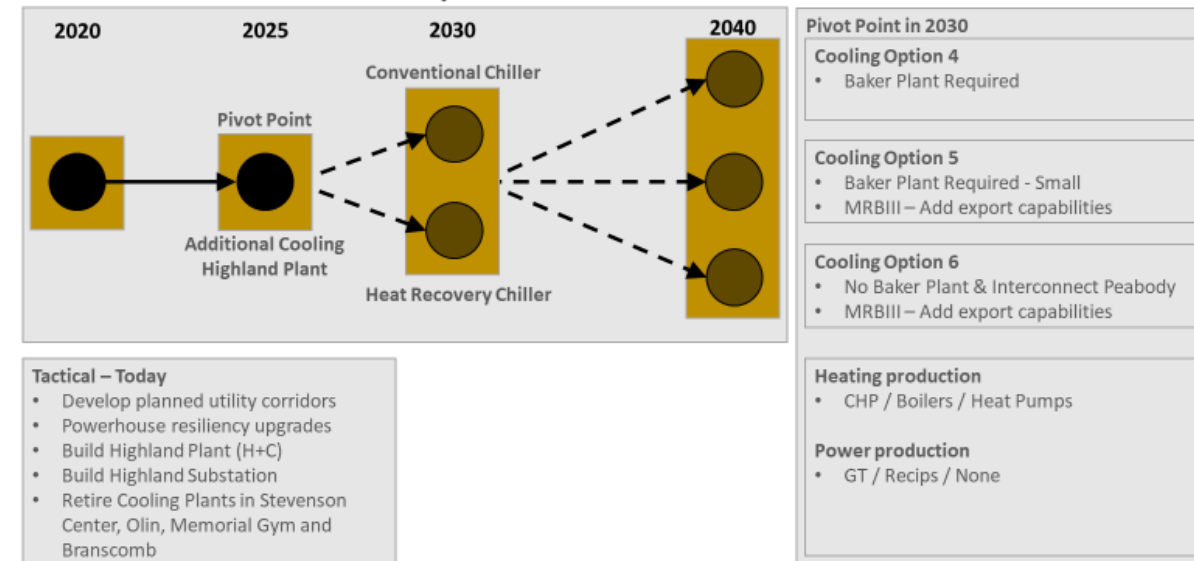
Utility Master Plan

Recommendations

- **Pivot:** Develop solutions for the existing generation that can pivot as renewable technology becomes more available and economical
- **Cogen:** Continue for foreseeable future
- **Chilled Water:** Continue to convert to district chilled water systems and eliminate unitary equipment
- **Hot Water:** Continue use of hot water for building loads that do not require steam. Connect where makes sense.
- **Power:** Convert 4.16kV to 13.8kV to increase reliability of electrical systems

