Introduction to the “MIT Thermal Energy Networks (MITTEN) Plan for Rapid, Cost-Effective Campus Decarbonization

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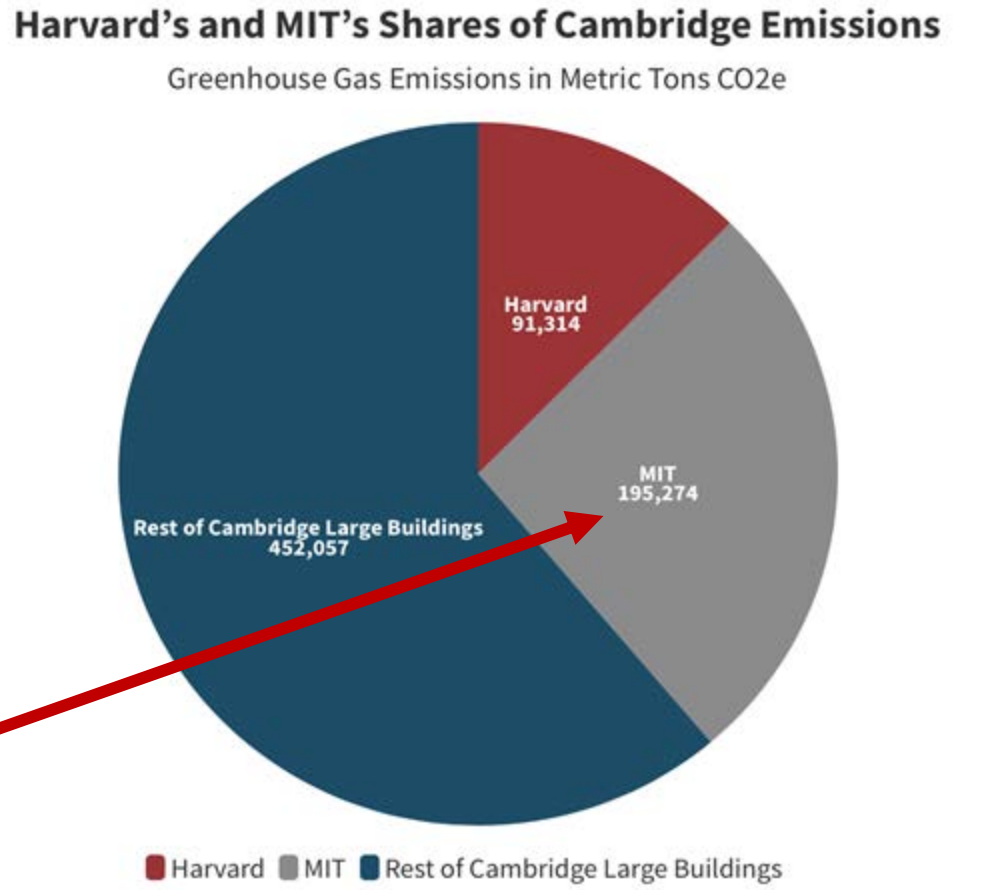
Geothermal Energy Networks Workshop
Jan. 30 – 31, 2025

MIT D-Lab designing for a more equitable world

MIT MANAGEMENT SLOAN SCHOOL

MIT's Decarbonization Challenge

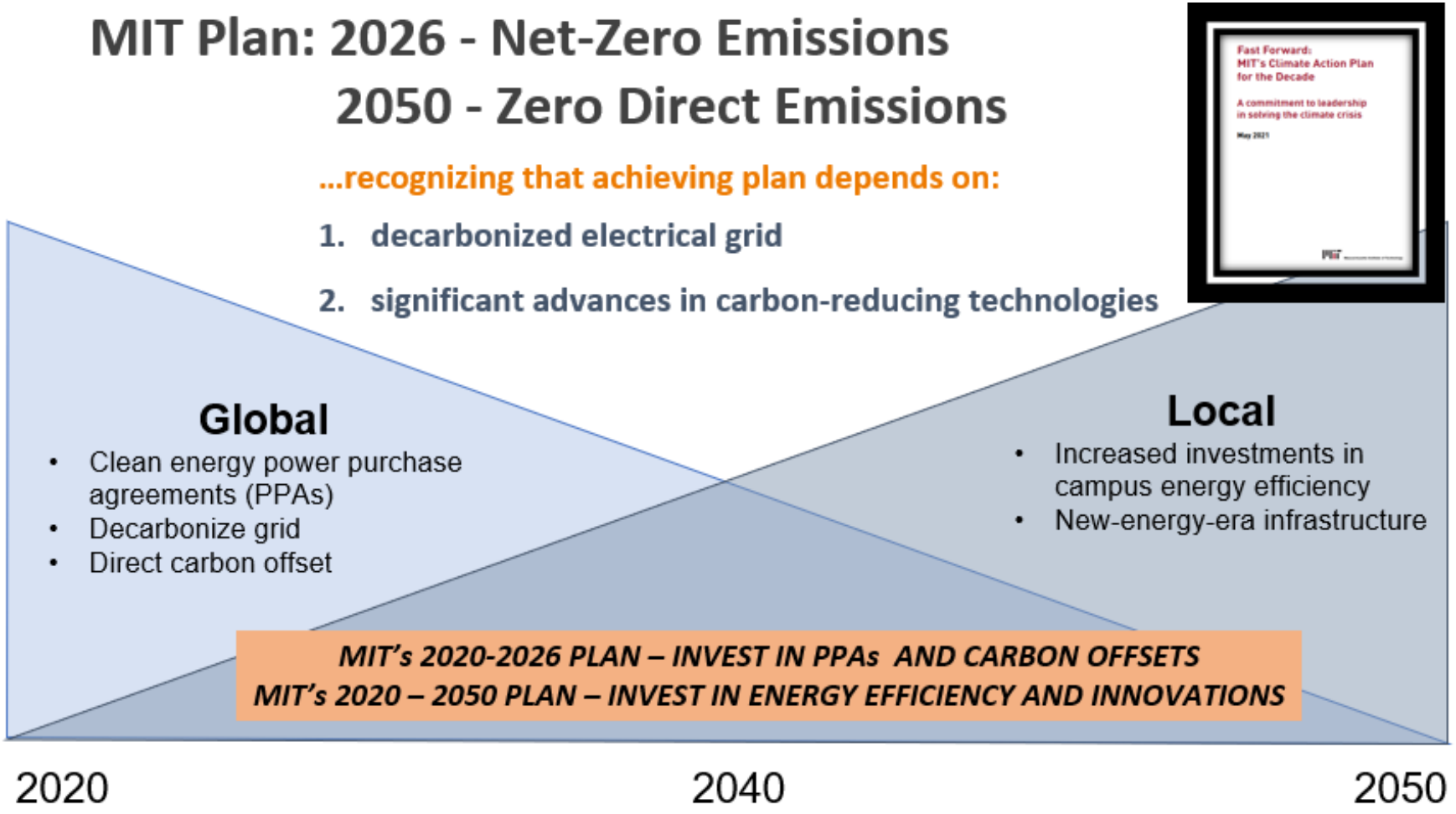
- 97% of MIT's greenhouse gasses are from the operations of its buildings.*
- 26% of all Cambridge's greenhouse gases are from MIT.



