ENERGY CENTER
OF WISCONSIN

Geothermal Heat Pump Systems: From Basics to Hybrids

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www.ecw.org/hybrid

Today's discussion

- The basics of geothermal
- The hybrid approach, our recent study
- Design and operational lessons learned
- Economic / environmental impacts of the geothermal and hybrid approaches
- Resources for you

BUILDINGS TEAM

powered by energy center of wisconsin

What we do

Energy analysis

Geothermal project assistance

Daylighting studies

Campus energy planning

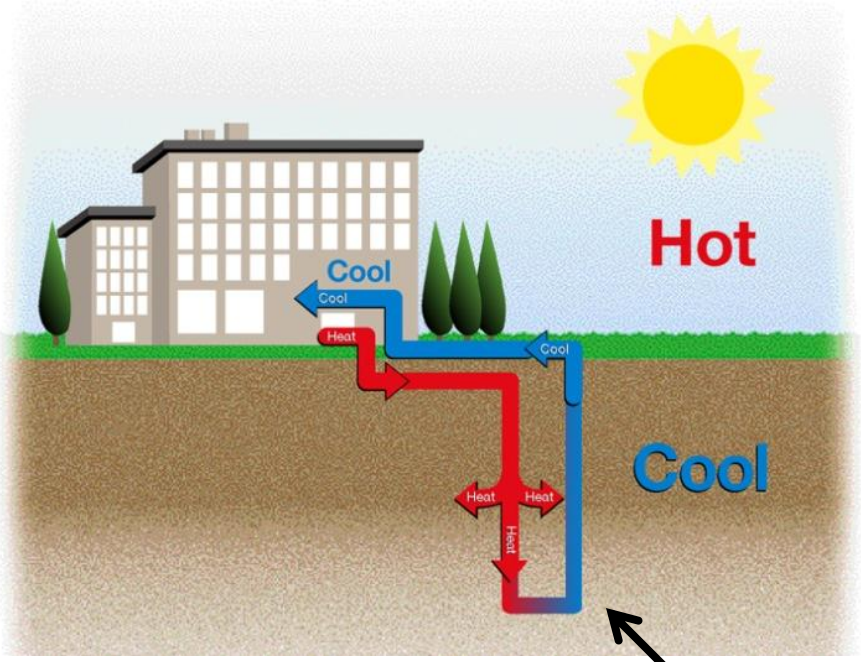
Economic analysis

Field research and evaluation

Education and training

Offices in Madison, Chicago, Minneapolis

Geothermal: The Basics



- Earth absorbs solar energy
- Heat is stored in the earth
- Constant temp below the frost line
- Exchange/storage medium for heat transfer

Closed loop system

Field Types

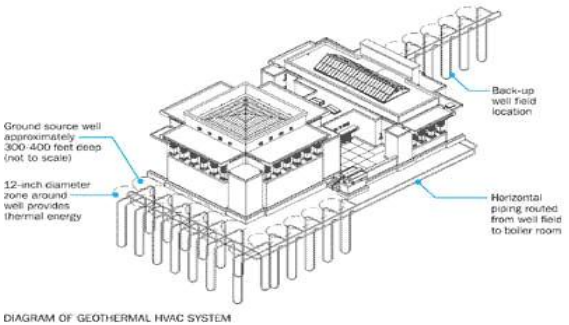


DIAGRAM OF GEOTHERMAL HVAC SYSTEM

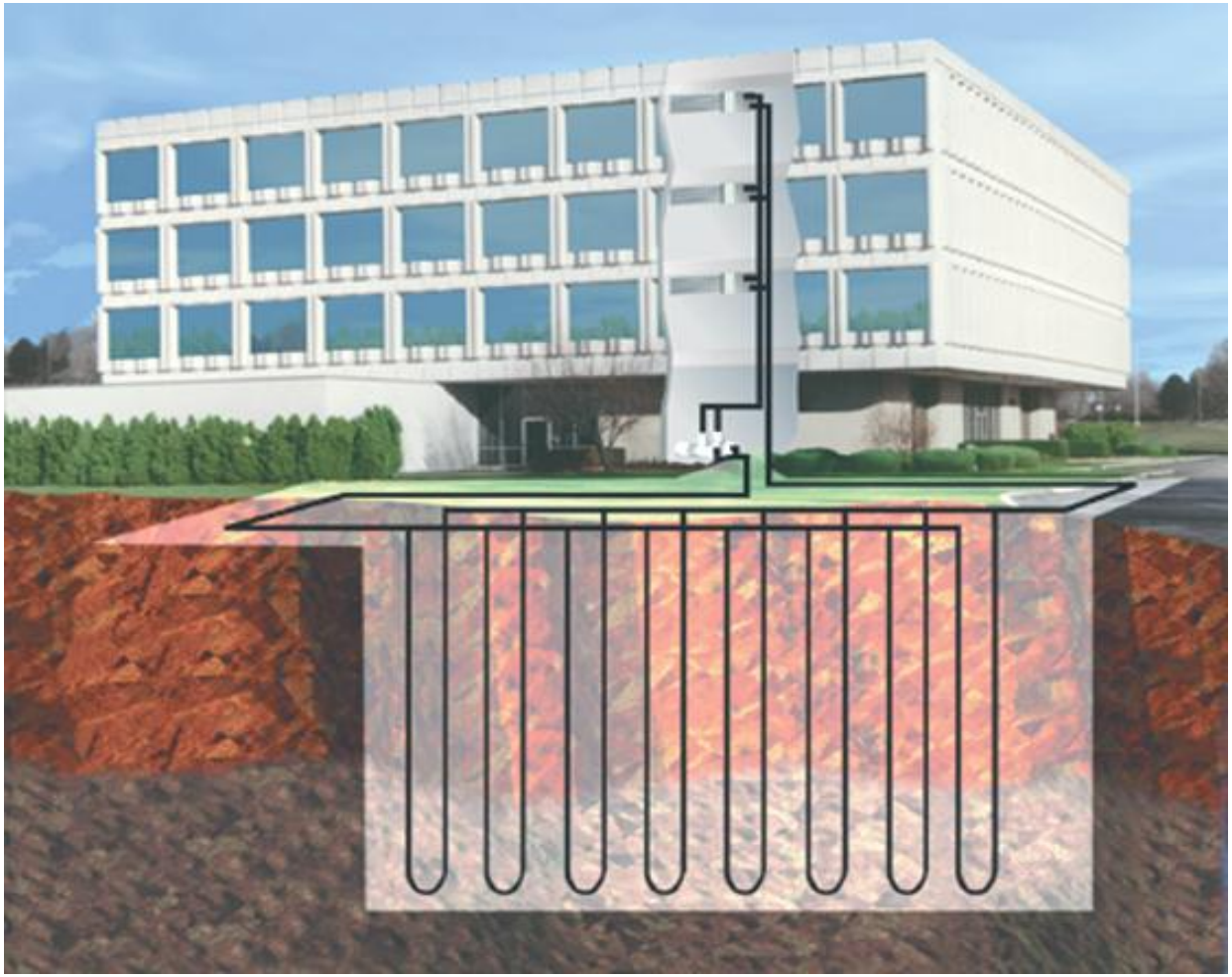
Vertical bores: 300’ deep
common, >600’ possible
Smallest footprint

Horizontal bores: 6-10’ deep
Can be stacked layers
Typically the largest footprint

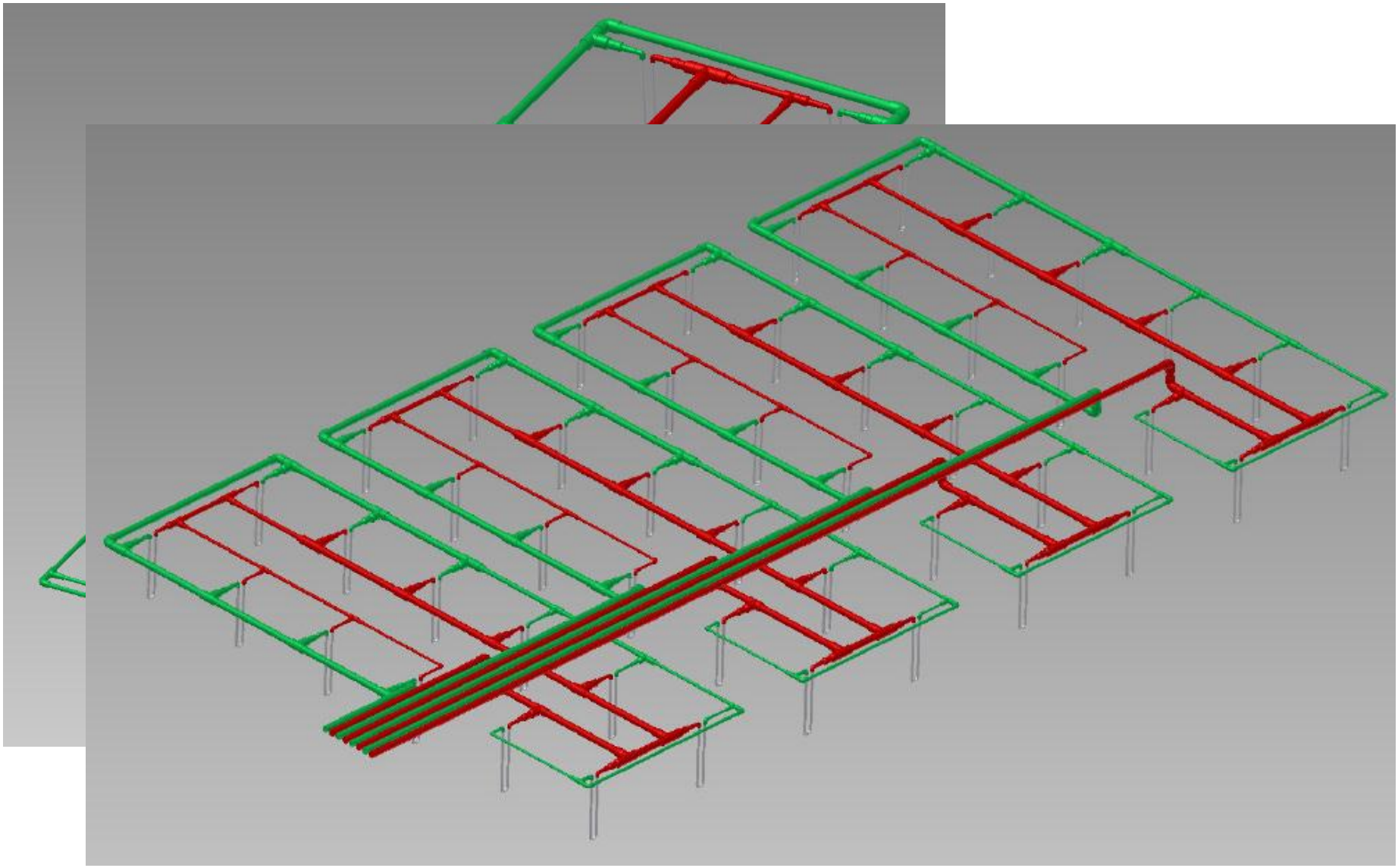
Lake coupled
Medium footprint
High cost: need other
reason to justify the lake

