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Center for Energy and Environment

Sustainable Resources Center
Creating Healthy & Efficient Homes

Combining Space and Water Heating with Highly Efficient Results

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Sponsors and Partners

A. NorthernSTAR - A DOE Building America Research Team

B. Sustainable Energy Resources for Consumers Grants

C. Center for Energy and Environment

D. Sustainable Resources Center

E. University of Minnesota

F. The Energy Conservatory

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Building America Solutions Center

basc.pnnl.gov

Overview

A. Background: Project and Equipment
B. System Design
C. Field Results: Efficiency, Savings, Comfort
D. Cost
E. What's next

How this project came about

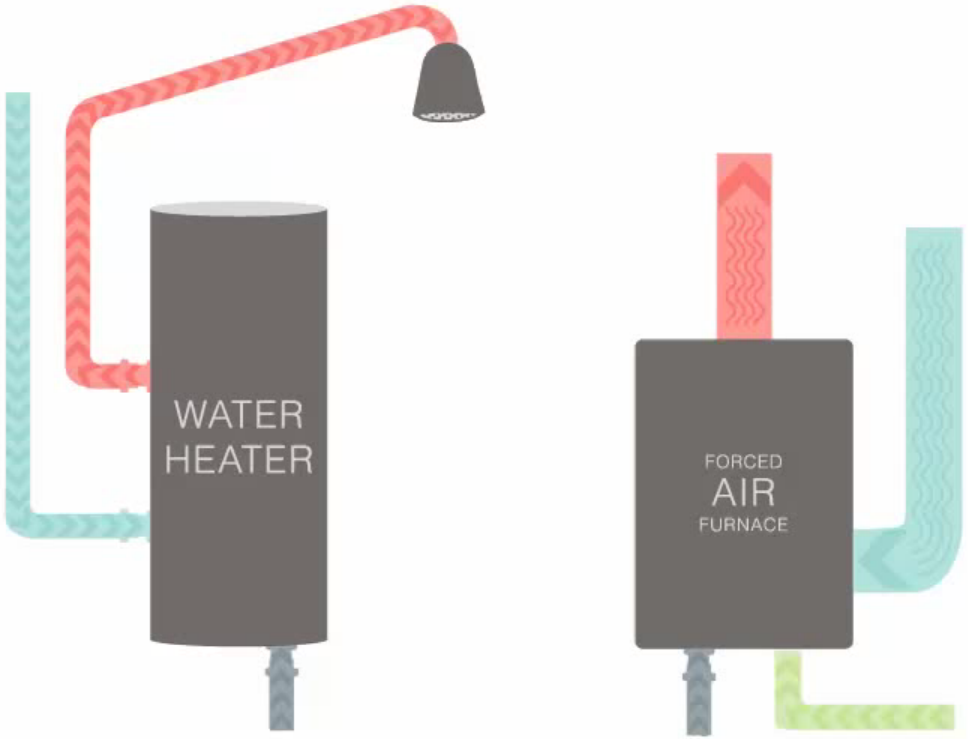
- Weatherization is able to seal homes tighter and tighter
- Leads to combustion safety issues
- Requires sealed combustion
- Requirements on Savings vs installed cost rule out high efficiency water heaters
- Forced to use safety budget to install 60% direct vent tanks with very little energy savings
- SRC got a SERC grant to look at using a DIA

What is a Dual Integrated Appliance?

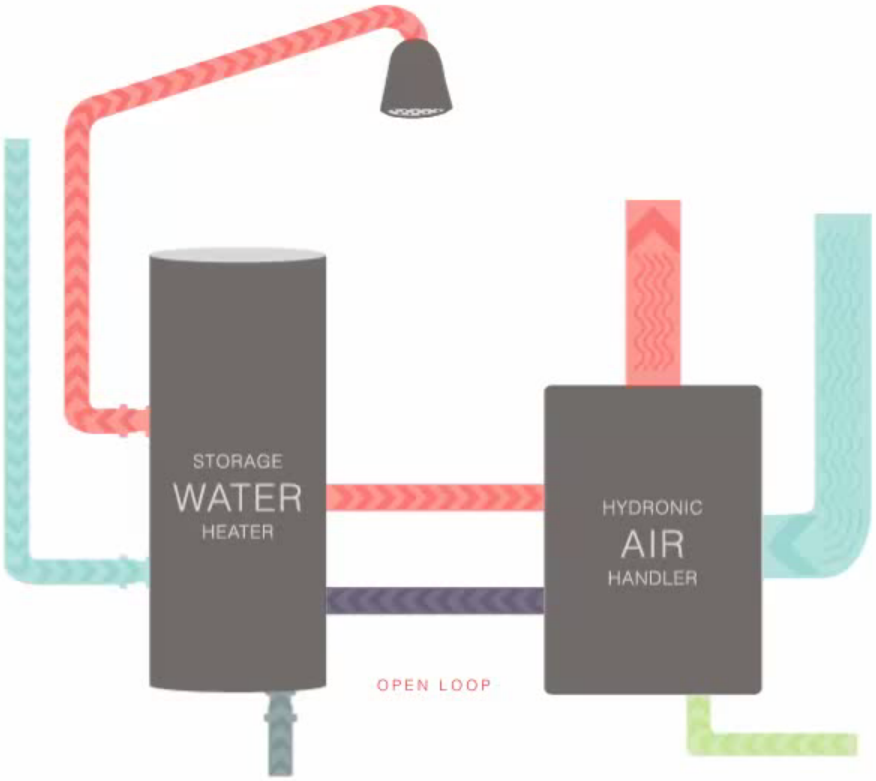
A. A mechanical system that uses one heating plant (natural gas burner) to provide both space heating and hot water
B. Space heating side can be either hydronic or forced air
C. Systems can use a closed or open heating loop

This project will look at natural gas forced air DIA systems. Boiler based systems will be closed loop and water heater systems have an open loop.