Source: Cambridge Open Data • By Julian J. Giordano—Crimson Designer
Data from the most recently published BEUDO report, which includes reporting from 70 percent of buildings under the ordinance.

* MIT Office of Sustainability Website:

MIT's Climate Action Plans (2016) and (2021) postpone significant investment in direct MIT Campus Decarbonization until later.



Slide credit: Steve Lanou, MITOS, 2023

The MIT Thermal Energy (MITTEN) Decarbonization Plan

- All-electric campus fueled by carbon-free power.
- Implementing energy conservation measures including waste heat recovery from ventilation systems to reduce heating and cooling demand.
- Installing high-efficiency Water Source Heat Pumps in each building for heating and cooling

MITTEN Decarbonization Plan (con't)

- Repurposing existing chilled water loop to an Ambient Loop, circulating 45-85^{o}F water year-round to WSHPs in each building

- Repurposing oil tanks at the CUP for thermal storage

- Energy Transfer Stations operated by the Cambridge Water Department exchange heat with the Ambient Loop. If not possible, connect to existing wastewater sewerage or drill geothermal boreholes

MITTEN: Thermal Energy Network Advantages

MITTEN plan is the most cost-effective and energy-efficient way to heat and cool campus buildings:

- Demonstrates MIT's leadership,
- Leverages MIT's investment in existing infrastructure,
- Eliminates cost impact of maintaining separate systems because WSHPs provide both heating and cooling;
- Eliminates energy transmission losses;
- Enables the capture of "free energy" when there is concurrent heating and cooling on campus;
- Might tap into federal and state subsidy program.

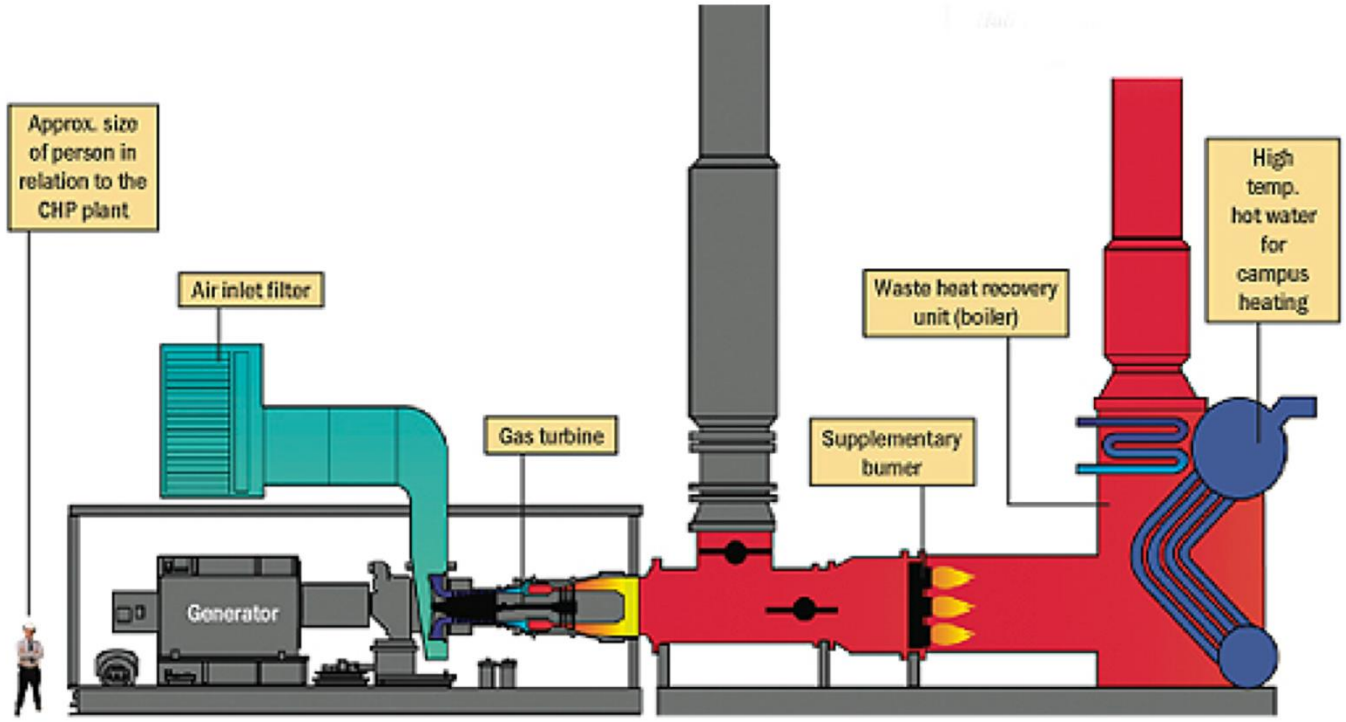
Met Building (W41) demonstration project is already underway!

