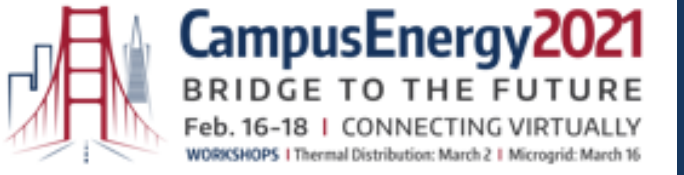
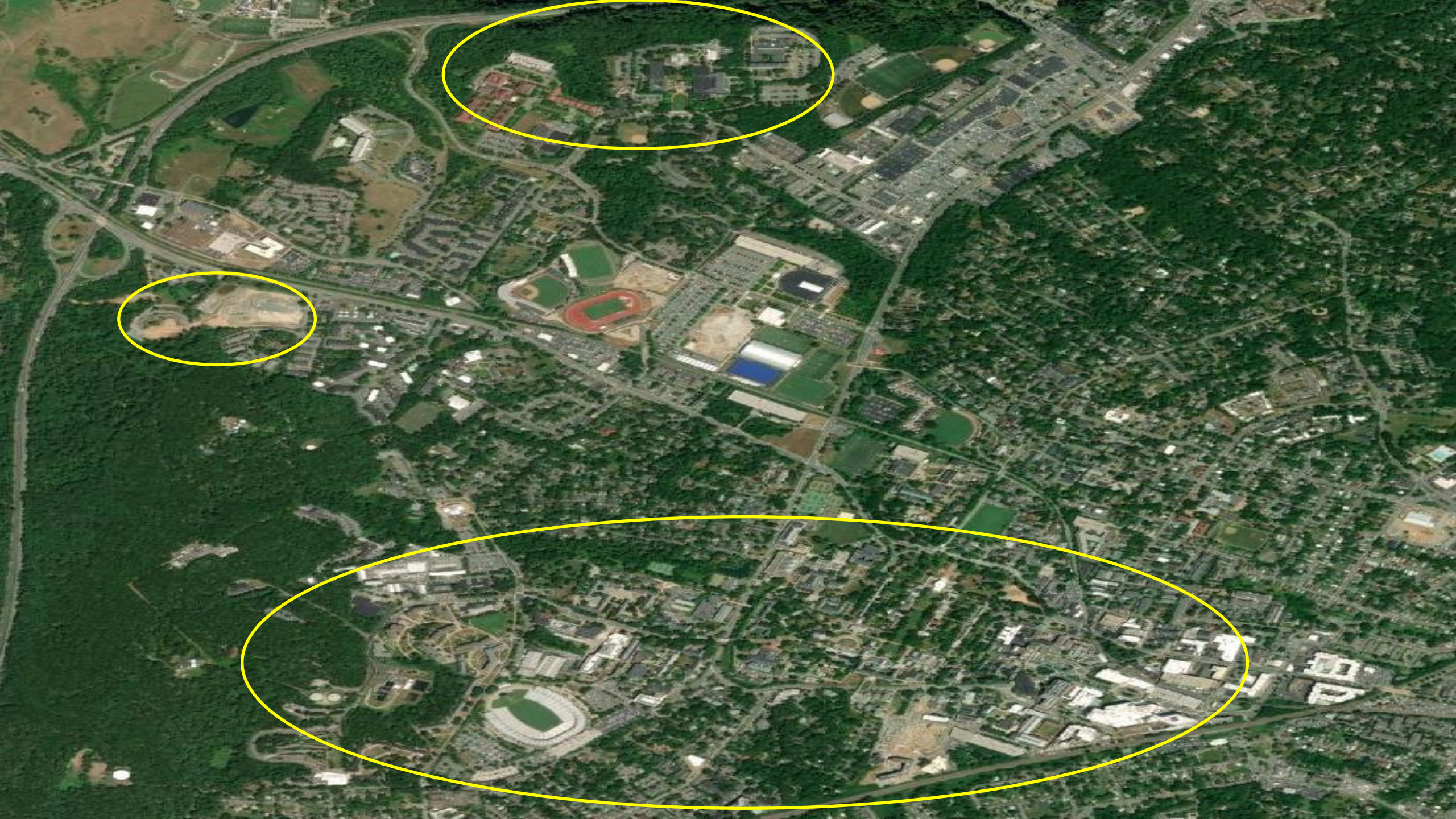

CampusEnergy2021
BRIDGE TO THE FUTURE
Feb. 16-18 | CONNECTING VIRTUALLY
WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

Three Applications of Heat Recovery Chillers Supporting LTHW at UVA

Paul Zmick, PE

University of Virginia





Heating Zones

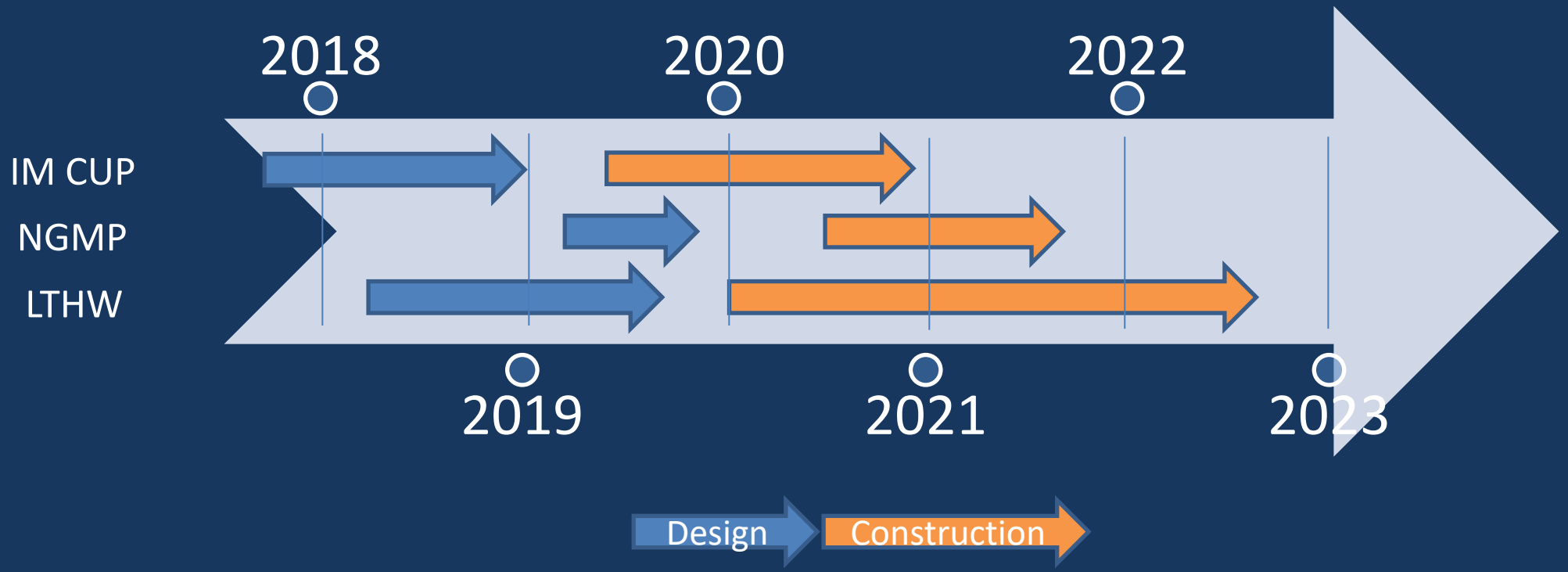
Three plants and three unique applications …