System/ground interaction

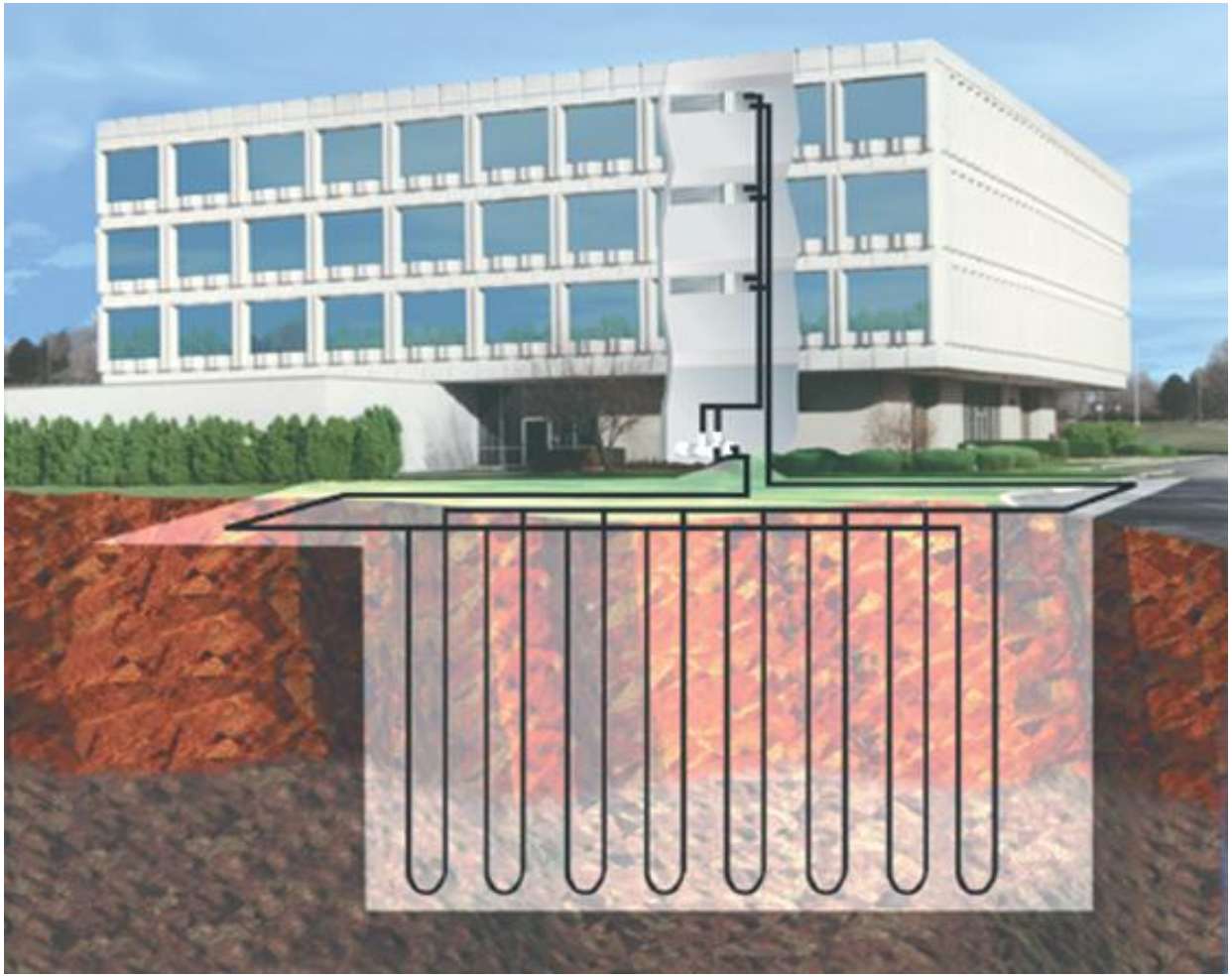
System/ground interaction



Loop Design



Distributed Geothermal Heat Pumps



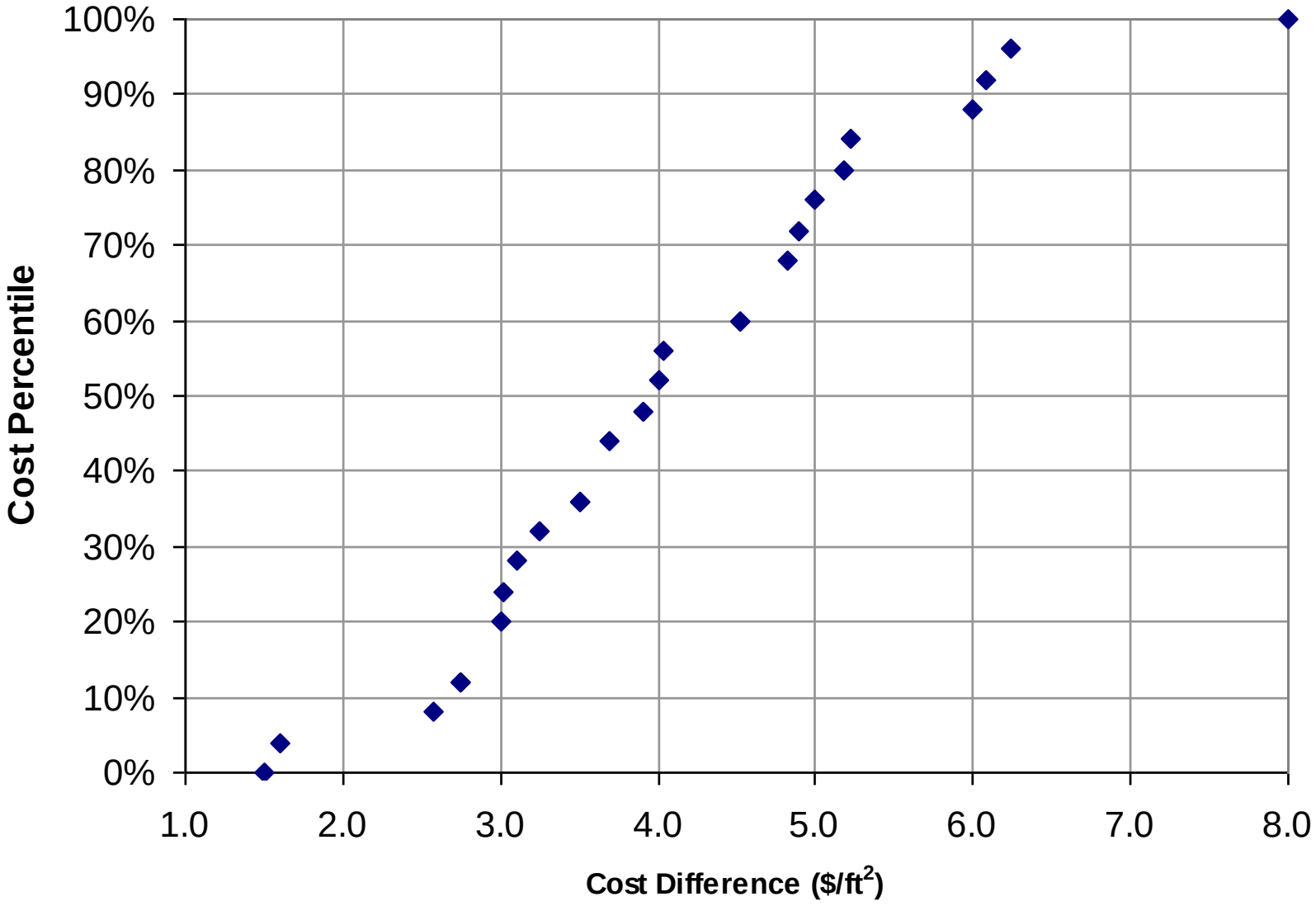
Central Geothermal

- Any size available
- Some modular, 30 – 120 ton units

Plumbing and geothermal

- Domestic hot water – often just preheat
  - Desuperheater (smaller units)
  - Water-to-water heat pumps
  - Heat recovery chillers (central geo)