How Is Campus Heated/Cooled Now?

- Central (CUP) with co-generating gas turbines.
- Produces steam and hot water.
- Operates steam-driven chiller.
- Generates over 22MW electric power.
- Connected to steam distribution system
- Connected to chilled water distribution to most buildings
- Cooling load is high and most affected by global warming

DECARBONIZATION ISSUES WITH EXISTING CENTRAL PLANT:

- Grid decarbonization is rapidly reducing carbon once touted for Combined Heat and Power (CHP)
- Fossil Fuel Backup is necessary.
- Efficiency of 50-55% source to output.
- Low Turndown Ratio (30%)
- High Thermal Loss in the steam distribution system (10%-20%)
- Non-zero losses in the Chilled Water System (5%-15%?)
- *BTW: Hot water district systems have losses in the 15%-20% range due to additional piping.*

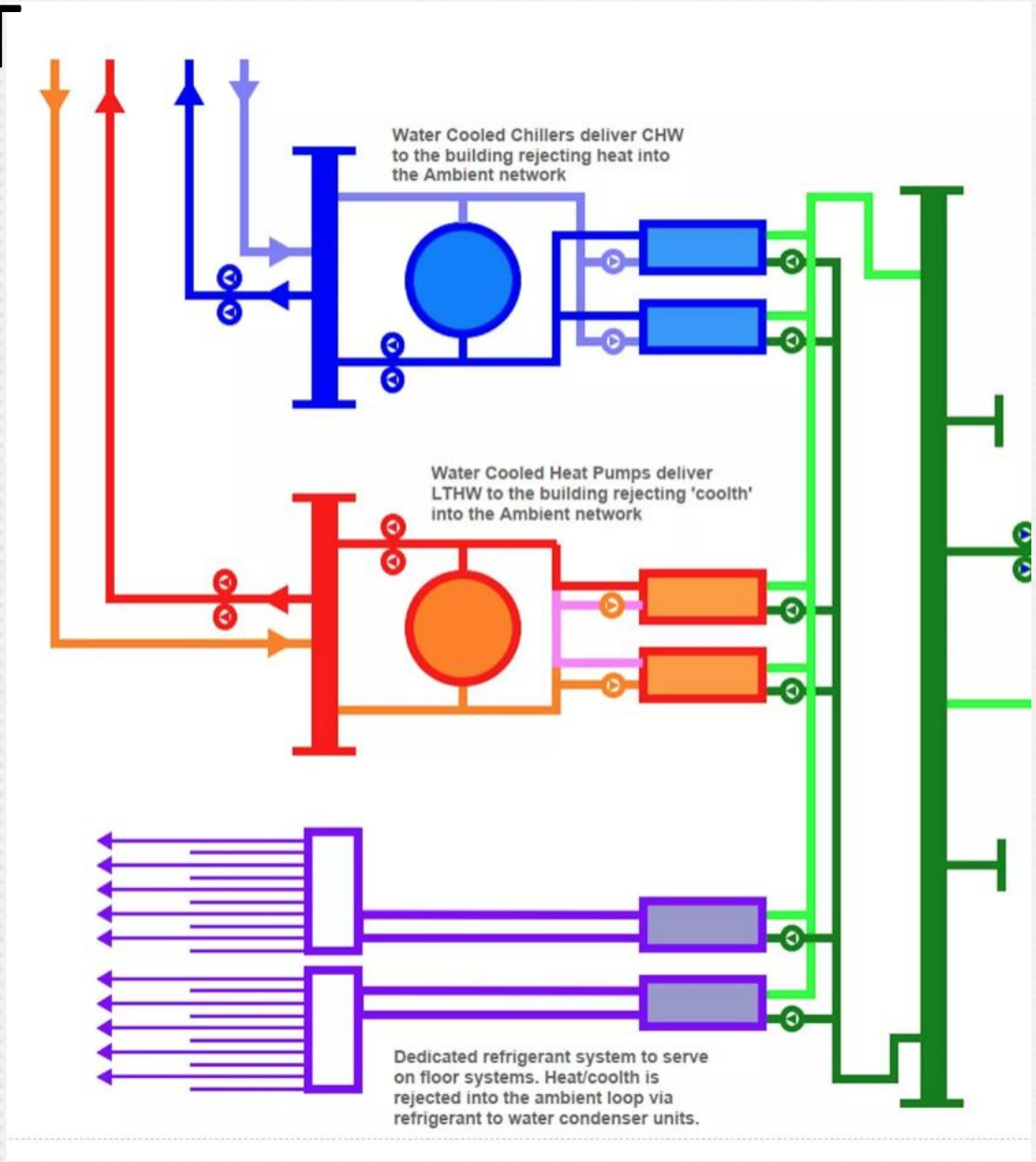


Source: University of Calgary

Source: public domain

HOW WOULD MITTEN HEAT AND COOL THE CAMPUS?