- Small … Ivy Mountain (CUP) … 200K SQFT
  - New development zone
  - 200K outpatient orthopedic clinic
  - 60-80K future capacity
- Medium … North Grounds (NG Mechanical Plant) … 1M SQFT
  - 550K existing buildings and 450K new load
  - 190K new Inn at Darden
  - 260K existing Darden School of Business
- Large … Academic Grounds (Main Heat Plant) … 12M SQFT
  - 12M of existing academic, historic, research, athletic, and health system buildings

Engineers of Record and Vendor Partners

- Collin Moyer, PE
- Joe Witchger, PE
- George Howe, PE

Timeline of each project



Ivy Mountain CUP

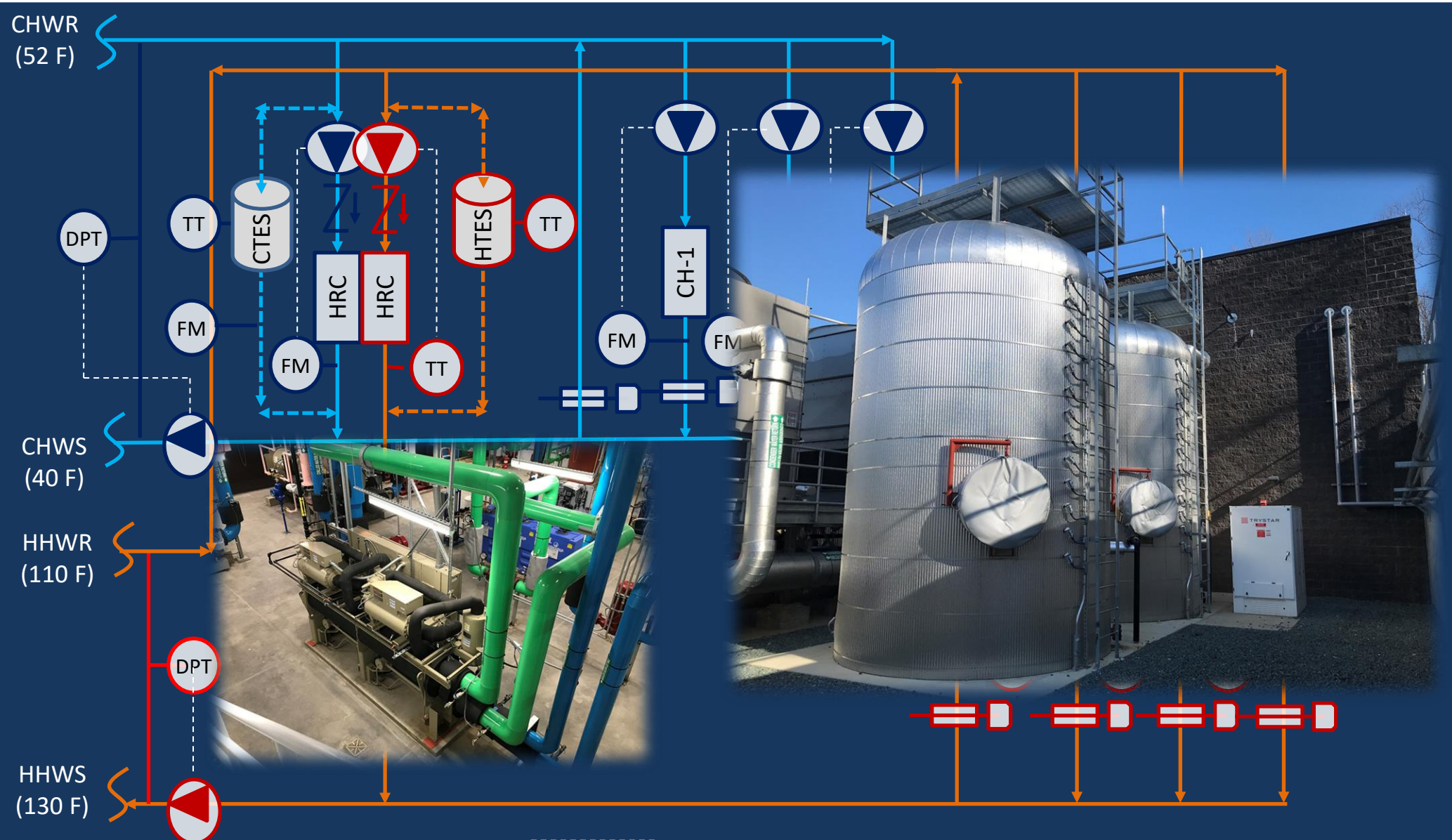
- Maximize HRC in order to minimize FF (gas boilers)
- New construction with nominal 140F heating supply
- Periods of low system heating/cooling load
- Small plant with future capacity requirements
- Tight budget
  - Proposed at $16M … increased to $19M due to high construction demand
  - HRC were actually a VM discussion