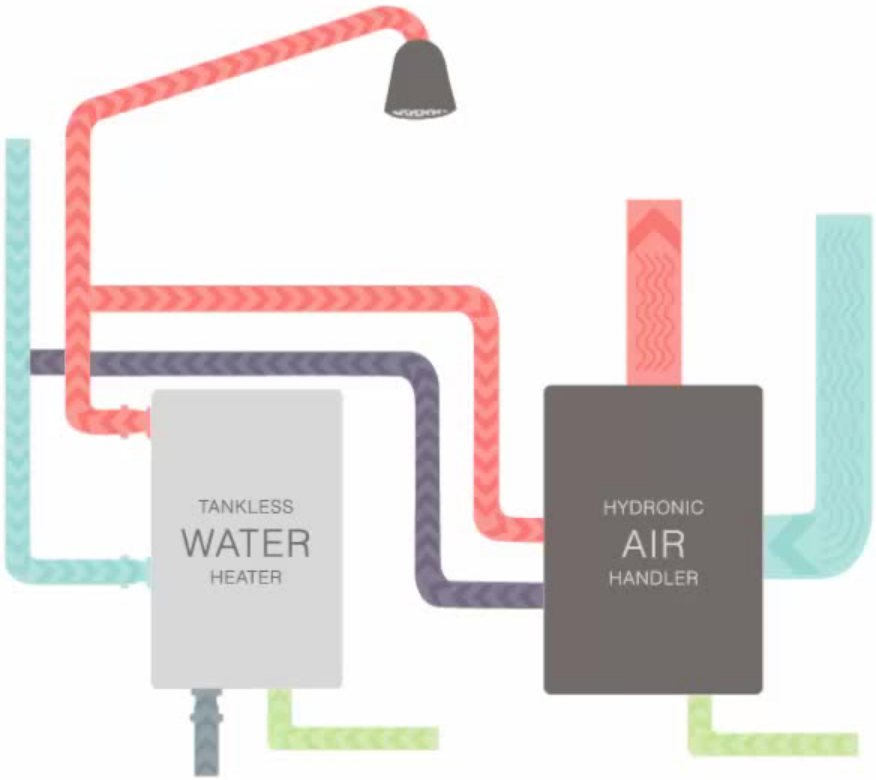
CONVENTIONAL SYSTEM
WATER AND SPACE HEATING



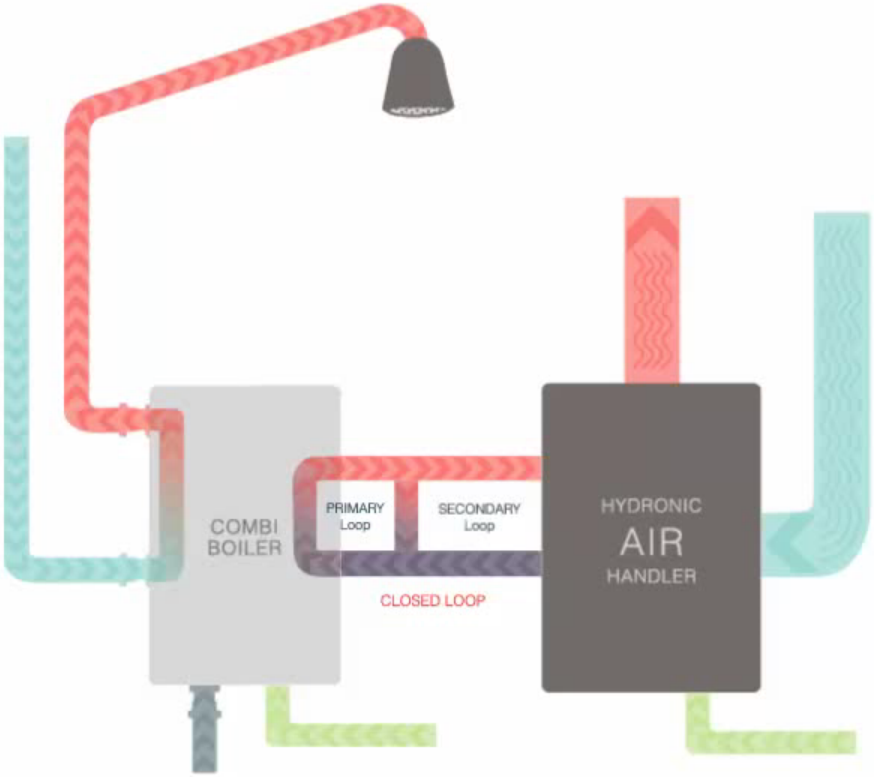
COMBINED WATER AND SPACE HEATER
USING STORAGE WATER HEATER



COMBINED WATER AND SPACE HEATER
USING TANKLESS WATER HEATER



COMBINED WATER AND SPACE HEATER
USING COMBI BOILER



Why Dual-Integrated Appliances?

+ Two high efficiency heaters (Space and Water) in one package
  - potentially cheaper
  - Simpler, less maintenance
+ Sealed combustion
  - Eliminates combustion safety issues
+ Further reduction in air infiltration
  - Removal of make up air inlets
  - Sealing chimneys

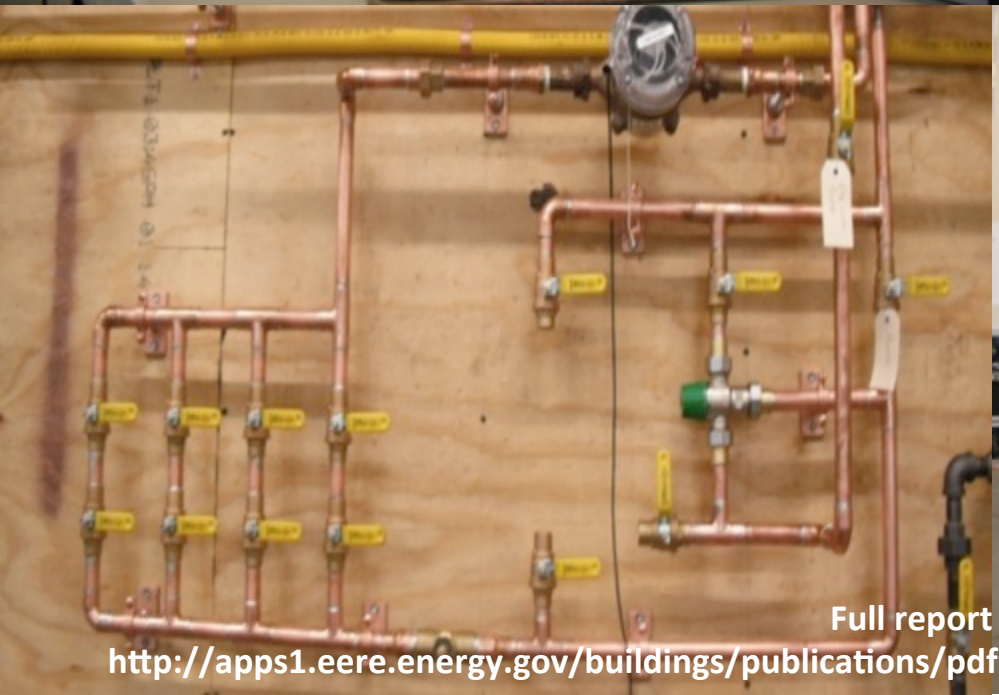
Installation and Sizing

PROBLEM

- Some contractor's had little experience
- System schematics often developed on site
- Little or no sizing information provided
- System components came from several manufacturers
- Manufacturer's settings typically do not lead to best performance

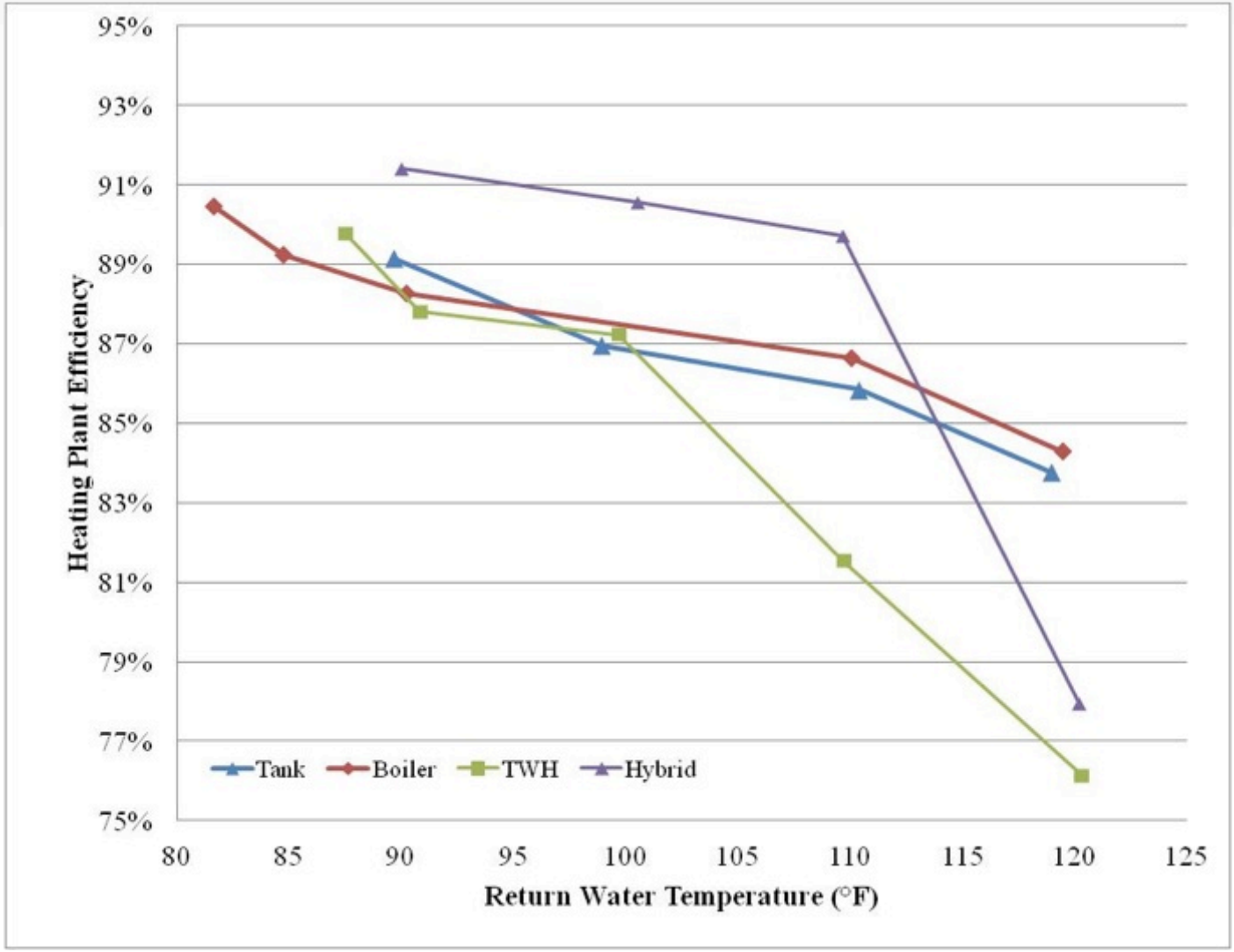
- Decided to design and optimize systems in a laboratory
- Could then provide contractors with more detail installation guidelines