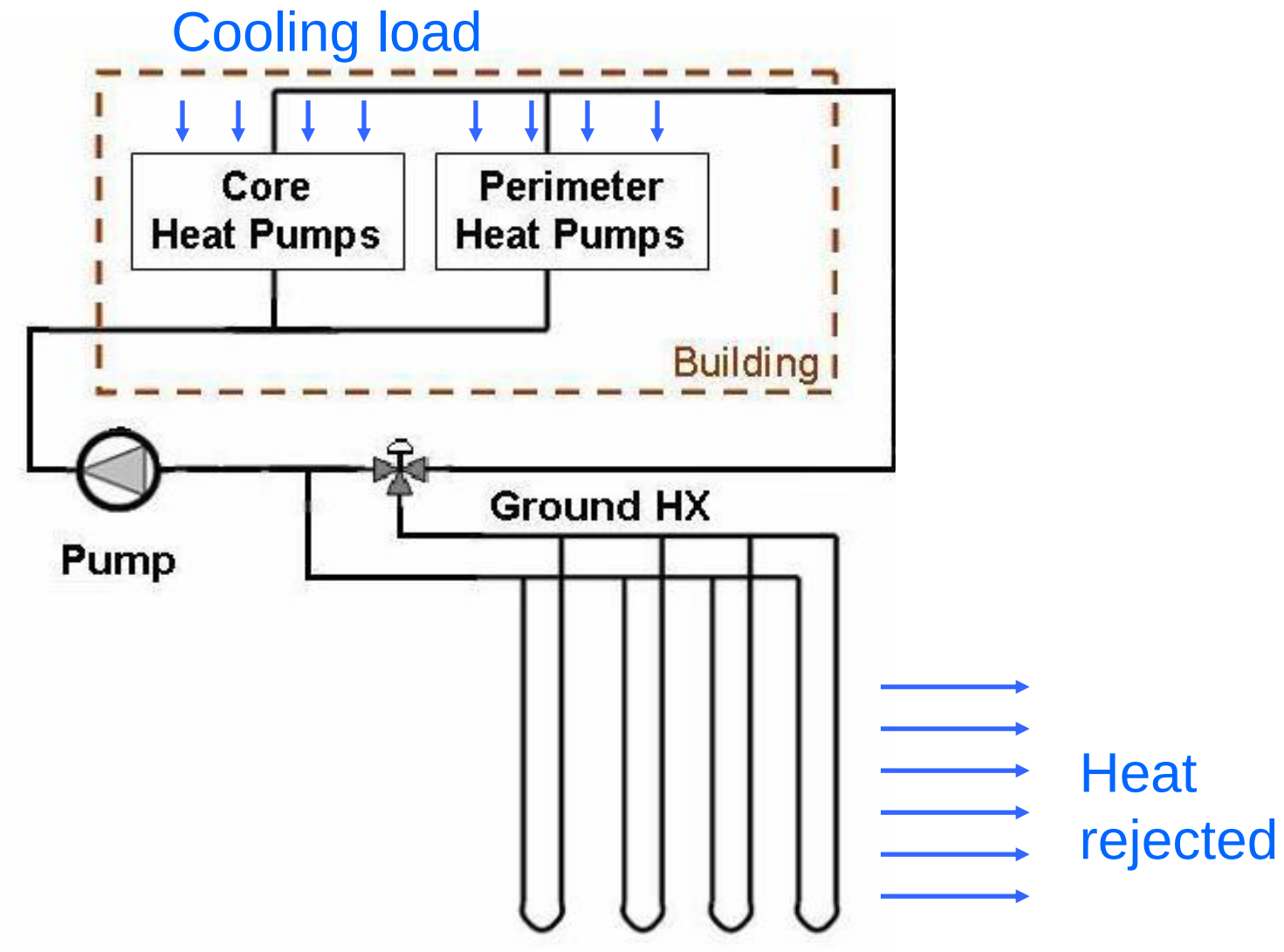
Costs



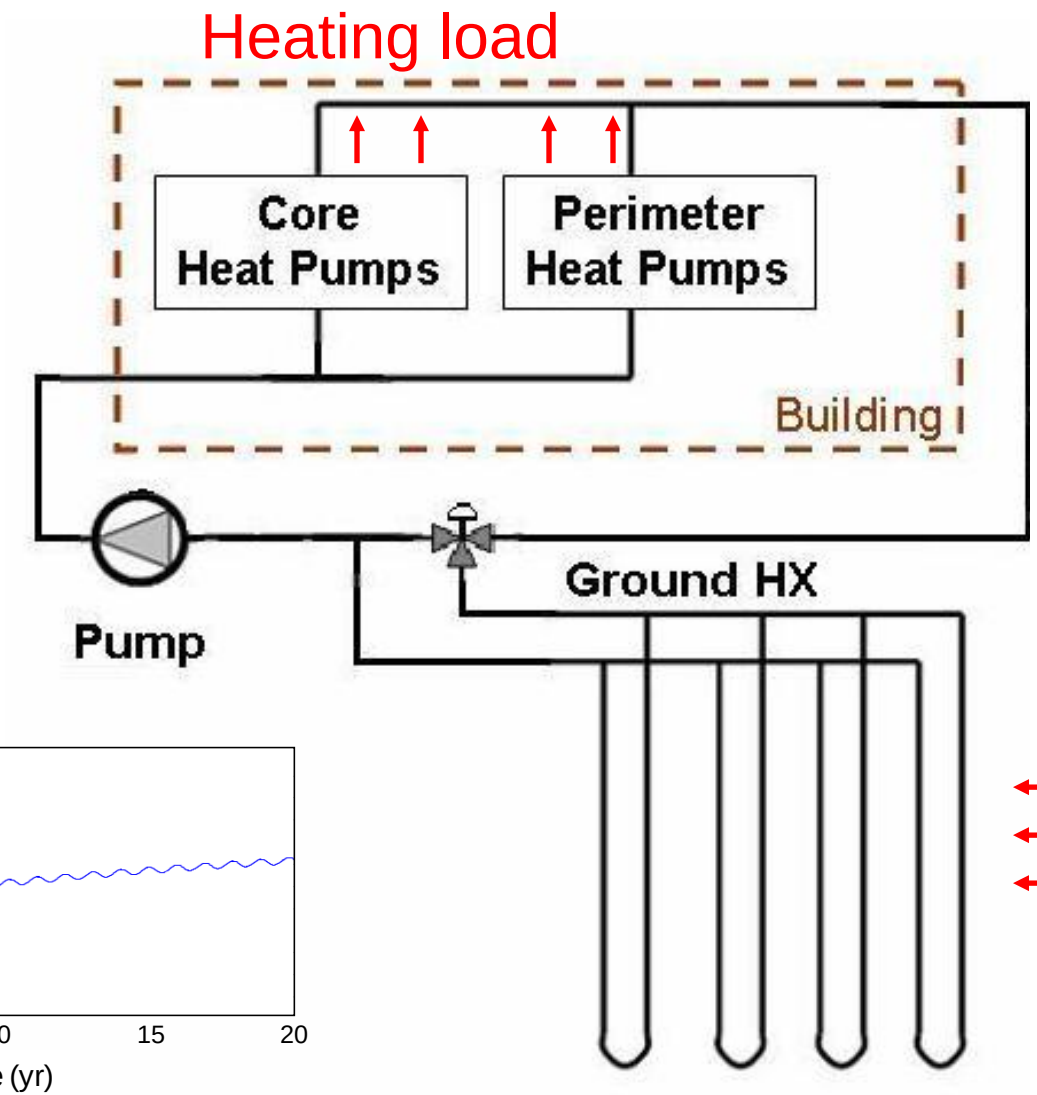
Wisconsin study, 2009

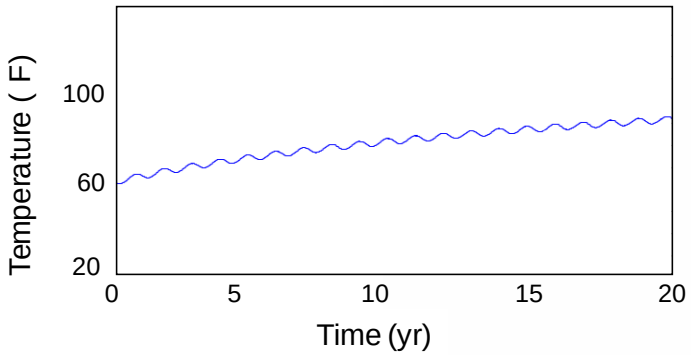
Hybrid Geothermal

Ground source heat pump system

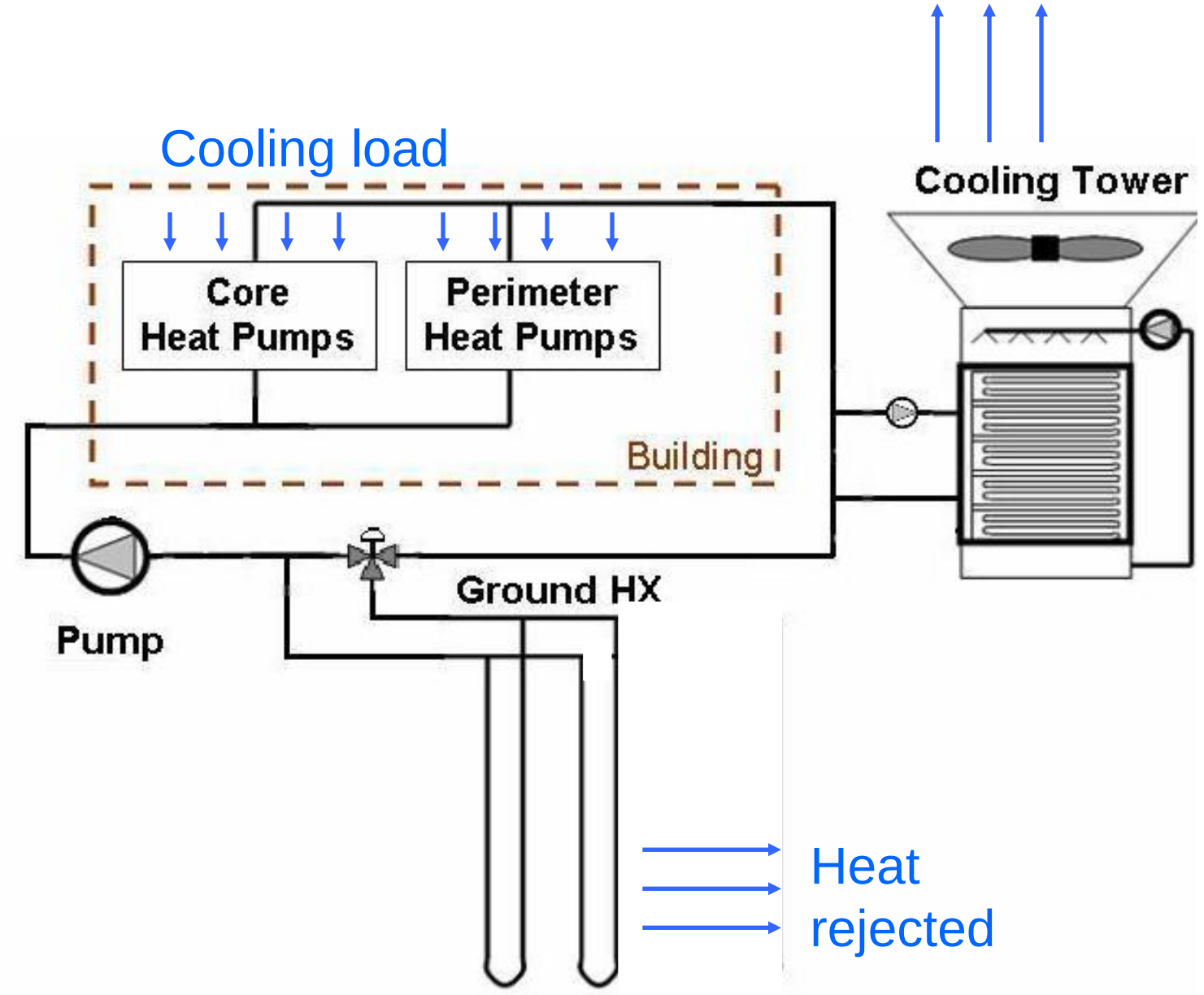


Ground source heat pump system

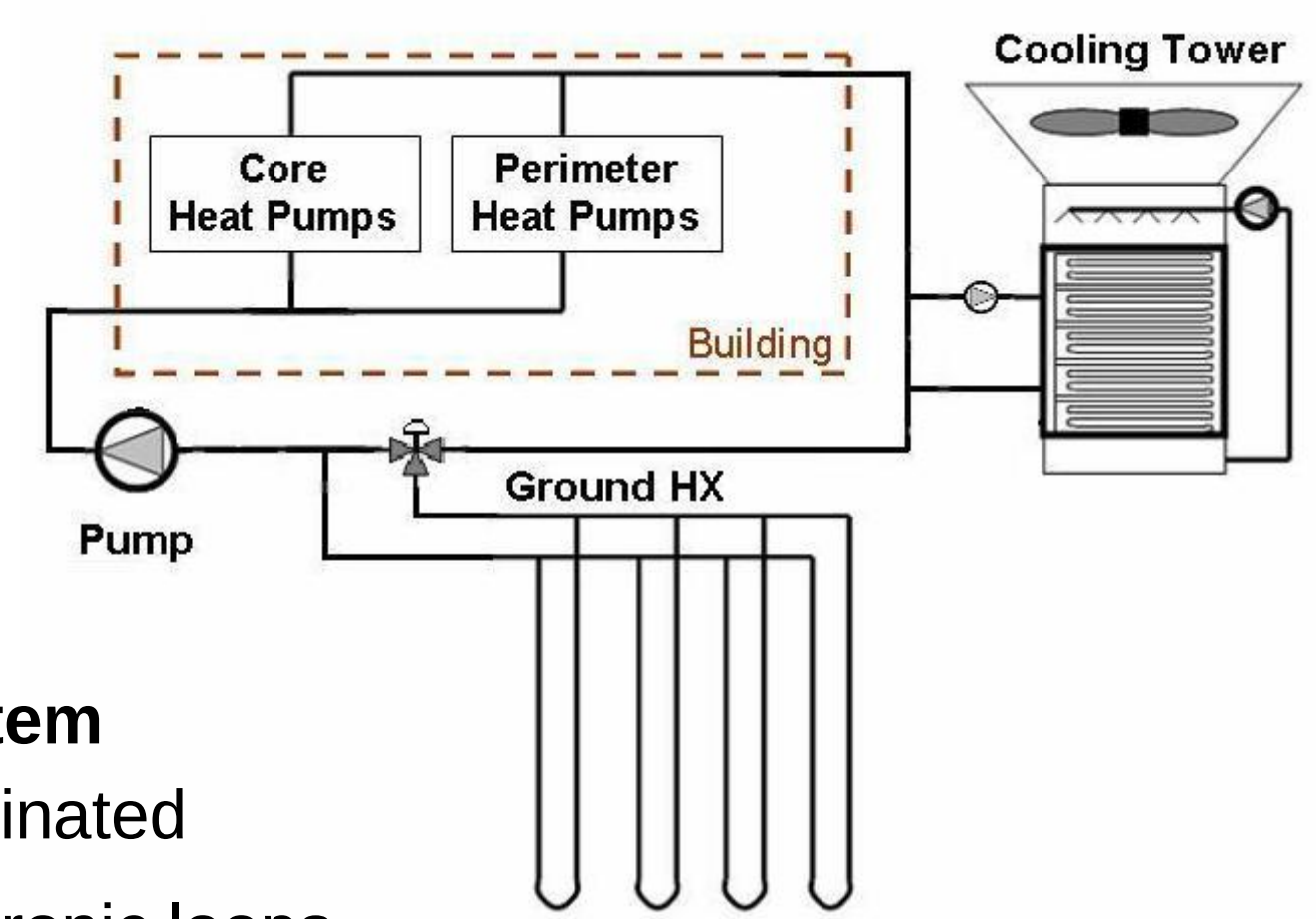




Ground source heat pump system



Hybrid ground source heat pump



A typical system

- Cooling dominated
- Coupled hydronic loops
- Series supplemental device
- Dedicated supplemental pump

The buildings (cooling dominant)

Cashman Equipment