Equipment Basis of Design – HRC

- Manufacturers: Trane, Carrier, York/JCI

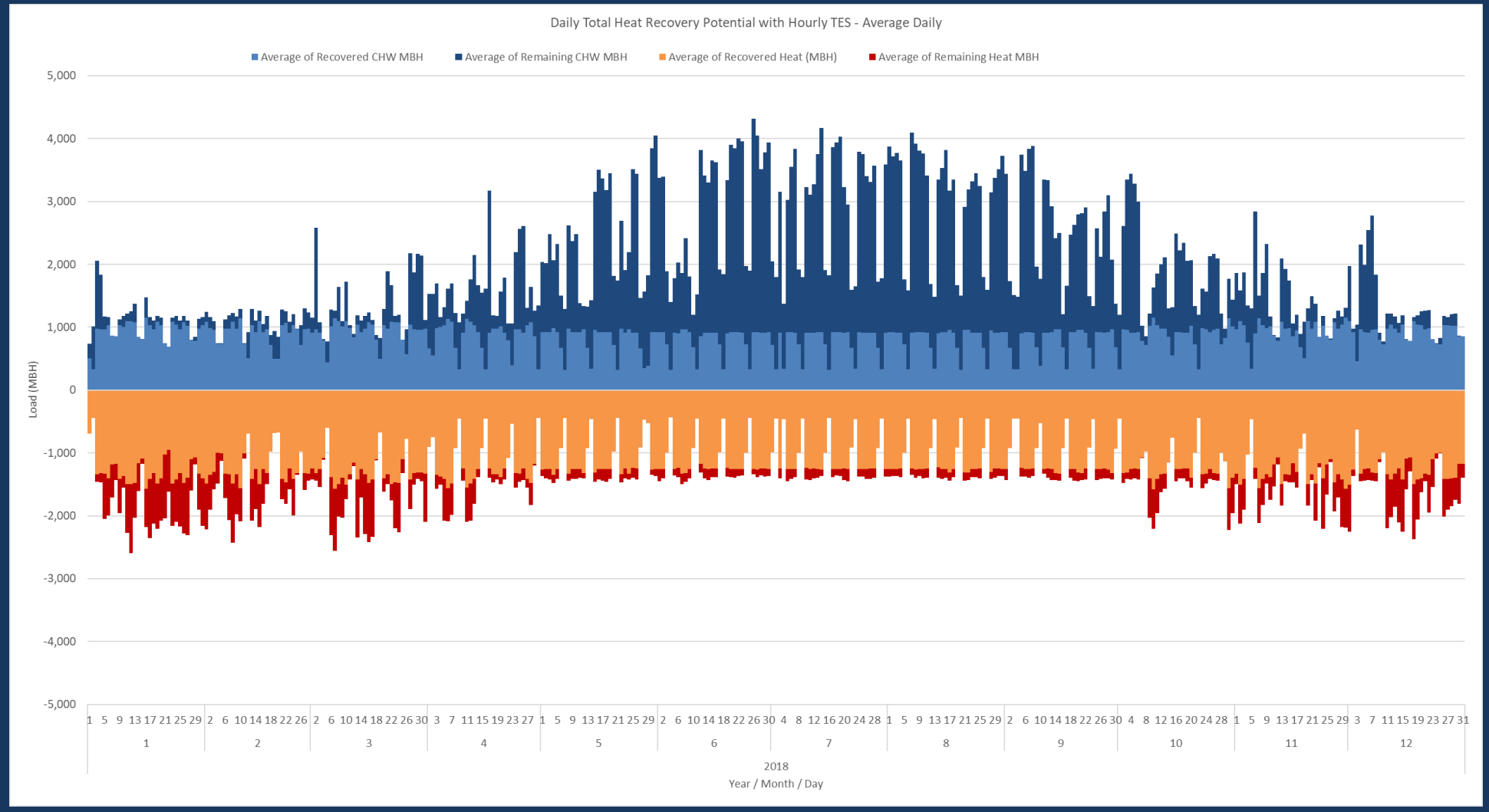
Criterion	Multistack Modular Chiller	York YCWL Scroll Chiller	JCI/Sabroe ChillPAC Recip. Chiller	York YVWA Screw Chiller	Trane RTWD Screw Chiller	Carrier 30XW Screw Chiller
$/MBH	$80	$45	-	$53	$61	$41
Heating Capacity (MBH)	2,012	1,870	-	1,980	1,800	1,840
Cooling Capacity (Tons)	120	112	-	121	110	115
Combined Heating/Cooling COP	6.1	6.2	-	6.7	6.4	6.3
Refrigerant	R-410A	R-410A	R-717 (Ammonia)	R-134A	R-134A	R-134A
Footprint (SF)	29	30	31	66	40	41
Tonnage Range	20-400	50-200	30-400	120-300	80-250	150-400
Maximum HHW Temp. (Deg F)	140	122	-	140	140	140
Noise (dBA)	75	77	74	-	73	-
Number of Compressors	4	4	1	1	2	1
Refrigerant Charge (lbs)	130	390	60	395	360	290
Ability for Capacity Increase	Easy	Difficult	Difficult	Difficult	Difficult	Difficult
Operability at Low Loads	Good	Good	-	Fair	Fair	Fair
Ability to Operate with Low CHW/HHW Delta-T	Poor	Fair	-	Fair	Fair	Fair

Sequence of Operation



Expected Load Profile

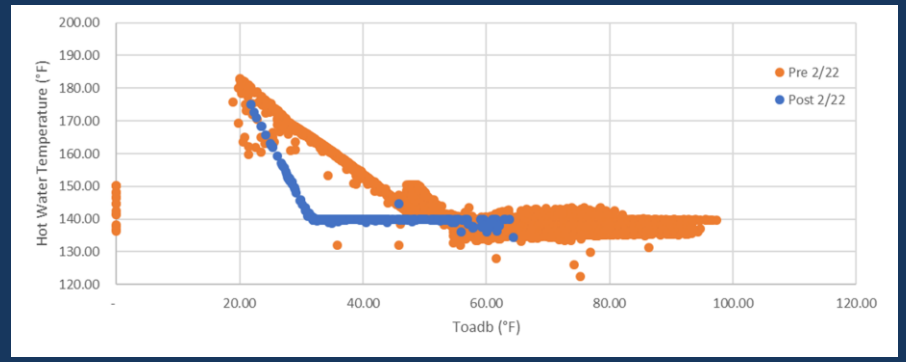
120 Ton HRC with TES - 83% of annual heat recovered



