



CampusEnergy2021

BRIDGE TO THE FUTURE

Feb. 16-18 | CONNECTING VIRTUALLY

WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16





PUTTING WASTEWATER TO WORK

CampusEnergy 2021

Lynn Mueller, CEO

SHARC Energy

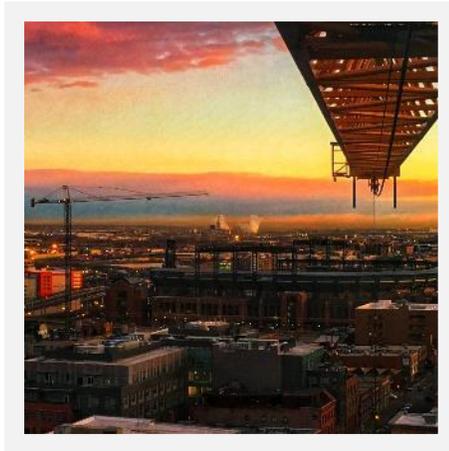


PRESENTATION OUTLINE

I PROMISE. YOU'LL NEVER THINK OF WASTEWATER THE SAME...



WHY
WASTEWATER



MARKET GETS
WHAT MARKET
WANTS



SMALL-SCALE
OPPORTUNITIES



LARGE-SCALE
OPPORTUNITIES



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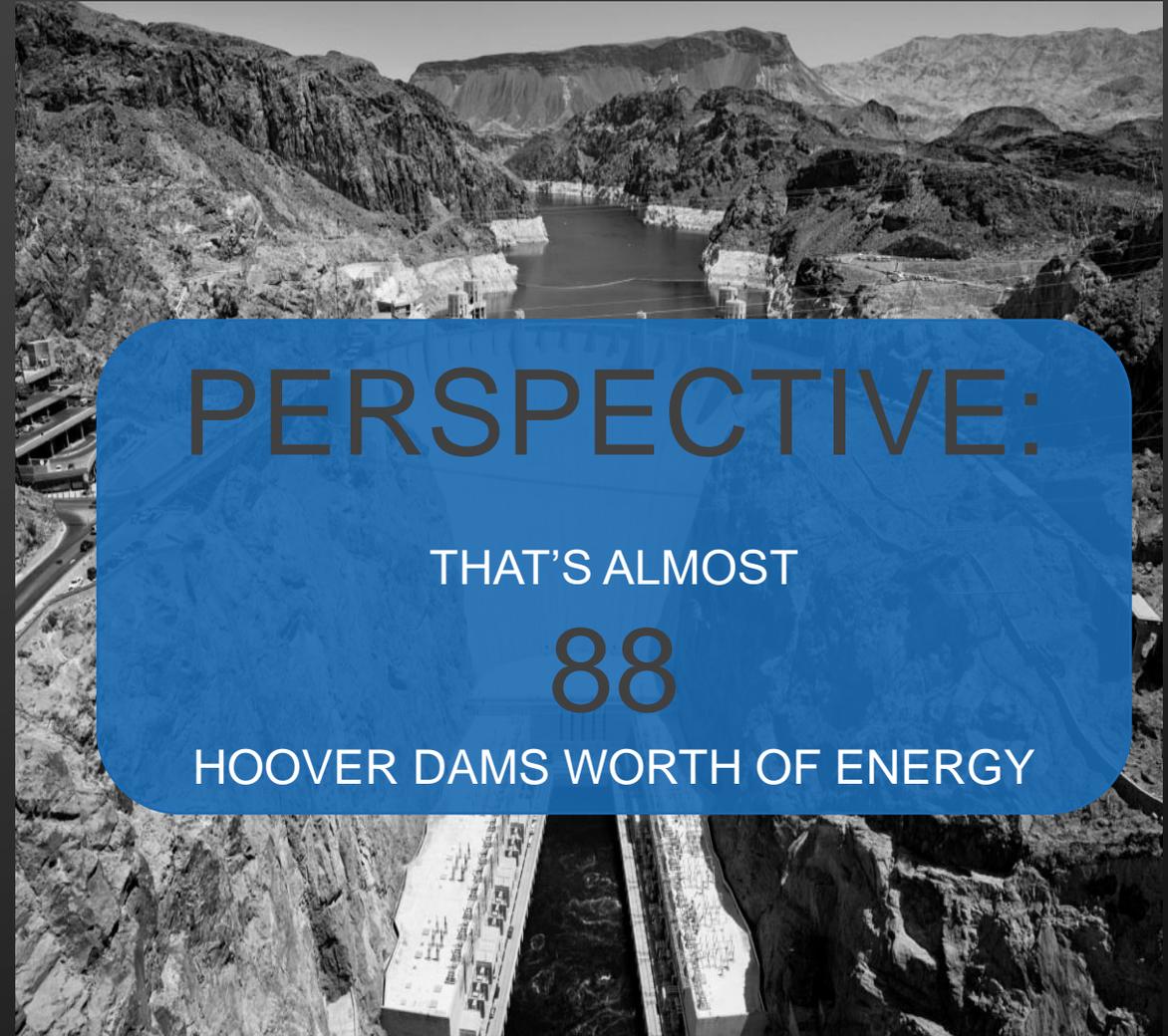
WHAT IS THE **VALUE** OF WASTEWATER?



US DOE ESTIMATES OVER

350,000,000,000 kWh

ARE DISCARDED DOWN THE DRAIN IN THE US ON AN ANNUAL BASIS



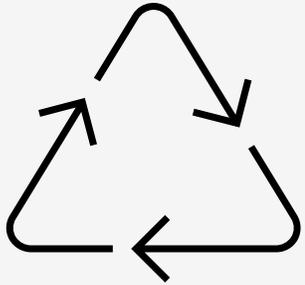
PERSPECTIVE:

THAT'S ALMOST

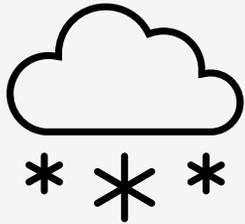
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HOOVER DAMS WORTH OF ENERGY

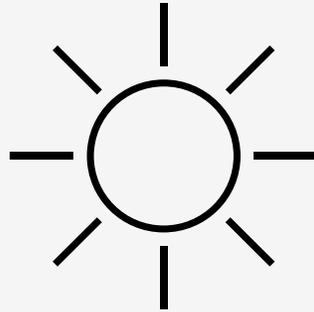
WHY WASTEWATER?



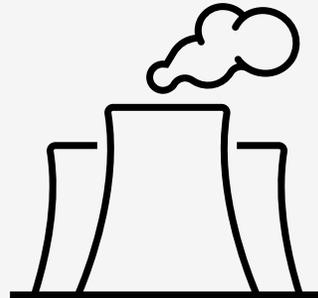
VIRTUALLY
LIMITLESS



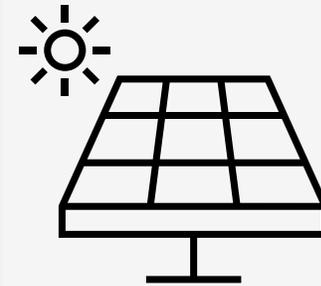
HEATING AND
HOT WATER



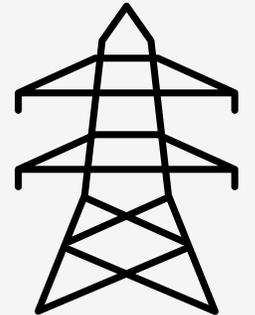
COOLING AND
AIR
CONDITIONING



GHG EMISSIONS
REDUCTIONS



ELECTRIFICATIO
N & NET-ZERO



DEMAND SIDE
MANAGEMENT



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WHAT IS THE MARKET SAYING?



BERKELEY, CA



DENVER, CO



NEW YORK, NY

Natural Gas Prohibition & Reach Code for Electrification (passed July 2019)

- Effective January 1, 2020
- Promotes Electrification
- Reach Code Allows For 'More Efficient Mixed-Fuel' Approach
- Requirements For Future Electrification Either Scenario

80x50 Climate Action Plan (passed July 2018)

- Green Buildings Ordinance (2018) and Green Code (2020) Encourage Electrification and High Efficiency
- Voters Overwhelmingly Approved Tax Increase To Fund Related Programs
- Net-Zero Commercial Base Building Code in 2027

NYC Local Law 97 (passed May 2019)

- Applies To Buildings 25,000+ SF
- Sets Emissions Intensity Limits (Metric Tons CO₂e per SF)
- Fines For Non-Compliance
- Buildings with Rent Regulated Tenants Exempt (May 2020)

MUNICIPAL SUPPORT: DENVER, COLORADO

- Actively promoting the concept
- EPA regulated to reduce effluent temperatures
- Provides feasibility analysis
- Alignment with City of Denver's Climate Action Plan
- Attracts eco-conscious clientele
- Enough energy to heat Cities of Arvada and Thornton **COMBINED**

METRO WASTEWATER RECLAMATION DISTRICT

A renewable heat source for your community is right under your feet.