300k ft² equipment dealer in Henderson, NV

- Distributed heat pumps
- Dedicated outdoor air
- GHX: 144,000 ft
- Towers: 500 tons (var. spd. fluid coolers)

Courtesy: SH Architecture

The buildings (cooling dominant)

East Career and Technical Academy

250k ft² vocational high school in Las Vegas, NV

- Distributed heat pumps
- GHX 168,000 ft
- Towers: 333 tons
  (two spd. fluid coolers)

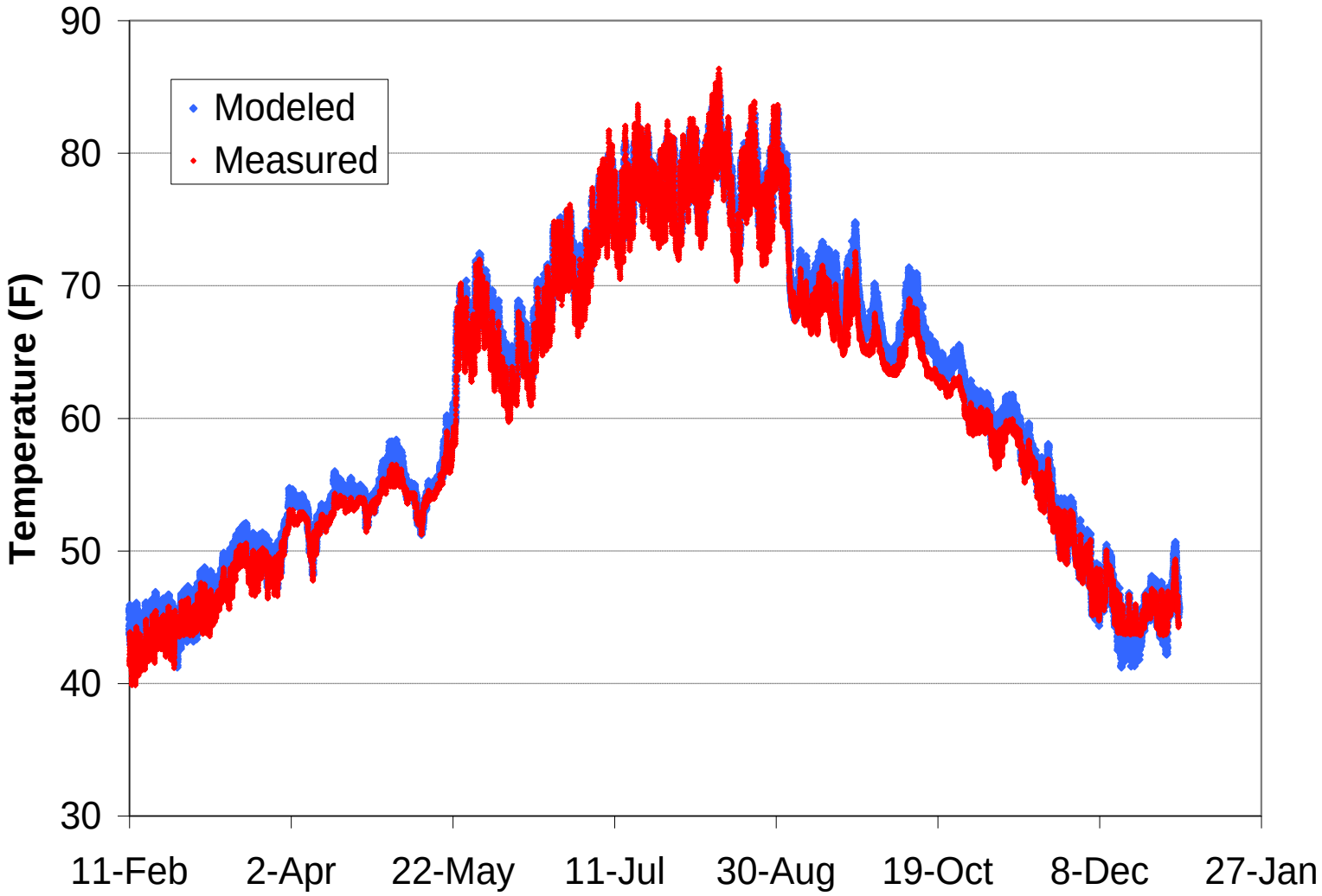
Courtesy: SH Architecture

The buildings (heating dominant)

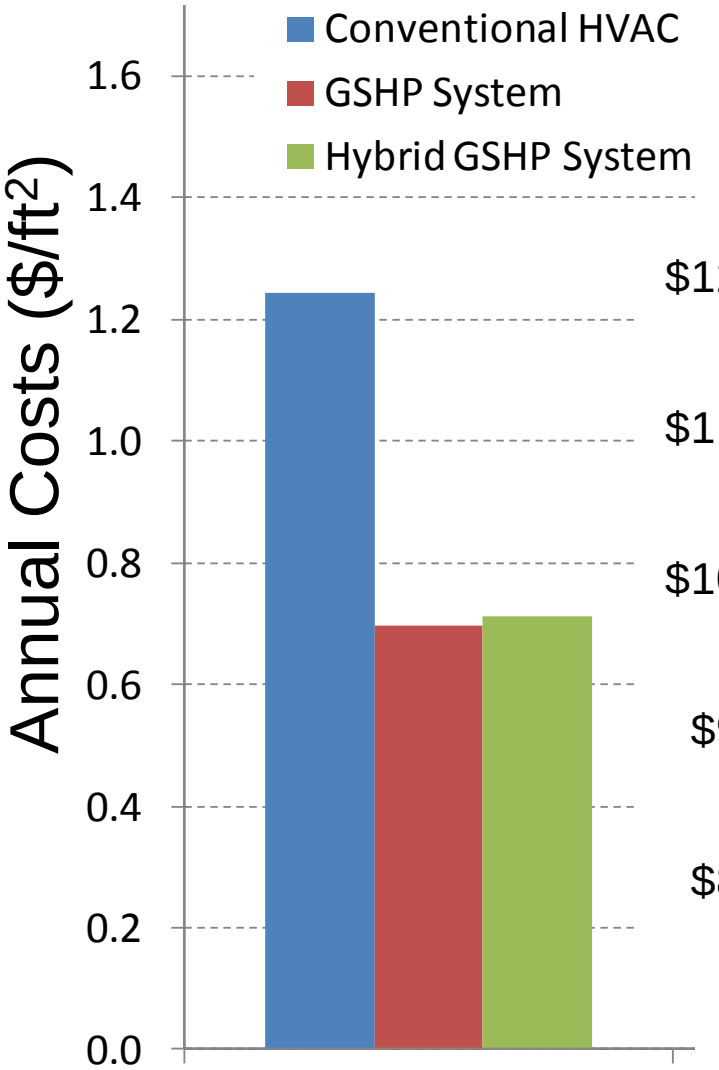
Tobacco Lofts
74k ft² multifamily building in Madison, WI

