Developing a Sequence of Operations for GSHP Systems

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Developing a Sequence of Operations for Networked GSHP Systems

Source-Side Considerations for Networked Geothermal Systems Having Multiple Thermal Sources

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SYSTEMS SHOULD WORK THE FIRST DAY THEY ARE HANDED OVER TO THE OWNER.

-ASHRAE Standard 202 Commissioning Process for Buildings and Systems

The purpose of the sequence of operations is to define how the components of a system will interact, throughout its various operating modes.

Presentation Outline:

- Learning objectives
- Description of **some** of the energy sources and sinks that can be used
- Things to consider when integrating energy sources and sinks
- Energy plant considerations
- Introduction to single-pipe layout for large geothermal systems
- Depiction of a single-pipe system demonstration project
- Sequence of operations for the demonstration project
- Question and answer period

LEARNING OBJECTIVES

After viewing this presentation, it is our intent that students will be able to:

1. Identify common energy sources and sinks for networked geothermal systems
2. Consider key elements of integrating energy sources and sinks
3. Understand the concept of single-pipe district geothermal systems
4. Recall the challenges with the single-pipe system demonstration project
5. Understand and use the sequence of operations that was developed for the demonstration project

SOME OF THE POSSIBLE ENERGY SOURCES AND SINKS

Energy sources and sinks can come in many forms, including the following:

1. Energy sources:
    a. Earth materials, groundwater and surface water, etc. (traditional geo)
    b. Waste energy from refrigeration processes and industrial processes
    c. Solar thermal, drinking water, wastewater, power plants, data centres, etc.
    d. Industrial processing plants
2. Energy sinks:
    a. Traditional geo
    b. Snowmelt and freeze protection systems
    c. Domestic and service hot water heating systems
    d. Drinking water, wastewater, and industrial processing plants

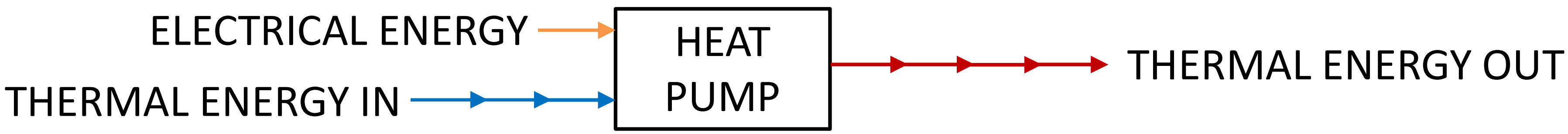
THINGS TO CONSIDER WITH ENERGY INTEGRATION SYSTEMS

There are many things to consider with energy integration networks. A few of the key elements to consider include:

1. Ideal temperatures for the sources and sinks
2. Timing of different loads
3. Pumping energy use and optimization of pipe sizes
4. **Maintainability, maintainability, maintainability!!**
5. **User engagement**, particularly when things go wrong – and they do!
6. Proper **third-party commissioning** provider engagement
7. Ongoing monitoring and **early intervention** – nothing works first try, ever!
8. **Conflict of interest**, documentation of promises and results, **warranty claims**

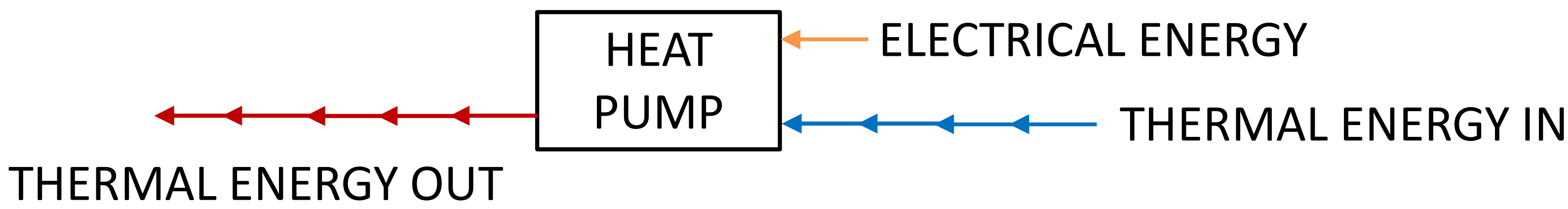
ENERGY PLANT CONSIDERATIONS:
HEATING OR COOLING PLANT WITH SEASONAL CHANGE-OVER

HEATING MODE EXAMPLE



COEFFICIENT OF PERFORMANCE = COP_h = THERMAL ENERGY OUT OF HEAT PUMP / ELECTRICAL ENERGY INTO HEAT PUMP = 4.0

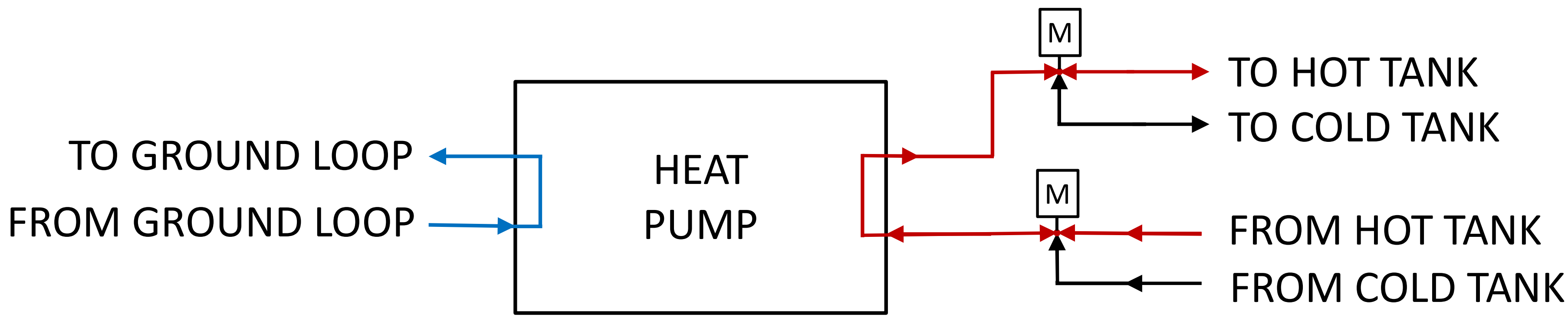
COOLING MODE EXAMPLE



COEFFICIENT OF PERFORMANCE = COP_c = THERMAL ENERGY INTO HEAT PUMP/ ELECTRICAL ENERGY INTO HEAT PUMP = 4.0

ENERGY PLANT CONSIDERATIONS:
TWO-TANK SYSTEM WITH 3-WAY VALVE CHANGEOVER
(REFRIGERANT CHANGE-OVER SYSTEM)

