



# Converting to hot water

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Massachusetts Institute of Technology

# Energy production locations





# SEEN



23,000

students, faculty & staff  
keeping the lights ON



160 buildings

research-enabled  
comfortable spaces



25% growth on campus

in square feet since 2002



25 LEED™

certifications achieved  
or in progress

# UNSEEN

16.5 miles of district energy  
infrastructure

10% less energy use  
per square foot since 2007

7% less GHG emissions since 2014

234 energy efficiency projects  
\$42M cost savings since 2010  
\$11M energy rebates

3 major utility projects

- Cogeneration plant upgrade
- Chilled water plant expansion
- Large scale solar installation

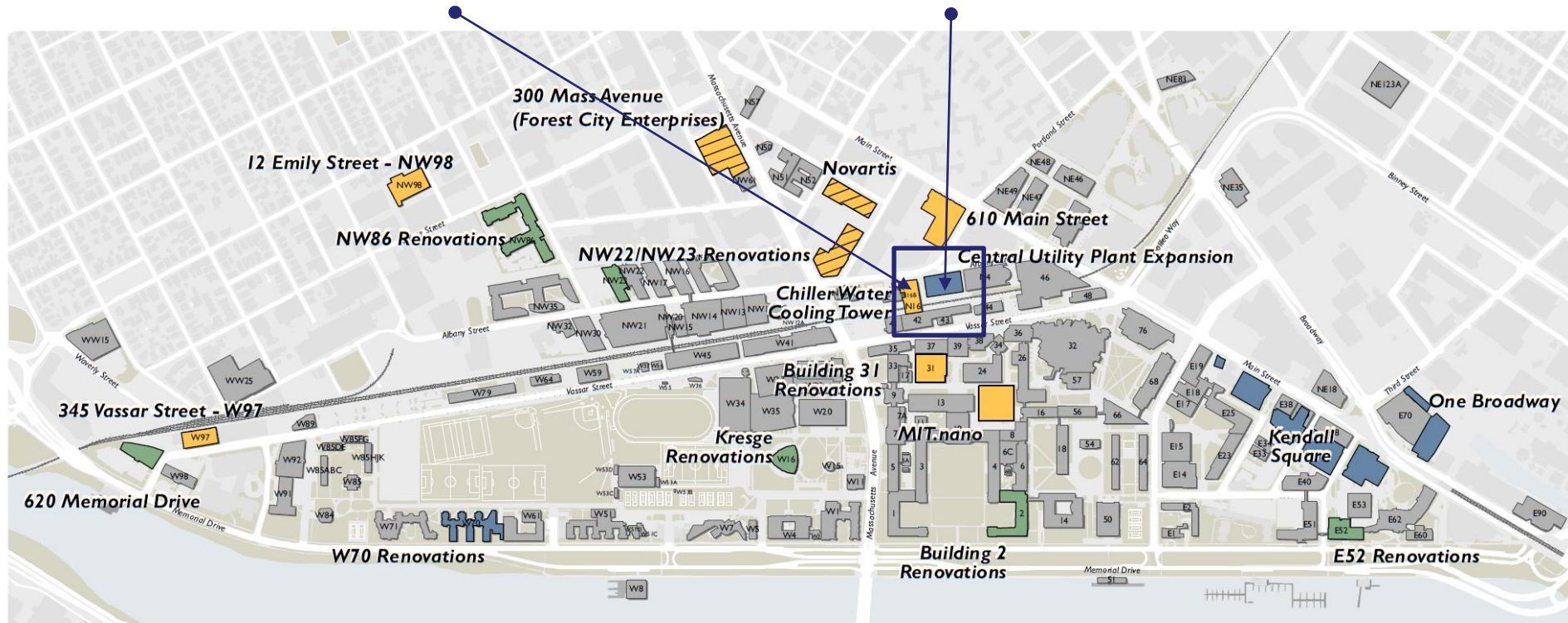
# Planning for growth



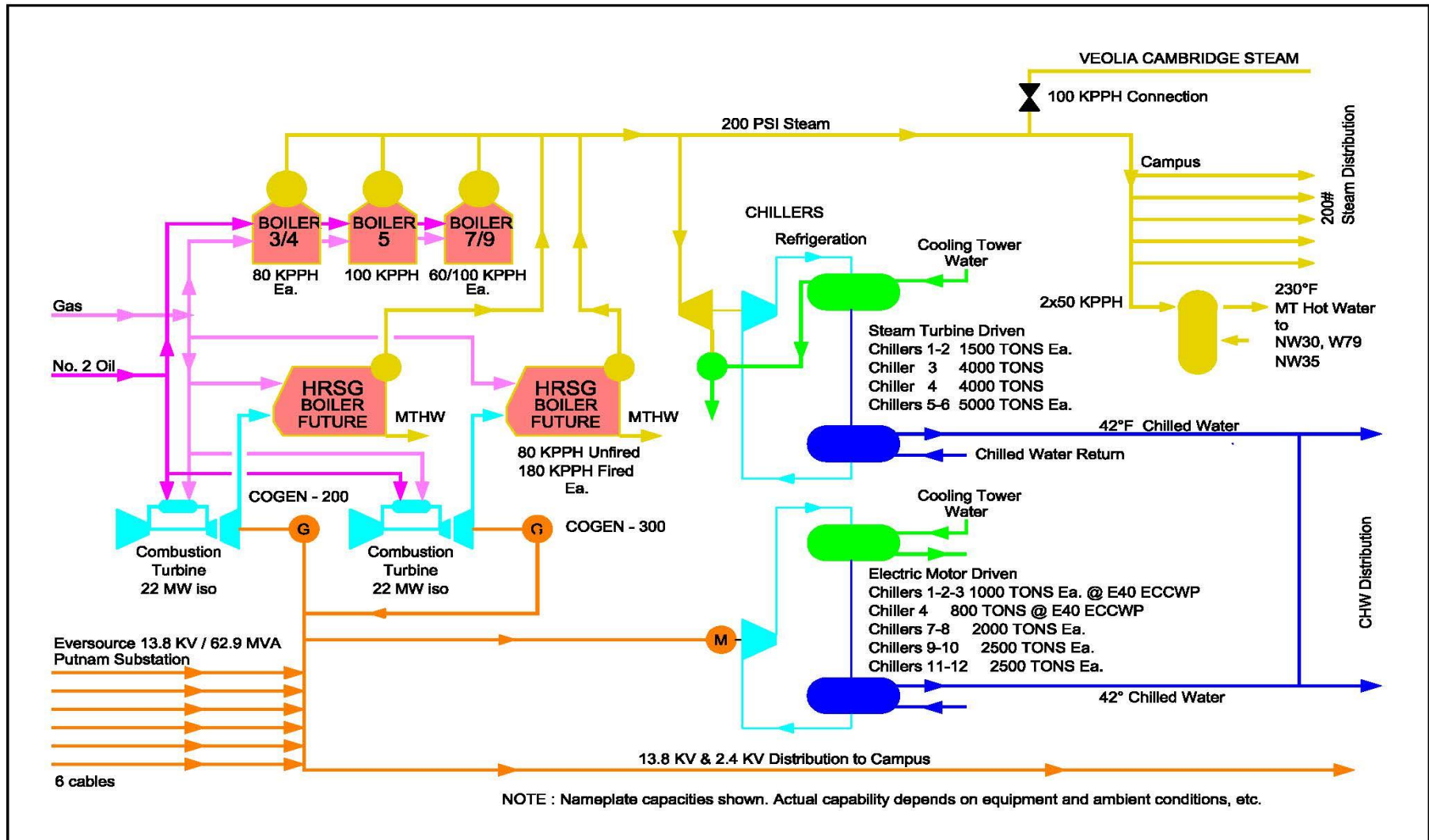
**Central chilled water  
plant expansion**  
On line 2017