- Distributed heat pumps
- Dedicated outdoor air
- GHX: 11,300 ft
- Boiler: 199 MBH (condensing)

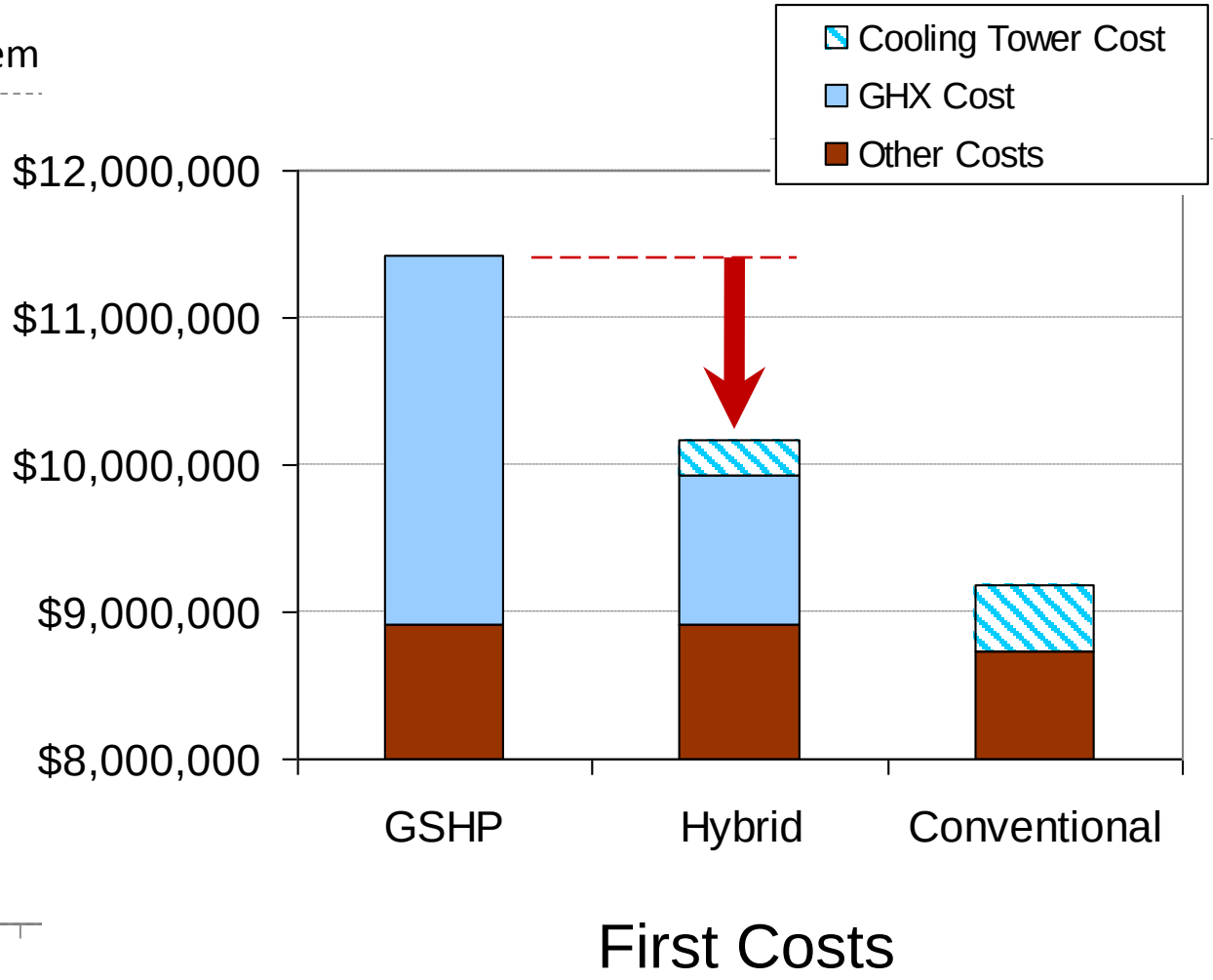
Data Collection and Validation



The bottom line

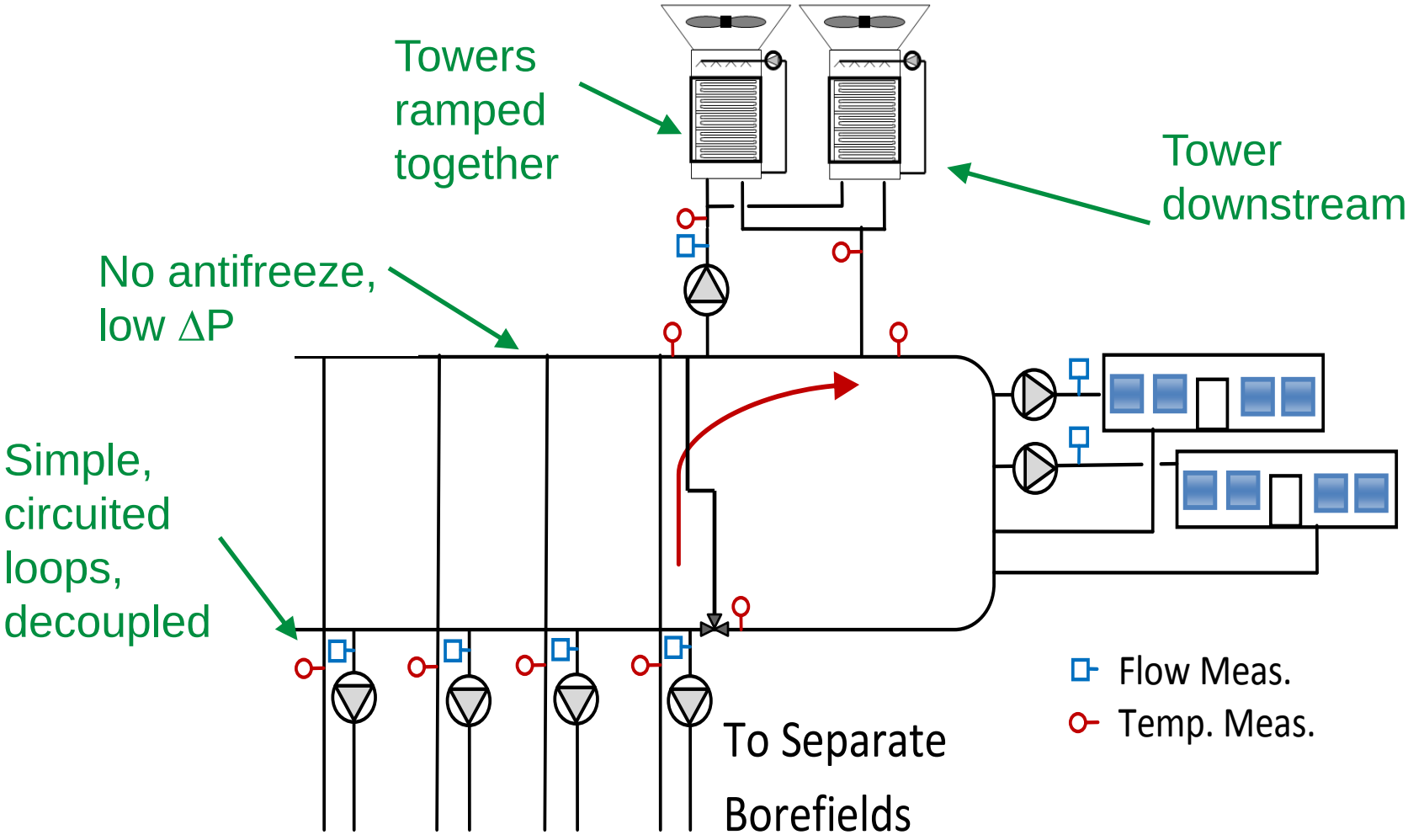


….for East CTA

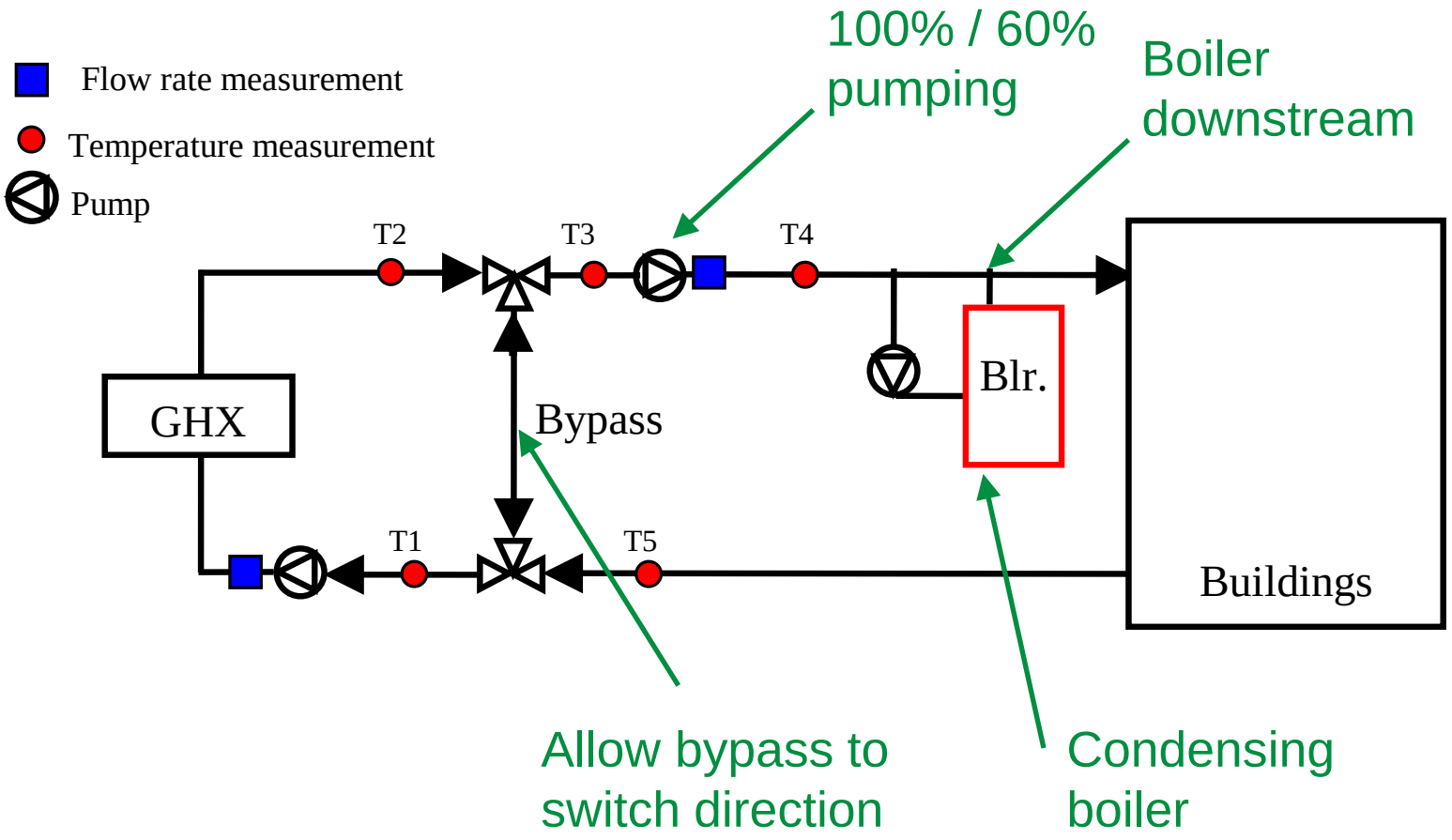


Effective hybrid design/operation

Lessons learned—Cashman/East CTA



Lessons learned—Tobacco Lofts



Extra care needed in sizing

	Ground Heat Exchanger		Supplemental Device	
	actual	optimized	actual	optimized
Cashman	144,000 ft	86,000 ft	500 tons	430 tons
East CTA	168,000 ft	92,000 ft	333 tons	400 tons
Tobacco Lofts	10,900 ft	7,400 ft	199 MBH	300 MBH