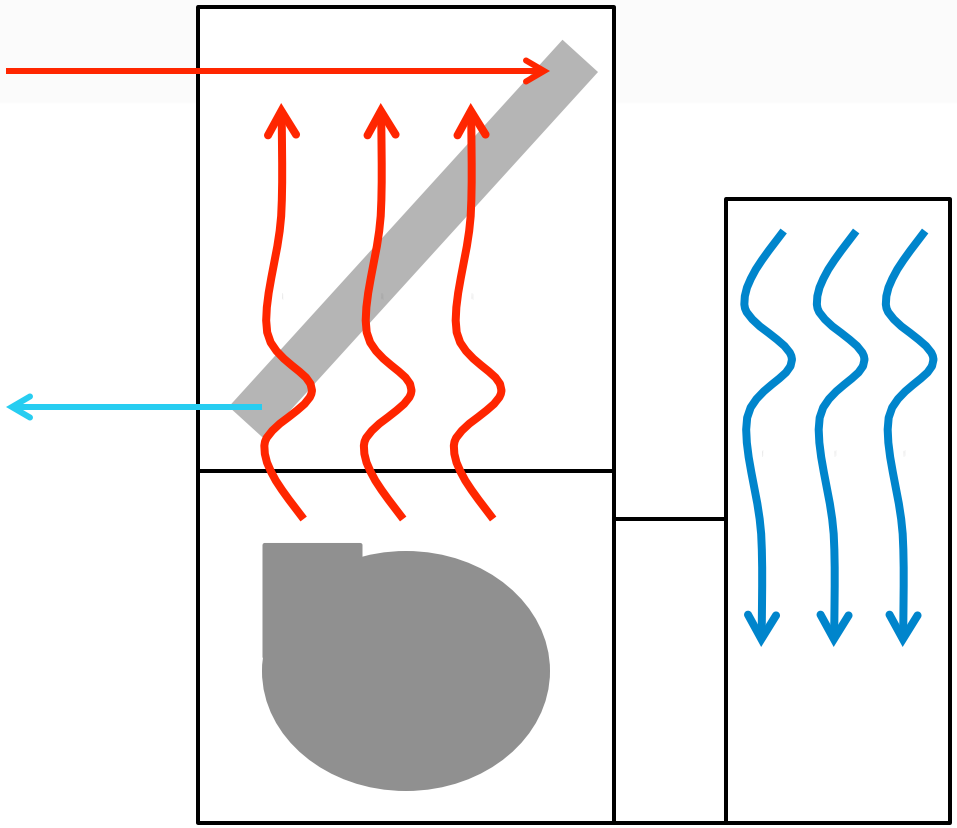



Full report at:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/labtests_combi_spacewh.pdf

Steady-state heating plant efficiency



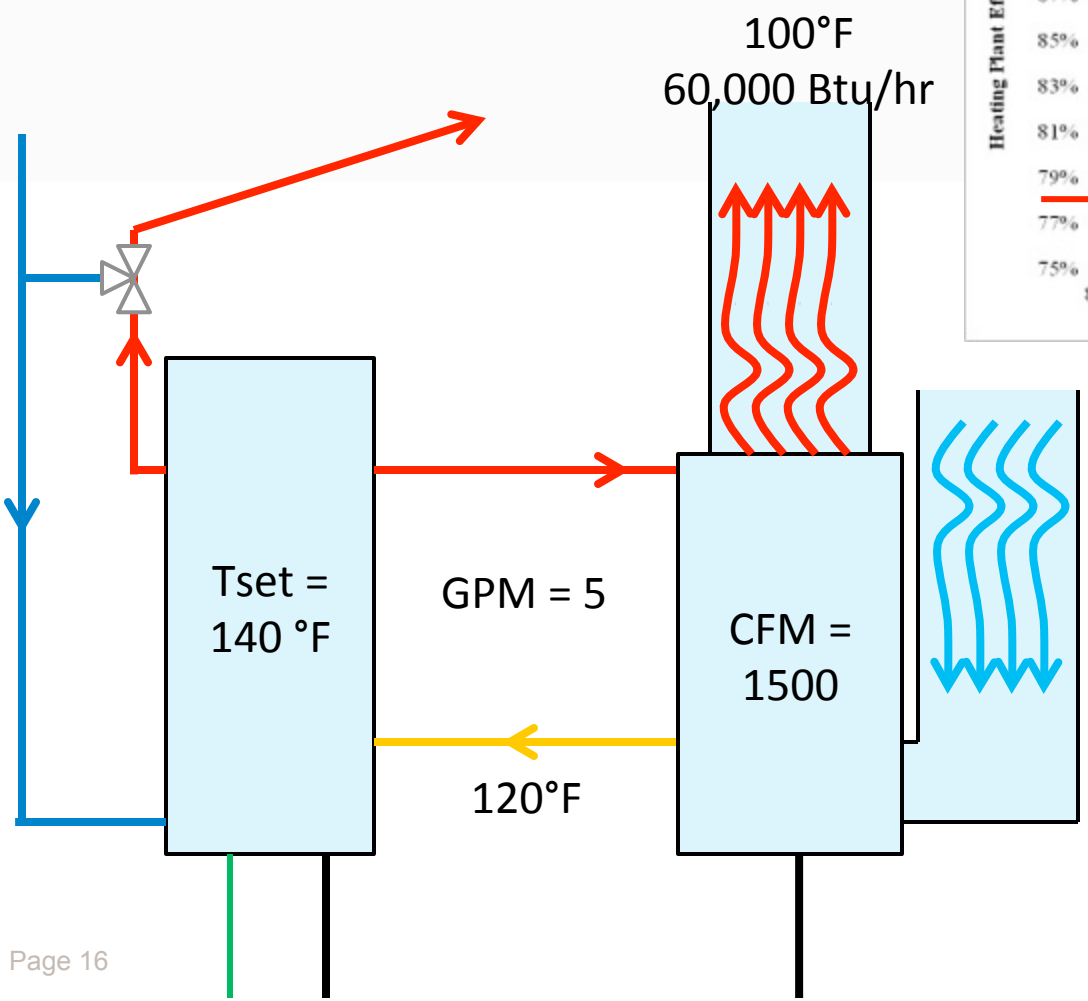
Air handler performance

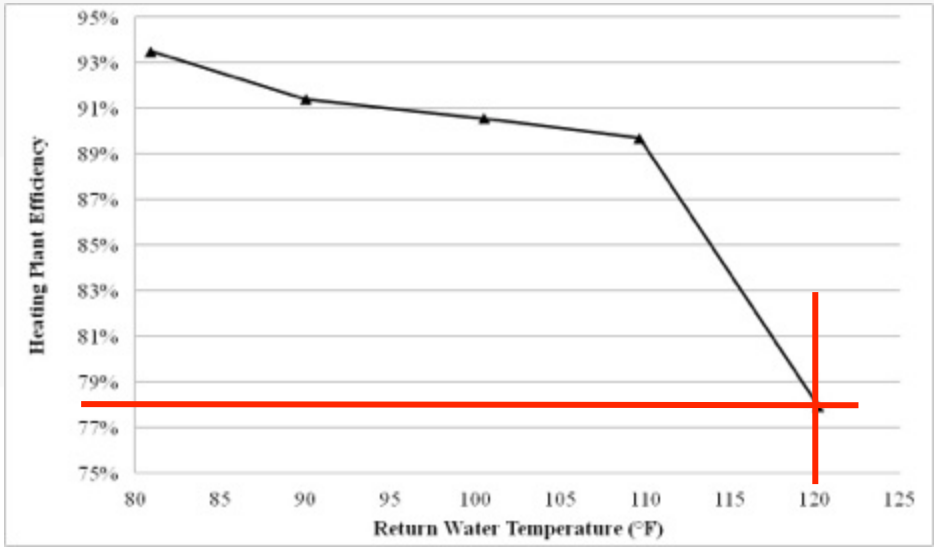


- Hydronic coil transfers heat from water to air
- Goals:
  - Return water <105 °F
  - Delivered air >110 °F
- Goals must be balanced with capacity needs
- Installation parameter charts were developed for each air handler