HEATING MODE EXAMPLE

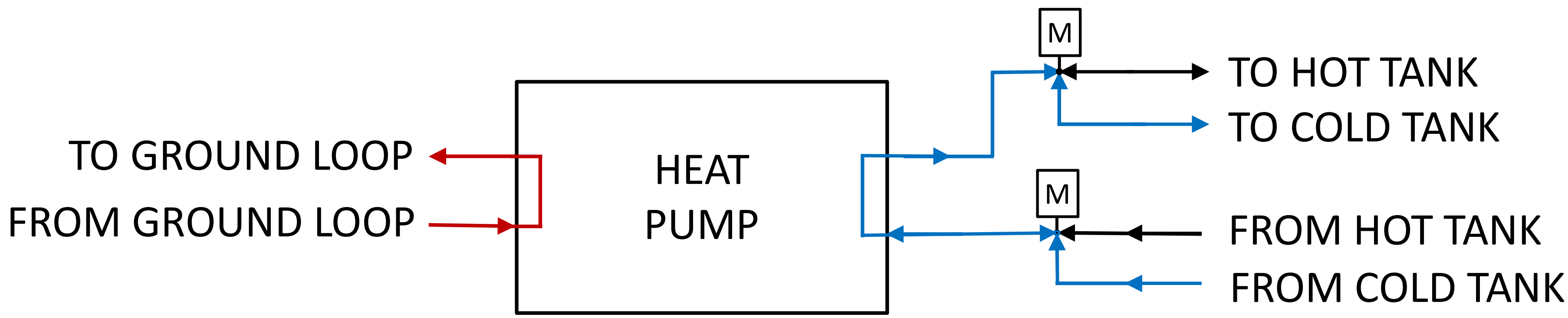


NOTES:

1. COP IS OFTEN EQUAL TO OR LESS THAN THE SEASONAL CHANGEOVER DUE TO VALVE LEAKAGE AND CROSS CONNECTIONS!
2. HAVE TO PRIORITIZE HEATING OR COOLING BECAUSE THEY CANNOT BE PROVIDED AT THE SAME TIME
3. EXPENSIVE VALVES REQUIRED

ENERGY PLANT CONSIDERATIONS
TWO-TANK SYSTEM WITH 3-WAY VALVE CHANGEOVER

COOLING MODE EXAMPLE



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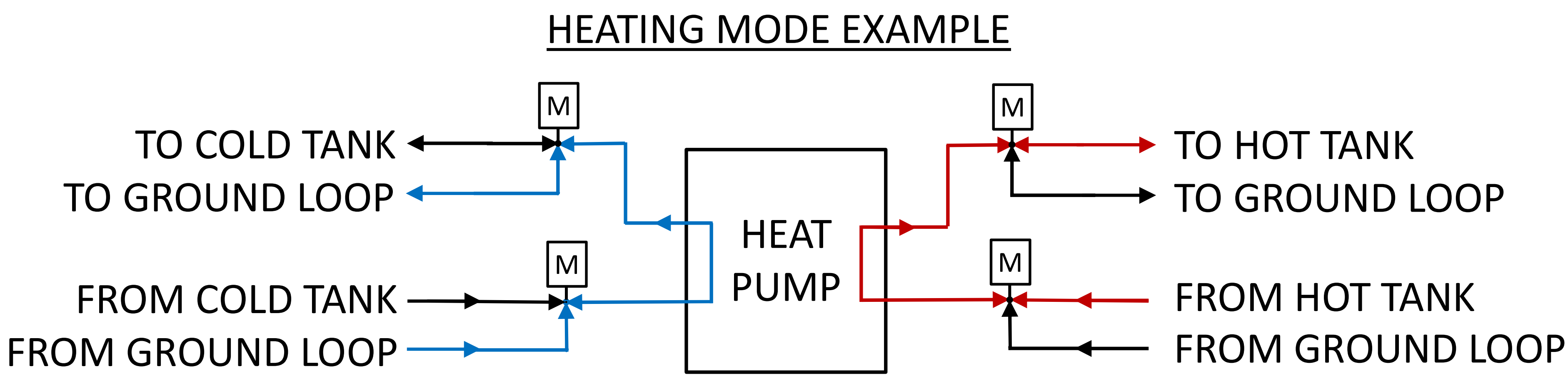
ENERGY PLANT CONSIDERATIONS:
TWO-TANK SYSTEM WITH 3-WAY VALVE CHANGEOVER
(WATER CHANGEOVER SYSTEM)

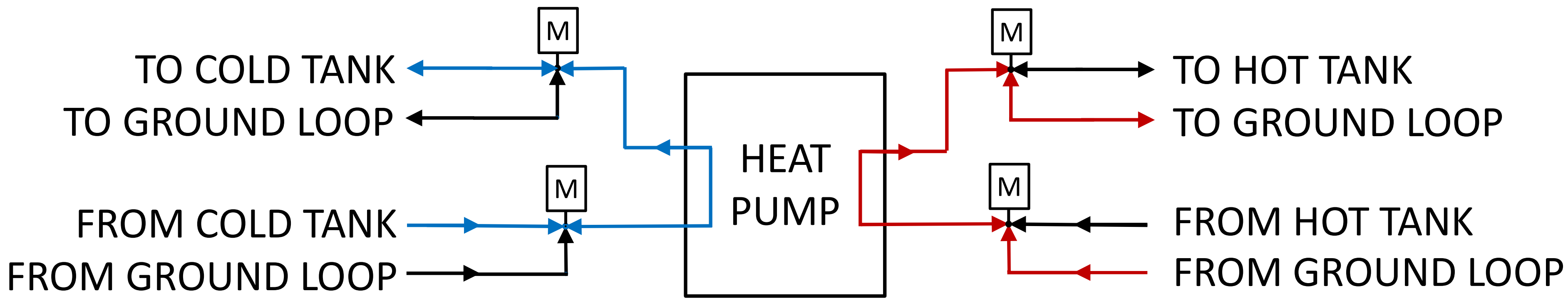


NOTES:

1. COP IS OFTEN GREATER THAN IN THE PREVIOUS METHODS
2. CAN PROVIDE SIMULTANEOUS HEATING AND COOLING BECAUSE THEY CAN BE PROVIDED AT THE SAME TIME
3. TWO ADDITIONAL, EXPENSIVE VALVES REQUIRED
4. CONSIDER EQUALIZING HOT SIDE AND COLD SIDE CIRCUIT PRESSURES BETWEEN MODE CHANGES
5. **CAN ALSO BE DONE WITH SIX-WAY VALVES OR BANKS OF TWO-WAY VALVES**
6. CONSIDER THE TIMING OF LOADS AND THE TIME TO SWITCH MODES (LOAD BANKING CONCEPT)

ENERGY PLANT CONSIDERATIONS:
TWO-TANK SYSTEM WITH 3-WAY VALVE CHANGEOVER

COOLING MODE EXAMPLE



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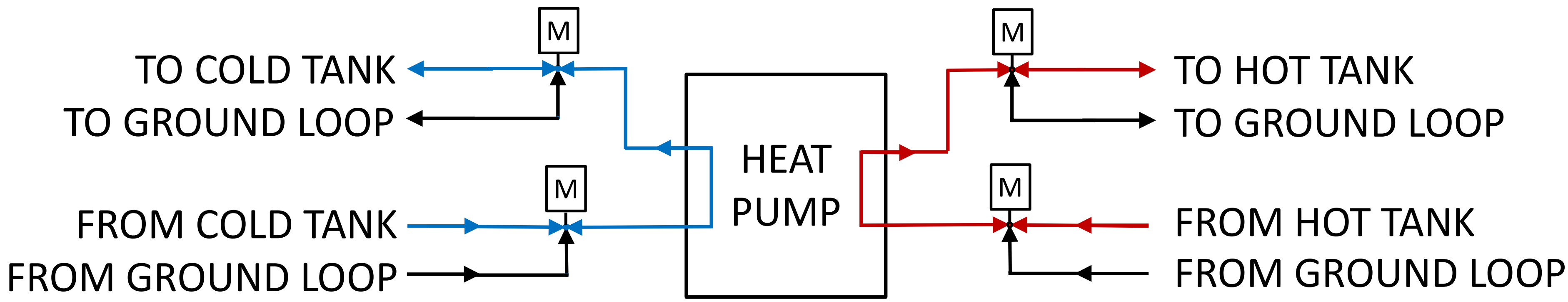
ENERGY PLANT CONSIDERATIONS:
TWO-TANK SYSTEM WITH 3-WAY VALVE CHANGEOVER

SIMULTANEOUS HEATING AND COOLING MODE EXAMPLE



NOTES:

1. COP IS **DOUBLED DURING THIS MODE**, COMPARED TO THE PREVIOUS METHODS
2. CAN PROVIDE SIMULTANEOUS HEATING AND COOLING BECAUSE THEY CAN BE PROVIDED AT THE SAME TIME
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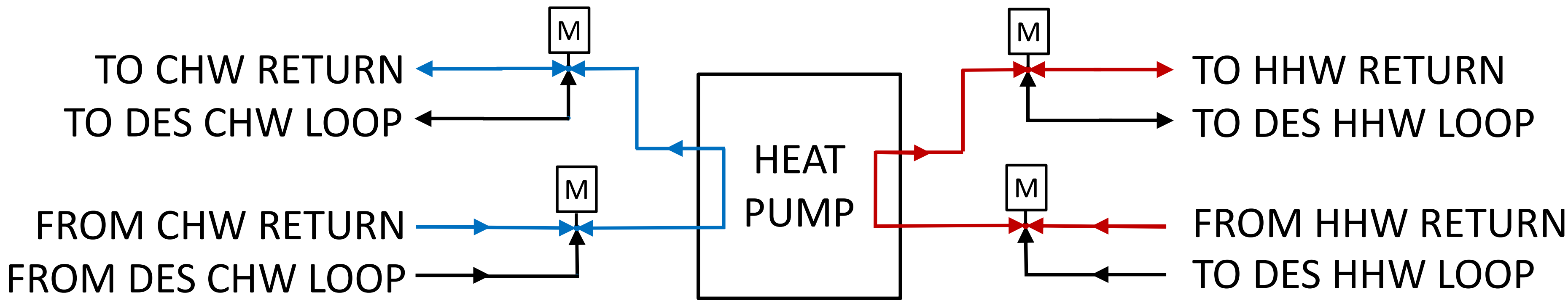
ENERGY PLANT CONSIDERATIONS:
FOUR-PIPE DISTRICT ENERGY SYSTEM (DES) ASSISTED BY DISTRIBUTED PLANTS

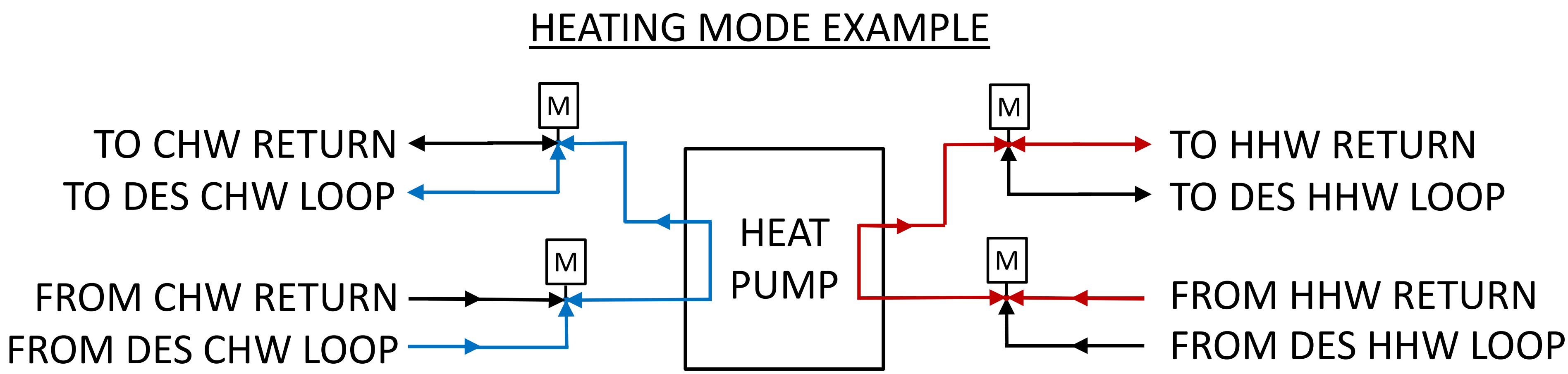
SIMULTANEOUS HEATING AND COOLING MODE EXAMPLE



NOTES:

1. IMPORTANT TO ENSURE THAT THERE IS A BI-DIRECTIONAL ENERGY METER FOR THIS TO MAXIMIZE REVENUE
2. THIS IS JUST AN IDEA. I HAVE NOT HAD A CHANCE TO PUT THIS INTO PRACTICE YET
3. WOULD NEED ISOLATING HEAT EXCHANGERS BETWEEN DES AND DISTRIBUTED PLANT HYDRONIC CIRCUITS

ENERGY PLANT CONSIDERATIONS:
FOUR-PIPE DES ASSISTED BY DISTRIBUTED PLANTS



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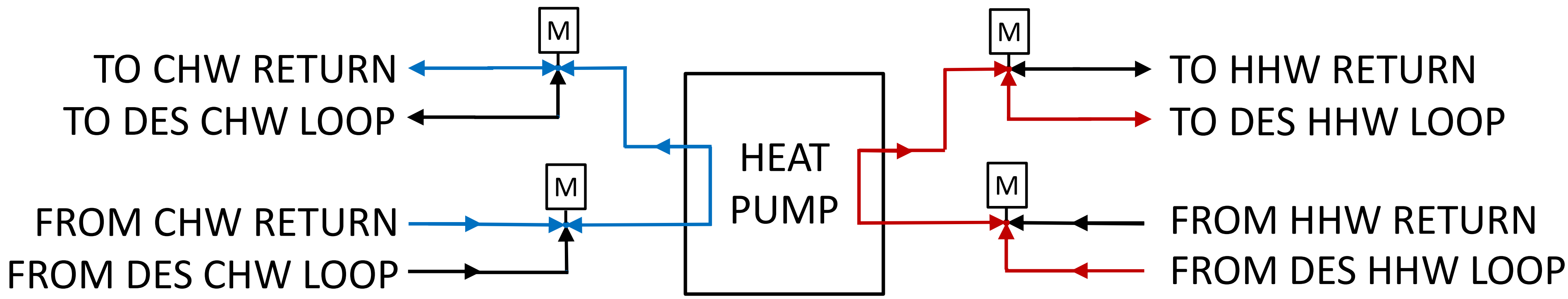

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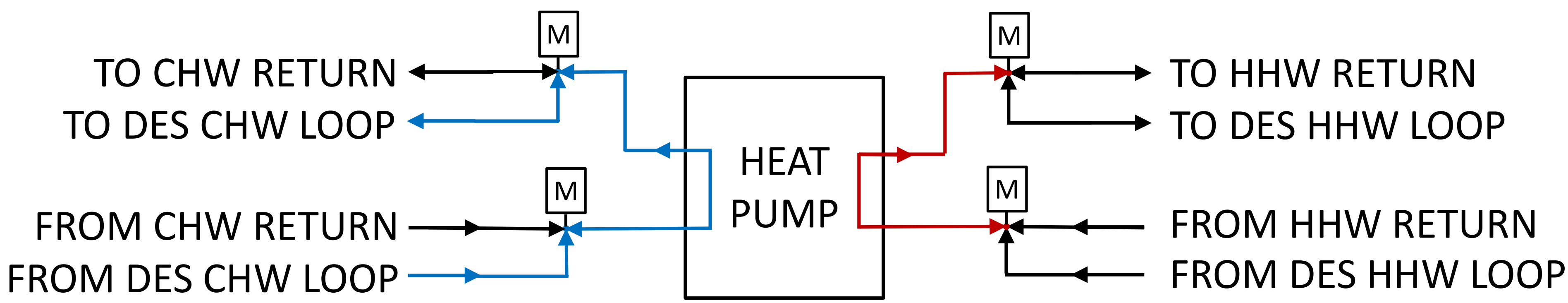
ENERGY PLANT CONSIDERATIONS:
FOUR-PIPE DES ASSISTED BY DISTRIBUTED PLANTS