- Primarily the GHX is oversized
- Systems oversized in general

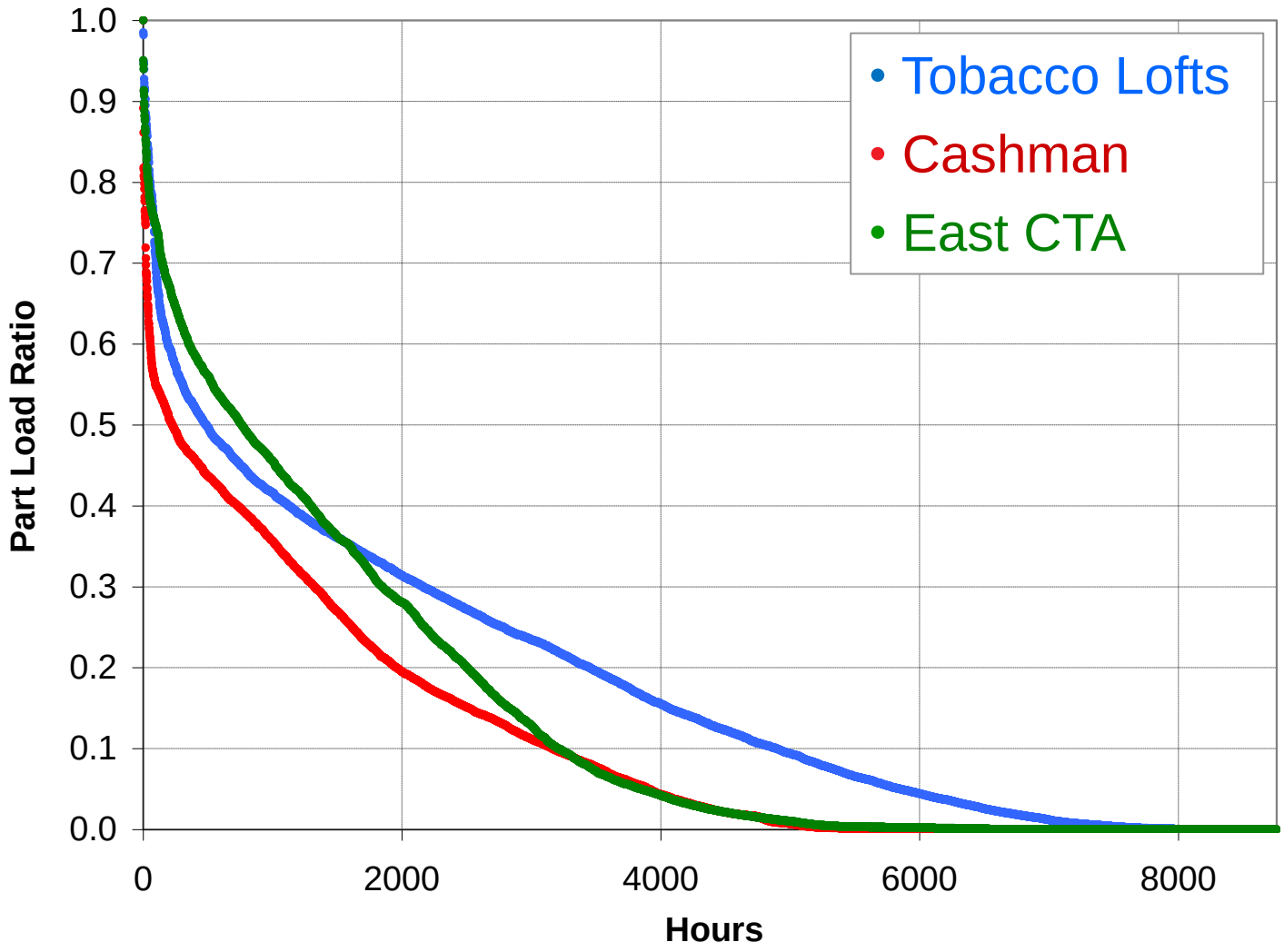
Pumping is significant

Pumping energy:
(% of HVAC)

- Cashman: 7%
- East CTA: 12%
- T. Lofts: 21%

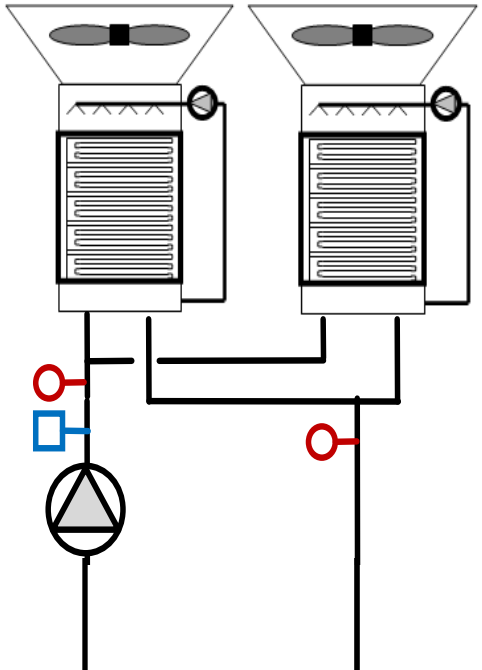
Focus on part-load pumping

- **Size for it**
- **Control for it**
- **Consider multiple pumps**



Control the tower

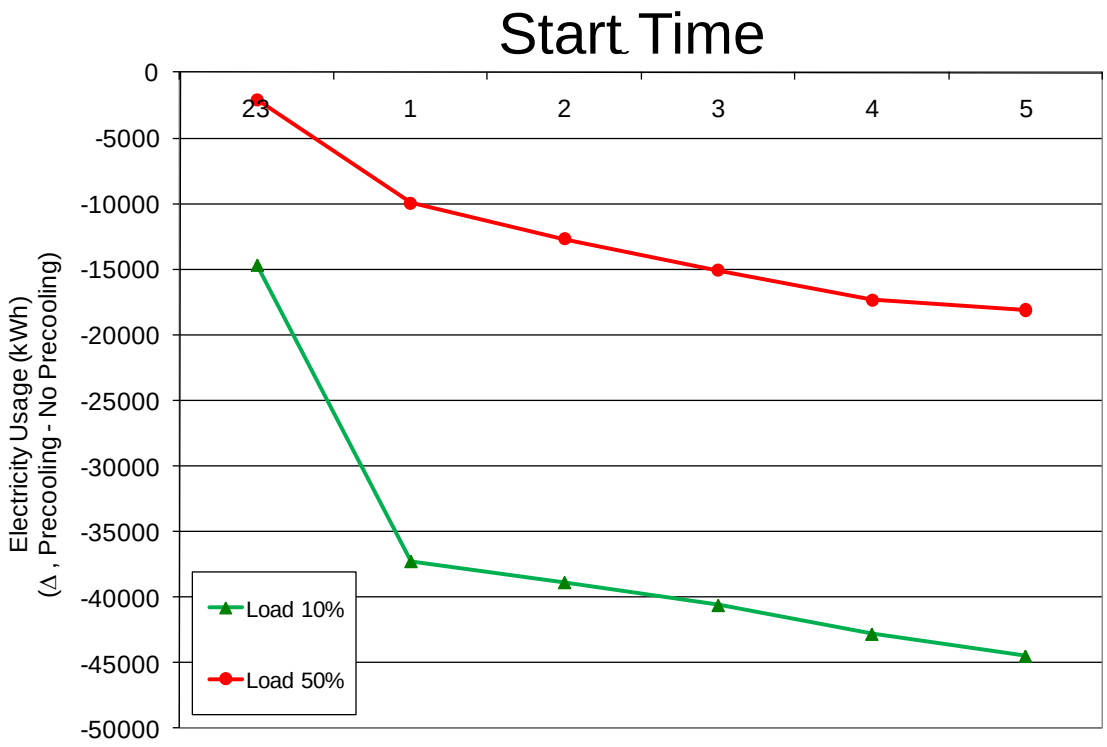
- Choose variable speed equipment
- Ramp equipment down quickly
- Tweak setpoints after occupancy
- Don’t pull energy out of the ground!



To precool or not to precool?

Precooling

- Operate tower at night
- Not all night



In ideal case, can save 10%+ of energy cost for pumps/towers

Careful: can also cause energy penalty.