Poor install

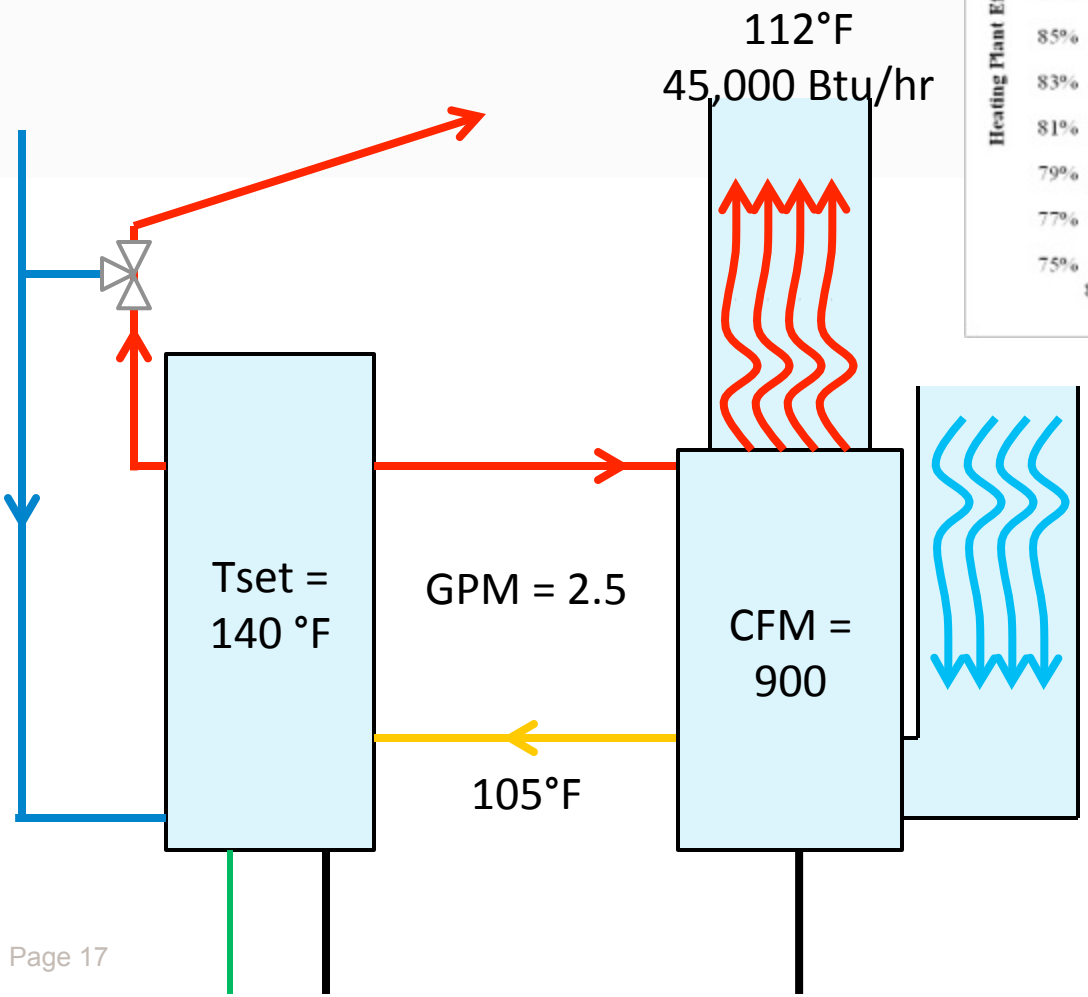
(for a 40,000 Btu/hr design load)

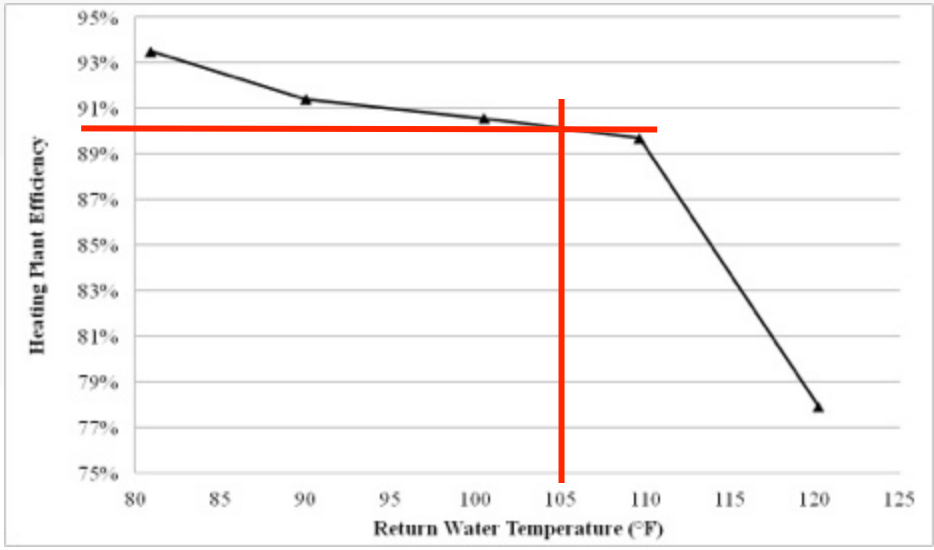




Better install

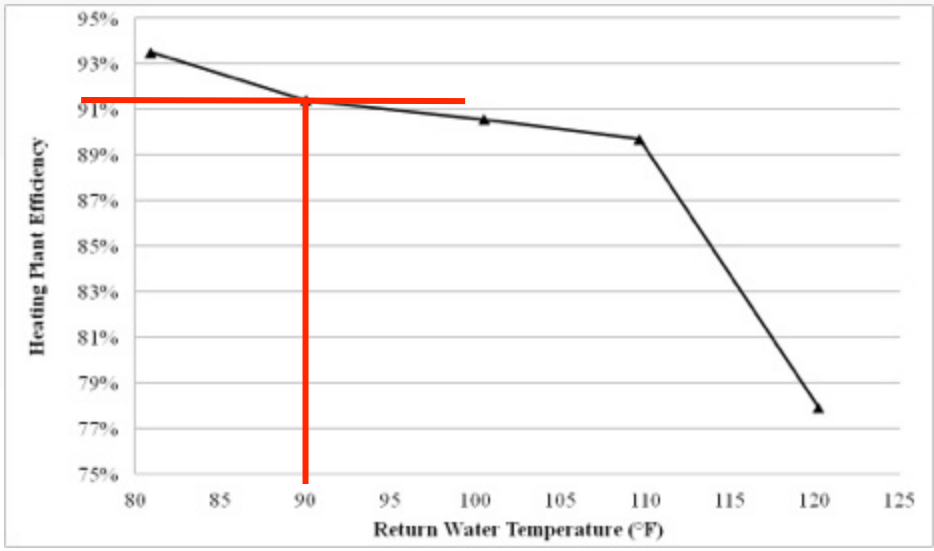
(for a 40,000 Btu/hr design load)