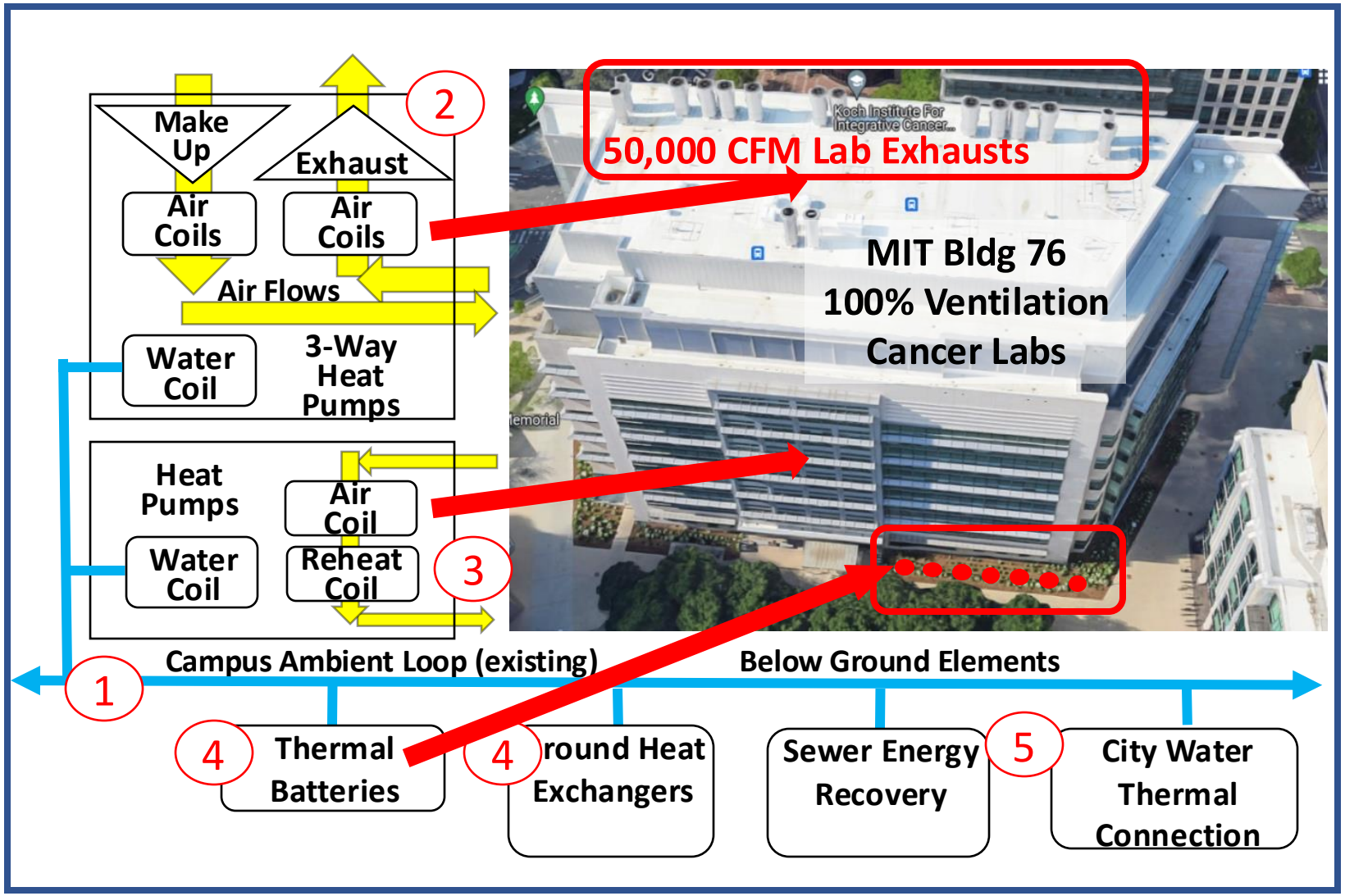
- DISTRIBUTED HEAT PUMPS CONNECTED INTO A NETWORK OF SOURCES AND SINKS.
- NO ONE SOLUTION SINCE THE BUILDINGS RANGE OVER A HISTORY OF 100 YEARS.
- USE OF BUILDING TO BUILDING AND BUILDING IN BUILDING SOURCES AND SINKS.
- USE OF THERMAL STORAGE AND GROUND COUPLING.
    - CAMBRIDGE WATER THERMAL ACCESS
    - SEWER THERMAL ACCESS
    - GROUND THERMAL EXCHANGERS



5th/6th Generation District HVAC Decarbonization

Key Transitions:

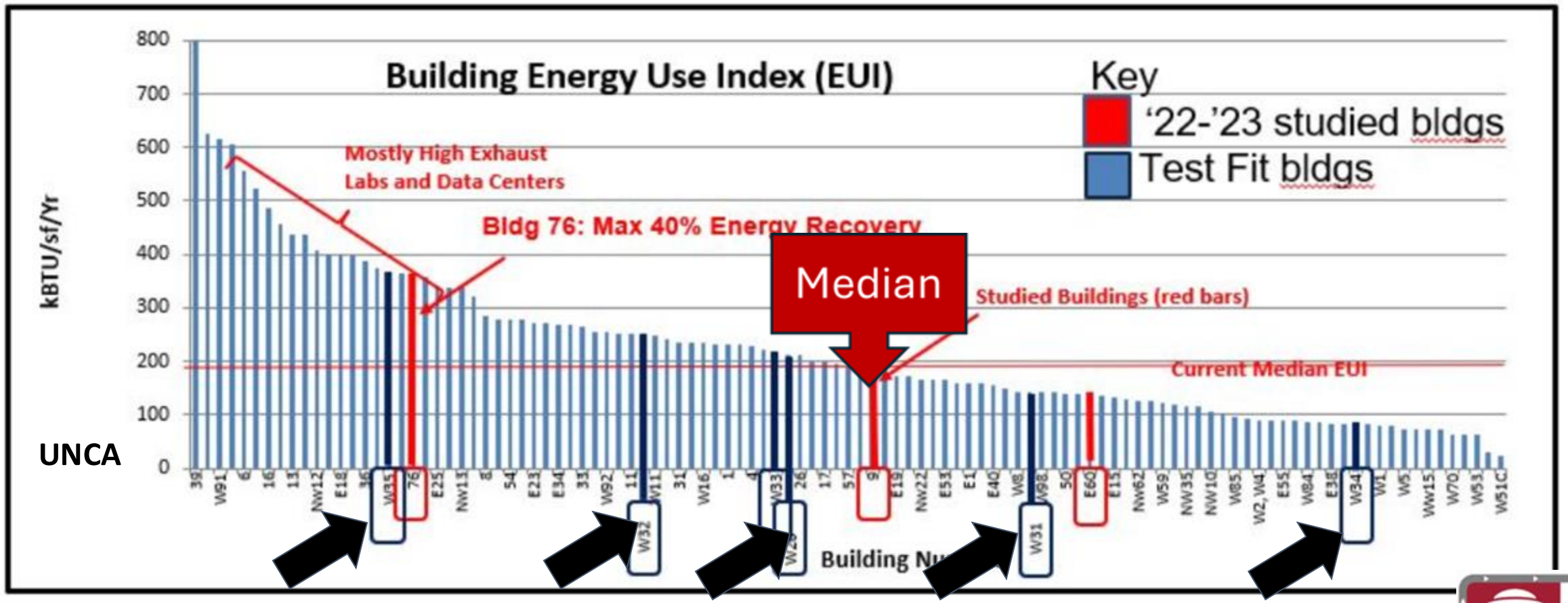
1. Ambient Loop
2. Exhaust Recovery
3. Distributed WSHPs
4. Thermal Storage, ASHP, GHEX
5. Municipal Water Thermal, CSP Solar, Other