UMP Pivot Plan

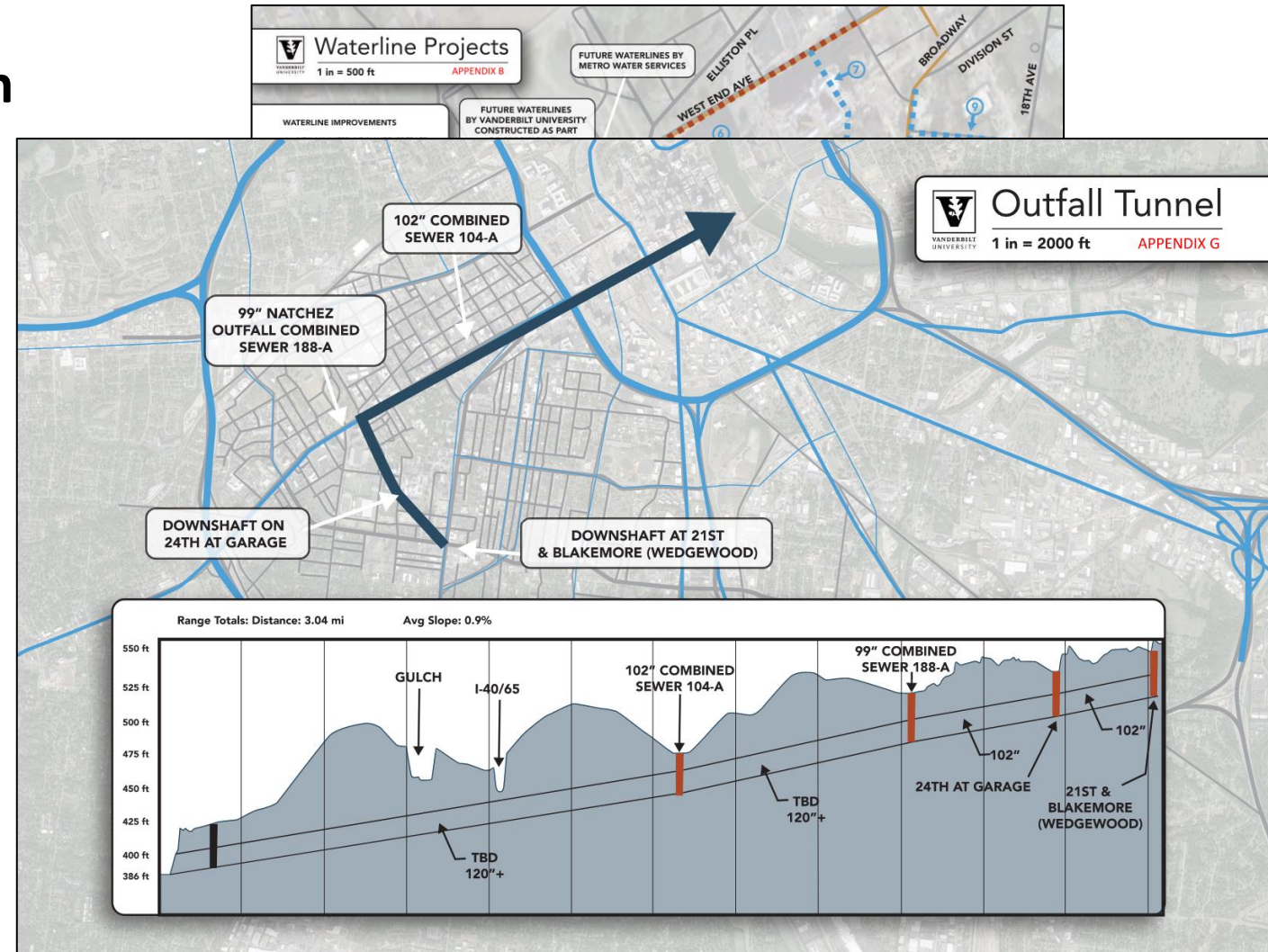
Path Forward – Composite



Water Management Master Plan

Focus: Metro Upgrades / Separation

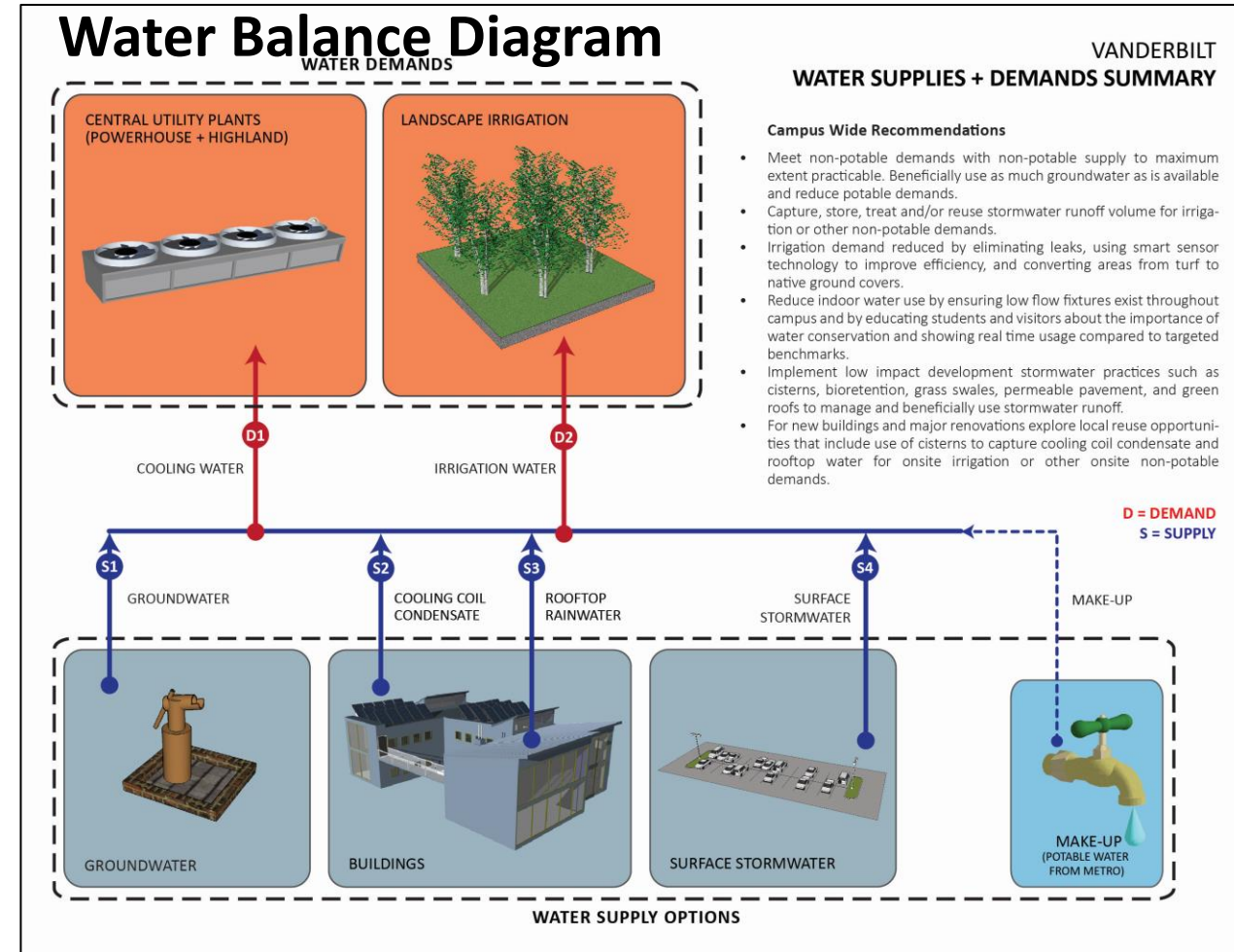
- **Upgrades:** Implementation of sanitary, storm and water upgrades that support the campus development and separate combo sewers.
- **Pipe Dream:** Broadway deep tunnel stormwater project being evaluated by Metro. Alleviates campus and city flooding due to undersized infrastructure.