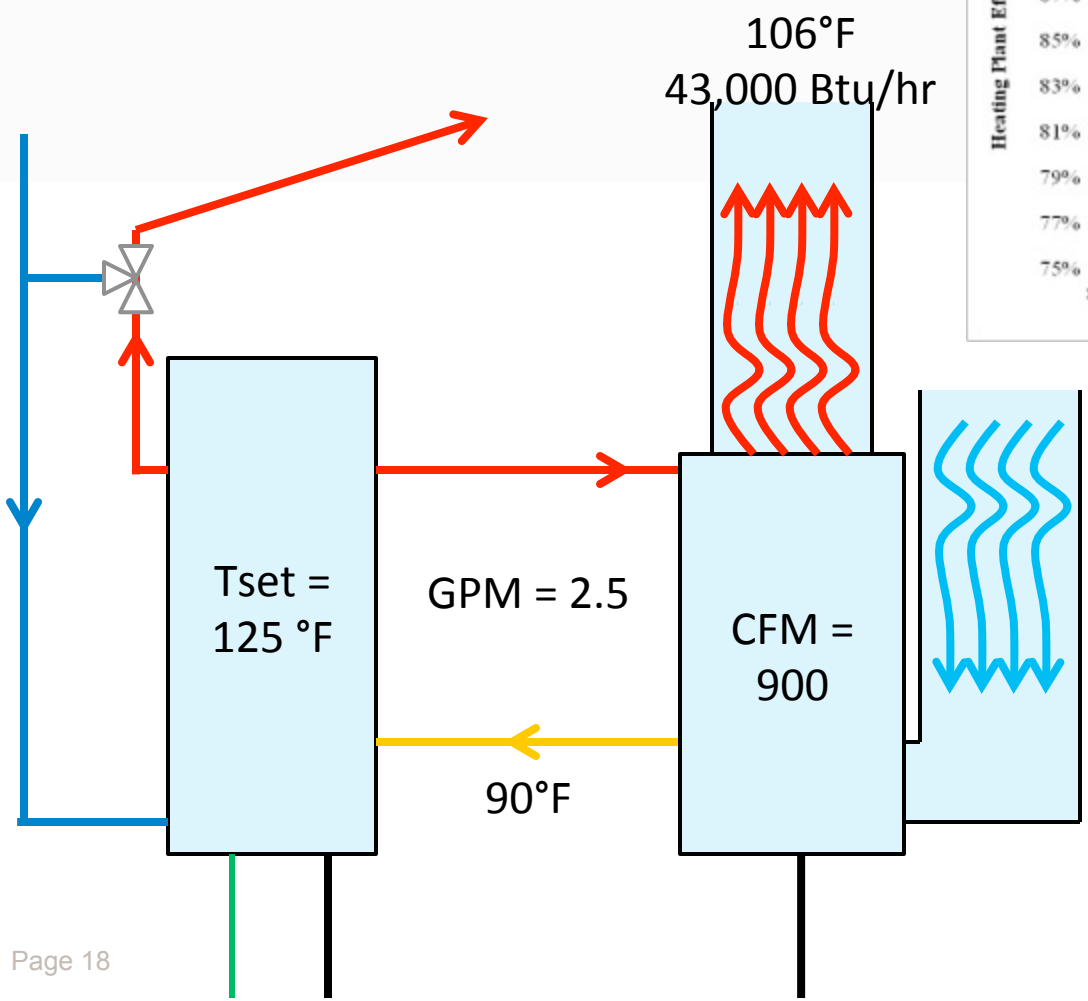




Best install

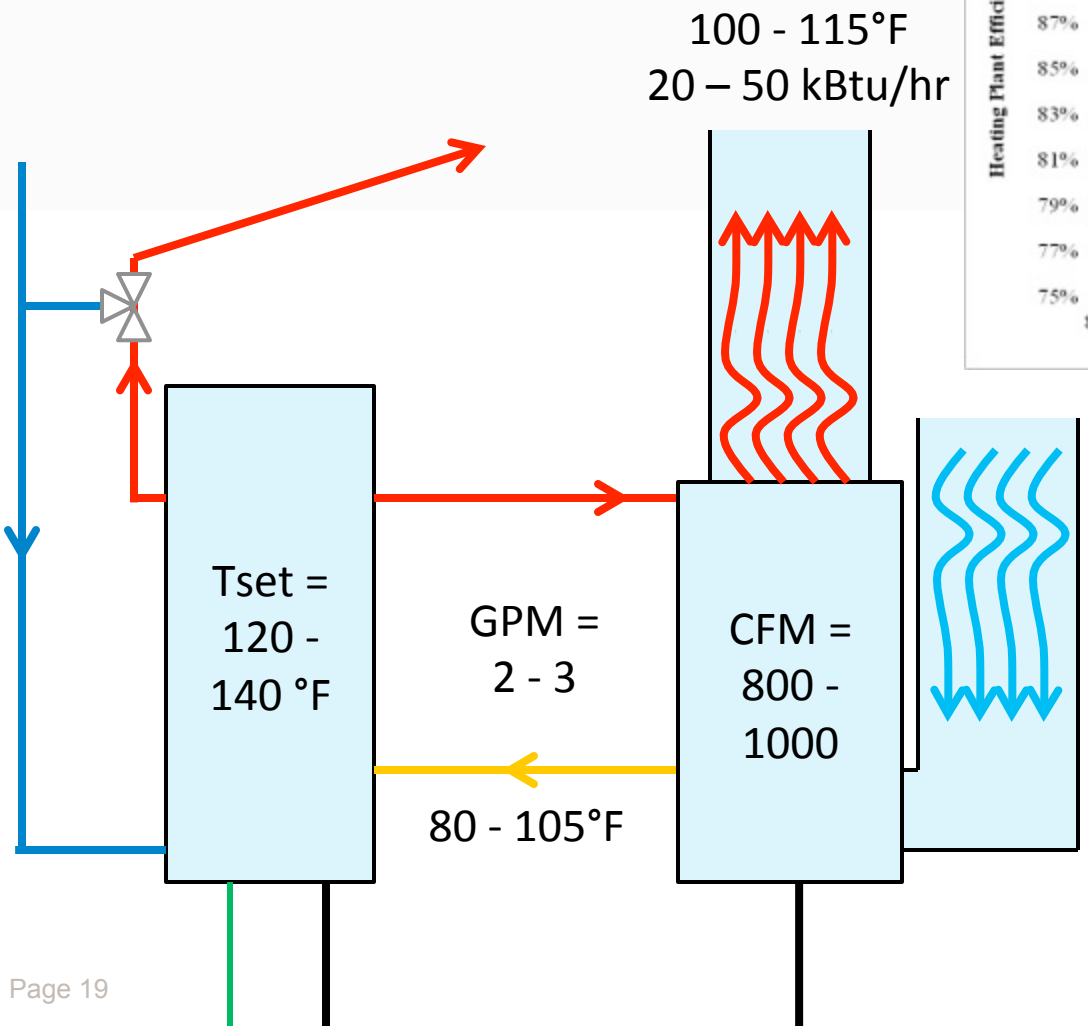
(for a 40,000 Btu/hr design load)

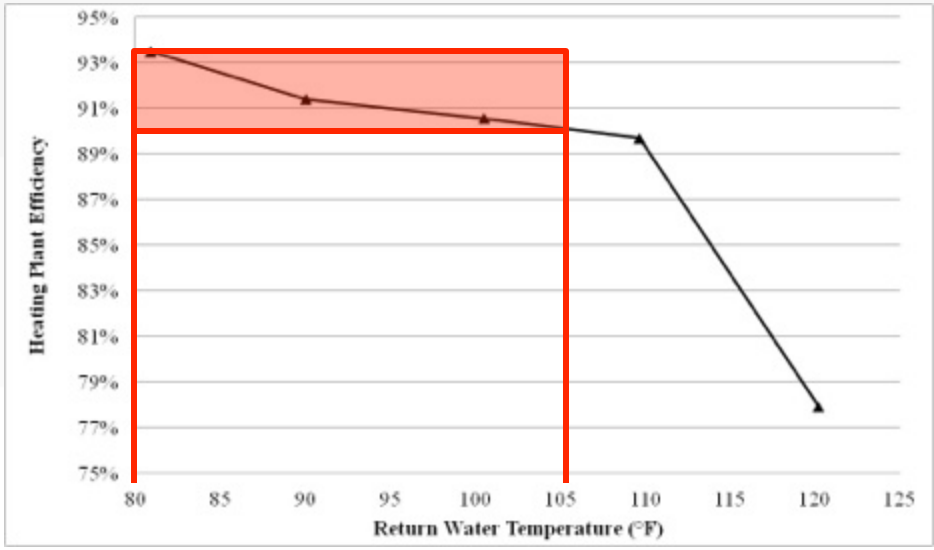




Ideal future install

(for a 40,000 Btu/hr design load)





Equipment and Site Selection: Trouble Areas

- Very large DHW loads
  - High flow rate showers
  - Several simultaneous or back to back showers
- Water quality
- Integration with existing duct work and mechanical room
- Heating load estimates

Field Implementation and Monitoring

- 250 installs in Minnesota
  - Utility bill analysis on all 250 sites (to come in 2013)
  - Detailed pre/post monitoring on 20 sites (NEXT!)

House Characteristics

Minneapolis

+ Heating Degree Days: 7565
+ Heating Design Temp: -13.4 F

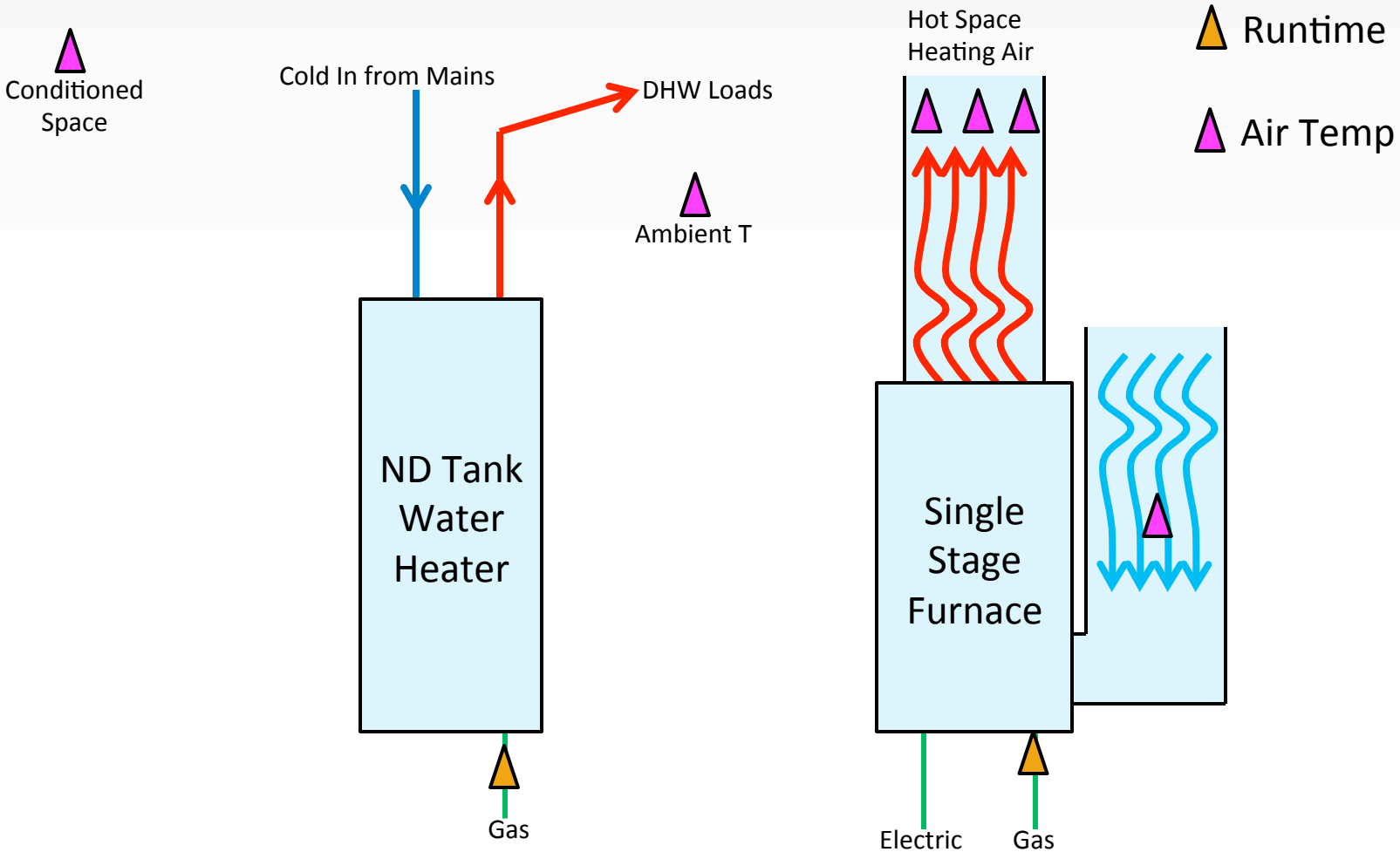
Project Averages

+ Space Heating Design Condition: 25,000 btu/hr
+ DHW Daily Usage: 41 gallons/day (830 Btu/hr)
+ Combined Gas Consumption (AFUE~80 and EF~58):
  900 therms/year