The MIT Solution: Chiller Loop to Ambient Loop Conversion: Same 2 pipes w/o thermal limits, add heat pumps and sources/sinks

- Very little new pipe needed
- All new pipe HDPE/PP fusion welded
  - Will outlast the buildings!
  - Far less costly to install
  - Can use horizontal boring to install

MIT Buildings:
Wide Range of Energy Efficiencies, All High!



6 Test Fit Buildings: W35 W32 W33 W20 W31 W34

Adding New Ambient Loop Pipe in W33
3D Graphic - Hanging Pipe in Available Space

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MITTEN


Henry G. Steinbrenner '27 Stadium
MIT Building W32
MIT Building W31
duPont Athletic Center
Layers
Google
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W20

Multi-Stack Heat Pump Units on Roof of Stratton Building

3D Infographic

Electrical room

Mechanical room

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MITTEN

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W34

Option 1: Multistack -> Mech Room (W34-228)

Multistack

Modular units

Dimensions (12 Units)

H:60”

W:50”

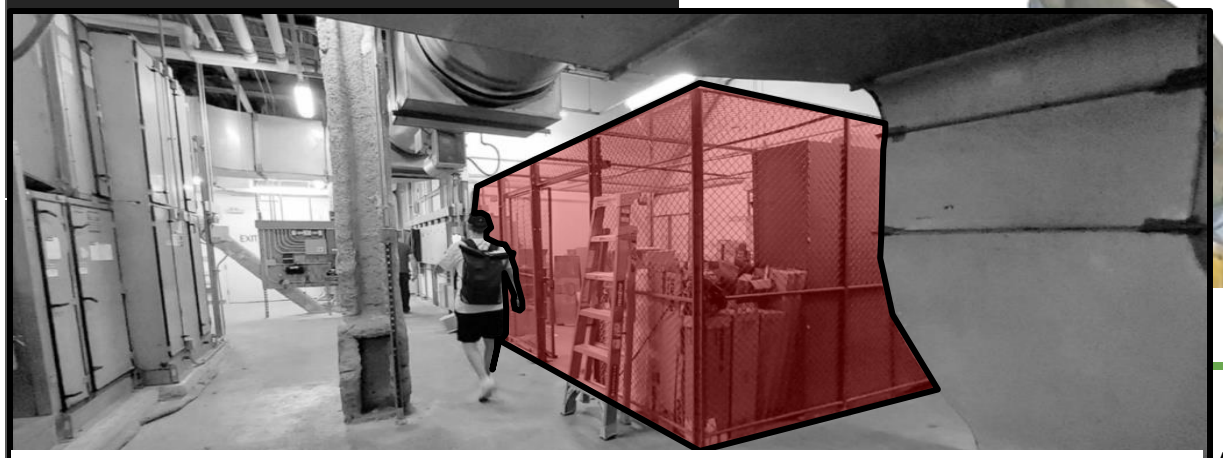
D:32”