Water Management Master Plan

Focus: Water Stewardship

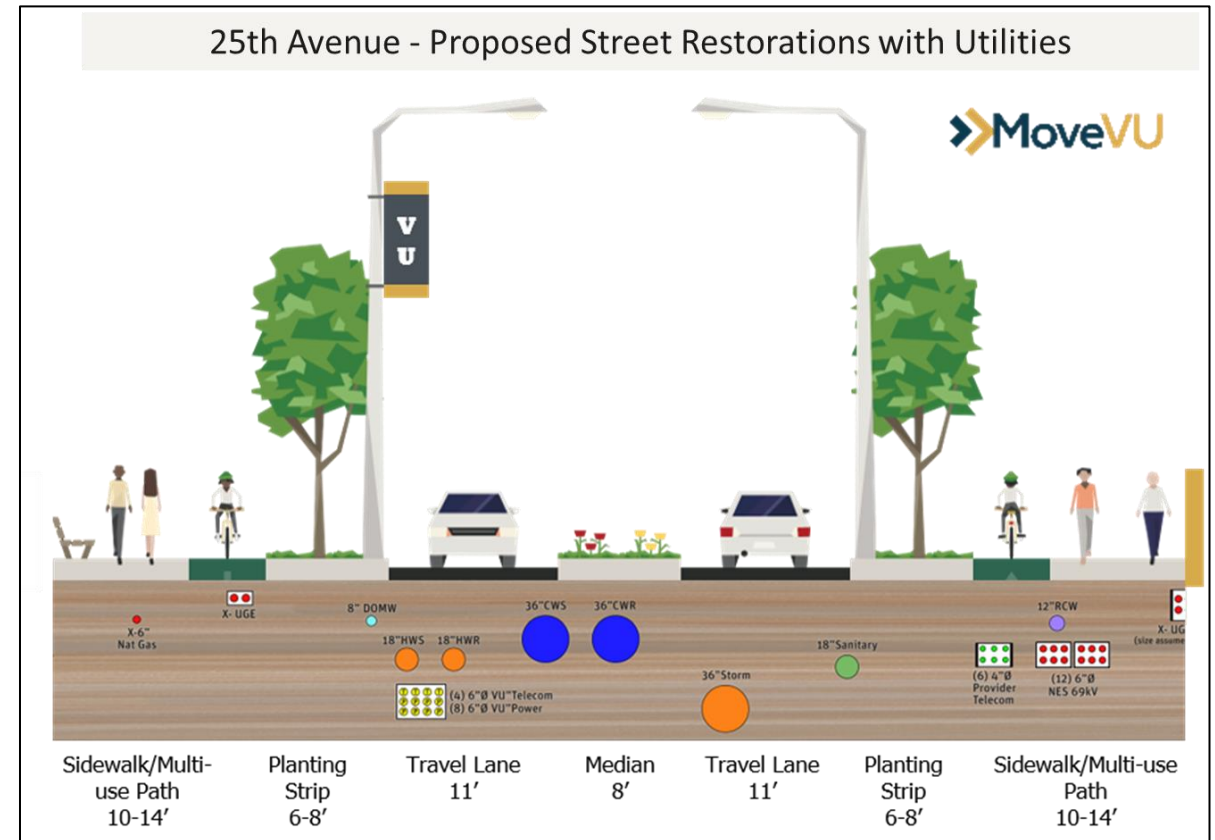
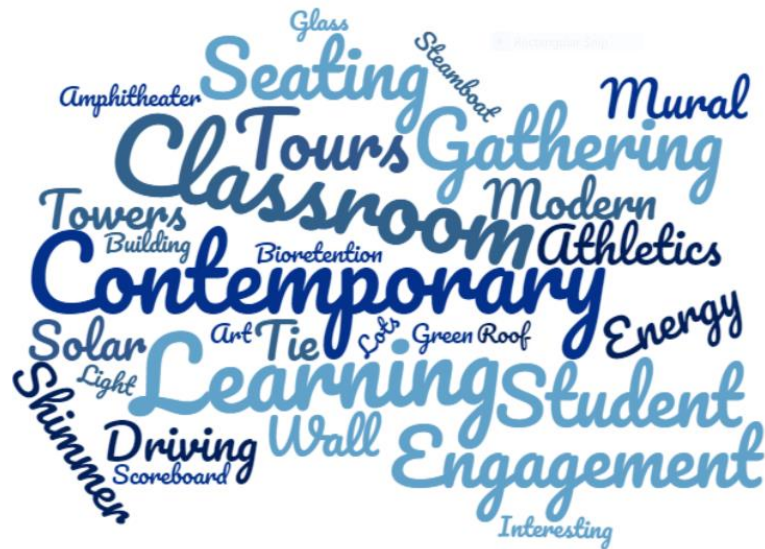
- **Established Series of Goals**
- **Groundwater:** Allocating space within Highland Plant for future groundwater reuse treatment system for makeup water in cooling towers.
- **Irrigation:** Proposed expansion of existing groundwater irrigation system that serves the Student Rec Fields to extend north and include the Athletics Fields.



Central Utilities Initiative – Opportunities

Owner's Project Requirements

- MoveVU
- Underground utility poles
- Minimize campus disturbance
- Engagement with campus



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Pulling it all together...Notable Scope Increases

- **Highland Plant**

- Site Selection
- Integrated Substation
- Loads: Timing & Increase
- Plant Space: Larger, not Phased
- Program Space
- Flex Space
- Downshaft Building Removal

- **Power House**

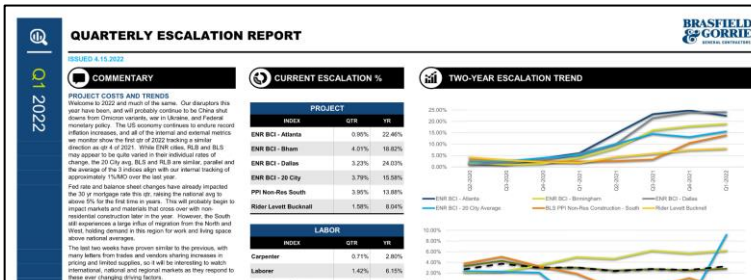
- Larger CT & HRSG (H2 capable)
- Gas Compressor
- Fuel Oil Polishing Systems
- HRSG-1

- **Utility Corridors**

- Incorporation of MoveVU restorations
- Utilities in Public Streets
- Building connections & improvements
- Underground of overhead public utilities (NES & 3rd Party Telecom)
- Water Management Master Plan
- 25th Avenue Tunnel
- WEN Utilities
- VUIT



And then Escalation...