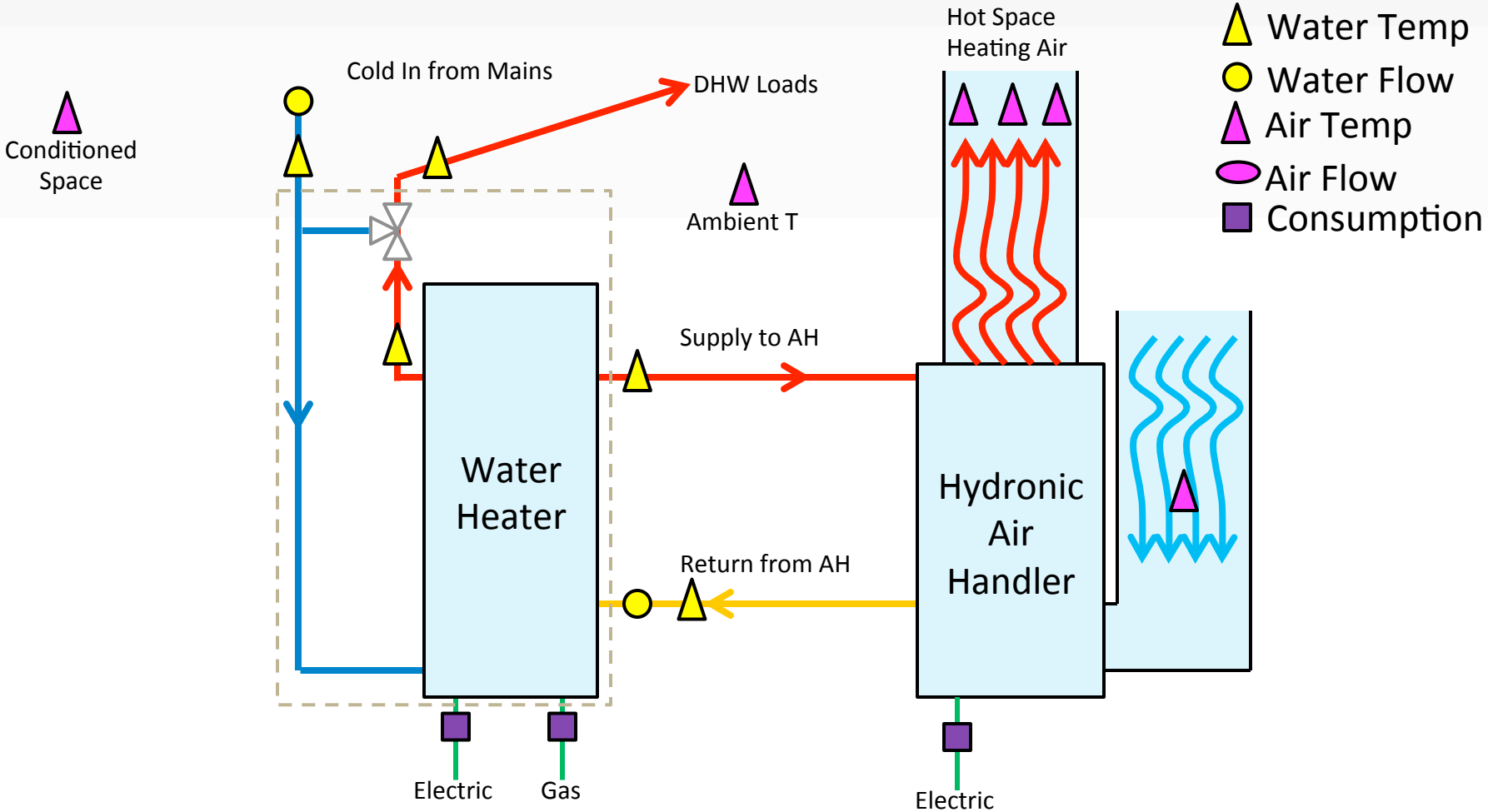
Typical Installation

+ Unfinished basements or mechanical rooms in finished basements

Existing Equipment



DIA Installation




EXISTING


COMBI

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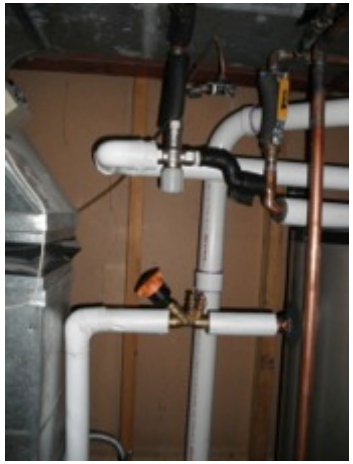
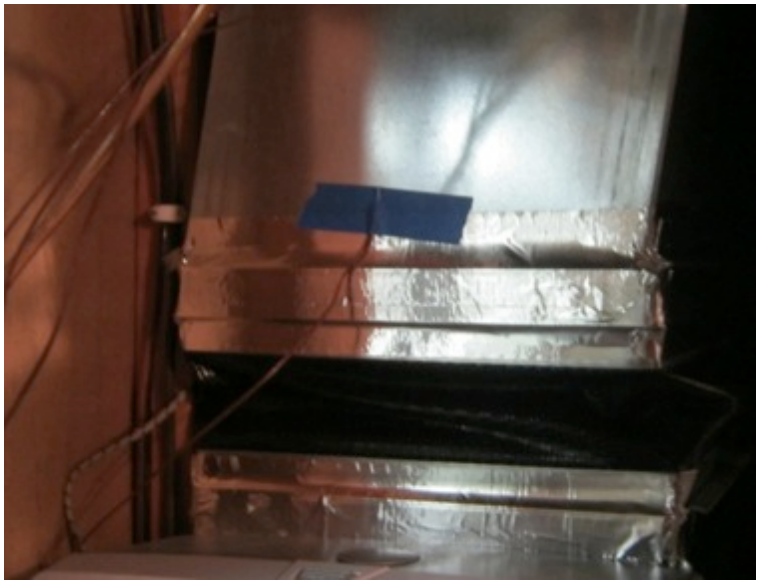
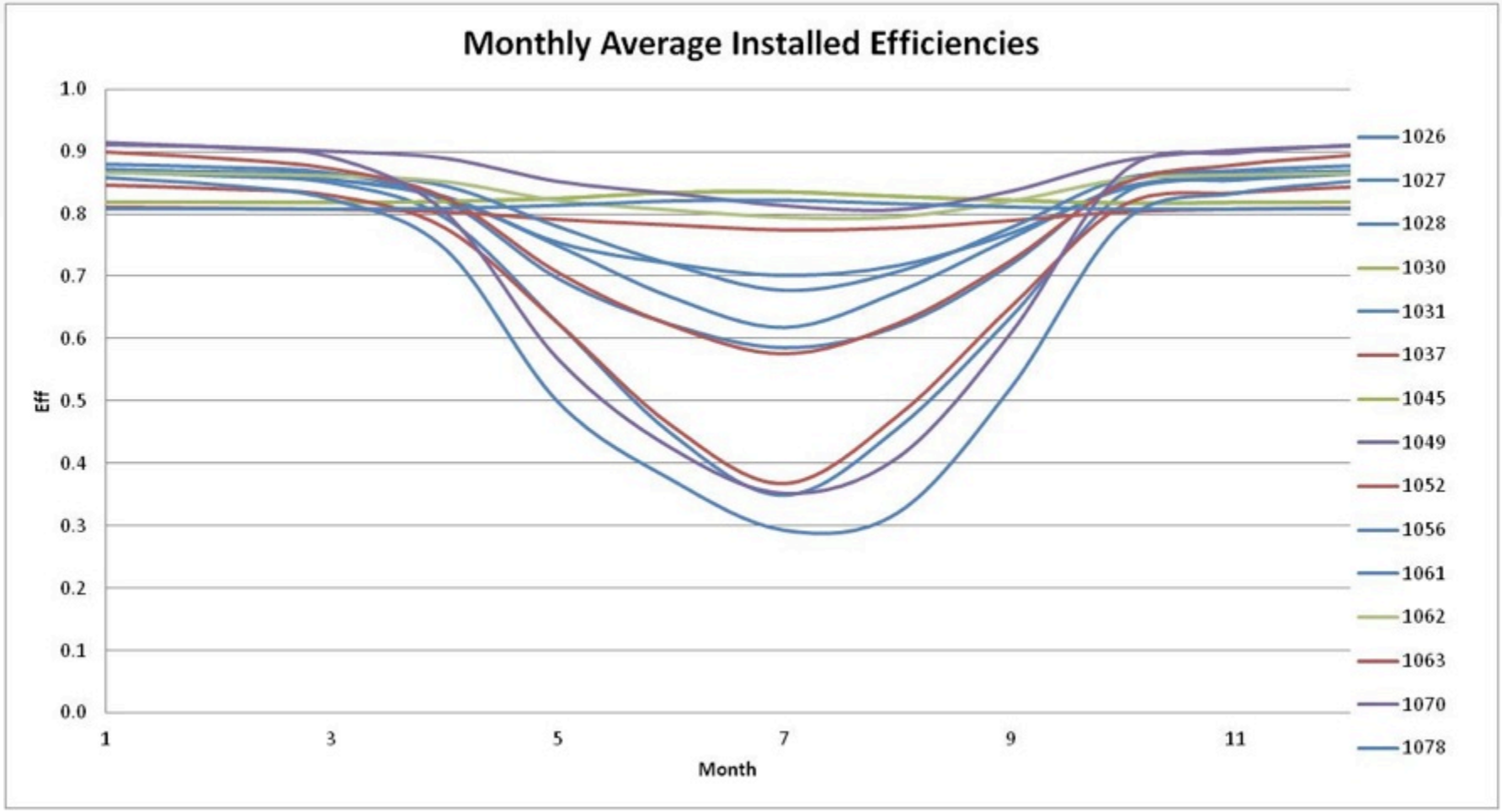