Distance

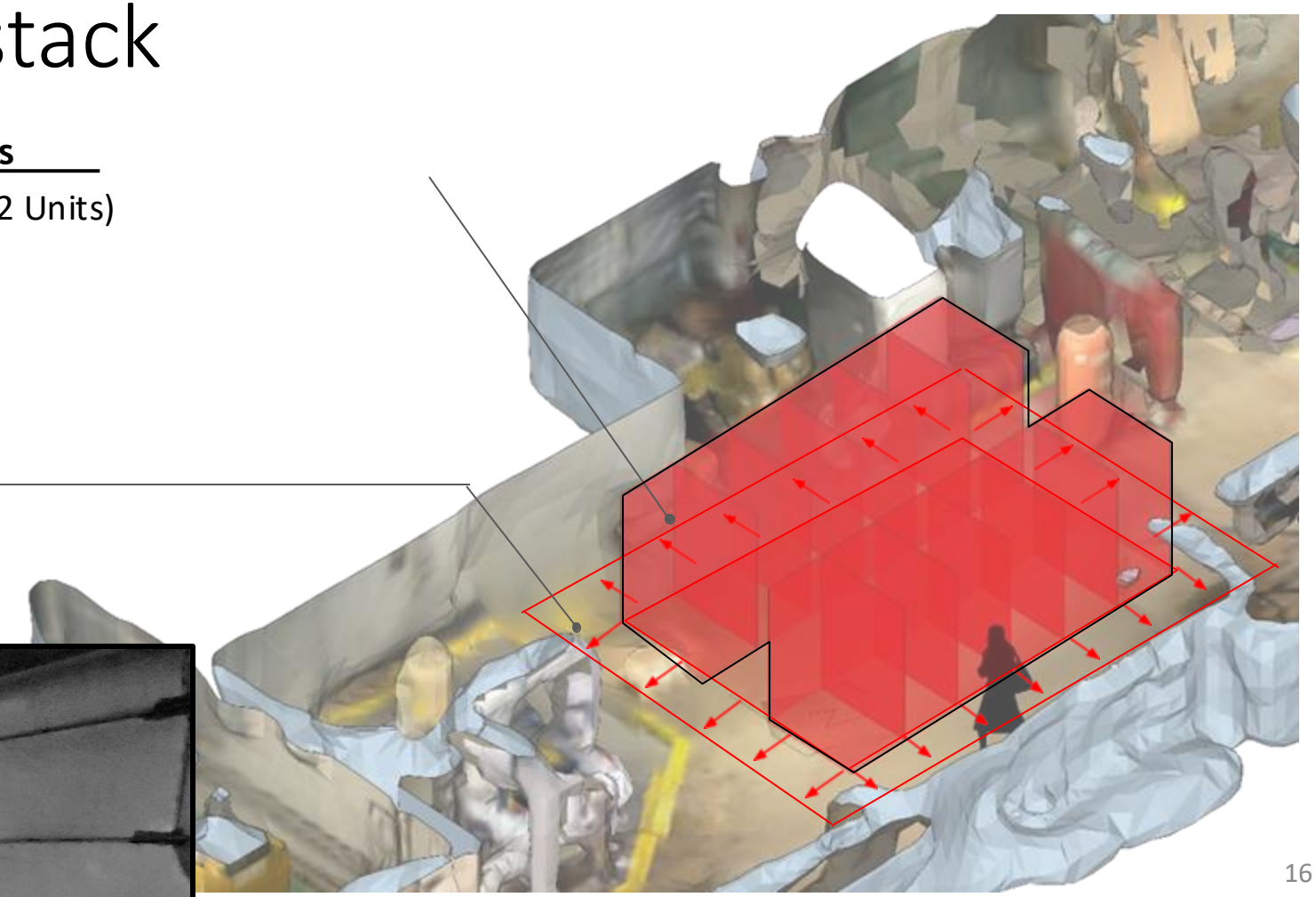
offset distance

W:42”

D:36”



Also used photo analysis



Source: Figure created by the author

AAON
A-23

4 x ??
(exhaust)

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MITTEN

MACA-Campus GEO@MIT

W34

Option 2: AAON SA-23 Heat Pumps -> Mech Room (W34-125M)

3D Infographic

Electrical room

Mechanical room

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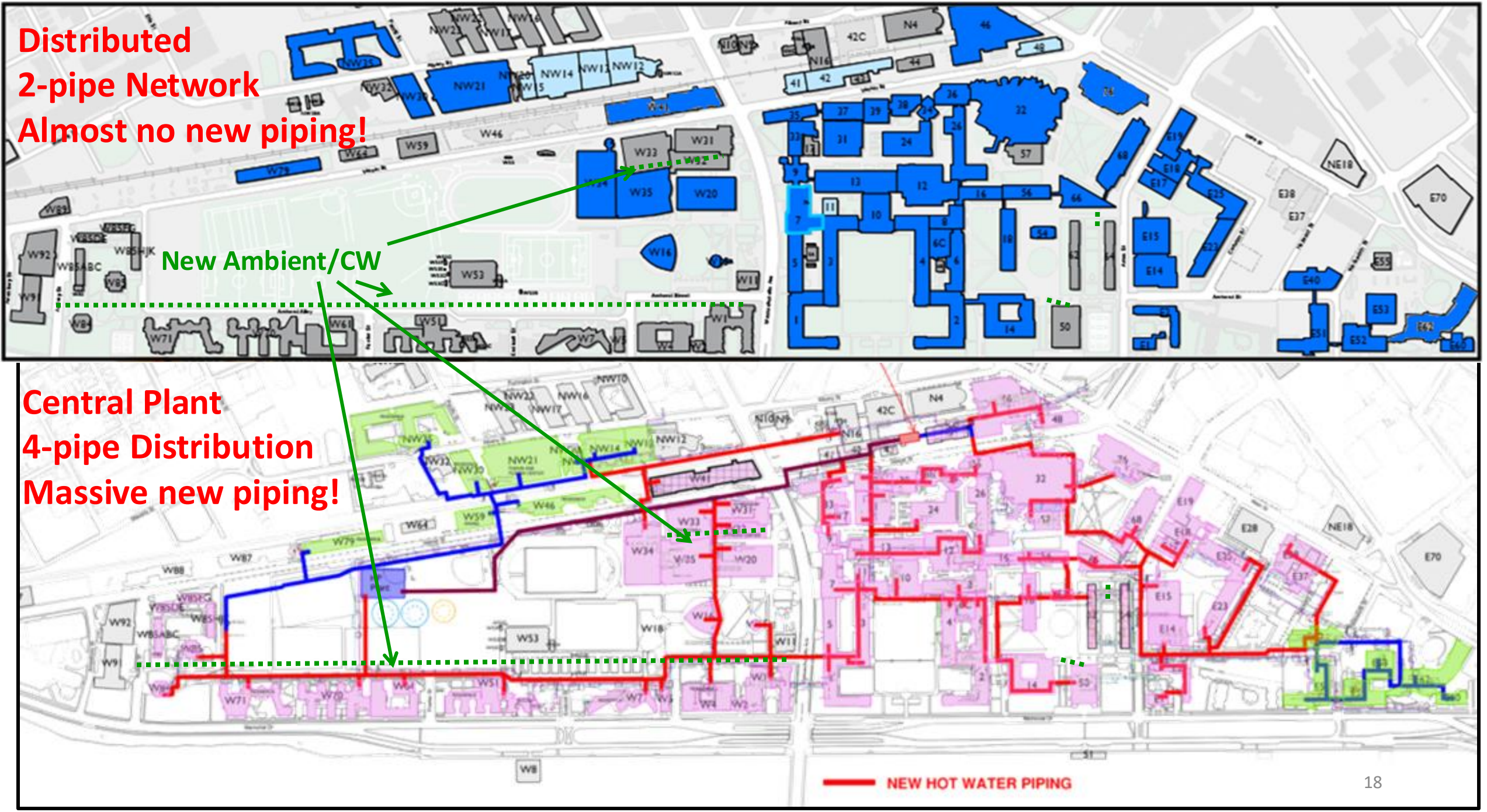
Modular units dimensions