NATIONAL

WHAT IS IN THIS REPORT? Among the information included in this publication and of special importance, is the Turner Building Cost Index. The Turner Cost Index, an industry recognized index now for over half a century, is determined by several factors considered on a nationwide basis, including labor rates and productivity, material prices and the competitive condition of the marketplace. The index does not necessarily conform to other published indices because those do not generally take all of these factors into account.

Our mission in publishing this report is to share thoughtful insight with professionals we engage with in our industry regarding trends and their potential impacts.

MATERIAL

Material Producer Price Index * The selling price in processed goods used or bought for construction.

In Dec 2021, total material inputs to construction increased +4.3% since Sept 2021 and +19.7% since Dec 2020.

MATERIAL, LABOR & CONSTRUCTION PRICING

Graphic representation of tables to the left:

- MATERIAL** - Total Inputs to Construction Material PPI
- LABOR** - Construction Employment Cost Index
- CONSTRUCTION PRICE** - Final Demand Construction PPI

Over the 12 month period from Dec 2020 to Dec 2021, the Total Inputs to Construction PPI increased +19.7%, the Employment Cost Index increased +3.9%, and the Final Demand Construction PPI increased +12.5%.

Material PPI - 12/21	Qtr	Yr
Inputs to Construction	+4.3%	+19.7%
Ready Mix Concrete	+1.1%	+7.1%
Steel Mill Products	+7.0%	+127.2%
Flat Glass	+2.9%	+47.2%
Aluminum Mill Shapes	+1.2%	+29.9%
Sheet Metal Products	+6.6%	+36.9%
Gypsum Products	+1.6%	+26.7%
Diesel Fuel	+1.1%	+54.9%
Construction Machinery	+4.3%	+30.1%

LABOR

Construction Employment Cost Index * The cost to employers for wages and salaries, employer share of benefits, and legally required payments such as unemployment and workers' compensation.

Through Sept 2021, construction wages and salaries increased +0.5% for the quarter and +3.9% for the year.

Construction Employment Cost Index	Qtr	Yr
Total Compensation	+0.4%	+3.0%
Wages & Salary	+0.5%	+3.9%

Construction Employment * The employment rate in construction, not seasonally adjusted.

Through Dec 2021, construction employment increased by 113,000 jobs (+1.52%) since Sept 2021.

TURNER BUILDING COST INDEX

The **Turner Building Cost Index** is determined by the following factors considered on a nationwide basis: labor rates and productivity, material prices and the competitive condition of the marketplace.

The 4th Qtr index value of 1230 is a +1.93% change from the 3rd Qtr. The last four quarters indicate a cumulative +4.96% increase.

Turner Cost Index - Quarterly Index

Turner Cost Index - Average Index

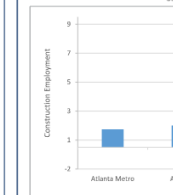
Quarter	Index	%
4th Quarter 2021	1230	1.93
3rd Quarter 2021	1207	1.08
2nd Quarter 2021	1187	1.28
1st Quarter 2021	1172	0.99

Year	Avg Index	%
2021	1199	1.9
2020	1177	1.8

ATLANTA

CONSTRUCTION EMPLOYMENT

Construction Employment Dec 2020 - Dec 2021



CONSTRUCTION ECONOMICS

ENR's 20-city average cost indexes, wages and material prices. Historical data for ENR's 20 cities can be found at ENR.com/economics

Construction Cost Index	ANNUAL GROWTH RATE
MAY 2022	+8.5%
Building Cost Index	ANNUAL GROWTH RATE
MAY 2022	+15.3%
Materials Cost Index	ANNUAL GROWTH RATE
MAY 2022	+3.0%

The Construction Cost Index's annual escalation rate is 8.5%, while the monthly component rose 0.8%.

The Building Cost Index was up 15.3% on an annual basis, while the monthly component increased 1.4%.

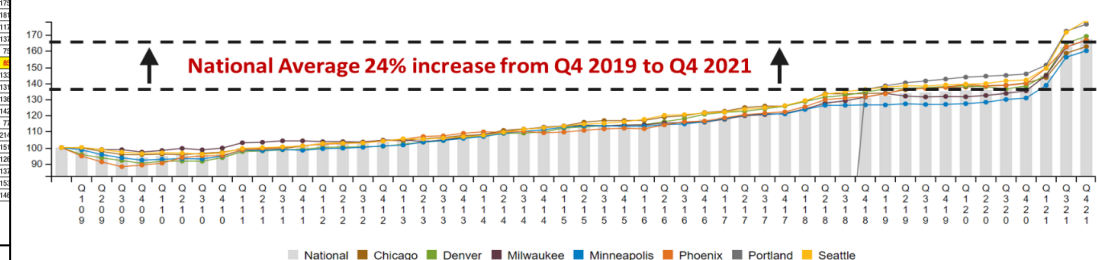
The MCI rose 3% since last month, while the annual escalation rate rose 0.8%.