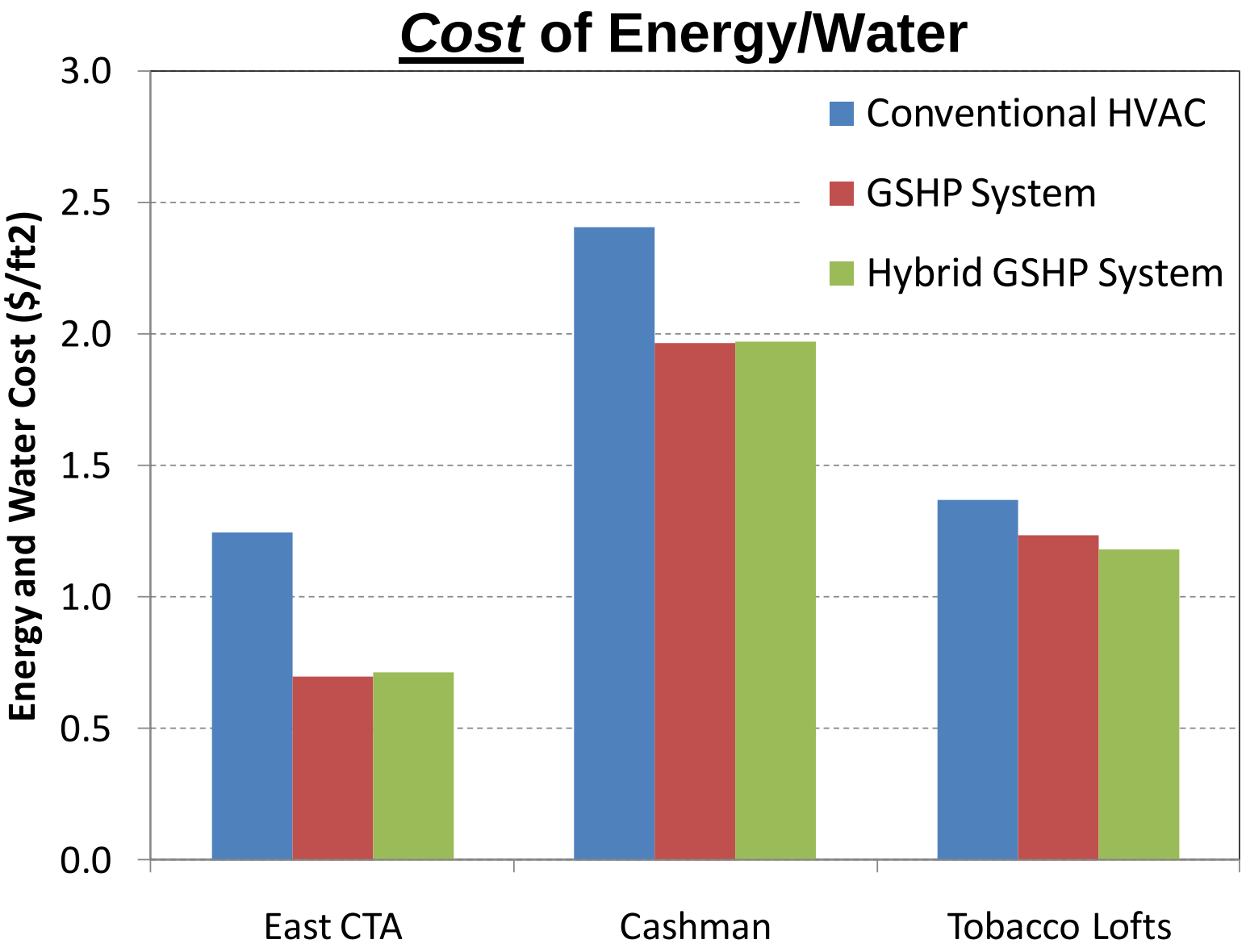
Other control learnings

Boiler

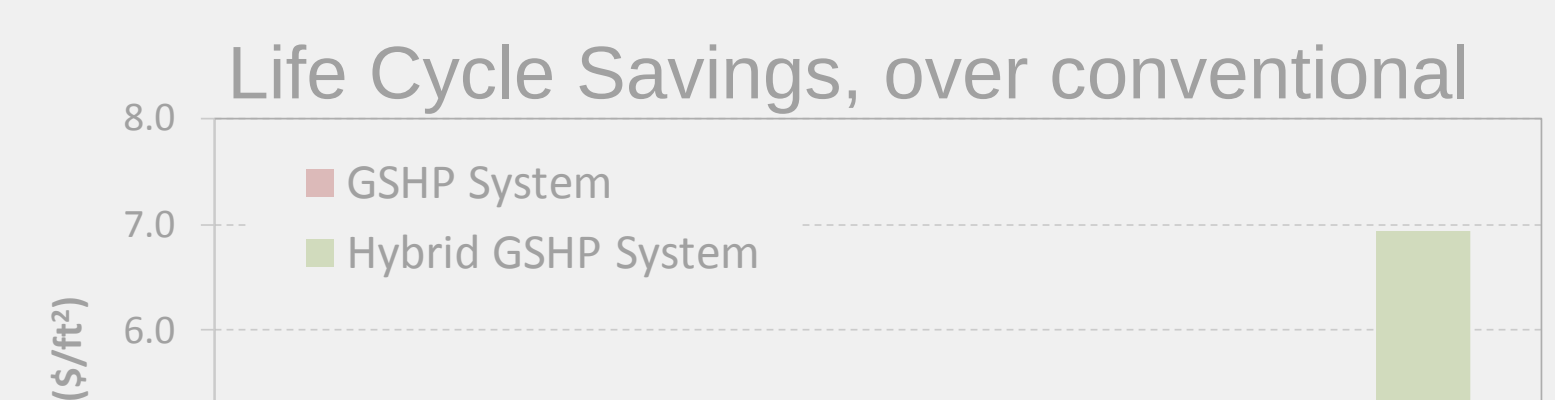
- ‘On’ setpoint should be ~5–10°F below the GHX
- 40°F optimum at Tobacco Lofts
- Facility staff should maintain this setting

More bottom line

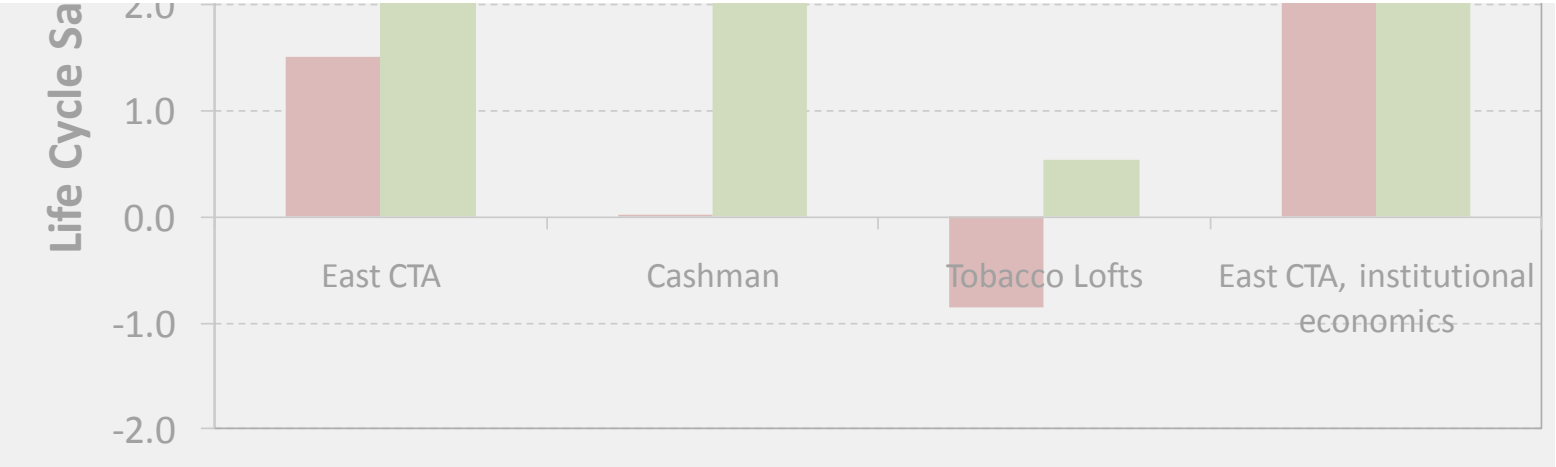
The bottom line



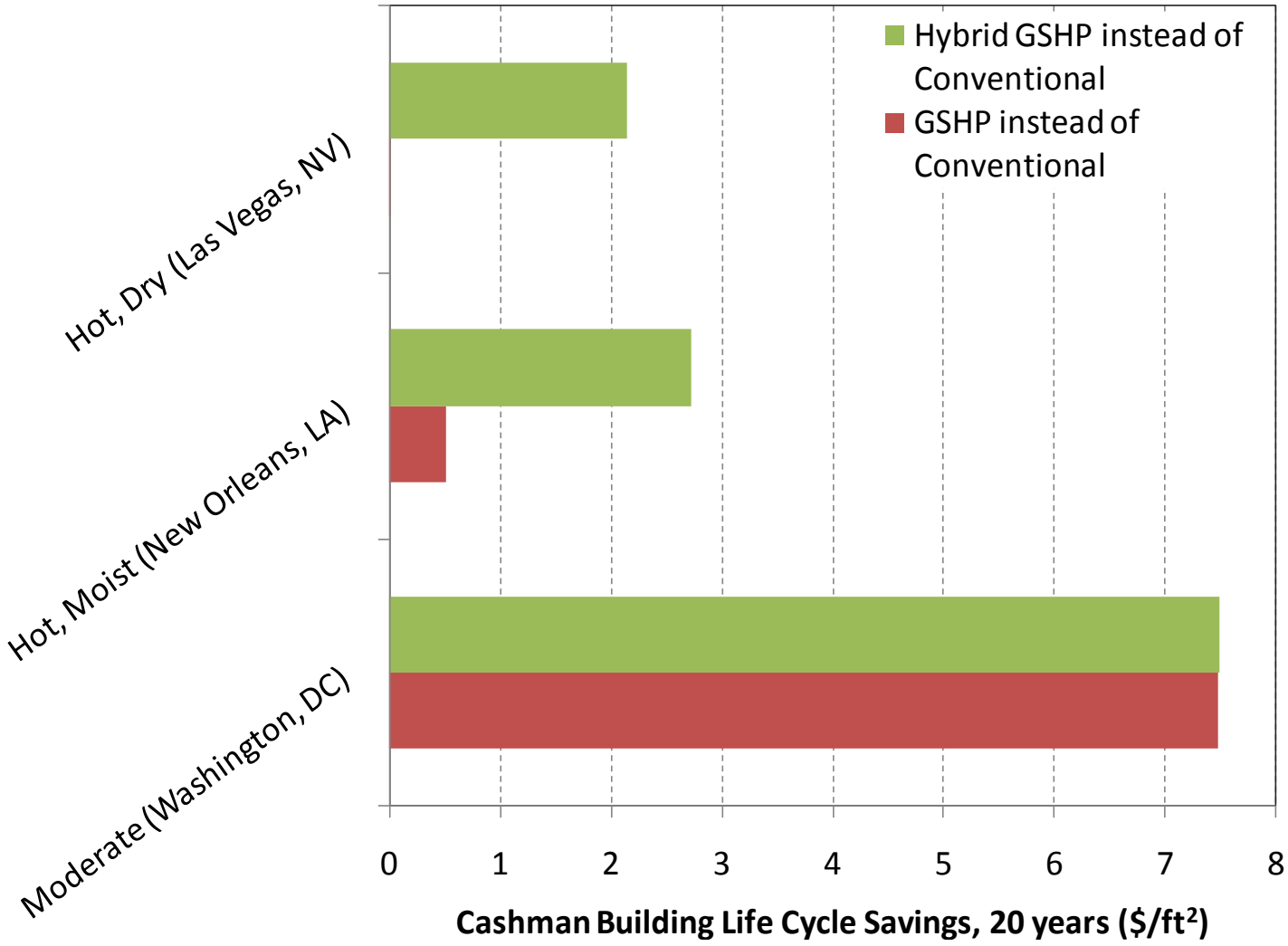
The bottom line



	Cashman	East CTA	Tobacco Lofts
Hybrid instead of Conventional	**10%**	**12%**	**9%**
GSHP instead of hybrid	5%	4%	1%