Free access to a sustainable heating source may be available near your real estate development.

- Hot water from homes and businesses travels down the drain and enters wastewater pipelines underground
- The heat available in wastewater pipelines is a proven thermal energy source
- The thermal energy in these pipelines offers a low carbon option for indoor heating, similar to other geothermal exchange systems
- This innovative technology uses reliable, well-established heat transfer technology to extract the heat and distribute it to nearby homes and businesses

A MODEL FOR SUSTAINABLE HIGH-DENSITY DEVELOPMENT

- Reduces greenhouse gas emissions compared to natural gas or electric baseboard heating
- Offers an opportunity for LEED credits
- Aligns with city sustainability goals and the potential to attract an eco-conscious clientele
- Contains ample energy for even campus-scale developments. The District's pipeline system could supply enough energy to heat the cities of Arvada and Thornton combined

There are hundreds of installations that use wastewater for thermal energy recovery in operation globally. These systems have been installed at both the campus energy scale (10kW) and the district energy scale (20kW) in cities like Vancouver, B.C., Oslo, Norway, and Colorado's very own town of Avon.

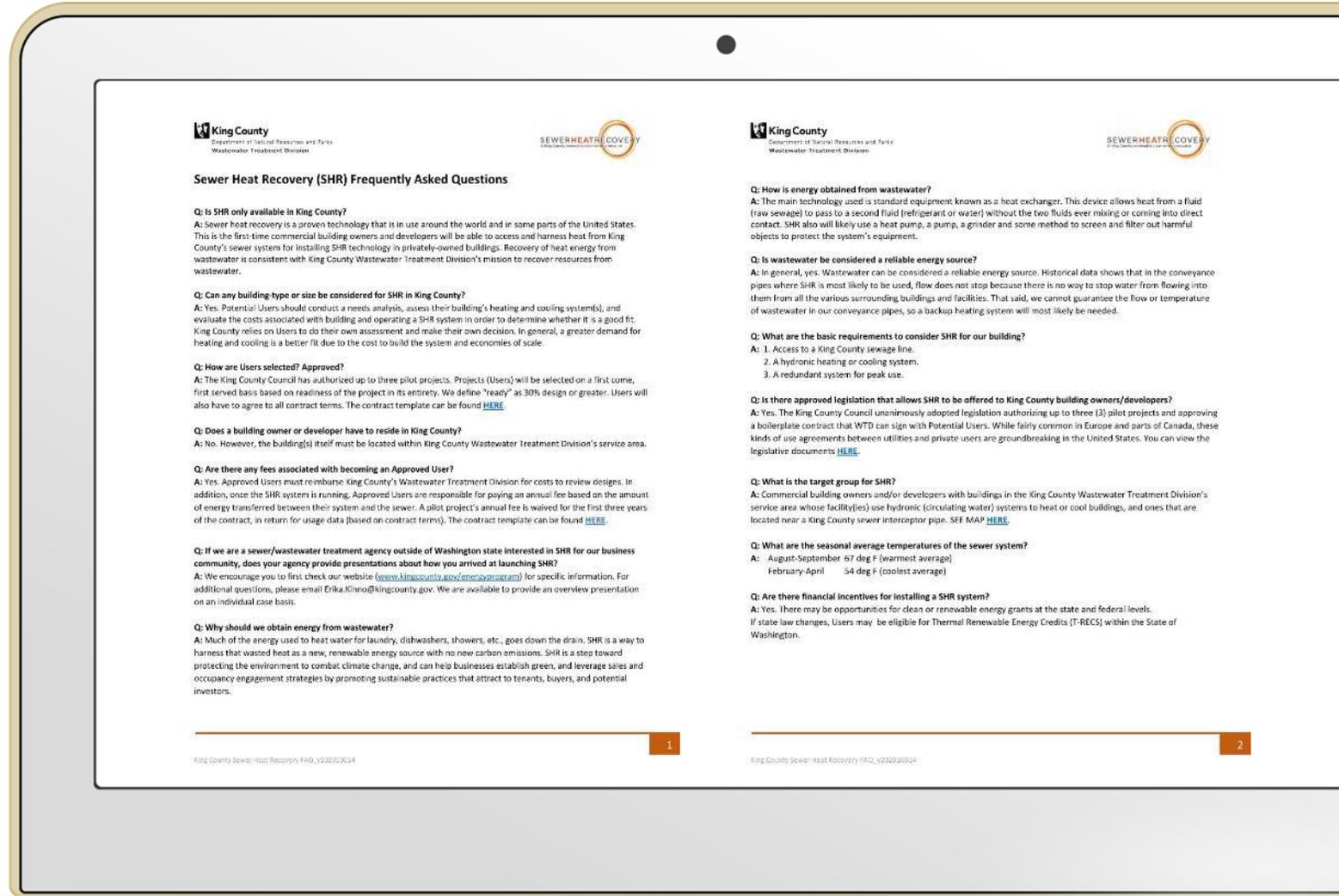
ARE YOU IN OUR SERVICE AREA?

Interested?
If your future real estate development is in our service area, reach out to us to learn more about this opportunity.



MUNICIPAL SUPPORT: KING COUNTY, WASHINGTON

- Supports King County's Strategic Climate Action Plan (SCAP)
- Legislation Passed 09/15/2020
- Pilot project RFP ends 12/18/2020; 1 of 3 slots remains
- Open to private commercial property owners and developers
- Provides a new \$0.005 per Ton-Hour revenue stream for King County



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A REQUEST FROM THE MEP INDUSTRY

Date: January 14, 2020
Re: Electrification product needs for the MEP industry

o Domestic hot water generating units (DHW heater on the VRF refrigerant loop, rated for potable use, double wall HX, etc.)

Heating / Service Hot Water Solutions:

- Water-to-water domestic heaters (ASME rated, capable of using CW loop to heat domestic HW, domestic/potable equipment with double wall HX in place)
- Air-to-water heat pump heaters with a focus on higher instantaneous capacity (requiring less HW storage)
- Electric boilers

We ask you to make it a priority to research, develop, market, and support the product types listed below. Please join us in the effort to support international climate goals and improve our industry together.

The list below represents many of the areas and elements of targeted product development we think crucial to the future success of decarbonized buildings. We're also encountering similar needs for process loads in many of the buildings we design, such as laboratories, hospitals, and commercial kitchens, but we have not itemized those.

You can keep us apprised of your progress in this area by emailing RoseAnn Grimes: RoseAnn@BuildingGreen.com. We look forward to sharing updates on your progress within our network and through public outreach to the entire industry.

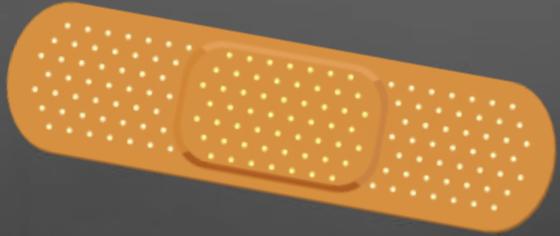
Very truly yours,

The following leading MEP design firms:

- Air-to-water heat pumps capable of producing warmer water at 0°F (HW supply targets):
 - o Simultaneous cooling / heating machines (producing HW and CHW simultaneously through heat recovery operation)
 - o Target warmer HW supply temperatures (100°F - 140°F or higher)
 - o A full product line with heat pump sizes to include larger capacity systems, comparable to current water-cooled chillers and gas-fired boiler product sizes