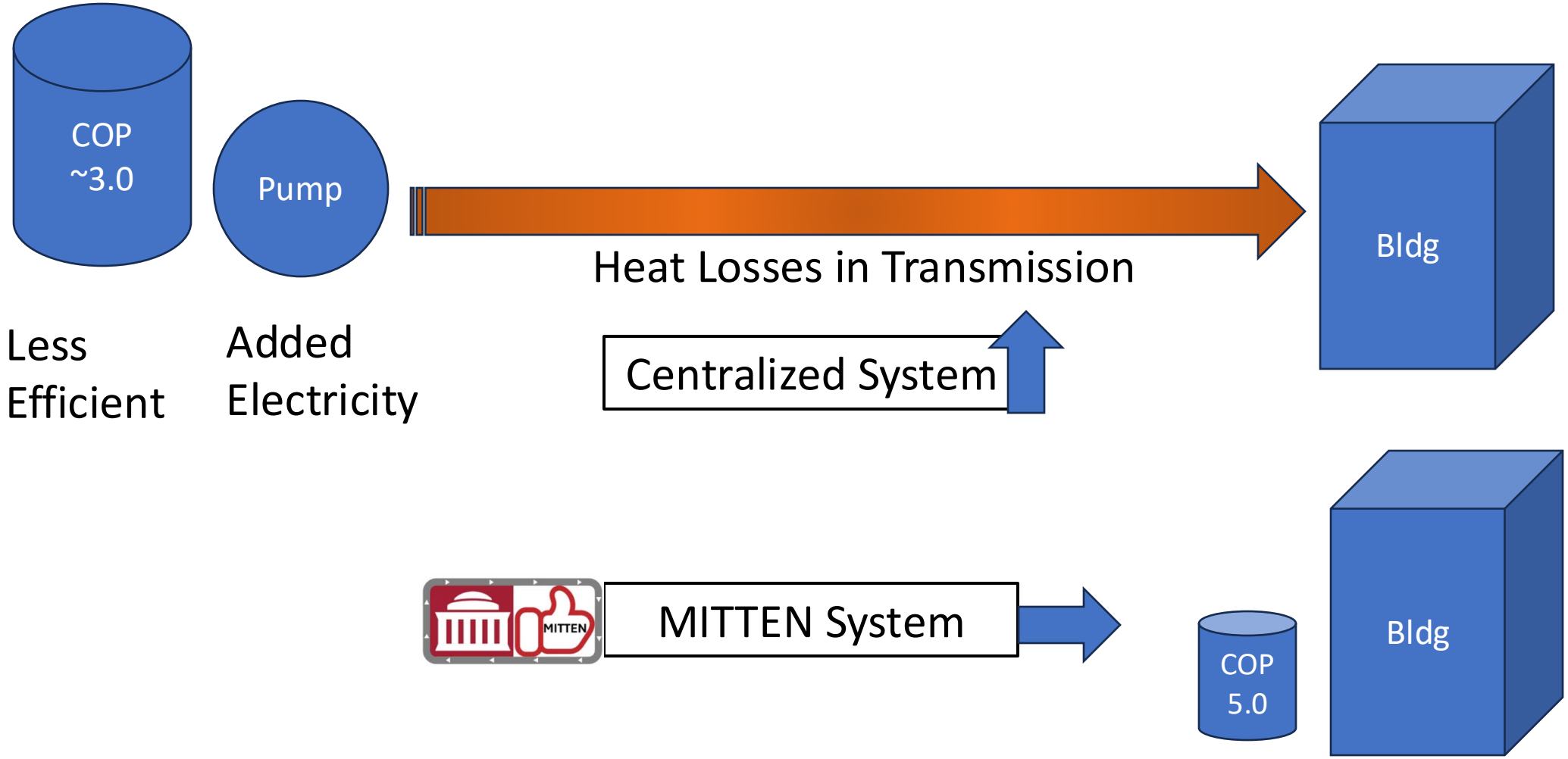
(4) UNITS

H:9’ W:6.2’ D:5’

MITTEN


Distributed
2-pipe Network
Almost no new piping!
New Ambient/CW
Central Plant
4-pipe Distribution
Massive new piping!
NEW HOT WATER PIPING