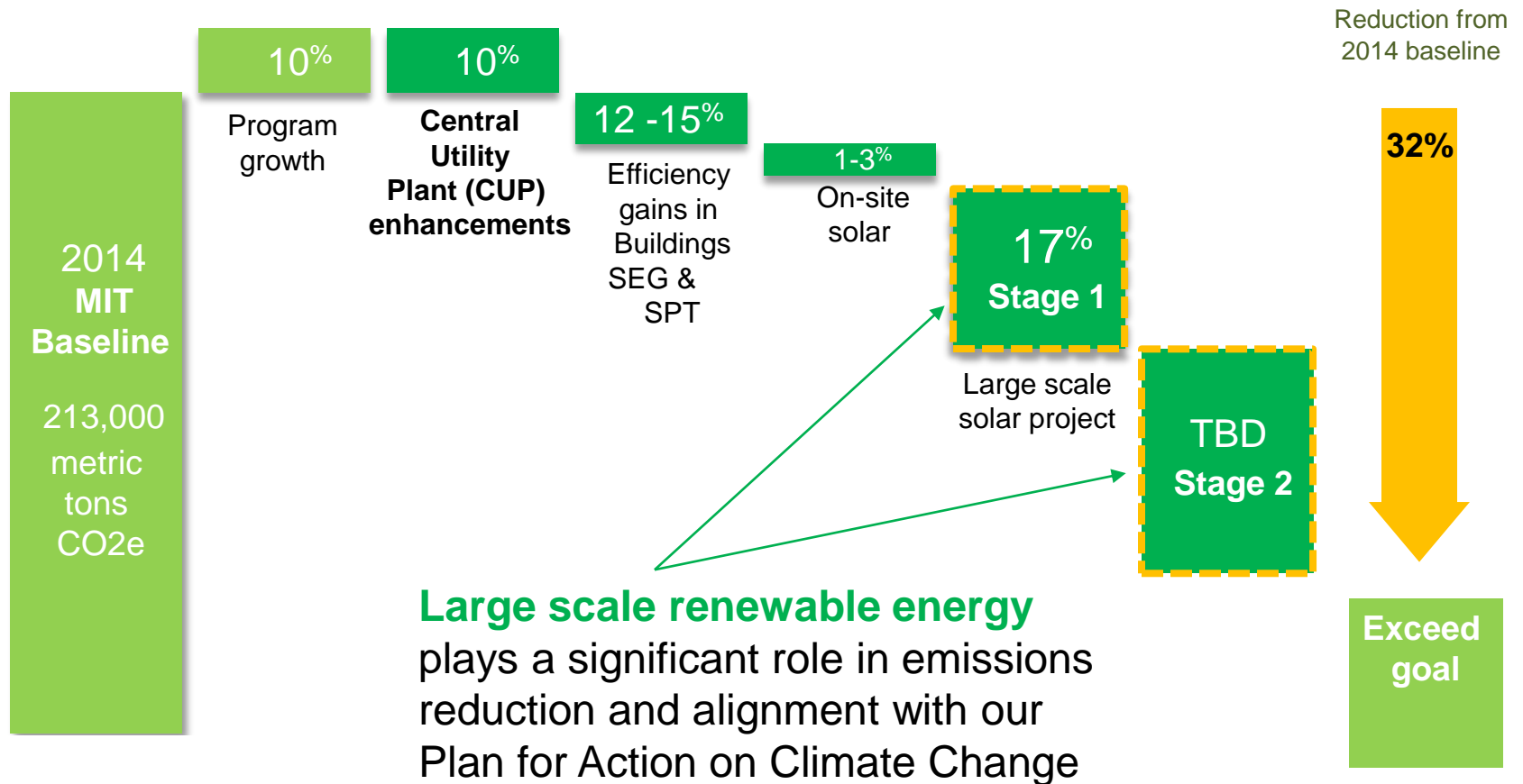
**Cogeneration  
plant upgrade**  
On line 2020