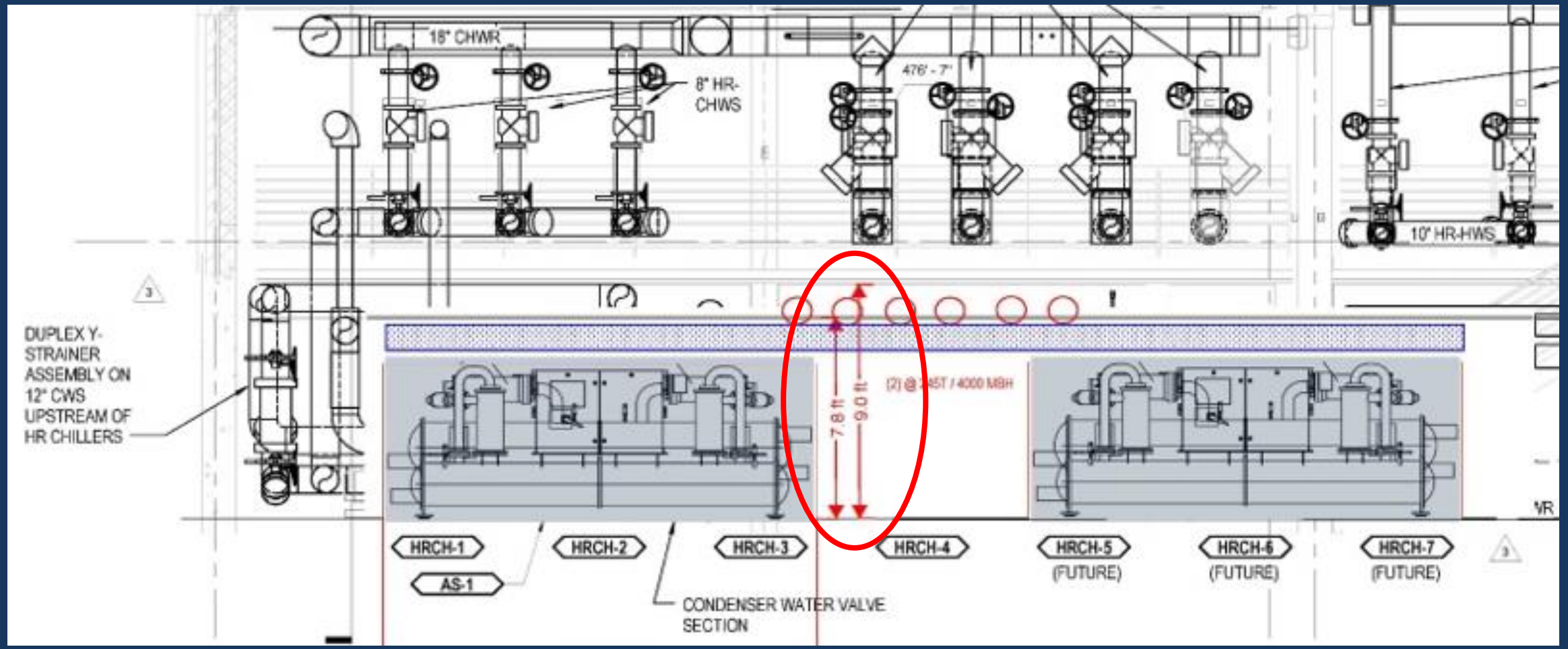
Ivy Mountain CUP

North Grounds Mechanical Plant

- Maximize HRC in order to minimize FF (gas boilers)
- Mix of existing and new construction
- Waterside economizer inherited and encouraged
  - Darden: Existing
  - Inn at Darden: New
- Existing buildings required winter heating temp setback up to 180F
- Existing mechanical plant with limited space



Vertical space … very challenging



Engageable Load Ratio

NGMP ONLY (BASED ON 2018 DATA)

			Ideal HRCH		R410a Scroll HRCH			R410a Scroll (Future) HRCH			R134a Screw 149° HRCH			R134a Screw 140° HRCH			R134a Scroll 160° HRCH			R134a Scroll 165° HRCH			Centrifugal HRCH			Ammonia HRCH		
		Total Load (MBTU)	Engageable Load (MBTU)	Engageable Load Ratio (ELR)	Achievable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}	Engageable Load (MBTU)	Achievable Load Ratio (ALR)	η_{ELR}
Total	Cooling	32,907,356	11,571,582	35%	8,385,310	25%	87%	8,385,310	25%	87%	7,449,500	23%	79%	8,016,255	24%	84%	6,839,703	21%	81%	6,881,533	21%	81%	1,401,071	4%	14%	736,800	2%	9%
	Heating	30,685,875	11,583,153	38%	11,739,434	38%		11,739,434	38%		10,790,085	35%		11,404,360	37%		11,868,924	39%		11,868,152	39%		1,944,754	6%		1,303,522	4%	
Toa < 50°F	Cooling	-	-	0%	-	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%
	Heating	15,199,926	-	0%	-	0%		-	0%		-	0%		-	0%		-	0%		-	0%		-	0%		-	0%	
Toa > 50°F	Cooling	32,907,356	11,571,582	35%	8,385,310	25%	87%	8,385,310	25%	87%	7,449,500	23%	79%	8,016,255	24%	84%	6,839,703	21%	81%	6,881,533	21%	81%	1,401,071	4%	14%	736,800	2%	9%
	Heating	14,935,419	11,583,153	78%	11,739,434	79%		11,739,434	79%		10,790,085	72%		11,404,360	76%		11,868,924	79%		11,868,152	79%		1,944,754	13%		1,303,522	9%	

NGMP & DARDEN (BASED ON 2018 DATA)