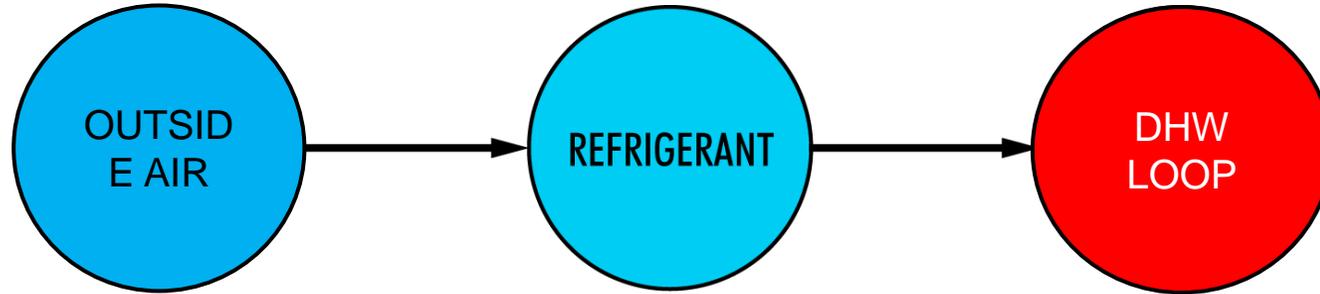
(for individual units in multifamily Passive House projects, for example).

o Customizable units

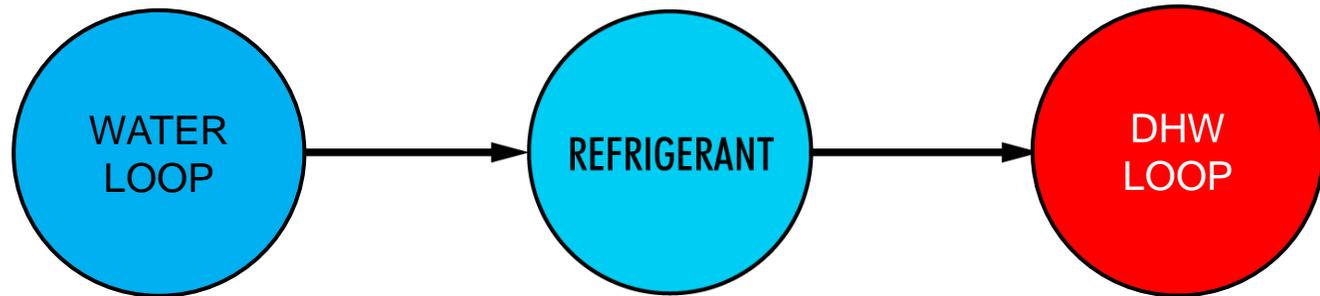


SMALL SCALE OPPORTUNITIES

HEAT PUMP WATER HEATERS



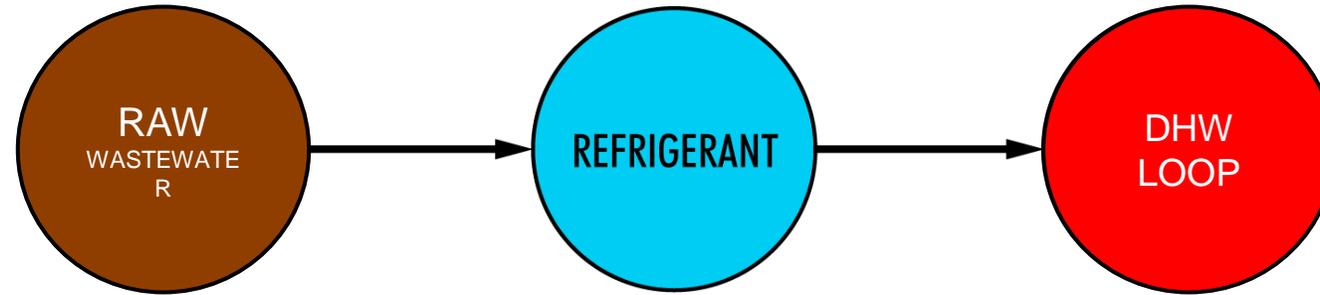
Air-source units absorb heat from the outside air and reject it to the DHW loop.



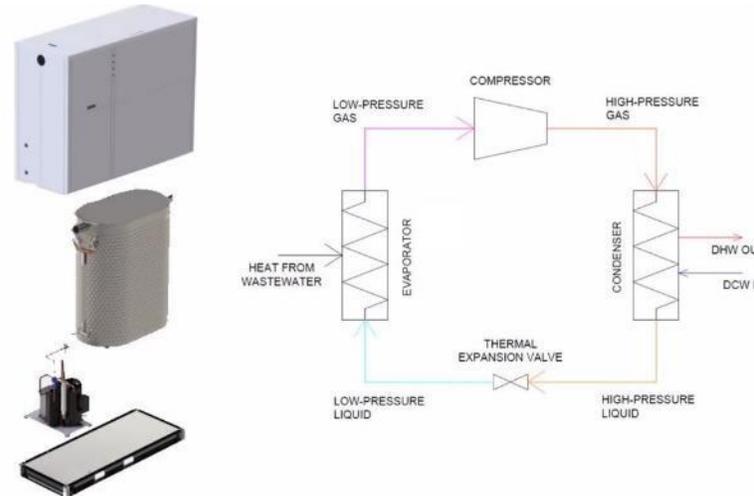
Water-source units absorb heat from a source water loop and reject it to the DHW loop.



WASTEWATER-SOURCE HEAT PUMP WATER HEATER



Refrigerant absorbs heat from a *raw wastewater source* and rejects it to the DHW loop.

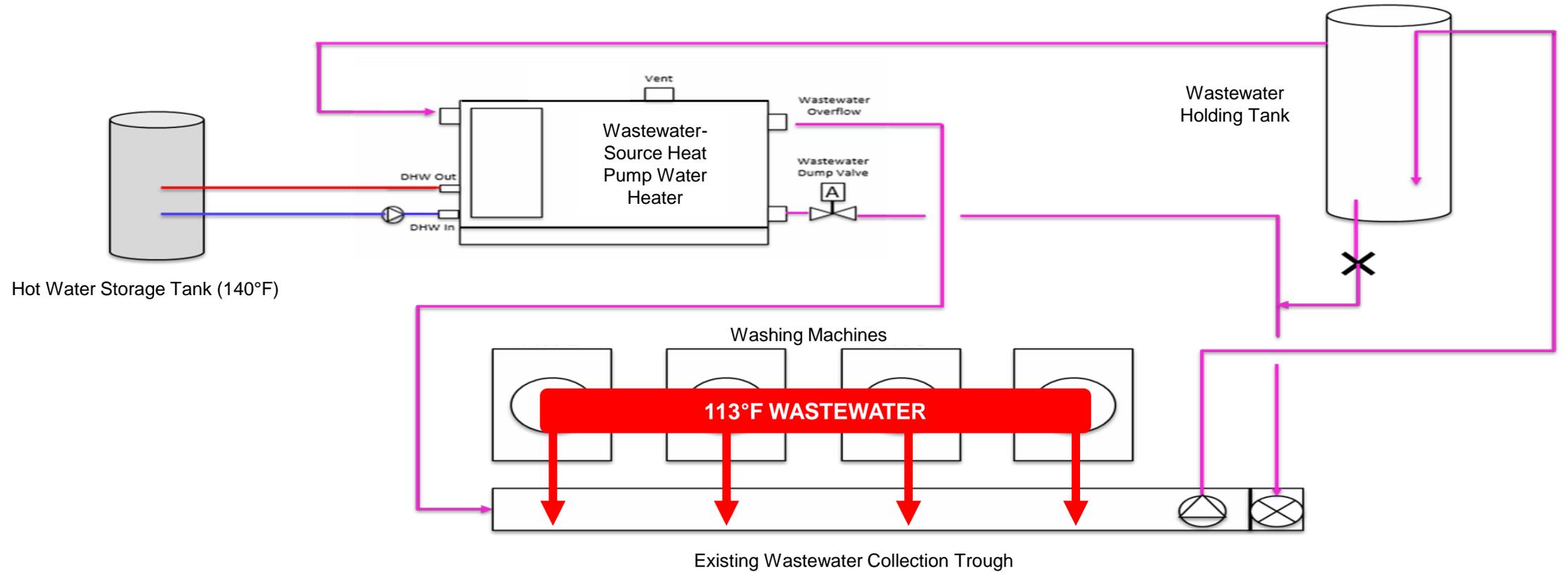


- 56t CO₂e/Year Reduction
- 9,720 Gallons/Year of Propane Saved
- \$28,800/Year Utility Cost Reduction
- 1,700-Gallons Per Day, 140°F
- 4.7 Average COP, 8.8 Peak COP
- 10.7 Hours Per Day Operation