# MIT energy flow diagram in 2020



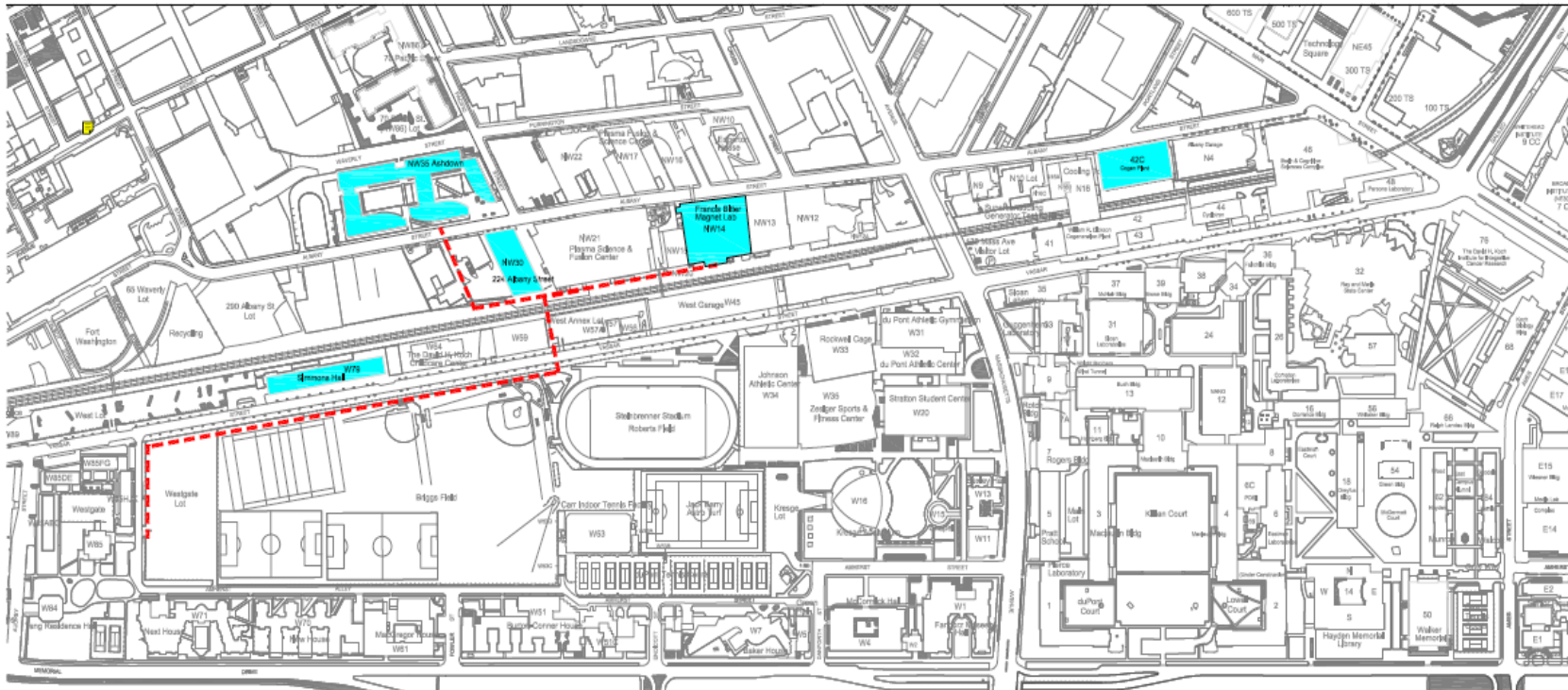
# Reducing 32% carbon emissions by 2030





# Existing hot water system

Steam to hot water conversion stations in NW14 produce the Medium Temperature Hot Water (MTHW) that is fed to three (3) buildings on the Northwest Campus NW30, NW35, and W79. The MTHW system was installed as a cost saving exercise when the 200 psig steam system was proposed to be extended to serve the new construction.