			Ideal HRCH		R410a Scroll HRCH			R410a Scroll (Future) HRCH			R134a Screw 149° HRCH			R134a Screw 140° HRCH			R134a Scroll 160° HRCH			R134a Scroll 165° HRCH			Centrifugal HRCH			Ammonia HRCH		
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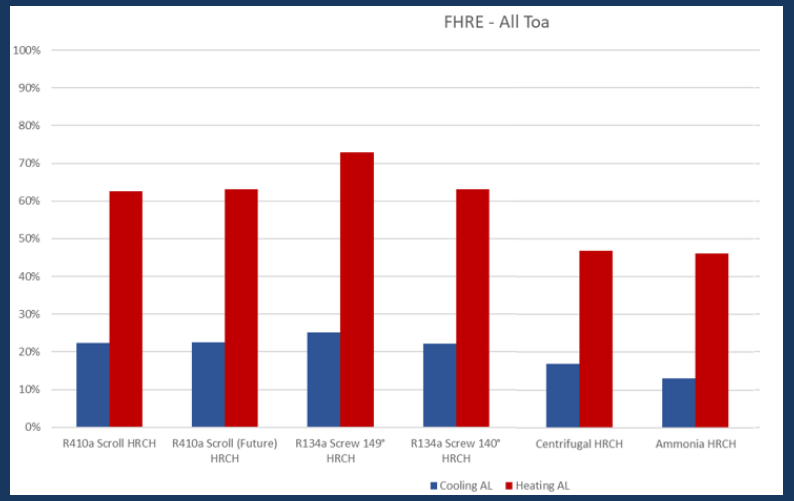
Total	Cooling	67,610,850	27,594,282	41%	19,394,837	29%	84%	19,404,445	29%	84%	19,913,979	29%	88%	19,046,224	28%	84%	17,262,693	26%	86%	17,975,202	27%	89%	15,744,882	23%	68%	8,908,800	13%	45%
	Heating	50,007,874	27,621,877	55%	27,154,095	54%		27,166,222	54%		28,845,438	58%		27,096,191	54%		29,963,122	60%		31,000,652	62%		21,854,672	44%		15,761,152	32%	
Toa < 50°F	Cooling	5,113,346	4,940,063	97%	2,721,174	53%	66%	2,721,174	53%	66%	4,079,115	80%	101%	2,671,393	52%	65%	3,909,988	76%	108%	4,253,898	83%	117%	3,688,582	72%	89%	2,239,200	44%	63%
	Heating	24,769,374	4,945,003	20%	3,809,644	15%		3,809,644	15%		5,908,848	24%		3,800,469	15%		6,788,346	27%		7,336,403	30%		5,119,929	21%		3,961,518	16%	
Toa > 50°F	Cooling	62,047,637	22,225,078	36%	16,296,218	26%	88%	16,305,826	26%	88%	15,482,805	25%	85%	16,005,940	26%	87%	13,027,759	21%	80%	13,384,646	22%	82%	11,762,655	19%	63%	6,475,200	10%	40%
	Heating	24,341,248	22,247,303	91%	22,816,029	94%		22,828,156	94%		22,426,634	92%		22,770,917	94%		22,610,738	93%		23,083,635	95%		16,327,149	67%		11,455,708	47%	

ELR Continued …

$\eta_{ELR} = ALR / ELR$

- Two senarios (existing load and new load)
- Two conditions (Toa <50F and >50F)
- Eight heat recovery chillers evaluated
  - Two conditions (heating and cooling)
- York YVWA Selected
  - 149F
  - 200T
  - Three units



			Ideal HRCH		R134a Screw 149° HRCH		
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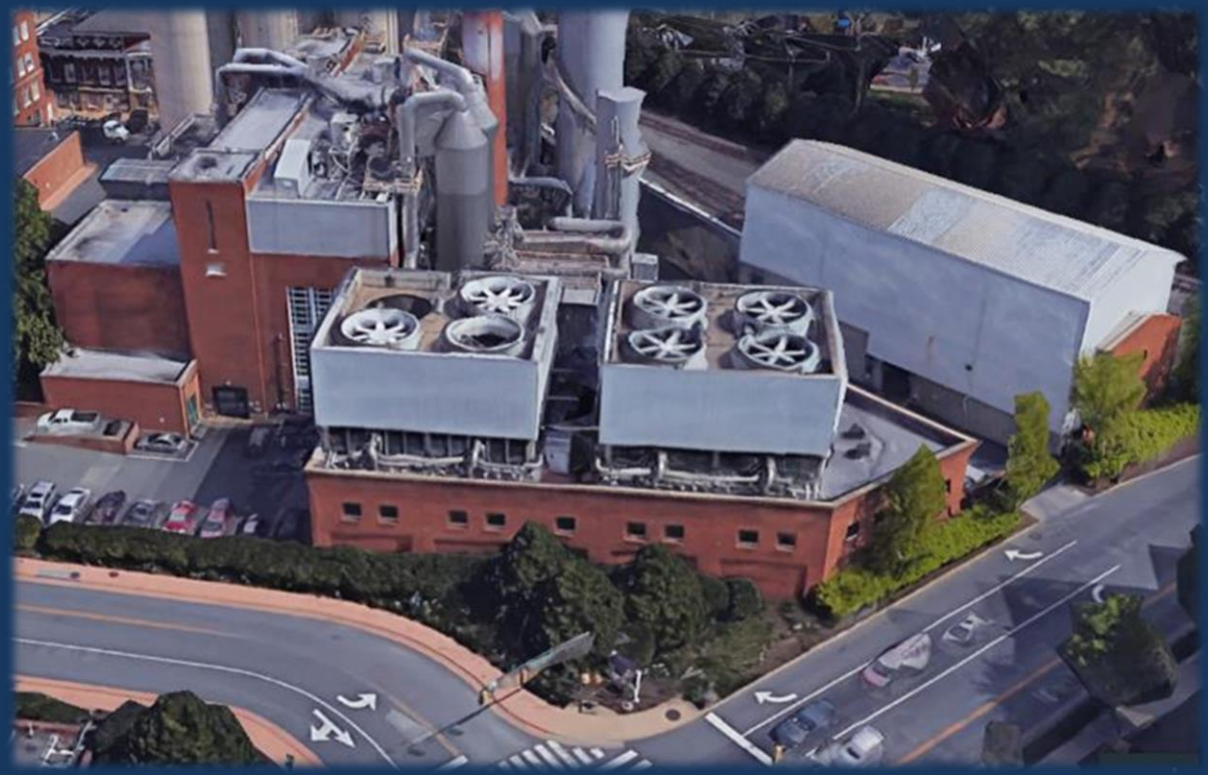
	Heating	50,007,874	27,621,877	55%	28,845,438	58%	
Toa < 50°F	Cooling	5,113,346	4,940,063	97%	4,079,115	80%	101%
	Heating	24,769,374	4,945,003	20%	5,908,848	24%	
Toa > 50°F	Cooling	62,047,637	22,225,078	36%	15,482,805	25%	85%
	Heating	24,341,248	22,247,303	91%	22,426,634	92%	