HOTEL LAUNDRY RETROFIT

HOTEL LAUNDRY RETROFIT



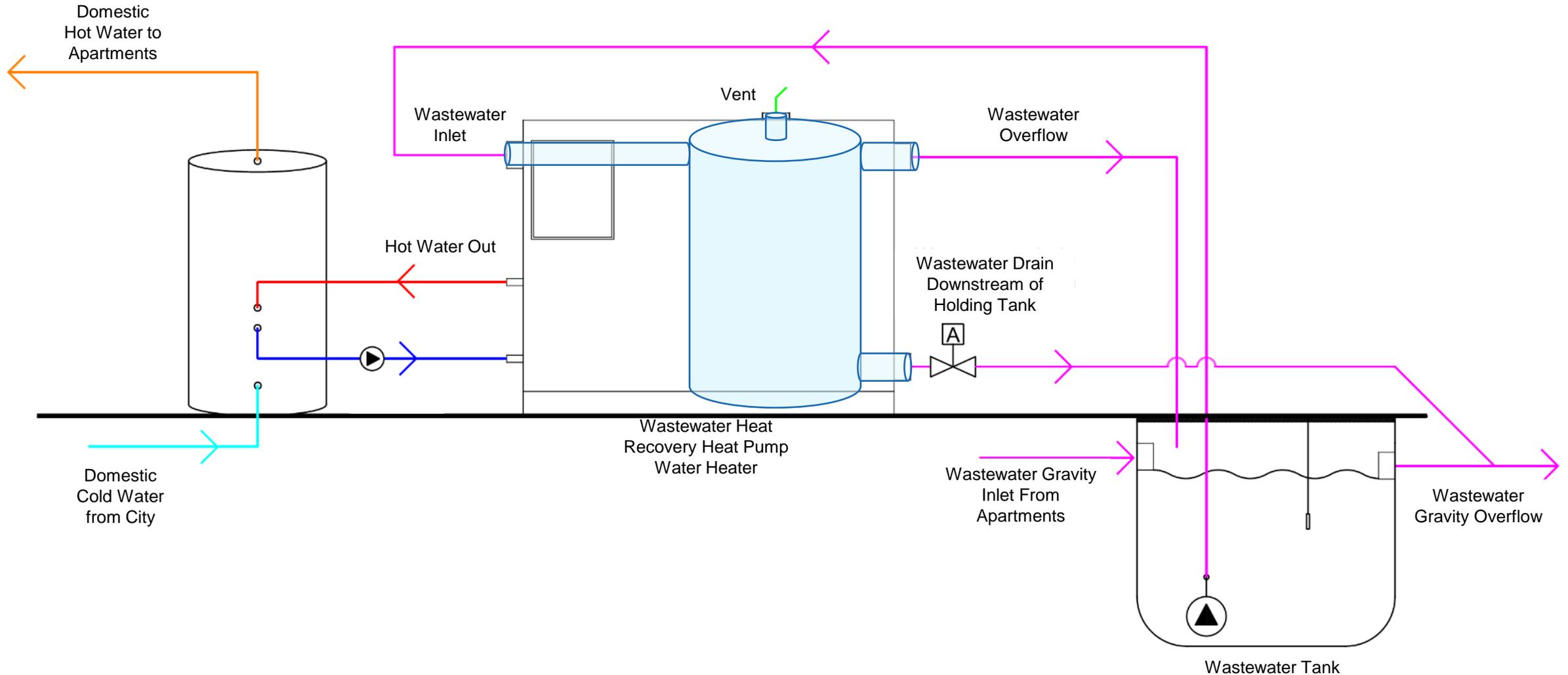
- 37-Unit Multifamily Apartments
- *To-Be* Commissioned Early 2021
- 100% Net-Zero Energy
- Wastewater Captured From Building
- 90% DHW Demand Met
- Modeled Combined COP of 3.6
- Utility Rebate for Peak kW Reduction



Rendering Courtesy Coburn Architecture

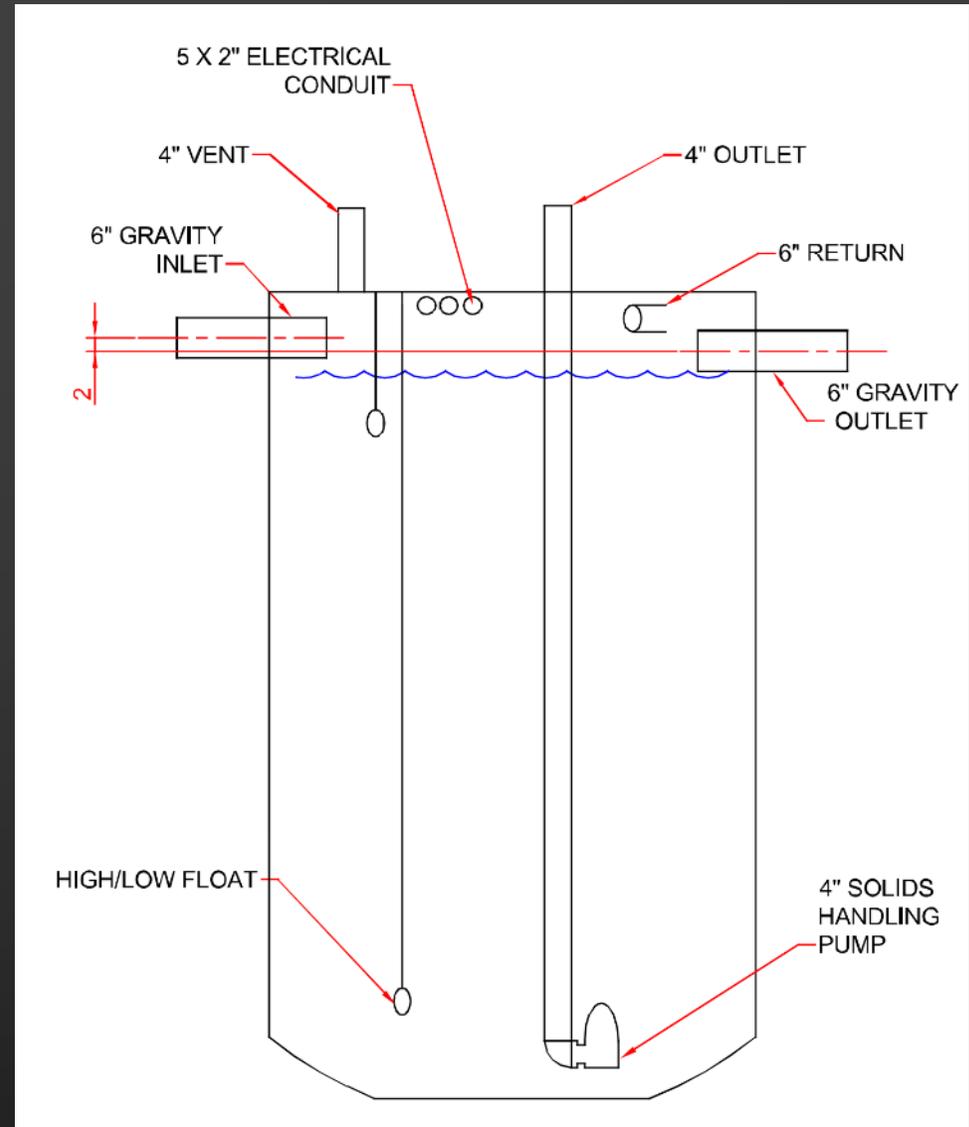
NET-ZERO MULTIFAMILY

BUILDING-LEVEL WASTEWATER ENERGY RECOVERY



WASTEWATER BATTERY

- Captures a percentage of peak wastewater flow leaving building
- Float system maintains usable liquid level
- Gravity overflow
- Vented per code requirements
- Volume is proportional to DHW storage volume
- Heat pump output capacity is proportional to wastewater storage volume
- Higher wastewater sources can decrease volume