**EXISTING**

# Medium Temperature Hot Water Expansion Analysis

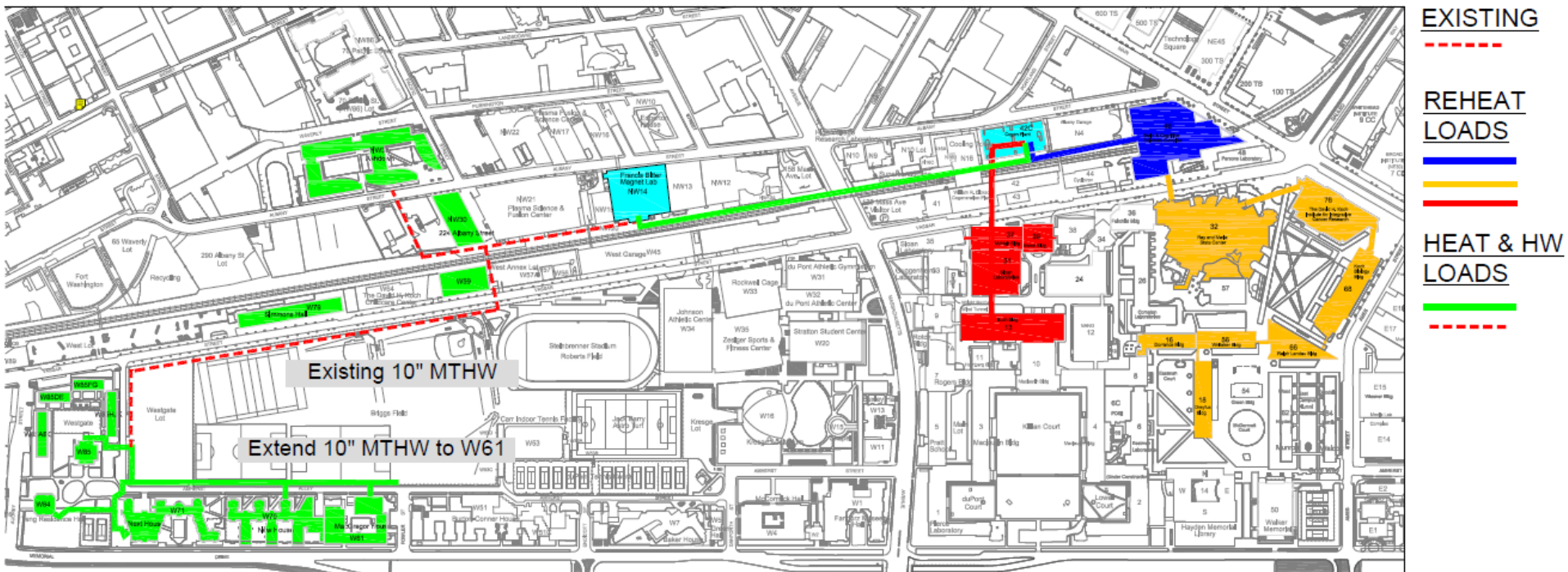
MTHW Alternate Summary Analysis Table

Scenario	Combination includes:						Building Area	Project Cost	Cost per Area Served	Annual GHG Reduction	Project Cost per Annual GHG	Quantity of Buildings Served	Waste Heat Utilized (245,280 MMBTU/yr max)	Simple Payback	Overall Rank
	Through Existing Steam Tunnel under Vasser St	East Run to B46 then South Under Vassar St to B32	West run under Mass Ave with Direct Buried Pipe	Backfeed to West Run through Run 1	Extension of existing MTHW pipe in West Campus (W85 to W61)	Extension of existing MTHW pipe in West Campus (W85 to W5)									
#	Run 1	Run 2	Run 3	Run 3	Run 4	Run 4	sq. ft	\$1,000	\$/sq. ft	Metric Tons	\$/Metric Ton	#	MMBTU/yr	Years	#
1			x				566,141	\$12,445	\$21.98	1,654	\$7,526	4	26,417	9.9	13
2	x	x	x		x		3,465,598	\$83,477	\$24.09	11,988	\$6,964	21	191,509	20.7	9
2B	x	x	x		x		3,465,598	\$77,512	\$22.37	11,924	\$6,501	21	190,491	19.4	5
3	x	x					2,272,878	\$43,037	\$18.93	9,284	\$4,636	12	148,317	32.3	4
4			x		x		1,192,720	\$43,887	\$36.80	3,087	\$14,218	9	49,313	11.8	17
4B			x		x		1,192,720	\$37,923	\$31.80	2,958	\$12,821	9	47,252	10.4	15
5		x	x				2,414,737	\$45,380	\$18.79	9,509	\$4,772	12	151,906	33.9	7
6	x						424,282	\$10,101	\$23.81	1,429	\$7,070	4	22,827	8.1	19
7		x					1,848,596	\$36,382	\$19.68	7,855	\$4,632	8	125,490	27.6	6
8	x		x				990,423	\$19,099	\$19.28	3,082	\$6,196	8	49,244	15.0	12
9	x		x		x		1,617,002	\$50,541	\$31.26	4,516	\$11,192	13	72,140	13.4	14
9B	x		x		x		1,617,002	\$44,577	\$27.57	4,387	\$10,162	13	70,078	12.0	11
10		x	x		x		3,041,316	\$76,822	\$25.26	10,874	\$7,064	17	173,725	19.3	10
10B		x	x		x		3,041,316	\$70,858	\$23.30	10,767	\$6,581	17	172,006	18.0	8
11	x	x	x				2,839,019	\$52,035	\$18.33	10,923	\$4,764	16	174,505	38.4	2
12	x		x			x	1,784,925	\$87,565	\$49.06	5,612	\$15,602	16	89,658	21.1	20
12B	x		x			x	1,784,925	\$71,366	\$39.98	5,374	\$13,281	16	85,845	17.8	16
13				x		x	1,360,643	\$74,269	\$54.58	4,183	\$17,753	12	66,831	18.4	21
13B				x		x	1,360,643	\$58,070	\$42.68	3,945	\$14,721	12	63,018	14.9	18
14	x	x		x	x		3,465,598	\$76,809	\$22.16	11,988	\$6,407	21	191,509	19.3	3