Construction starts in the Denver metro area are expected to rise 12.5% in 2022, to \$10.8 billion, according to Dodge Data & Analytics. Dodge predicts a 33.3% increase in non-residential construction, while residential work is expected to rise 4.5%. Warehouse, retail and education construction are expected to see the largest increases, while total work is predicted to

Overall Construction Cost Index Q4 2021

(JANUARY 2009 = 100)

Source: Mortenson Construction



CONCLUSION

- Reality:** Construction materials remain at or near all time highs with most materials expected to continue growing modestly in cost through 2022. Current prices could be the new normal.
- Recognize:** Inflation, largely silent for a decade, is very much alive and kicking.
- Watch Supply:** Logistical and manufacturing issues are delaying a market correction. Clogged ports, lack of parts and chips, lack of workers, continue to burden manufacturing.

es: Keep a continued eye on the labor wages. High demand for borers is pushing wages higher.

he Envelope: The use of jobsite technology and Prefabrication may be improvement to labor shortages.

Ordering materials with long lead times earlier in the design process, setting upon a generic approach. However, this introduces some risk if just change.

n: a minimum 6% inflation factor should be considered for future work 2022, then at least 4% - 5% for the next several years.

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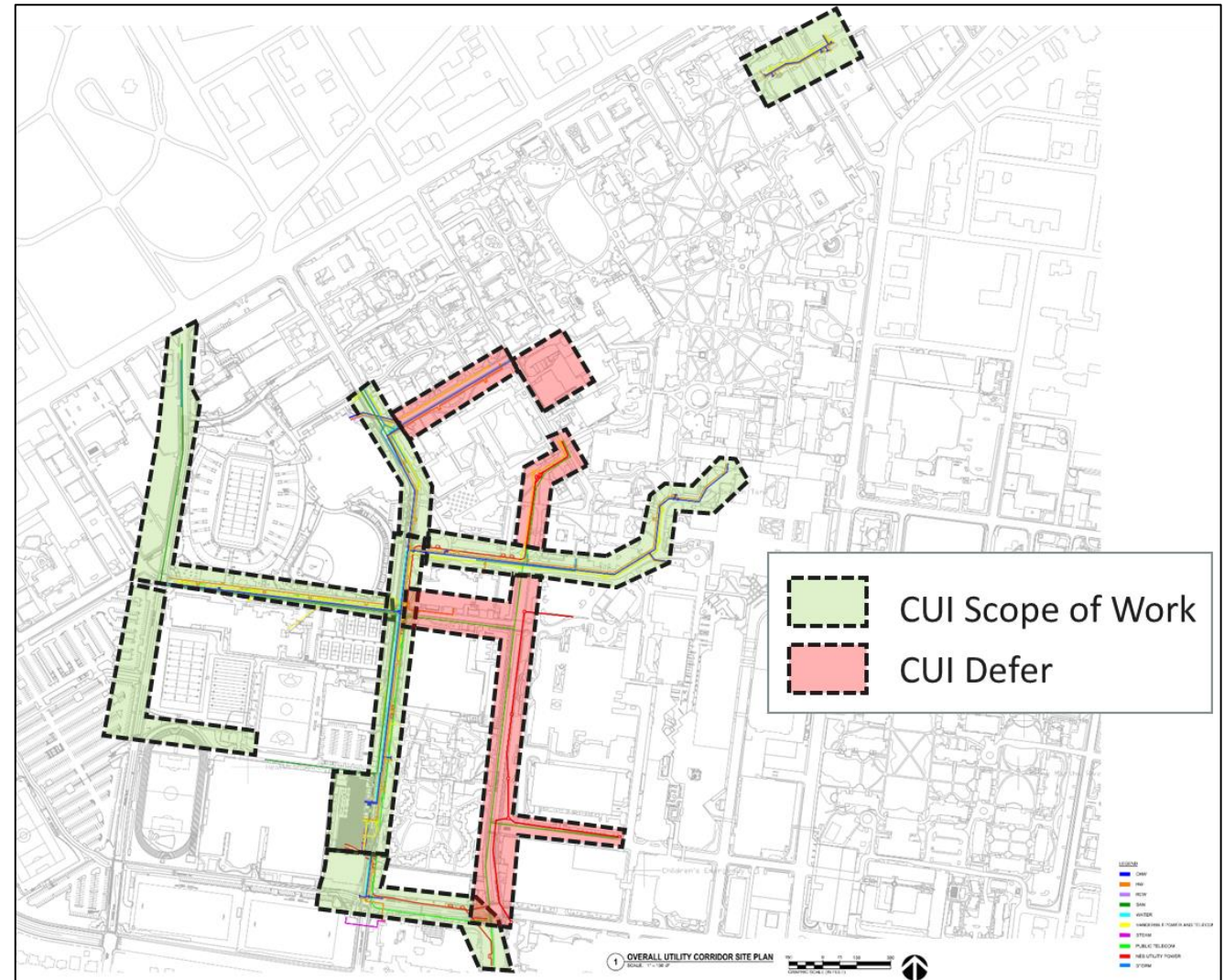
Affiliated Engineers®



INTERNATIONAL DISTRICT ENERGY ASSOCIATION

What's being implemented?

- Highland Plant
 - 11,200 T initial / 14,000 T full build
 - 160 MMBtu
 - Integrated 100 MVA substation
- Utility Corridors
 - Hot Water
 - Chilled Water
 - VU Power
 - VU IT
 - Sanitary
 - Stormwater
 - Road Beautification
 - NES and 3rd Party Telecom ductbanks



Challenges with Implementation of CUI

First Cost

- Resiliency
- Efficiency
- Phasing
- Scope creep
- Connecting developer buildings
- Undergrounding overhead systems

Technical

- Why hot water?
- Why continuation of Cogen?
- Modification of building standards
- Changing refrigerant landscape
- Series counter flow 480V chillers
- Integration of reclaimed water