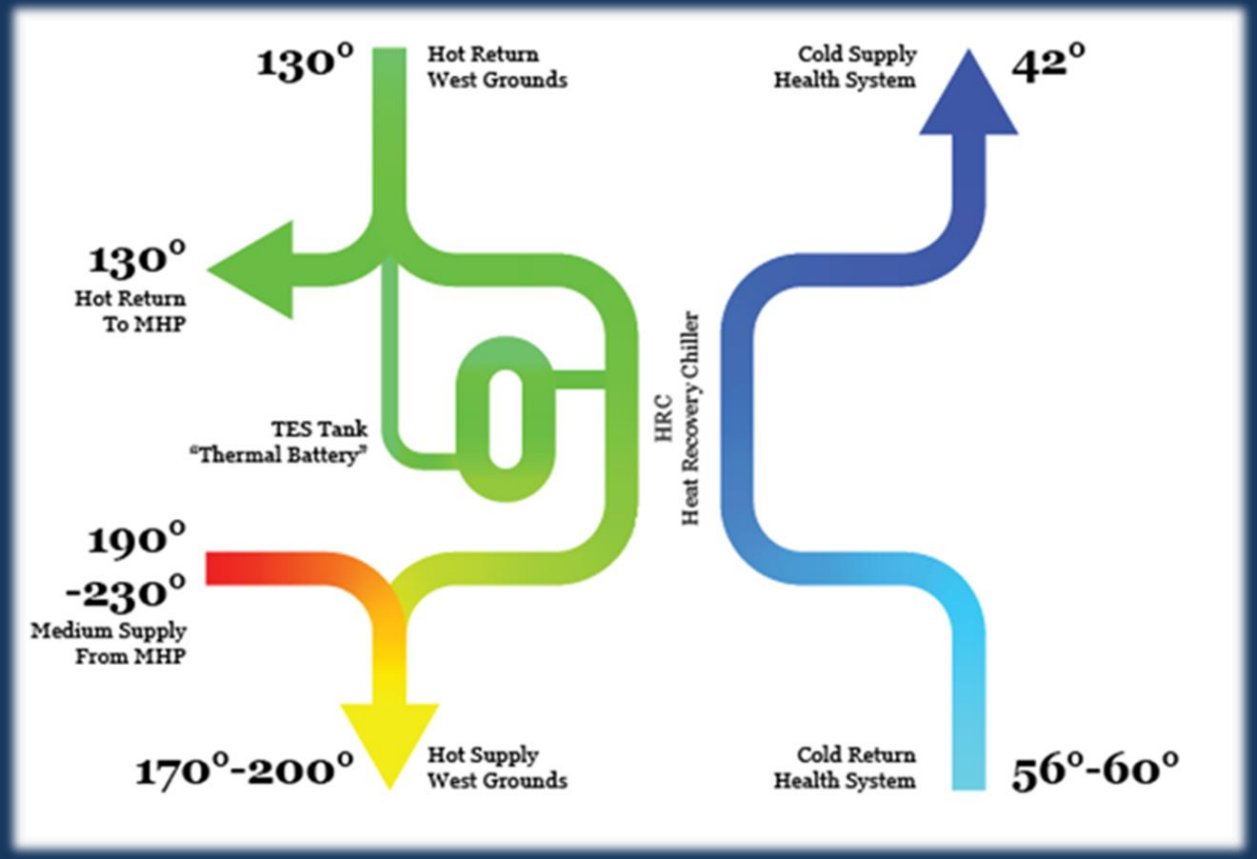
LTHW Project … North Chiller Plant/Main Heat Plant

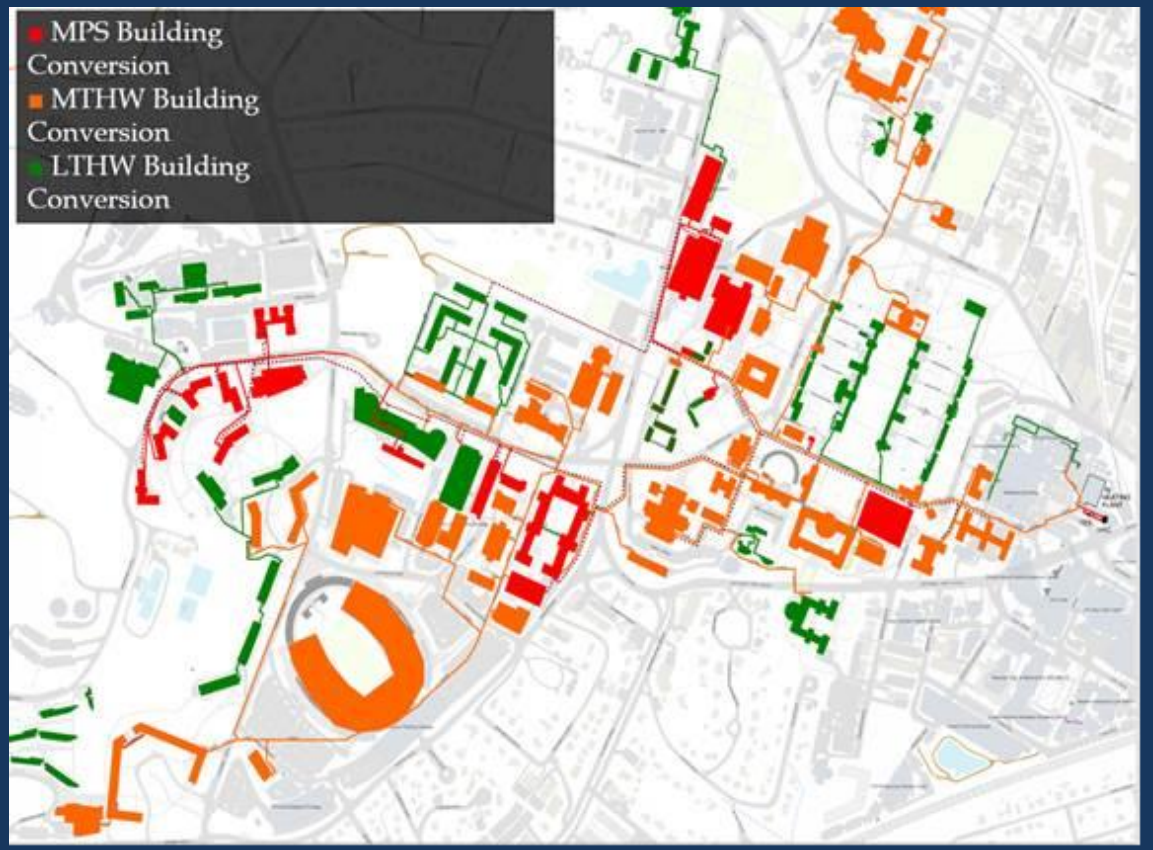
- Maximize HRC in order to minimize FF (coal, gas, oil boilers)
- Integrating a large HRC with large steam and hot water boilers
- Minimum LTHW temp of 170F
- Source of year-round chilled water load and hot water load