14B	x	x		x	x		3,465,598	\$70,845	\$20.44	11,924	\$5,941	21	190,491	18.0	1



# Hot water system master plan

Connect Main Campus and West Campus Buildings to the MTHW System to replace the steam load. The lab buildings on the main campus have a year round steam load for building reheats, converting to MTHW will reduce the summer steam load. The Dormitories use steam for heat and hot water. Converting the dorms will reduce the hazard of High Pressure Steam in occupied areas, cut maintenance costs and energy losses from steam stations and vaults.



Total Cost	Energy Savings MMBTU/yr	GHG savings Metric/Tons	GHG as a 1% of Campus	Annual Savings/revenue	Simple Payback yrs
\$68,632,690	197,631	12,672	5.95%	3,579,720	19.17

# Hot water system master plan

## Total annual savings

Total Annual Savings	Phase 1	Phase 2	Phase 3	Phase 4	Total	Description
Energy Savings (MMBTU/yr)	35,957	49,314	89,533	22,872	197,631	Total MMBTU per year was determined using an 8760 dispatch model of the hourly loads for all buildings connected in each phase
Fuel savings between boiler steam & duct burner steam	\$ 232,663.00	\$ 319,091.00	\$ 579,332.00	\$ 147,704.00	\$ 1,278,790.00	Cost basis of \$5.50 per MMBTU and 85% boiler/duct burner efficiency. Energy savings MMBTU based on hourly model for all buildings connected in each phase
Avoided energy losses	\$ -	\$ 63,317.00	\$ -	\$ -	\$ 63,317.00	Calculated total of make-up loss and heat loss energy loss from the underground piping on west campus from vaults 1006 to 1316 (10,361 MMBtu/yr). Cost basis of \$5.50 per MMBTU and 85% boiler / duct burner efficiency
Avoided maintenance (provided by MIT)	\$ -	\$ 950,000.00	\$ -	\$ -	\$ 950,000.00	Estimated yearly maintenance costs provided by MIT
Revenue from *APS *Massachusetts Department of Energy Resource's (DOER) Alternative Portfolio Standard (APS)	\$ 234,268.50	\$ 321,292.56	\$ 583,329.01	\$ 148,723.39	\$ 1,287,613.46	Calculated Revenue for APS Energy Credits. Cost basis of \$22.23 per MW converted from the MMBTU based on the 8760 model of all buildings connected per phase
<b>Total</b>	<b>\$ 466,931.50</b>	<b>\$ 1,653,700.56</b>	<b>\$ 1,162,661.01</b>	<b>\$ 296,427.39</b>	<b>\$ 3,579,720.46</b>	