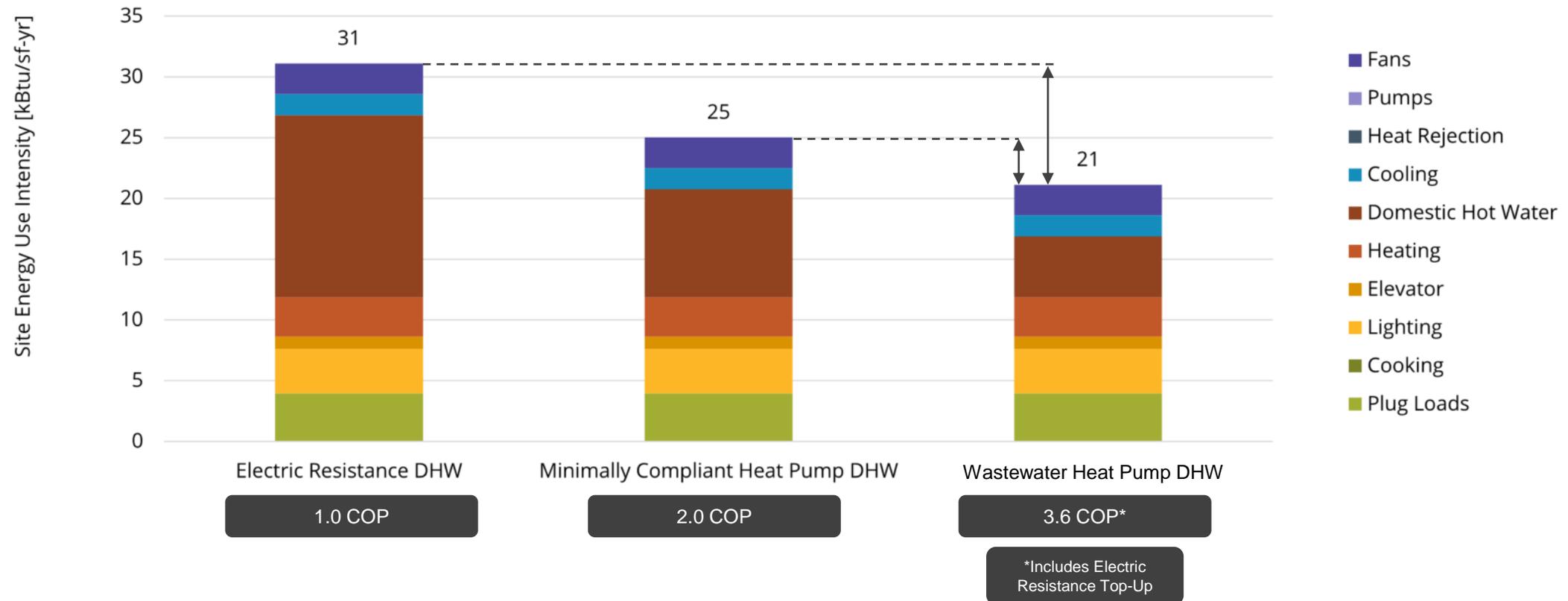


ACHIEVING NET-ZERO

FOCUS ON WHAT'S DRIVING THE LOAD

32% Less EUI vs. Electric Resistance

16% Less EUI vs. ASHP Water Heater



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A nighttime architectural rendering of a modern building. The structure features a multi-level design with a prominent canopy supported by several tall, slender, cylindrical columns. These columns are illuminated from within, casting a warm, reddish-pink glow. The building's facade is dark, with some glass panels reflecting the ambient light. In the background, several streetlights are visible, and the sky is a deep, dark blue. The overall atmosphere is futuristic and sophisticated.

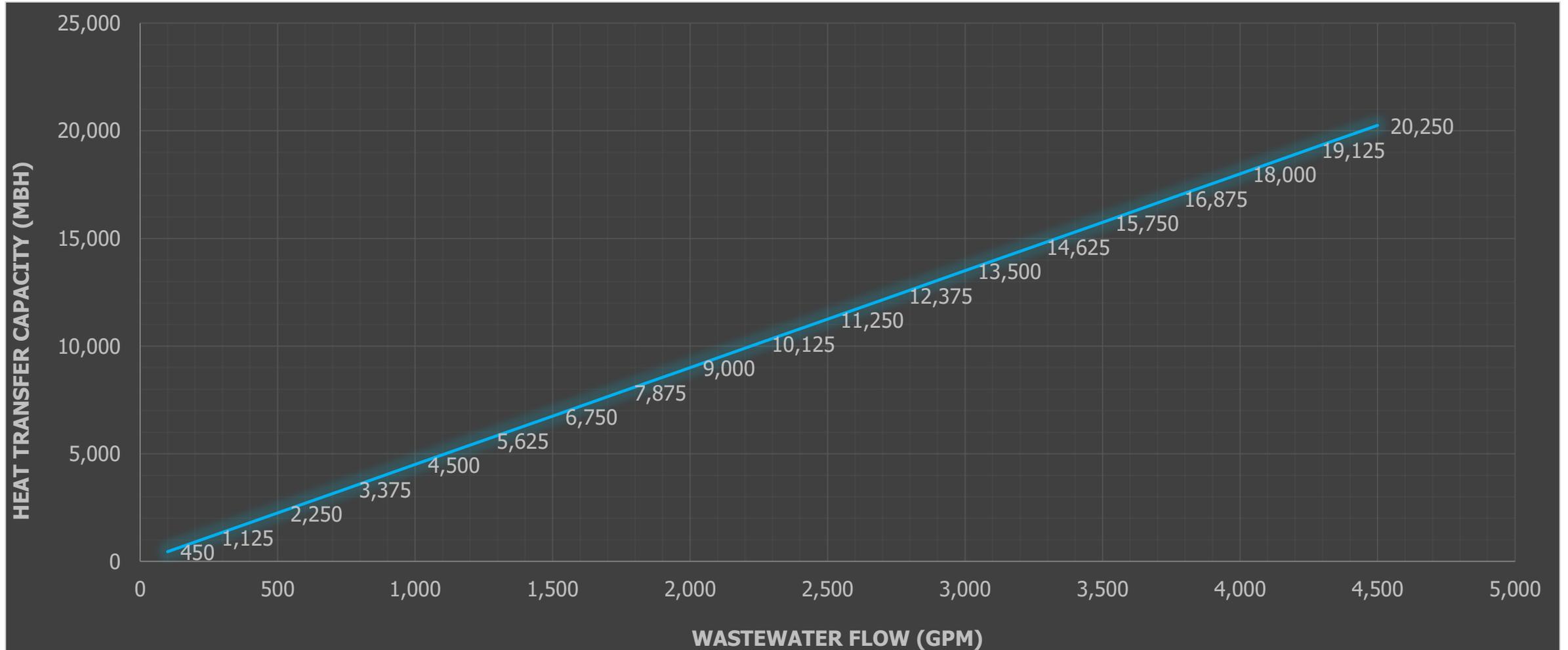
LARGE SCALE OPPORTUNITIES

FILTRATION AND SOLIDS REMOVAL

- 1,000 Ton / 3.5 MW System Capacity
- 2,000 GPM Wastewater Flow
- 6 Months of 24/7 Operation
- Approximately 518,400,000 Gallons



A LITTLE BIT GOES A LONG WAY



Based On PFHX Designed With 10°F and 5°F Approach

- Eastern United States
- 150,000 SF Class A Office Building
- LEED NC-Platinum
- 5x Award Winning Design
- Rooftop Wedding Venue