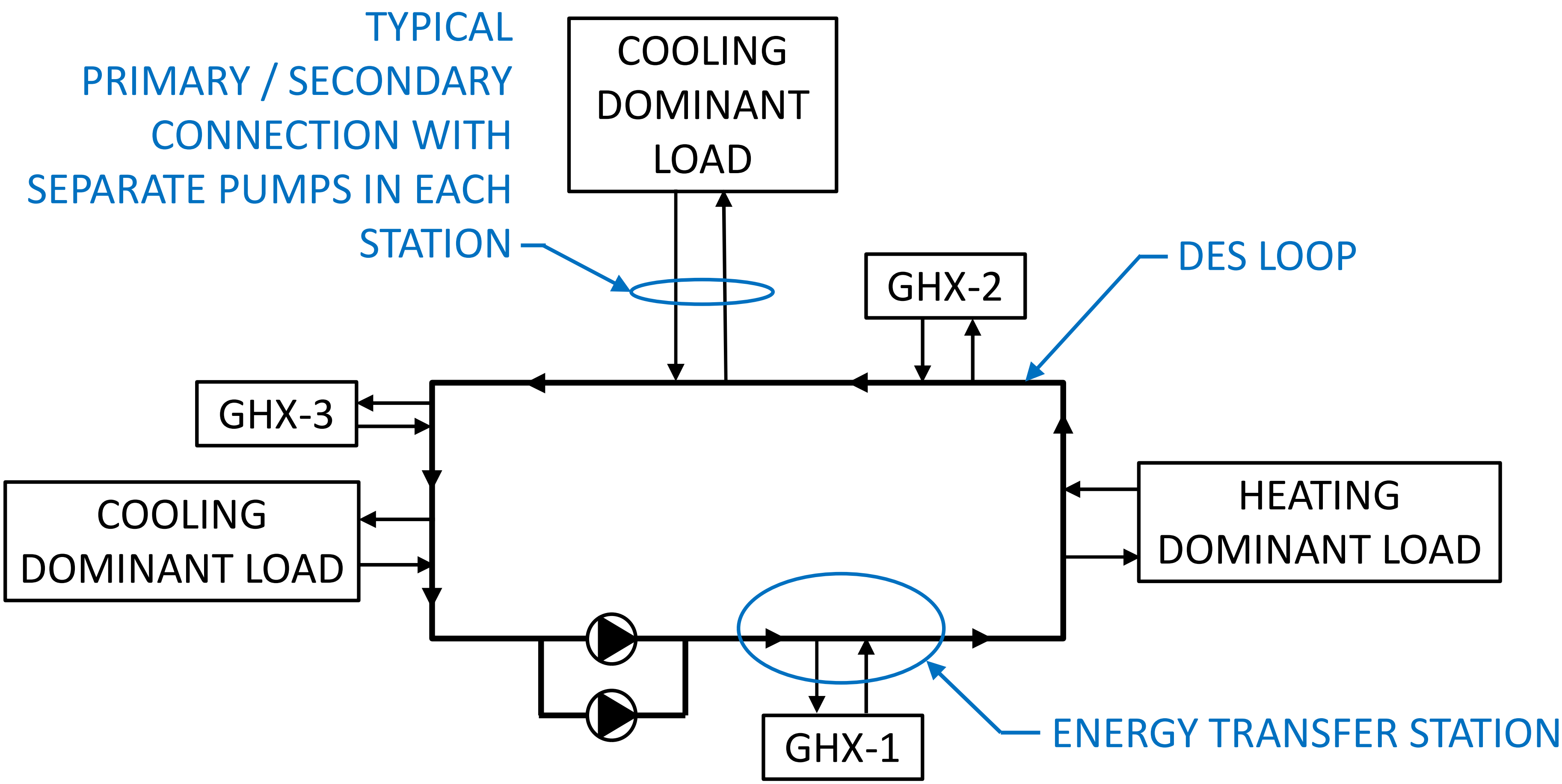
CENTRAL PLANT LOAD-ASSIST EXAMPLE



NOTES:

1. INCREASES THE EFFICIENCY OF A DES WHERE THE CENTRAL PLANT DOESN'T DO SIMULTANEOUS HEATING AND COOLING
2. IMPORTANT TO ENSURE THAT THERE IS A BI-DIRECTIONAL ENERGY METER FOR THIS TO MAXIMIZE REVENUE
3. THIS IS JUST AN IDEA. I HAVE NOT HAD A CHANCE TO PUT THIS INTO PRACTICE YET
4. WOULD NEED ISOLATING HEAT EXCHANGERS BETWEEN DES AND DISTRIBUTED PLANT HYDRONIC CIRCUITS

INTRODUCTION TO SINGLE-PIPE DISTRICT GEOTHERMAL



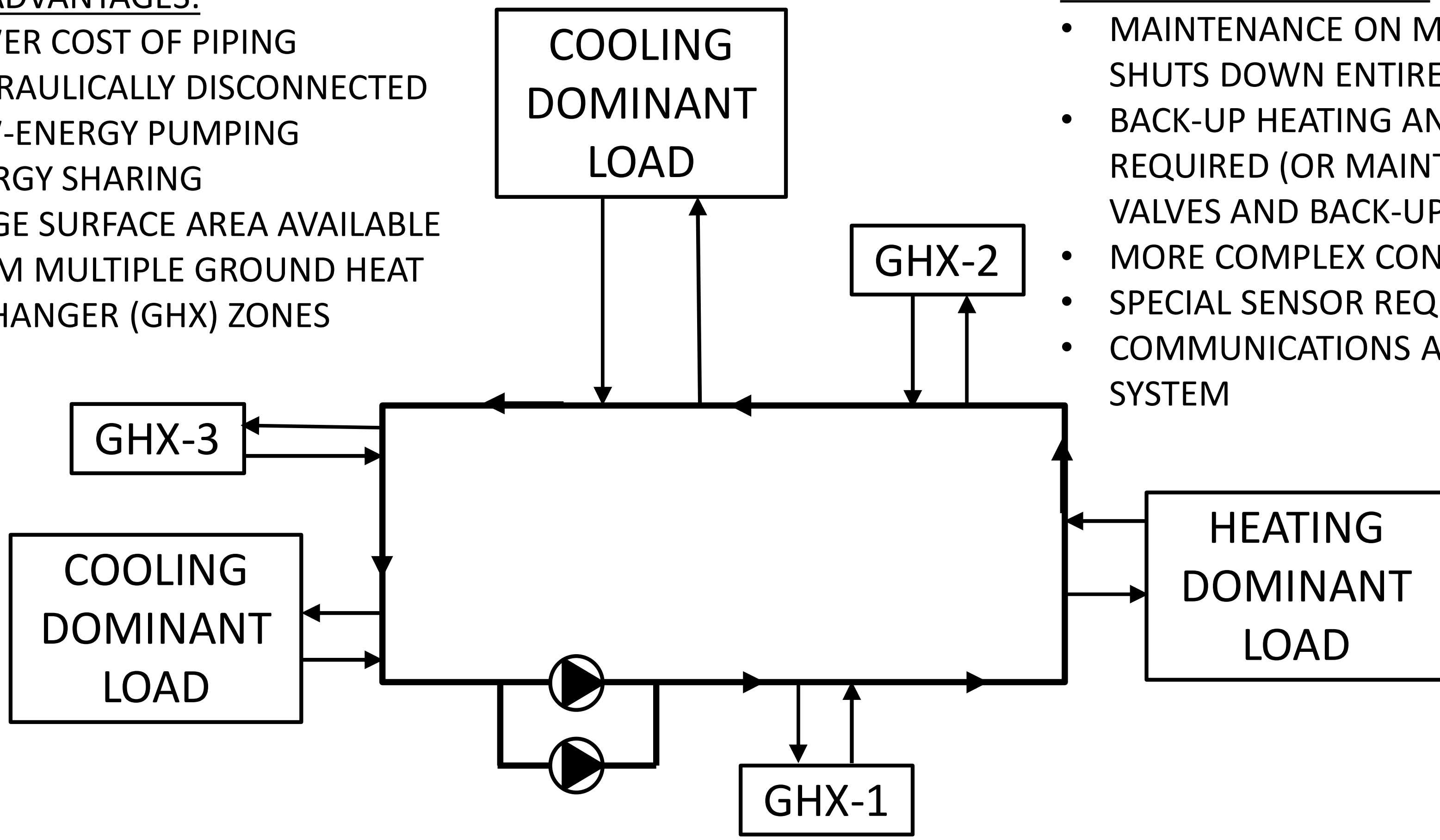
ADVANTAGES AND DISADVANTAGES OF THE SINGLE-PIPE DES

SOME ADVANTAGES:

- LOWER COST OF PIPING
- HYDRAULICALLY DISCONNECTED
- LOW-ENERGY PUMPING
- ENERGY SHARING
- LARGE SURFACE AREA AVAILABLE FROM MULTIPLE GROUND HEAT EXCHANGER (GHX) ZONES

SOME DISADVANTAGES:

- MAINTENANCE ON MAINLINE SHUTS DOWN ENTIRE SYSTEM
- BACK-UP HEATING AND COOLING REQUIRED (OR MAINTENANCE VALVES AND BACK-UP PUMPS)
- MORE COMPLEX CONTROLS
- SPECIAL SENSOR REQUIREMENTS
- COMMUNICATIONS ACROSS SYSTEM



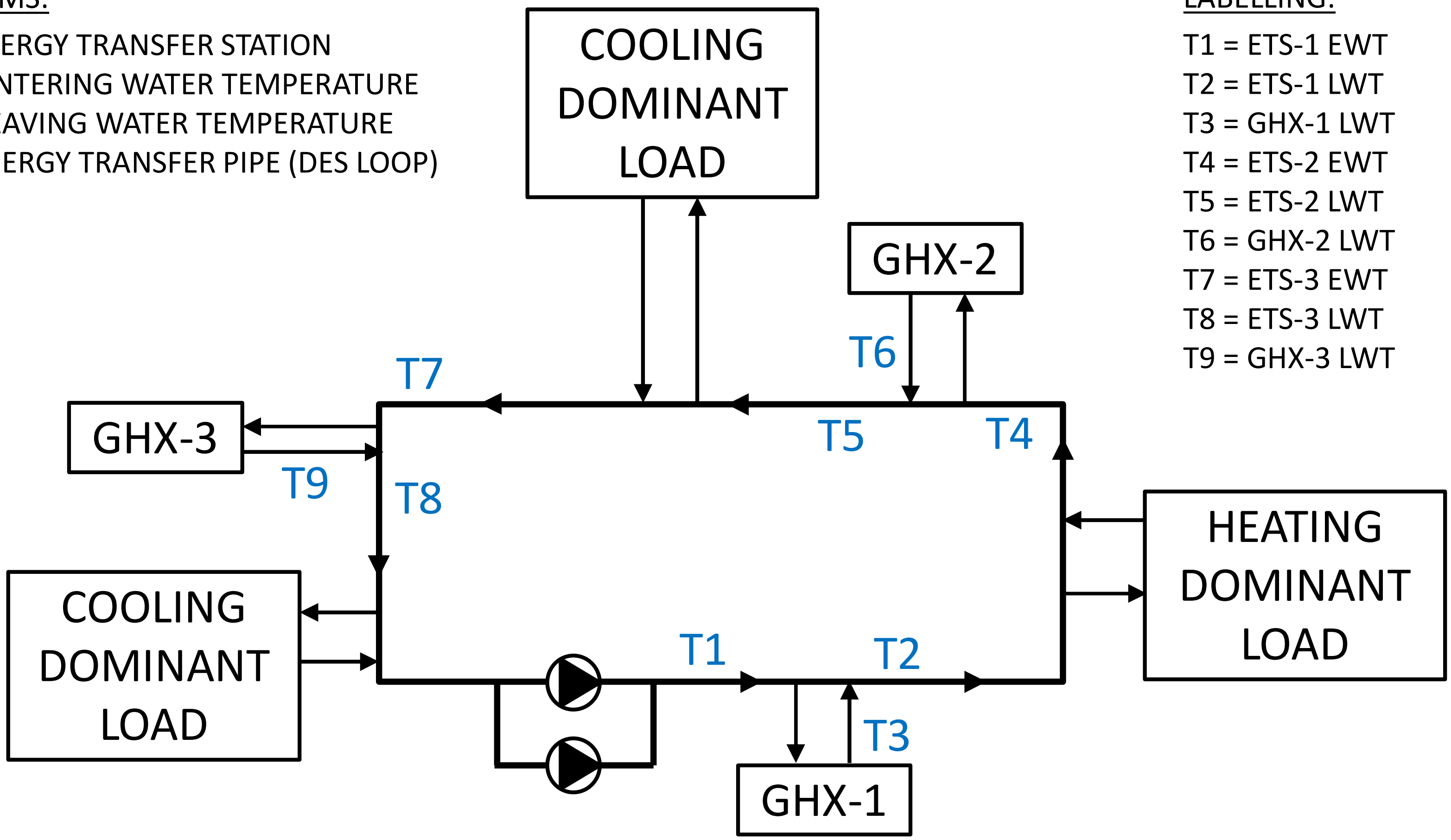
TEMPERATURE MEASUREMENTS IN SINGLE-PIPE DISTRICT GEOTHERMAL

ACRONYMS:

ETS = ENERGY TRANSFER STATION
EWT = ENTERING WATER TEMPERATURE
LWT = LEAVING WATER TEMPERATURE
ETP = ENERGY TRANSFER PIPE (DES LOOP)

LABELLING:

T1 = ETS-1 EWT
T2 = ETS-1 LWT
T3 = GHX-1 LWT
T4 = ETS-2 EWT
T5 = ETS-2 LWT
T6 = GHX-2 LWT
T7 = ETS-3 EWT
T8 = ETS-3 LWT
T9 = GHX-3 LWT