Planning for, Quantifying and Selling Resiliency

#1 Bring back to VU Goals

1. Supports Vanderbilt's Mission

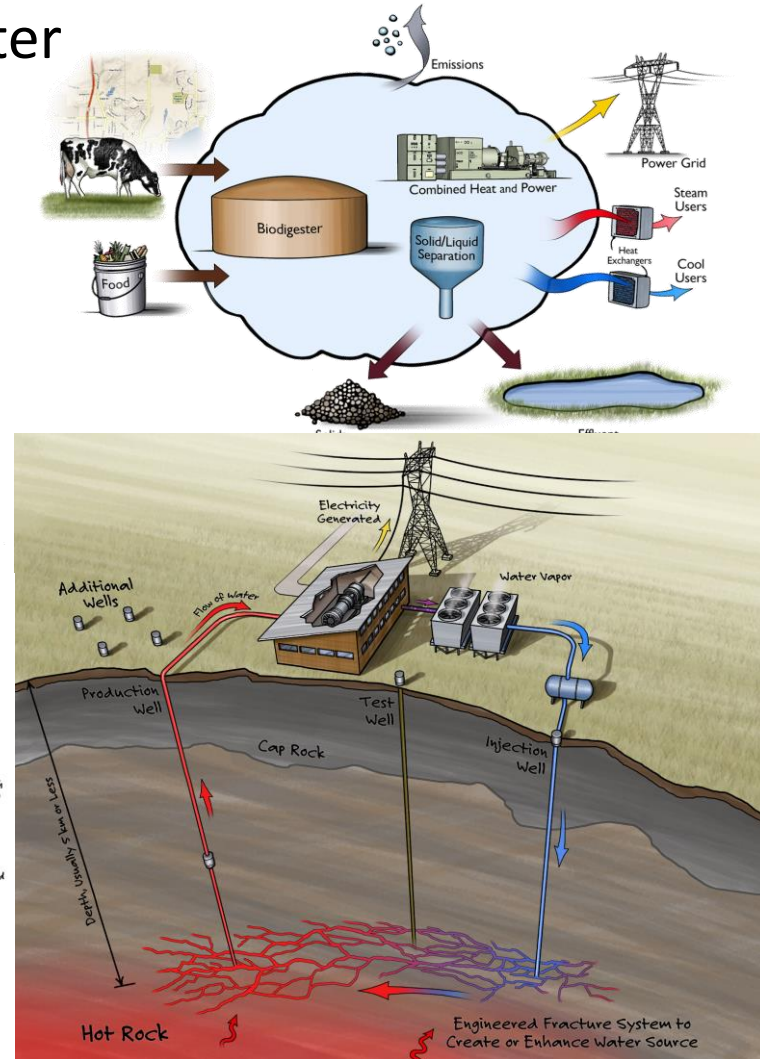
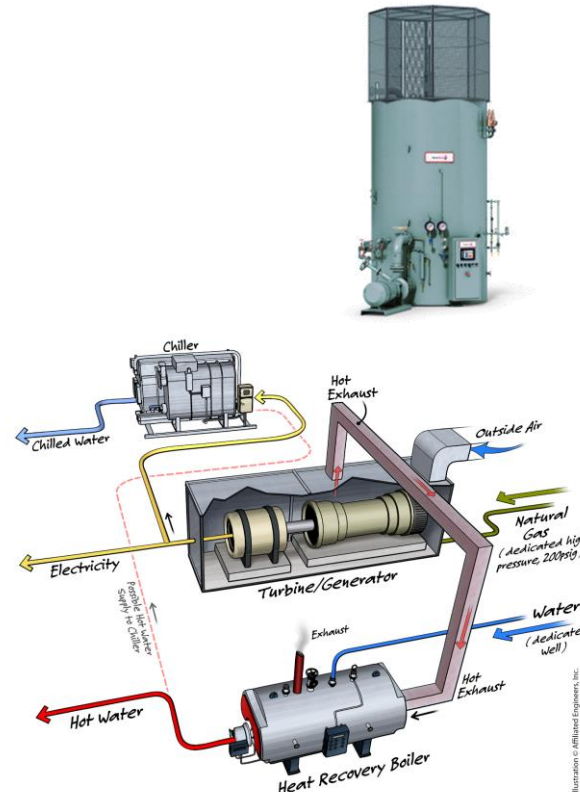
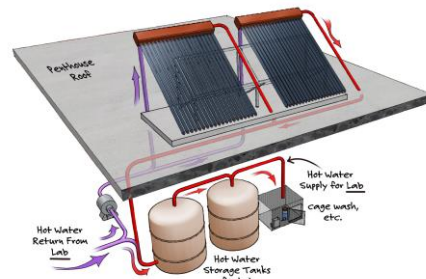
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Why hot water?