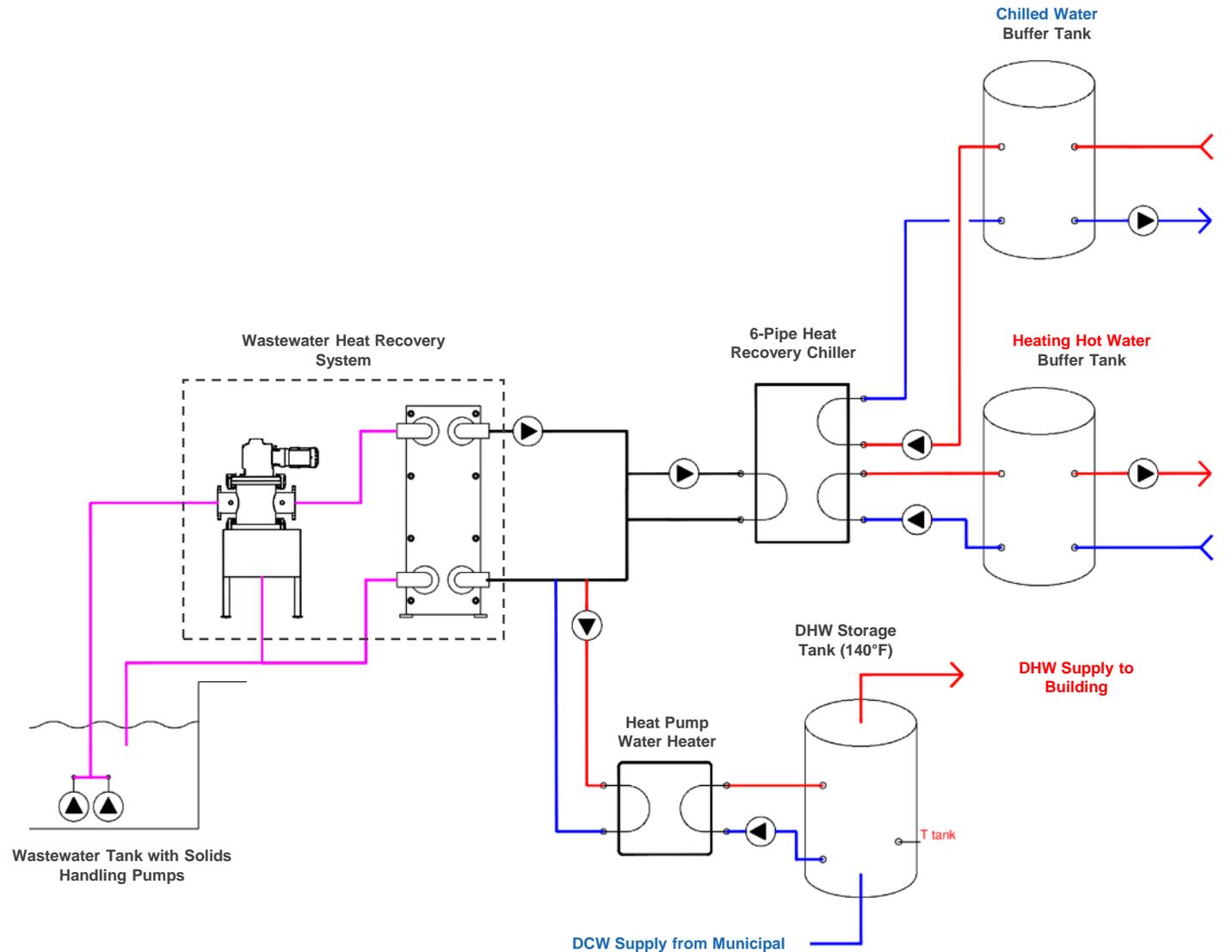


MUNICIPAL WATER HQ

WASTEWATER FILTRATION UNIT + HEAT PUMP

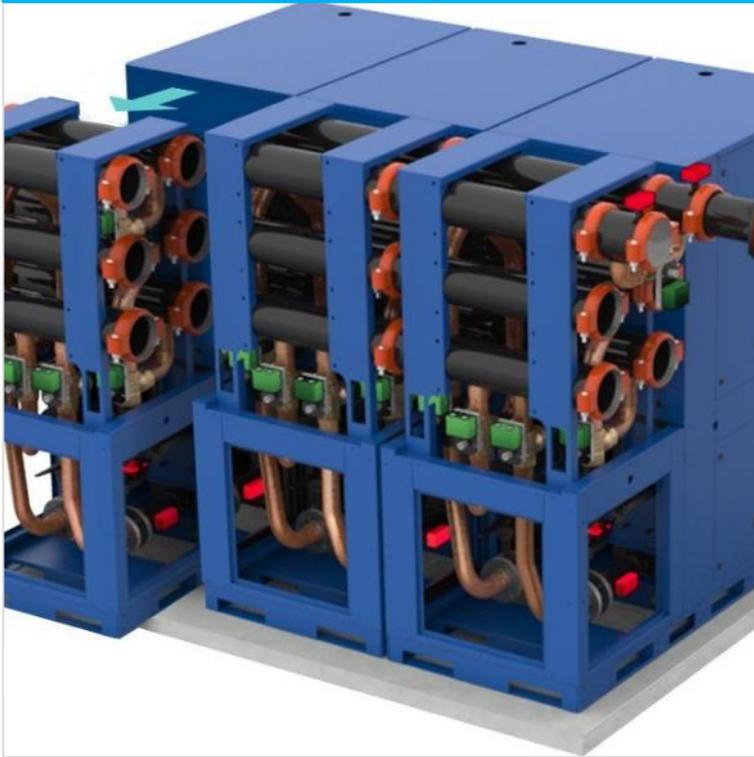
WASTEWATER HEAT RECOVERY SYSTEM

- Wastewater Filtration Unit
- Heat Exchanger
- Heat Pump HVAC System
- 100% of Heating/Cooling Loads
- Boilers Have Not Fired
- Cooling Towers Have Not Energized
- No Chemical Water Treatment
- Smaller Footprint



HEAT PUMP HVAC SYSTEM EQUIPMENT

6-Pipe Heat Recovery Chiller



4-Pipe Active Chilled Beams



WSHP DOAS Unit



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SAME HEAT PUMP SYSTEM, DIFFERENT SOURCE/SINK

BOILER/TOWER

- Cooling Tower Rejects Heat
- Gas Boilers Inject Heat
- Lowest First Installed Cost
- High Utility Costs
- High Maintenance Costs
- High Water Consumption
- Lose Rooftop Space

GROUND-COUPLED

- GHEX Rejects and Injects Heat
- High First Costs; Borefield
- Low Utility Costs
- Low Maintenance Costs
- No Water Consumption
- Rooftop Space Preserved

WWHR + WSHP

- WWHR Rejects and Injects Heat
- Slight First Cost Premium
- Lowest Utility Costs
- Low Maintenance Costs
- No Water Consumption
- Rooftop Space Preserved

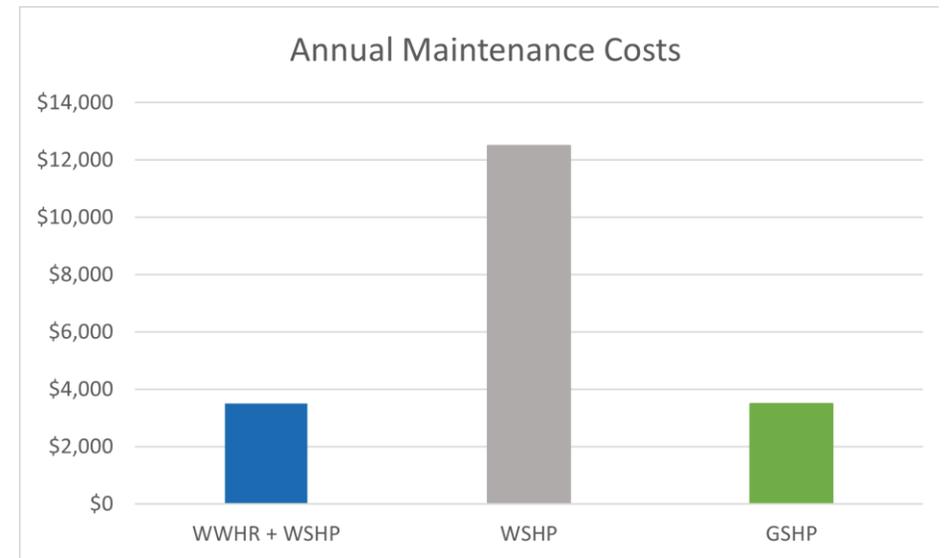
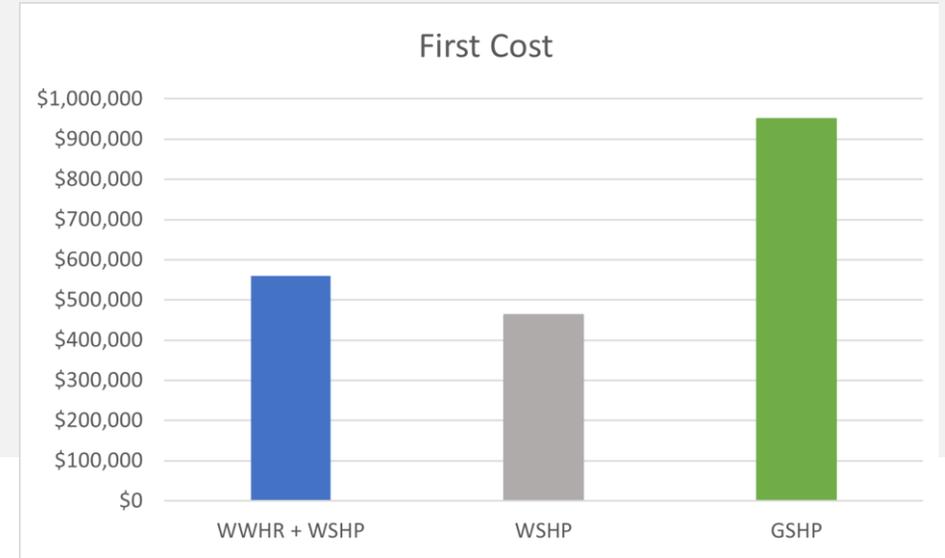