LTHW Project

200F to 170F from the Plant





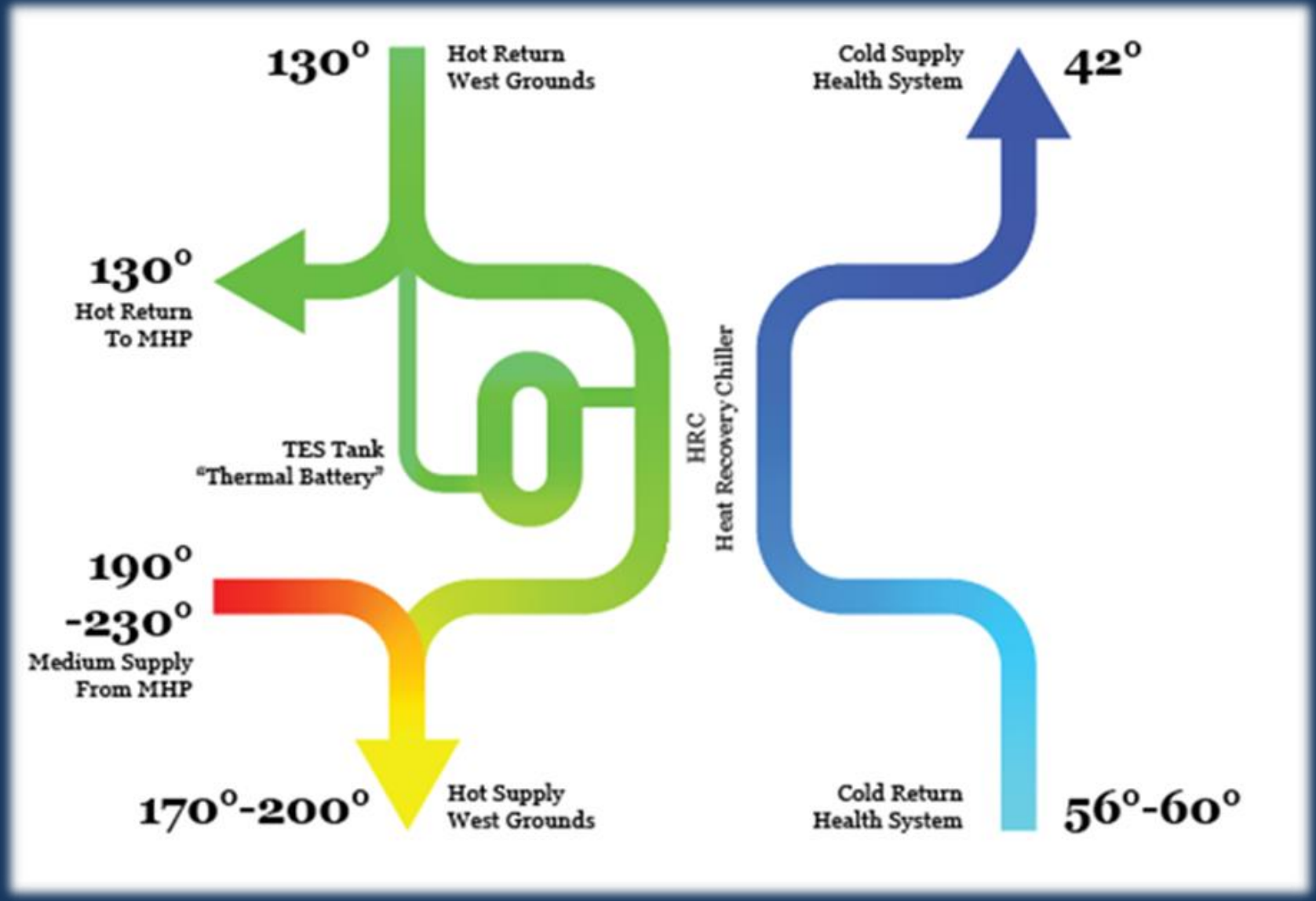
170F to 160F in the Building

Summary of HRC Options

- Lower temperatures provide more options
- Limited options for medium temperatures/size
- Very limited options for temperatures above 160F

HRC	Max Temp	Max Tons	CUP	NGMP	LTHW
York Scroll	122	112	x		
Multistack Scroll	140	400	x		
York Screw	140	300	x		
Trane Screw	140	250	x		
Carrier Screw	140	400	x		
York Screw	149	200		x	
Daikin Scroll	160	312		x	
ArcitChill Scroll	165	25		x	
York Centrifugal	170	2000		x	x
York FE	180	5000			
NH3 Recip	195	200	x	x	x