- These sources can be used directly for heating hot water

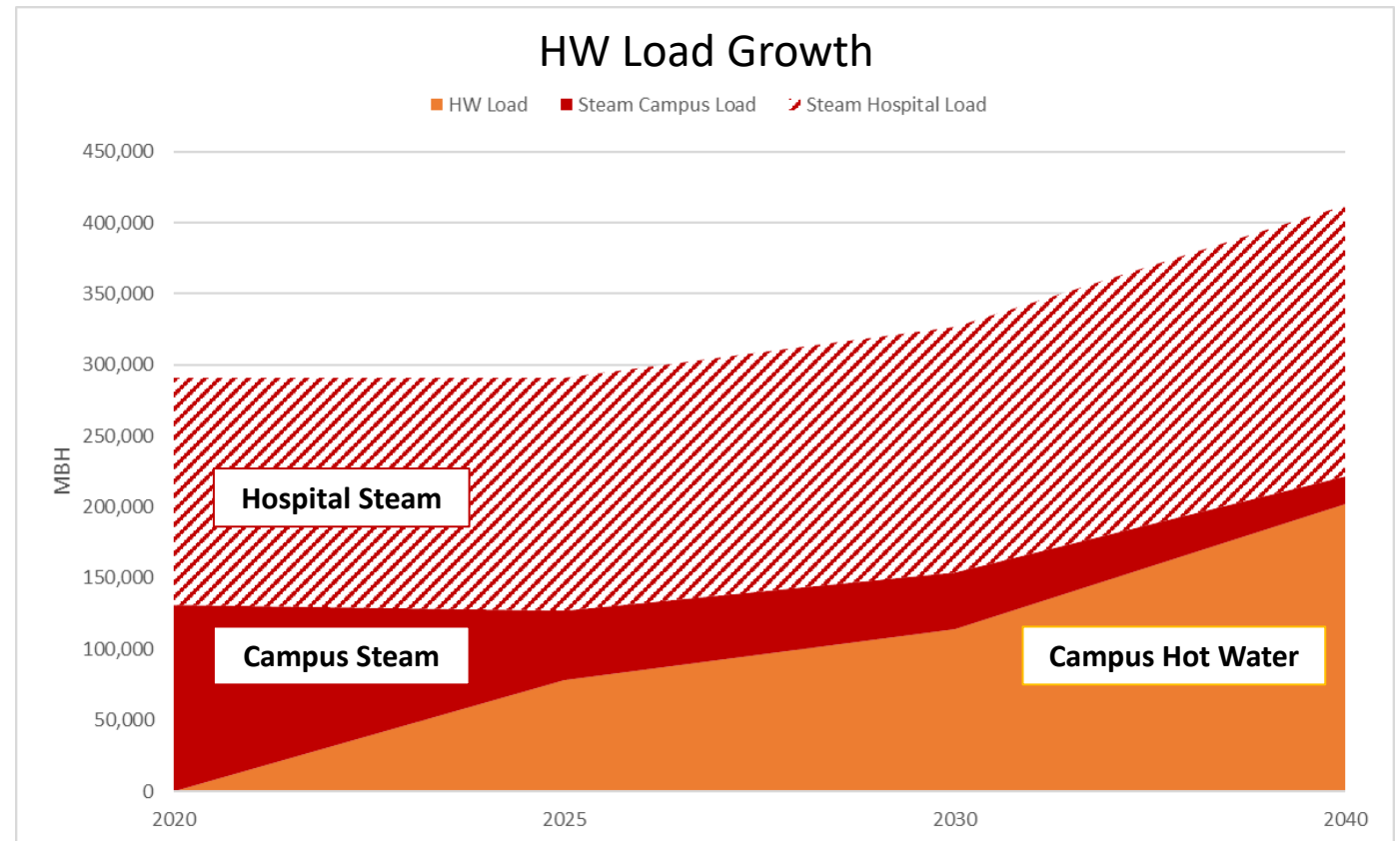
- ☐ Natural gas with carbon capture
- ☐ Biofuel
- ☐ Electric hot water generators
- ☐ Geothermal – very deep wells
- ☐ Hot water solar
- ☐ Combined Heating and Cooling
- ☐ Heat pump (Geothermal)



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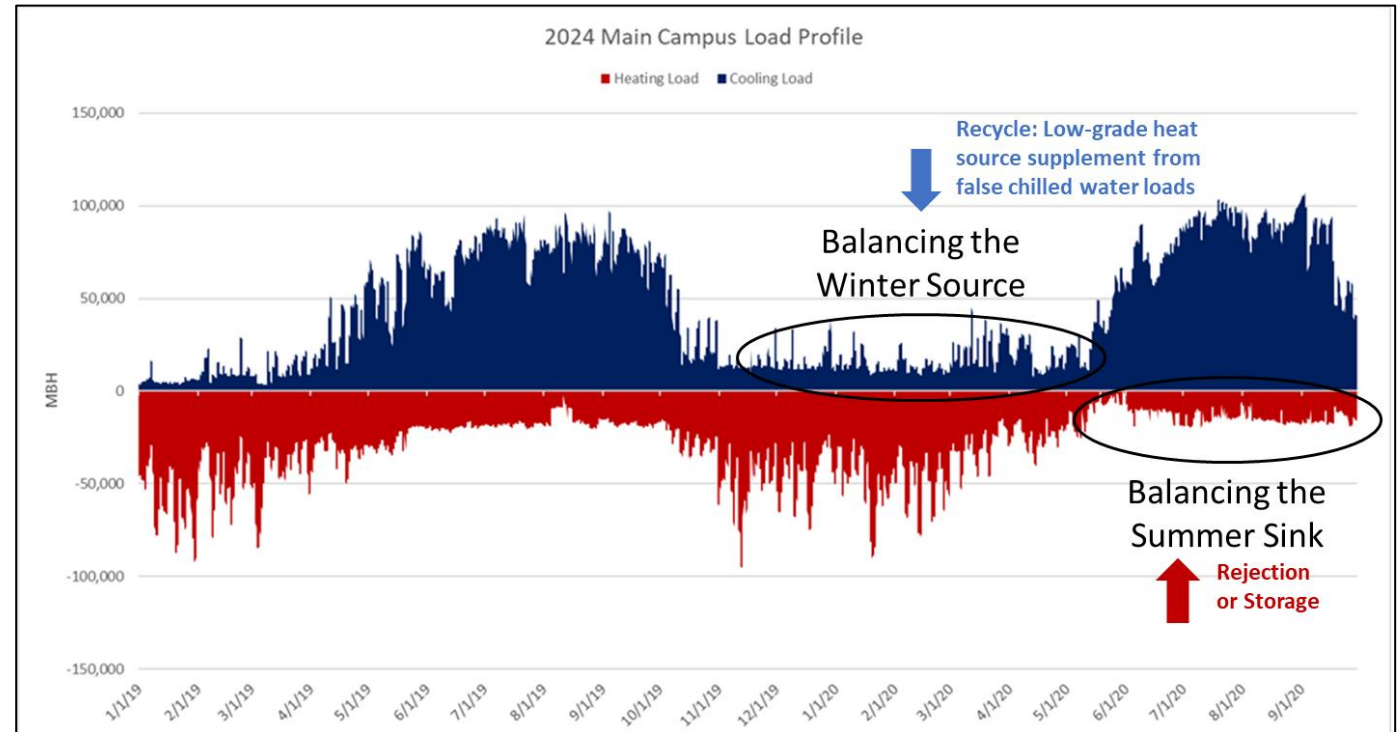
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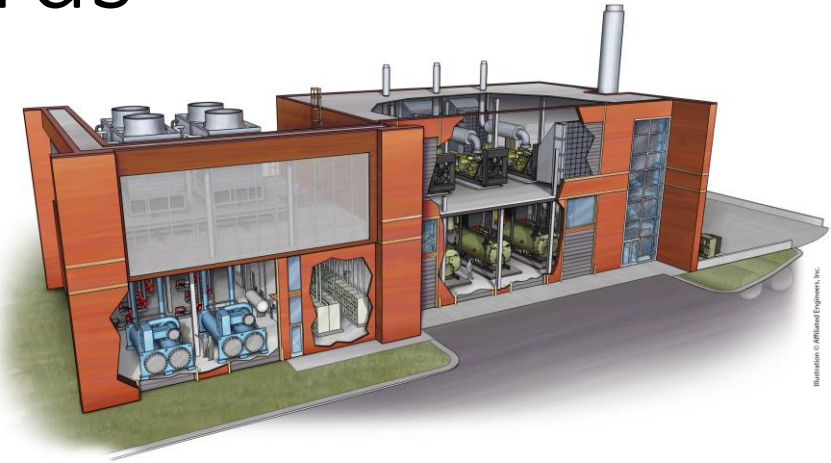
What does this mean to VU?