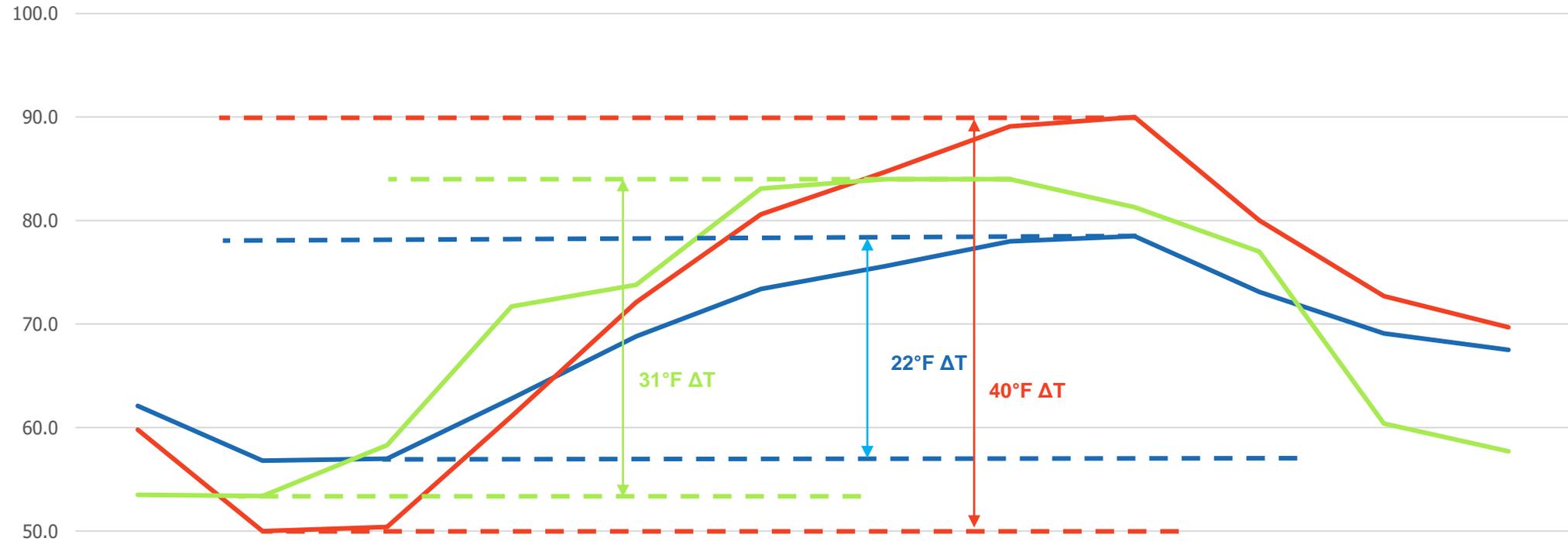
EQUIPMENT LIFE CYCLE ANALYSIS

Compared Three Systems:

- WWHR + WSHP vs. WSHP vs. GSHP
- 17% First Cost Premium vs. WSHP
- 72% Reduction in OPEX vs. WSHP
- 5-Year Simple Payback
- 1,350t CO₂e Avoided



THERMALLY OPTIMAL CONDENSER WATER SYSTEM



	January	February	March	April	May	June	July	August	September	October	November	December
Wastewater	62.1	56.8	57.0	62.8	68.8	73.4	75.6	78.0	78.5	73.1	69.1	67.5
Ground	59.8	50.0	50.4	61.1	72.1	80.6	84.7	89.1	90.0	80.0	72.7	69.7
CT/Boiler	53.5	53.4	58.3	71.7	73.8	83.1	84.0	84.0	81.3	77.0	60.4	57.7



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- Hypothetical Research Lab Facility
- Midwest, USA
- 235,000 Square Feet
- 1,000 Tons, 8:1 Cooling Dominant



HYBRIDIZING GEO SYSTEMS

HYBRID GEO - OPTIONS CONSIDERED

PURE GHEX

- 800 Boreholes
- 403'
- 322,000 Borefeet
- 7.3 Acre Site Requirement

HYBRID WITH CLOSED CIRCUIT COOLER

- 375 Ton Closed Circuit Cooler
- 400 Boreholes
- 402'
- 160,800 Borefeet
- 3.7 Acre Site Requirement

HYBRID WITH WASTEWATER HEAT RECOVERY

- 880 GPM Wastewater Flow
- 80 Boreholes
- 413'
- 33,000 Borefeet
- 0.7 Acre Site Requirement

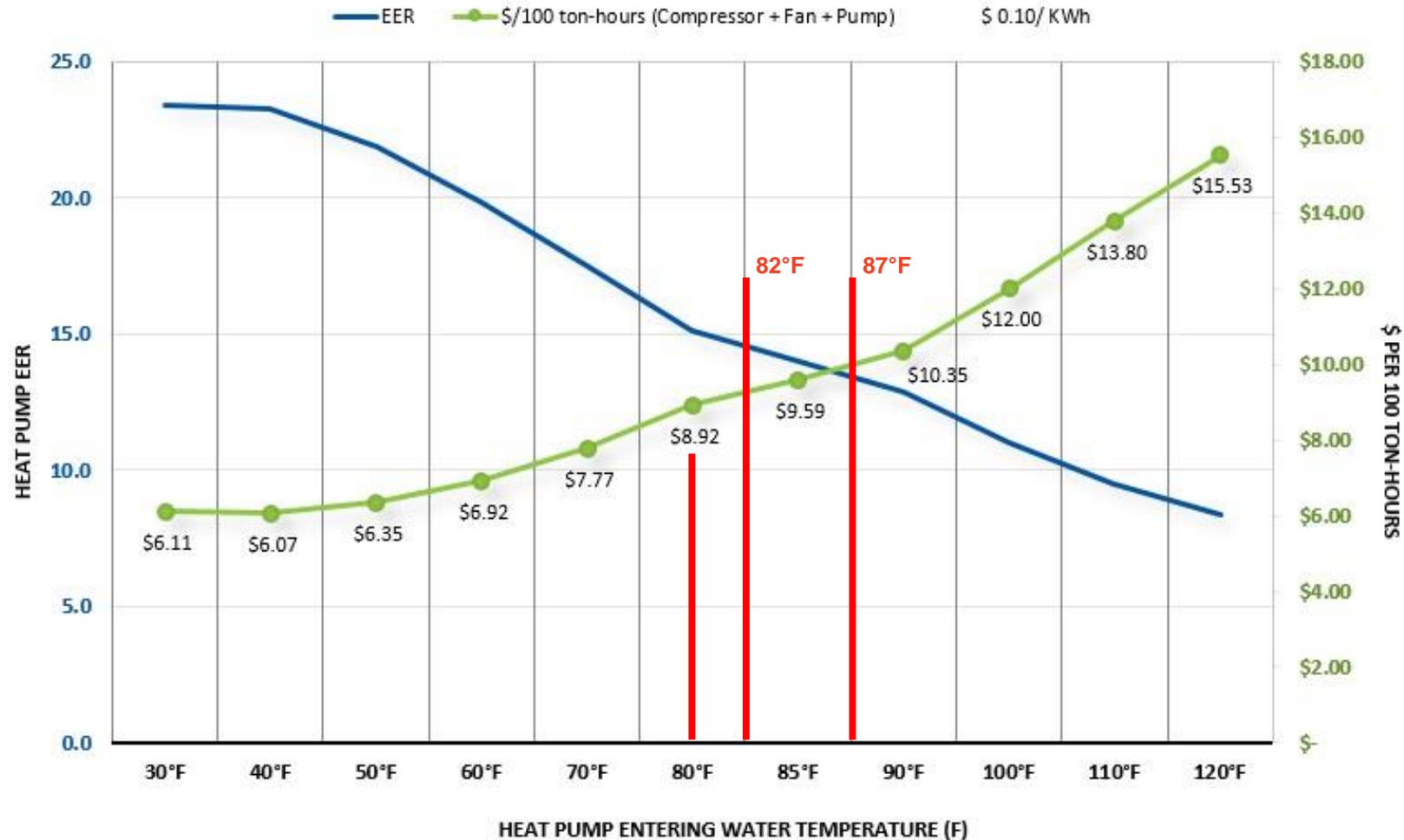
HYBRID GEO – COST AND PERFORMANCE IMPROVE

SYSTEM OPTION	CONCEPTUAL COST	MODELED COOLING EWT (°F)
FULL SIZE GHEX	\$5,300,000	87°F
HYBRID: 375-TON CLOSED CIRCUIT COOLER	\$3,000,000	82°F
HYBRID: WASTEWATER HEAT RECOVERY	\$1,500,000	80°F