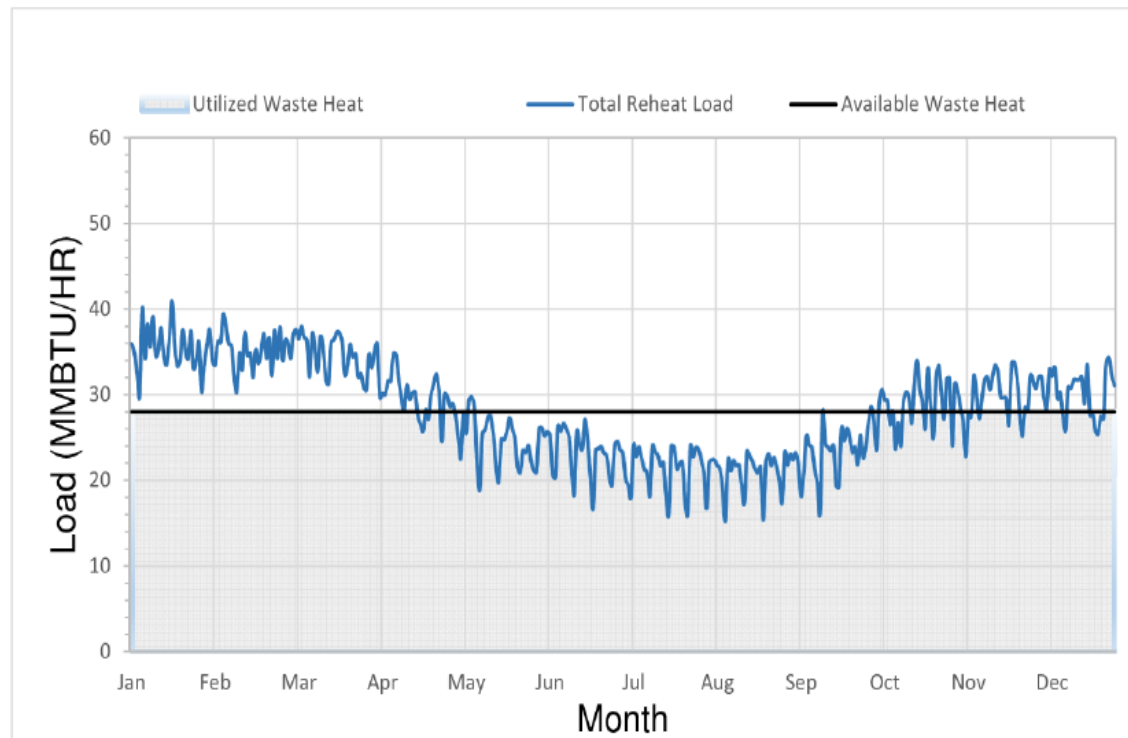
## Executive Summary: Hot water system expansion

- Master-plan to connect Main Campus Buildings 46, 32, 76, 68, 66, 56, 16 18, 37, 39, 31, 13, and West Campus Dormitories Buildings W59, W85, W84, W71, W70, W61 to the MTHW System. Buildings W79, W70, and W35 will remain on the existing MTHW System.
- The existing steam system on the West Campus can be shut down, reducing maintenance costs and the hazards of High Pressure Steam in student occupied areas.
- Life expectancy of the MTHW system is 50 years compared to steam/condensate systems at 10-30 years.
- Reduced Green House Gas (GHG) production

# Hot water system master plan

- Road Crossings include Massachusetts Ave. and Vassar St.
- 192,284 MMBTU/year of harvested waste heat from the HRSG Economizer will be used by the buildings connected for heat and hot water. The MMBTU/year is based on the dispatch model of the hourly loads of the connected buildings. The graph below shows the yearly campus load of the connected buildings based on measured data and the amount of waste heat that will be used to cover the load.

Total available waste heat vs. utilized waste heat





# Next steps

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- Review project financials for accuracy
- Develop addition of Carbon revenue analysis on project