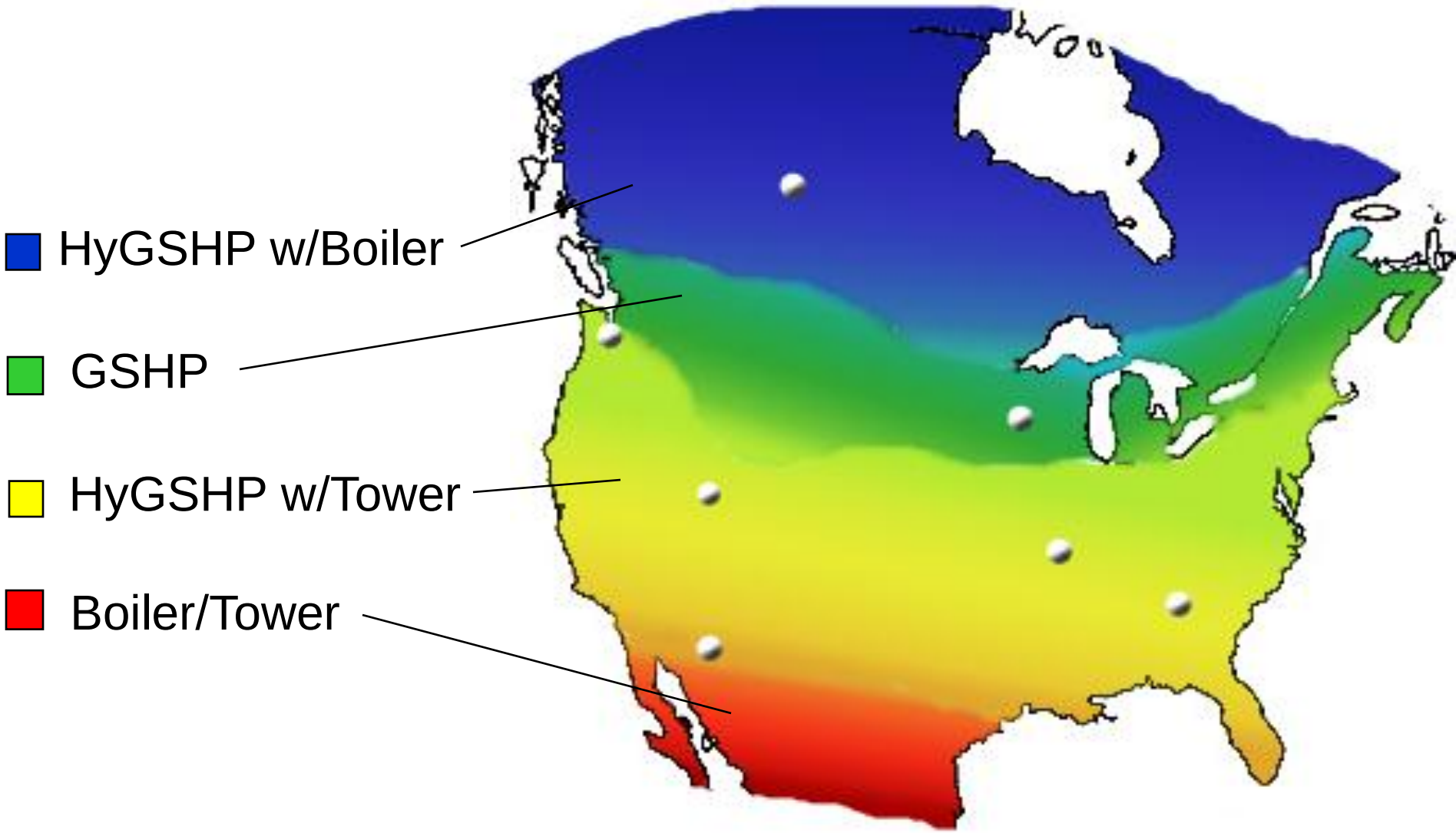
The bottom line: loads dependent



Balanced buildings benefit less

The bottom line: loads dependent

A high-level study with one building: office building



The other bottom line

Courtesy: NREL

Resources

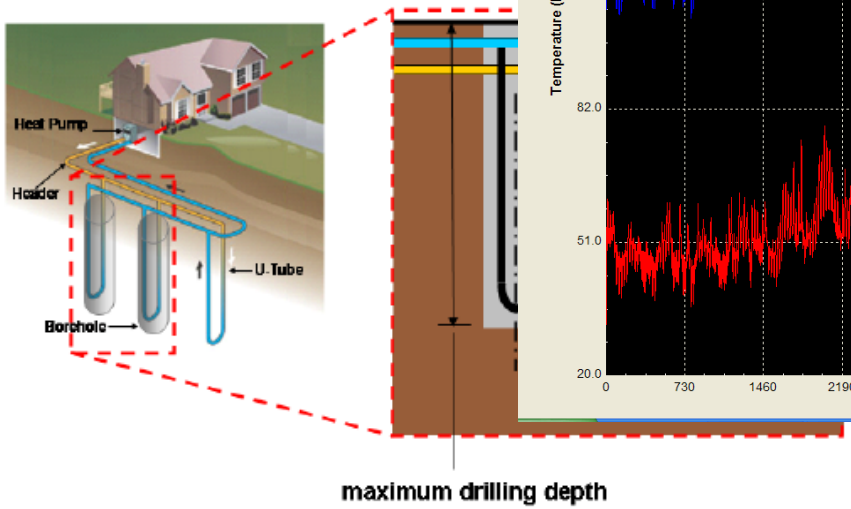
HyGCHP

File Calculate Windows Help

C:\HYGCHP\TRNSYS\HyGCHP_hybrid.trd

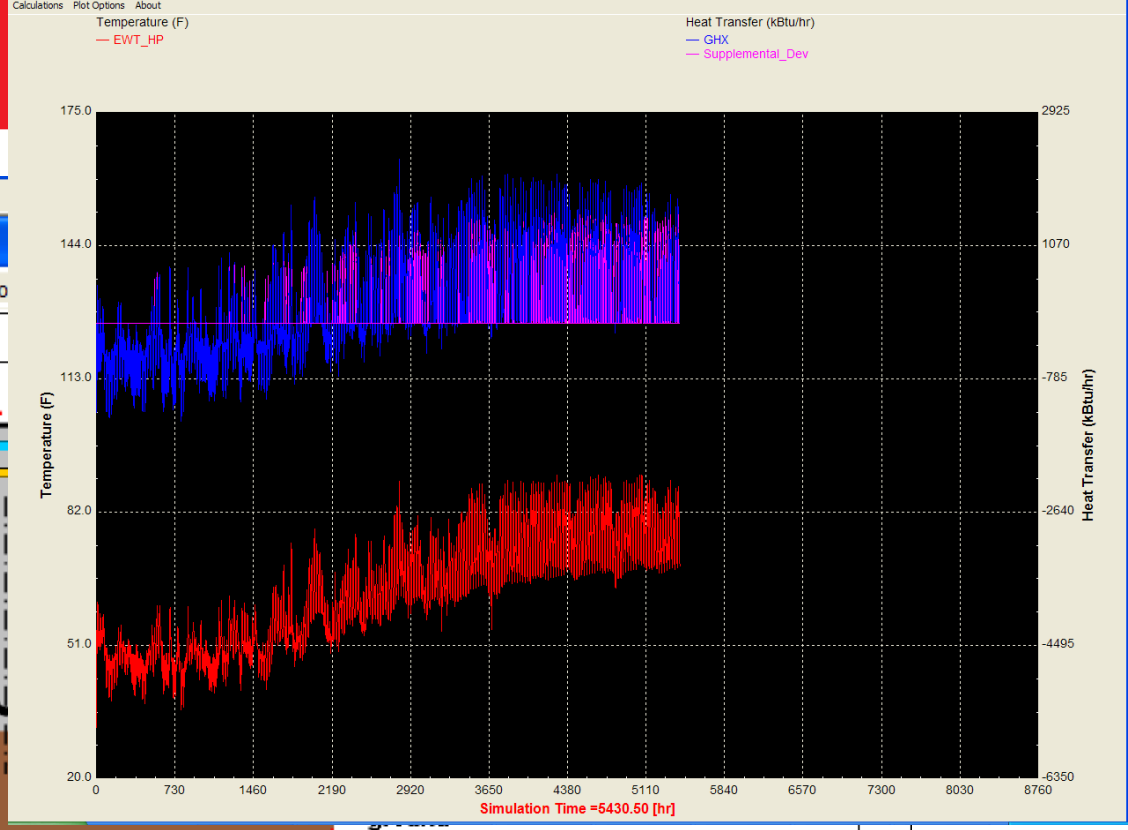
Main | Heat pumps | Ground Heat Exchanger | Fluid loo

Ground Heat Exchanger



Ground temperature (at mid-bore depth)	57.0	°F
Drilling depth	300.2	ft
Bore spacing	20.01	ft
Header depth	5.9	ft
Center-to-center half distance	1.496	in
Borehole radius	2.244	in
Ground thermal diffusivity	1.076	ft^2/day
Ground thermal conductivity	1.400	btu/h-ft-°F
U-tube size	20mm (0.75")	
Grout thermal conductivity	0.803	btu/h-ft-°F

Click for help, or press F1 while entering any input



Additional resources

Models

- HyGCHP
- Simulation: Energy Plus, TRNSYS, (eQUEST?)
- Sizing tools: GHLEPro, GLD2010
  - Limited guidance on supplemental device

Additional resources

References

- Kavanaugh – design basics
- OSU – controls information
  - Spitler
  - Xu
  - Others
- More info on this study: www.ecw.org/hybrid
  - Full report
  - Fact sheet

For more information

www.ecw.org/hybrid

Contact us to:

- Obtain a copy of the software.
- Obtain a copy of the full report.
- Ask a question.

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