HEATING
SYSTEM
SUPPLY

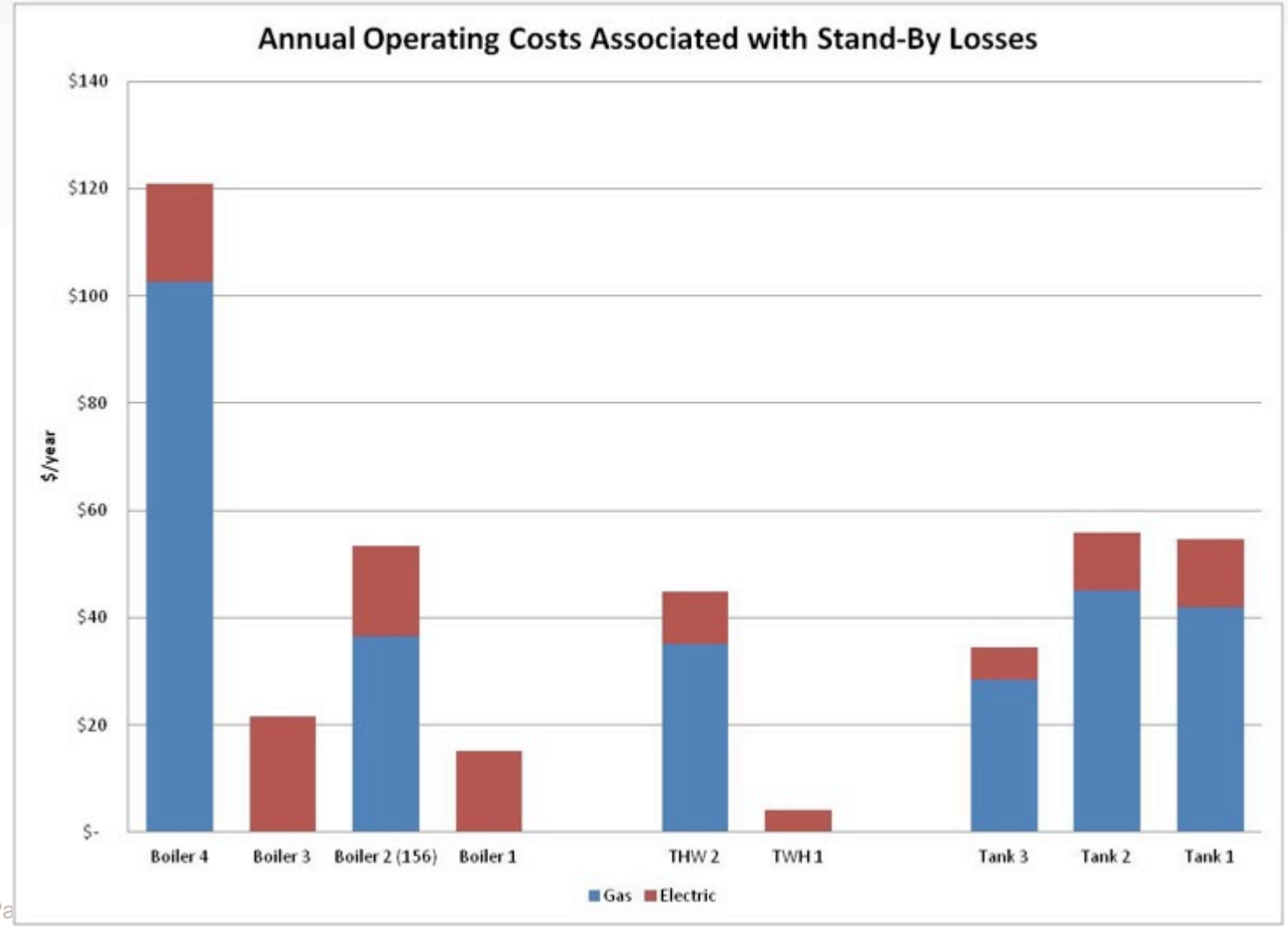


Efficiency

System Efficiencies under Actual Loads

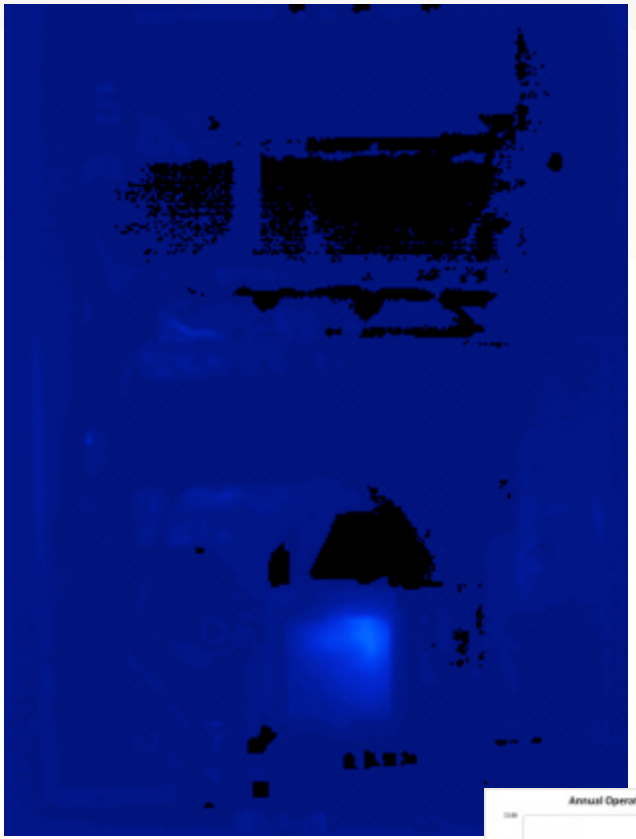


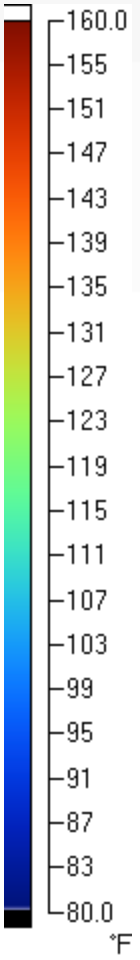
Why the low efficiencies in the summer?