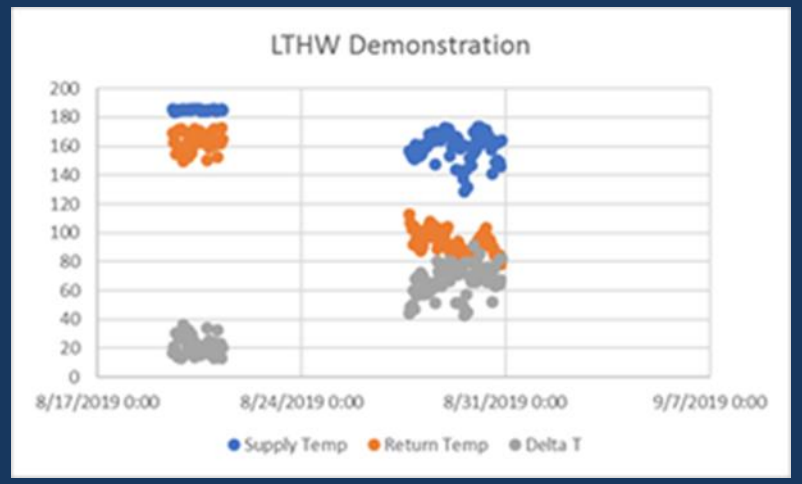
One 1,800 ton CYK and one 60K gal buffer tank

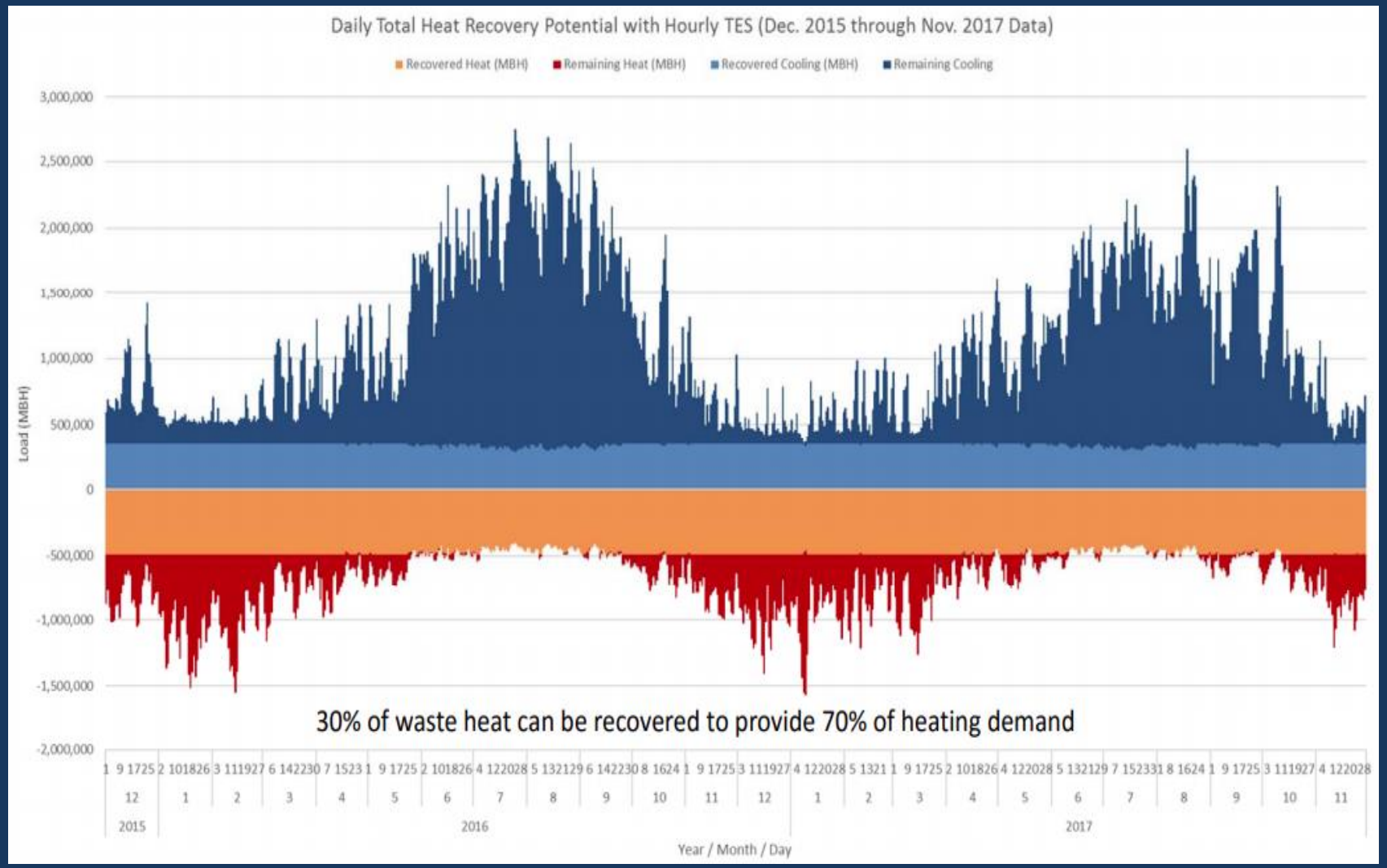


Expected and Preliminary Results (HRC and LTHW)

- 30% recovered
- 70% of demand

- DT increase …
  20 to 60+





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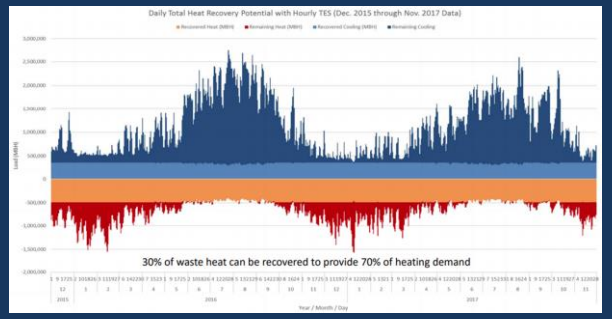
Carrier Screw	140	400	x		
York Screw	149	200		x	
Daikin Scroll	160	312		x	
ArcitChill Scroll	165	25		x	
York Centrifugal	170	2000		x	x
York FE	180	5000			
NH3 Recip	195	200	x	x	x

Process Steps

- Understand heating/cooling load profile
- Establish discharge temp of HRC
- Maximize use of HRC
  - Buffer tank(s)
  - Water side economizing
- Fit the equipment to space/budget
- Three projects
  - Unique constraints
  - Unique outcomes

$\eta_{ELR} = ALR / ELR$



Special thanks to Cheryl Gomez

- Director of Operations at UVA
- Early adopter of HRCs, elimination of FF, and all things sustainable
- Driver for LTHW effort at UVA
- Strong supporter of IDEA and former board member
- My boss

Questions?

Thank You!

Paul Zmick, PE