Hot Water for Heating
Central Thermal Plant vs Distributed Heat Pumps

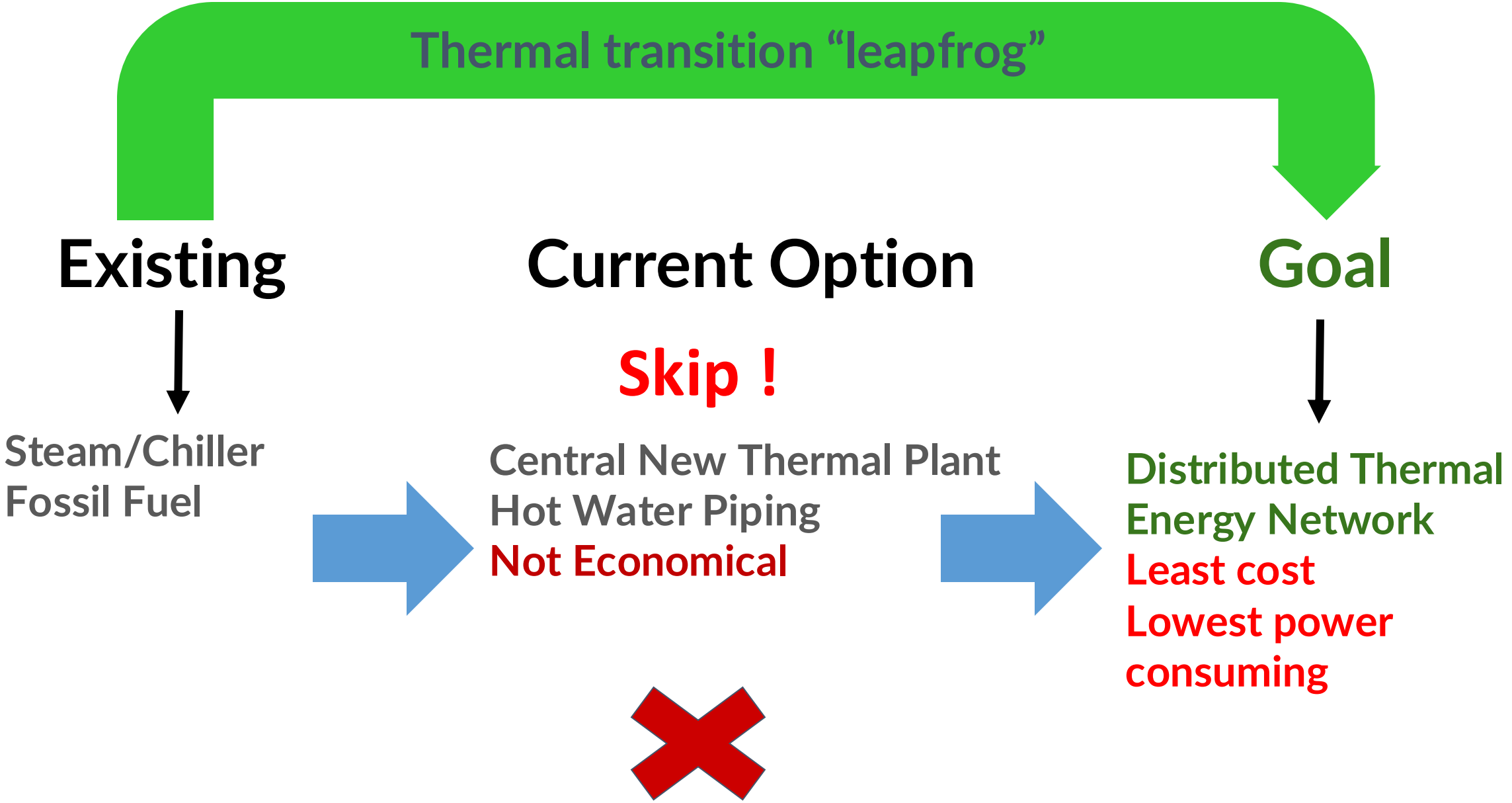


MIT HQ Fiduciary Responsibility

Top-Line Comparison of Approaches

Task	MITTEN	Centralized
Meets Bldg HVAC Specs	√ Yes	√ Yes
Achieves zero emissions	√ Yes	√ Yes
Achieves by 2035 -BEUDO	√ Yes	x No
Minimal Disruption	√ Yes	x No
Pilot to Confirm Projections	√ Yes	X No
Easy Upgrade Over Time	√ Yes	X No
Fiscally Responsible	√ Yes	x No
MIT Seriously Considering	???	√ Yes

Why not?


Thermal transition “leapfrog”
Existing
Current Option
Goal
Steam/Chiller
Fossil Fuel
Skip !
Central New Thermal Plant
Hot Water Piping
Not Economical
Distributed Thermal
Energy Network
Least cost
Lowest power
consuming

Summary

- **At the end of the day, this project is not about Public Relations, it should result in Real Progress.**
- **Central Utility Plant will play an important role in the MITTEN solution.**
- **MITTEN plan is available now, cost-effective, will eliminate carbon emissions, and be minimally disruptive.**
- **Let's show the world how to decarbonize! MIT is the world's foremost research institution and should do something no one else has done at scale.**
- **Next steps: pilot!**

“Climate change and its mounting consequences is the **greatest scientific and societal challenge of this or any age**…We need energy and expertise from every MIT school and the college, from every lab and every center, from every member of the faculty—and from **every one of you**.”

President Sally Kornbluth, Inauguration Speech 2023

The Goal: Zero-Emissions by 2035

We are proposing a rapid, cost-effective decarbonization solution.

MIT, when can we start?

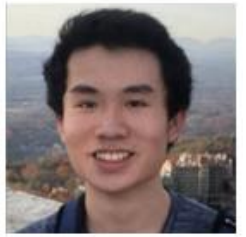
MACA-MIT Campus/Geo Core Team (2025)
(top to bottom, left to right)

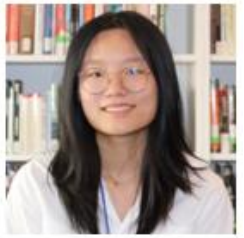
- John Dabels, MIT ’79, Sloan School of Management
- Shiladitya DasSarma, MIT Biochemistry, Founder MACA. Team advisor.
- David T. Williams, MIT ‘82 (affiliated with ‘81), Mech Eng. P.E.
- Herb Zien MIT ’73, Sloan School of Management
- Tunca Alikaya, MIT ’24, Sloan Executive-MBA
- Susan Murcott, MIT ‘90, ’92, Civil and Env. Eng.
- Rick Clemenzi, MIT’81, Computer Science; CGD certification, P.E.
- Judy Siglin. Director, Net Zero Foundation;
- Kevin Johnson, Harvard ‘25. GSD Architecture Engineering
- Jillian James, MIT ‘10, Aerospace Engineering ; ’16, AeroAstro Engineering
- Jason Chen, MIT ‘25 Mechanical
- Olivia Chen, MIT ‘26 Mechanical Engineering;
- Megan Lim, MIT ’24 Sloan School of Management
- + a lot of new students in Fall 2024!








Acknowledgements

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- Josh Raines
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- MIT Video Productions

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MACA.EARTH

MIT OpenCourseWare
https://ocw.mit.edu/

RES.ENV 007 Geothermal Energy Networks (GENs): Transforming our Thermal Energy System

IAP 2025