- Additional winter heat source.
- Additional summer heat sink.

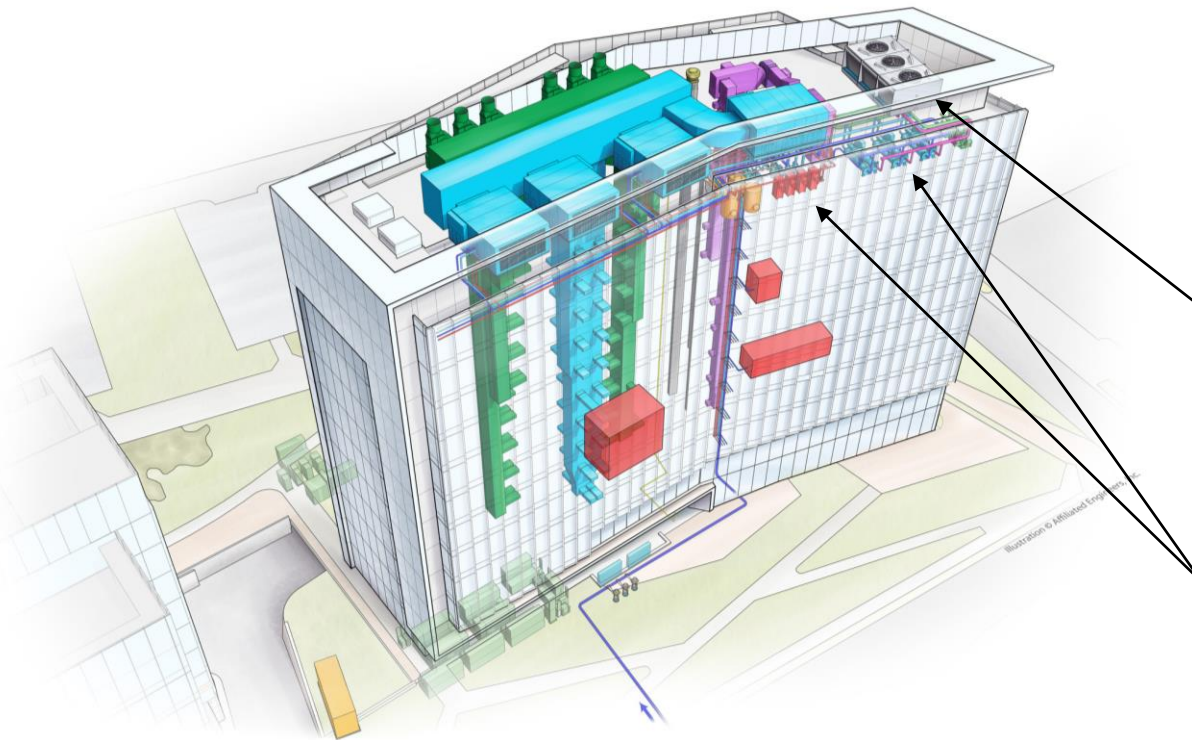


Modification of Building Standards

Centralized thermal systems example:
Consolidated equipment in a plant with underground distribution to buildings



Decentralized thermal systems example:



Cooling towers must be incorporated into the architecture and are difficult to access for maintenance

Chillers and boilers are typically located in basement or penthouse and difficult to access for maintenance

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Lessons Learned

- Establishment of Goals
- Campus leadership communication
- Coordination with other planning
 - IT / Water / Sewer / Storm / Metro
- Target Value Design
- Establish a Pivot Plan



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A vertical strip on the left side of the slide shows a building at night with lights reflecting in water.

Questions?

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Thank You!

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