Setpoint = 140 F
$1/therm
$0.12/kWhr

TWH 1

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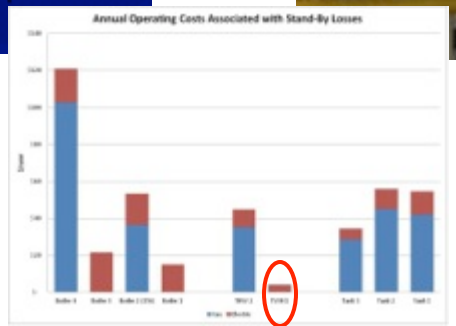
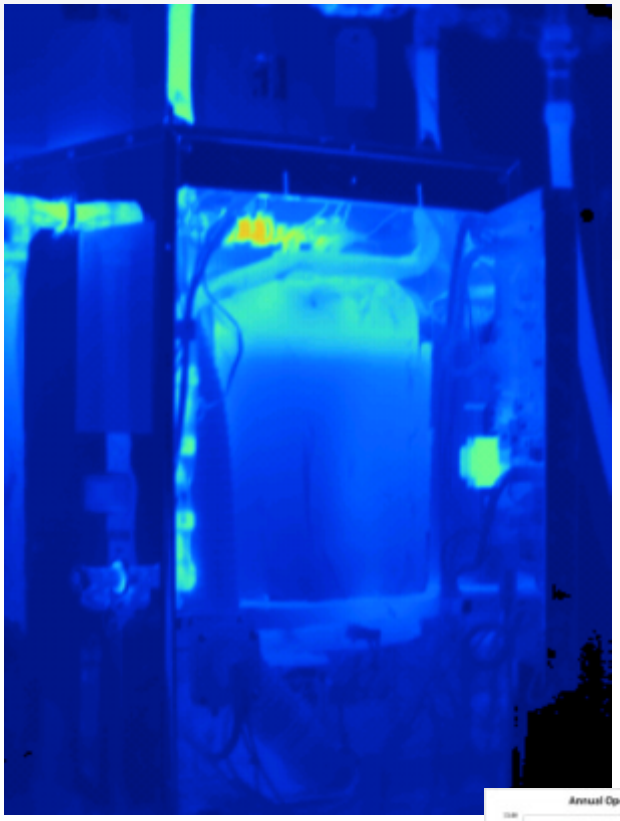
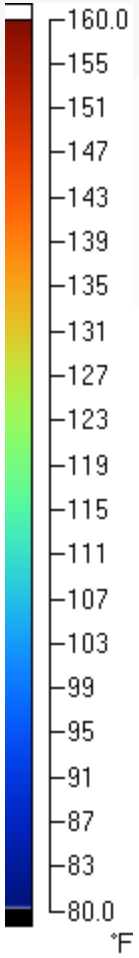
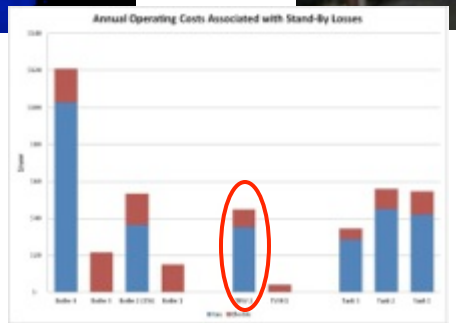

Annual Operating Costs Associated with Stand-By Losses

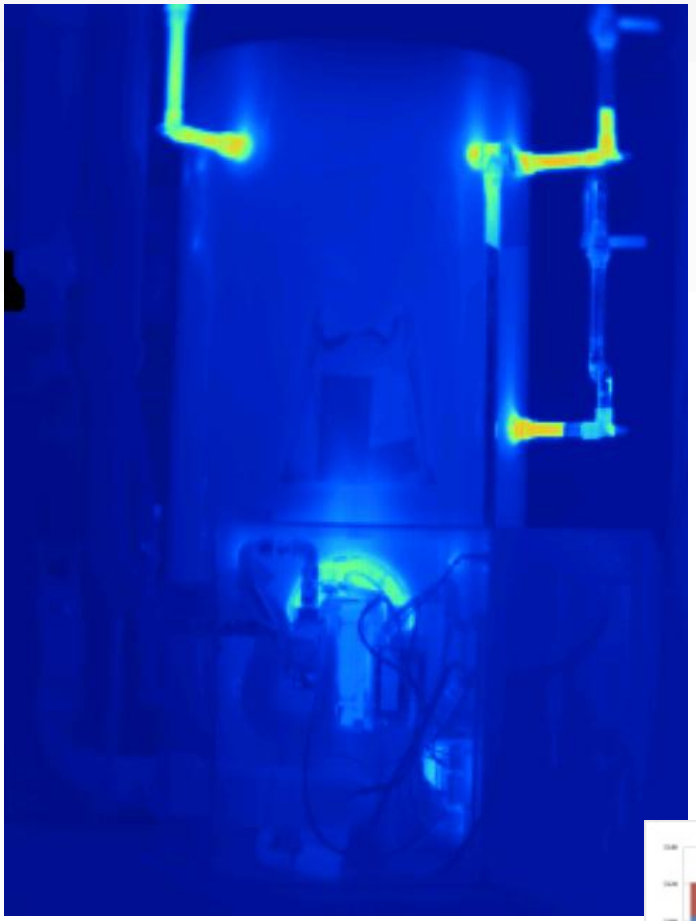
TWH 2 – Storage Tankless Hybrid



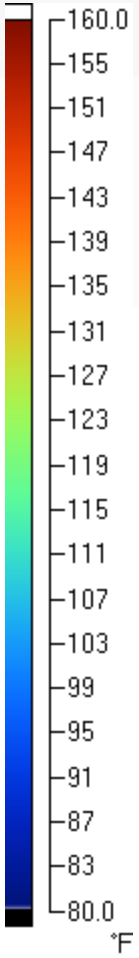




TANK 2




HTP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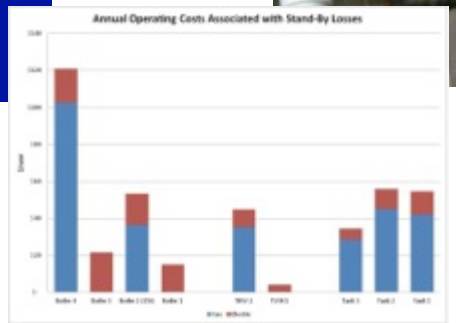
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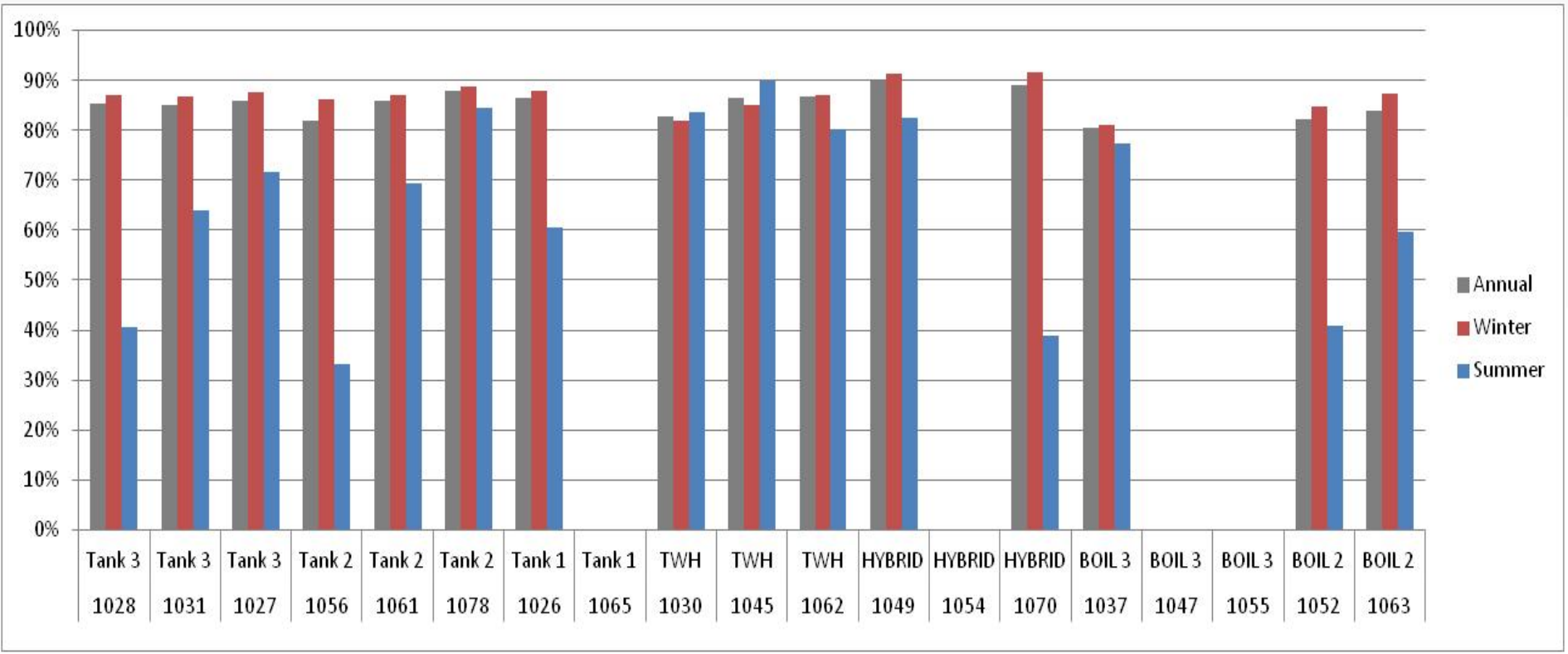
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