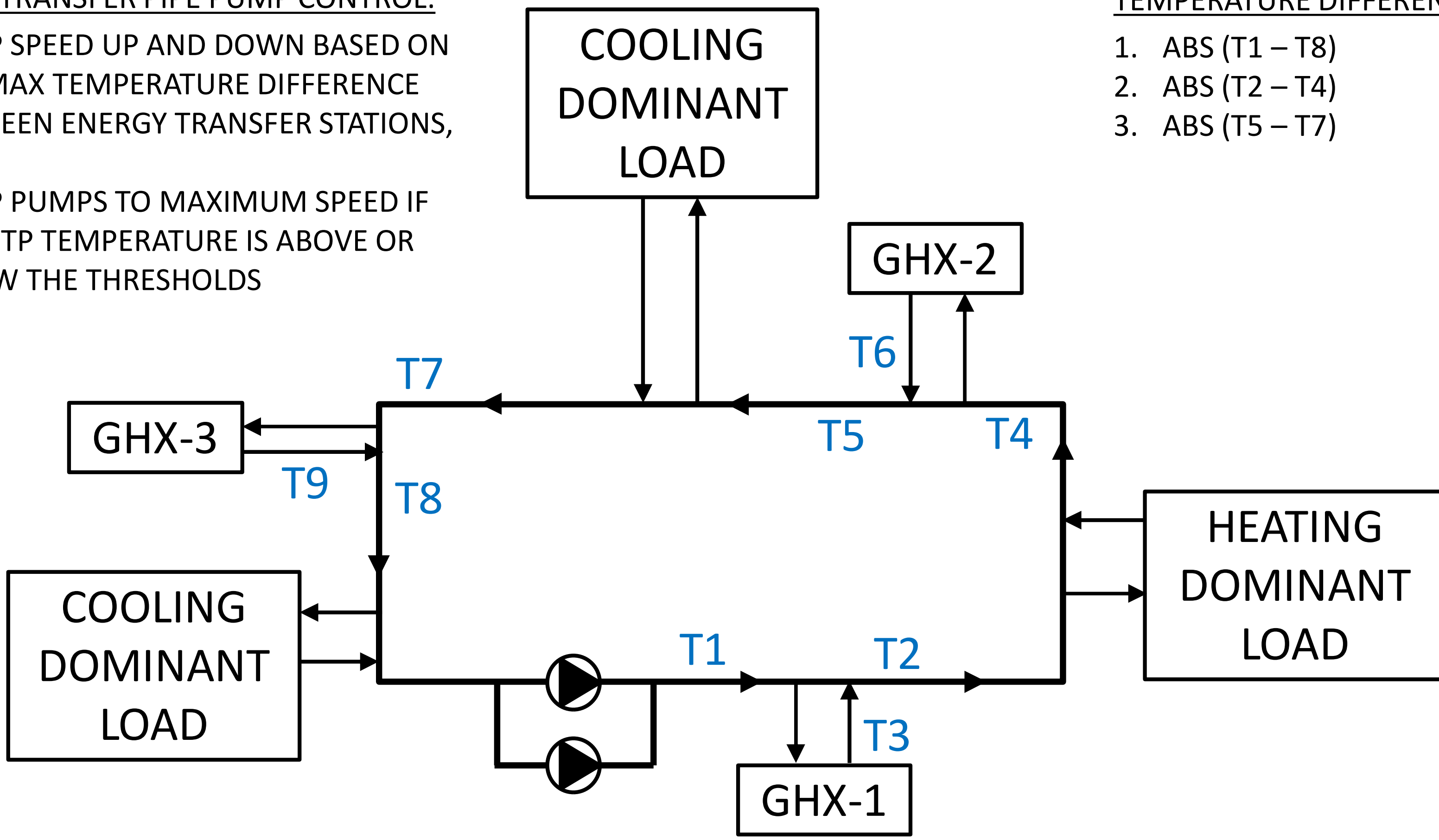
MAIN PUMP CONTROL IN SINGLE-PIPE DISTRICT GEOTHERMAL

ENERGY TRANSFER PIPE PUMP CONTROL:

- RAMP SPEED UP AND DOWN BASED ON THE MAX TEMPERATURE DIFFERENCE BETWEEN ENERGY TRANSFER STATIONS, AND
- RAMP PUMPS TO MAXIMUM SPEED IF ANY ETP TEMPERATURE IS ABOVE OR BELOW THE THRESHOLDS

TEMPERATURE DIFFERENCES:

1. ABS (T1 – T8)
2. ABS (T2 – T4)
3. ABS (T5 – T7)



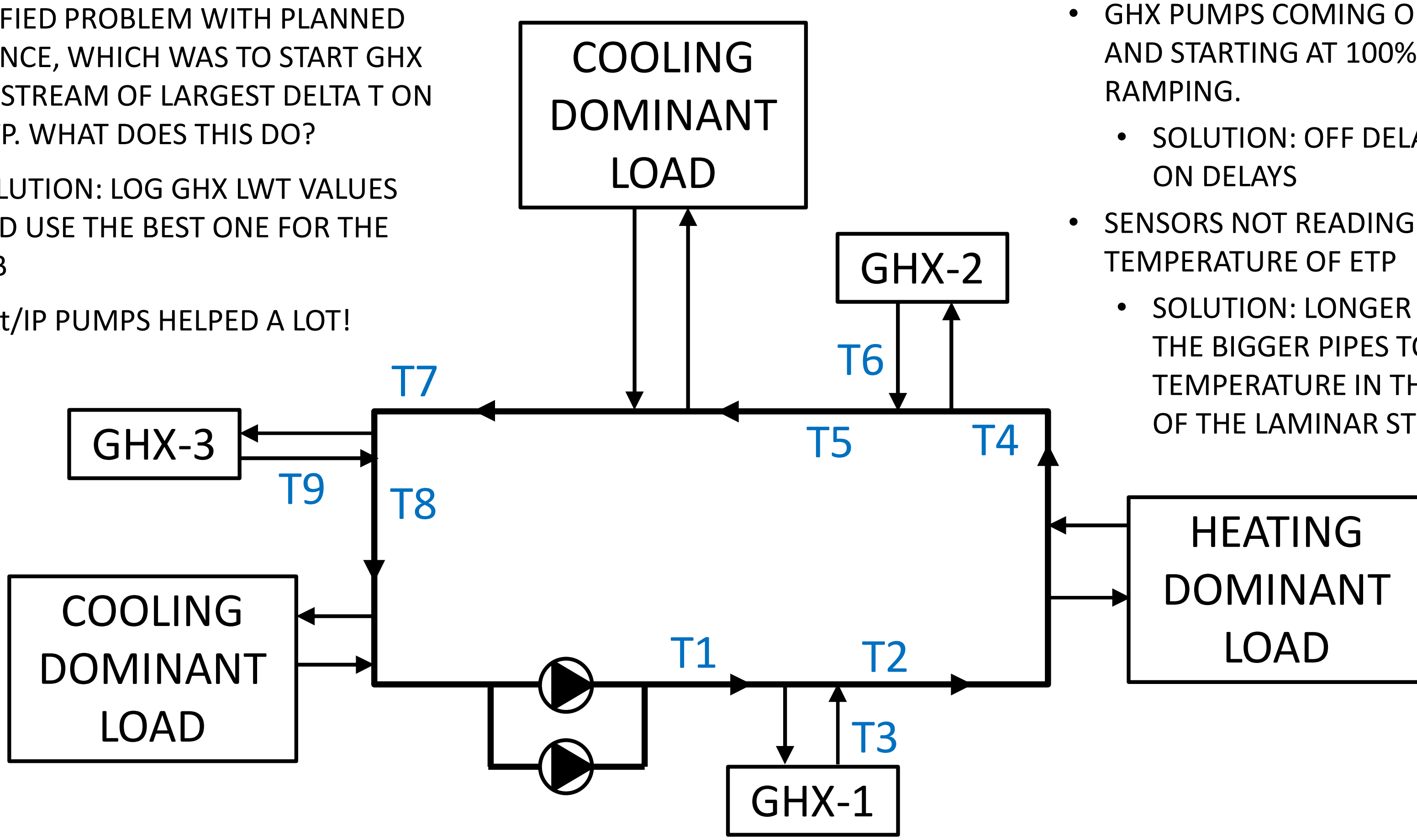
GHX PUMP CONTROL IN SINGLE-PIPE DISTRICT GEOTHERMAL

GHX PUMP CONTROL:

- IDENTIFIED PROBLEM WITH PLANNED SEQUENCE, WHICH WAS TO START GHX DOWNSTREAM OF LARGEST DELTA T ON THE ETP. WHAT DOES THIS DO?
  - SOLUTION: LOG GHX LWT VALUES AND USE THE BEST ONE FOR THE JOB
- BACNet/IP PUMPS HELPED A LOT!

CHALLENGES THAT WE OVERCAME:

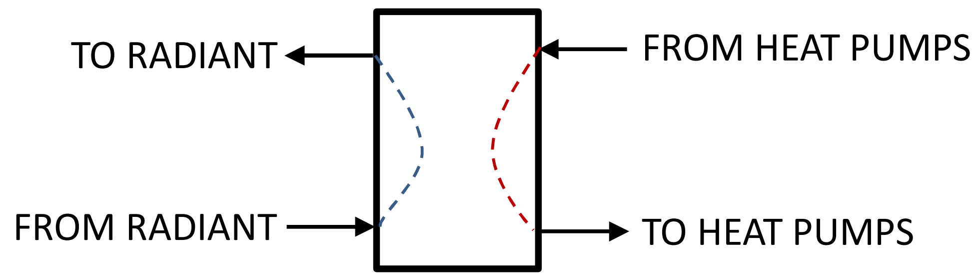
- GHX PUMPS COMING ON TOO LATE AND STARTING AT 100% INSTEAD OF RAMPING.
  - SOLUTION: OFF DELAYS, SHORT ON DELAYS
- SENSORS NOT READING TRUE TEMPERATURE OF ETP
  - SOLUTION: LONGER PROBES IN THE BIGGER PIPES TO READ TEMPERATURE IN THE MIDDLE OF THE LAMINAR STREAM



STORY TIME: BUFFER TANK MIXING ISSUE!

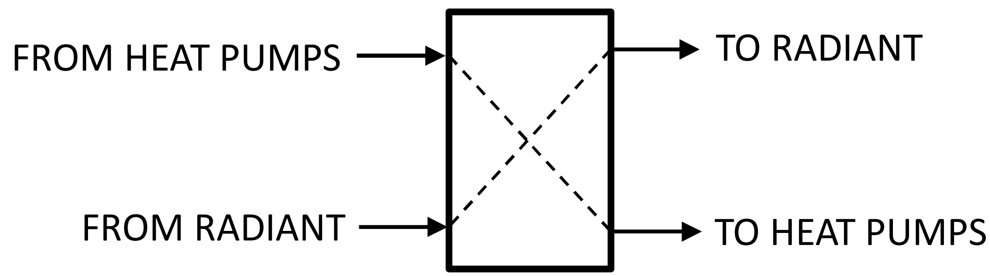
PROBLEM (HEATING MODE):

- RHS PIPES WERE HOT
- HEAT PUMPS WERE TRIPPED
- RADIANT SUPPLY WAS COOL



SOLUTION:

- PIPE IT SO IT MIXES! DUH!
- WE HAD TO INSTALL A PUMP BETWEEN THE UPPER RHS AND LOWER LHS TO SOLVE THE ISSUE, OOPS!



ASIDE:

- WE SEE THIS A BIT IN LOW-LOSS HEADERS THAT DE-COUPLE GROUND LOOPS FROM HEAT PUMPS AND IT IS NOT GOOD BECAUSE IT INCREASES THE DELTA T BETWEEN THE GROUND LOOP AND THE HEAT PUMP, SOMETIMES A LOT!

QUESTIONS FOR AUDIENCE

1. Audience to please call out some energy sources for energy integration systems
2. Audience to please call out some energy sinks for energy integration systems
3. What is one of the most important factors to consider with two-tank, 3-way valve change-over systems?
4. What is the primary advantage of using a water change-over system?
5. What needs to be equalized at some point in the sequence in a water change-over system?
6. What is a potential way to enable maintenance on the energy transfer pipe in a single-pipe DES while keeping a mission-critical application going?
7. What is the problem with always using the same GHX downstream of a heating or cooling dominant load attached to a single-pipe DES?
8. How would you pipe a buffer tank that has large ports but often has low flow?

CLOSING REMARKS AND QUESTION PERIOD

Please feel free to ask questions here or find me after the presentation and I will talk your ears off if you are interested in this stuff! Alternatively, please feel free to check out my articles, tips, and comments on LinkedIn. Some of my articles are also on the Altum Engineering webpage.

The best way to reach me directly is to start a post on LinkedIn so our networks can benefit from the Q&A. I want to share the information and experiences from the last 23 years of working in this field so we can decarbonize the planet together in a timely and appropriate manner. You can also email me or submit your information on the Altum contact page on our website.

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THANKS EVERYONE FOR ATTENDING, PARTICIPATING, AND FOLLOWING UP ON THIS!