HYBRID GEO – THERMALLY OPTIMAL CONDENSER WATER

Cooling Efficiency and Cost vs Entering Water Temperature



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- National Western Center
- Denver, Colorado
- \$1B Renewal Project
- Largest WWHR System in North America
- 3.8 MW Total System Capacity (Phase I)
- 90% of Heating/Cooling Loads Met



CAMPUS ENERGY SYSTEM

...*"We chose an innovative, clean-energy system that virtually makes something from nothing"*

- National Western Center CEO -

A PUBLIC-PRIVATE-PARTNERSHIP OF SORTS



**Metro
Wastewater**

**EAS Energy
Partners**

**NWC
Authority**

CSU

WSSA

**City of
Denver**

**Board Approved IGA
January 2019**

Contributed \$8.6M to
relocate & bury
Delgany interceptor

Providing thermal
energy from interceptor
free of charge

**Competitive
Procurement
December 2018**

Delivers low-carbon,
highly efficient heating
& cooling to NWC
buildings for 40 years

Designs, builds,
finances, operates and
maintains system

Meets stringent
performance standards

**Board Approved
February 2020**

Owner of the district
energy system

Counterparty to EAS in
the Campus Energy
Agreement

Pays monthly energy
payments to EAS

Enters into operating
agreements with CSU
and WSSA

**Board Approved
January 2020**

Enters into an operating
agreement with NWC
Authority

Pays energy payments
to the NWC Authority
for CSU's share of the
consumption

**Board Approved
February 2020**

Enters into an operating
agreement with NWC
Authority

Pays energy payments
to the NWC Authority
for WSSA's share of the
consumption

Provides partial credit
support to NWC
Authority

NWCO delivers a
portion of the
design/build work

DDPHE is providing
\$1M grant from
enterprise funds
towards campus
sustainability

TWO MAJOR PHASES

250 Acre Total Development

PHASE 1 & 2

- 190 Acres, 8 Buildings
- 2,215,765 Building Square Feet

FUTURE PHASE (THE TRIANGLE)

- 60 Acres, Seeking Developers



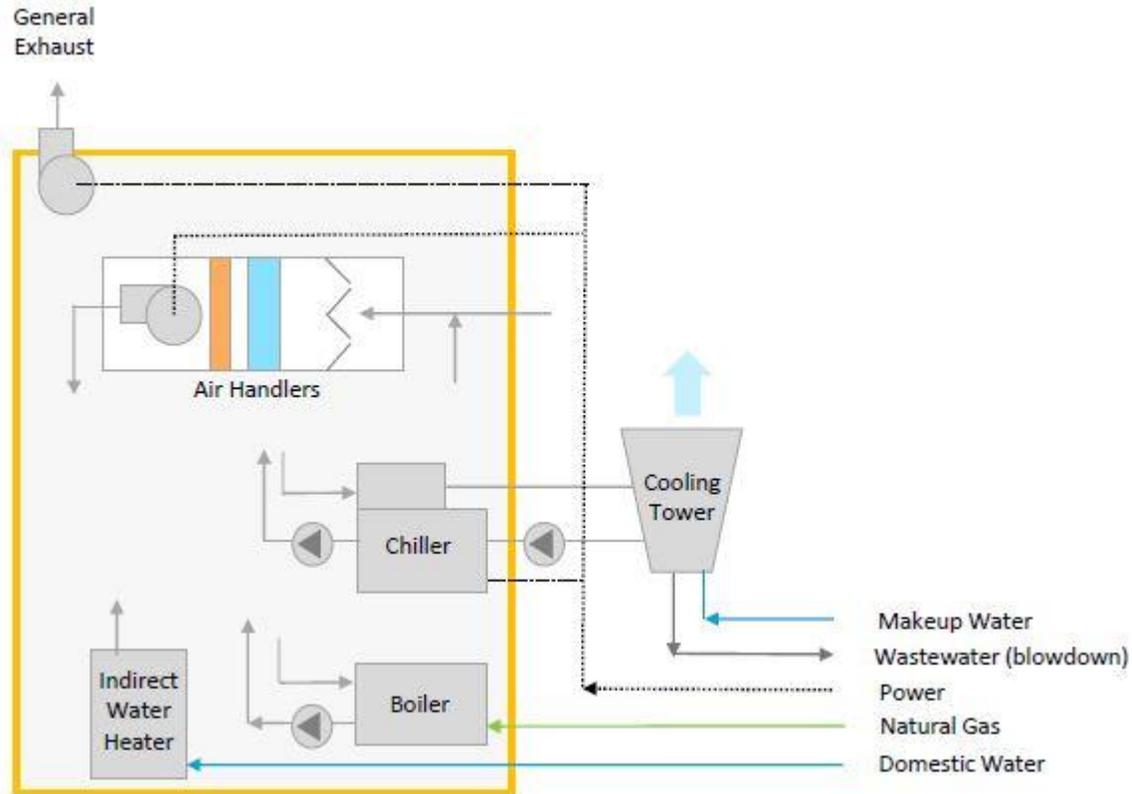
TURNING WASTE INTO OPPORTUNITY

- Existing Delgany interceptor pipes run along Platte River
- Infrastructure owned by MWRD
- 4 ,755 GPM Minimum Flow
20,000 GPM Maximum Flow
- 60°F Minimum Temperature
72°F Maximum Temperature

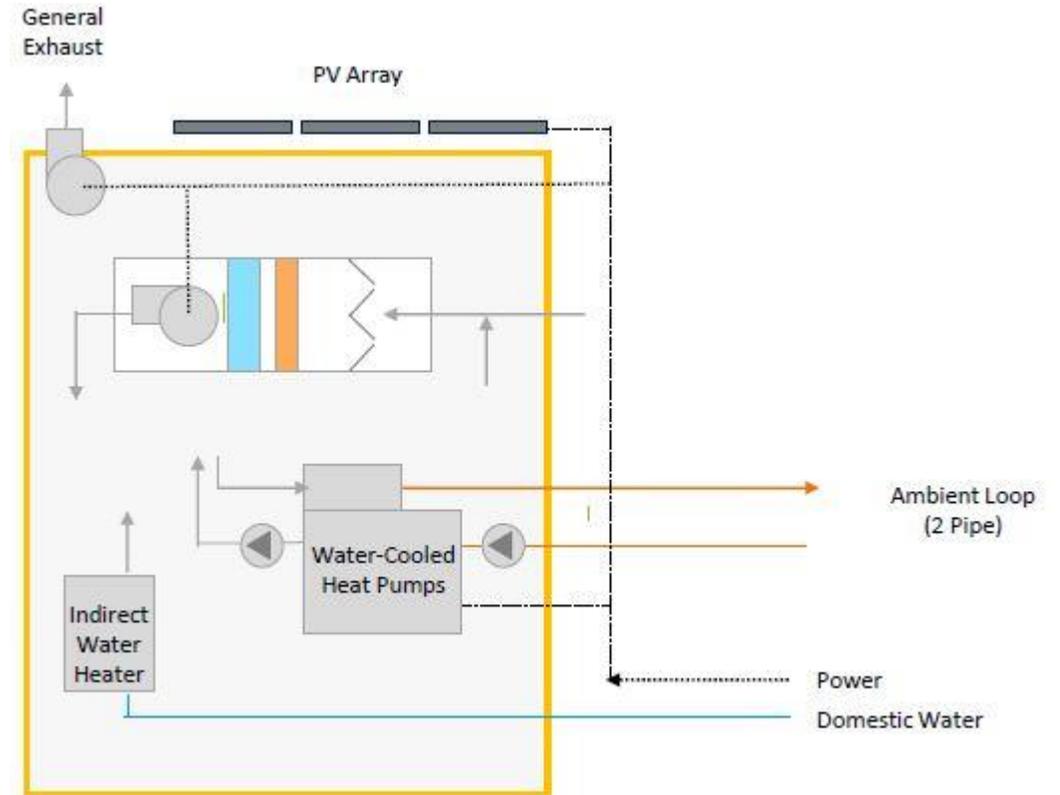


~~WE'VE ALWAYS DONE IT THIS WAY~~

STATUS QUO



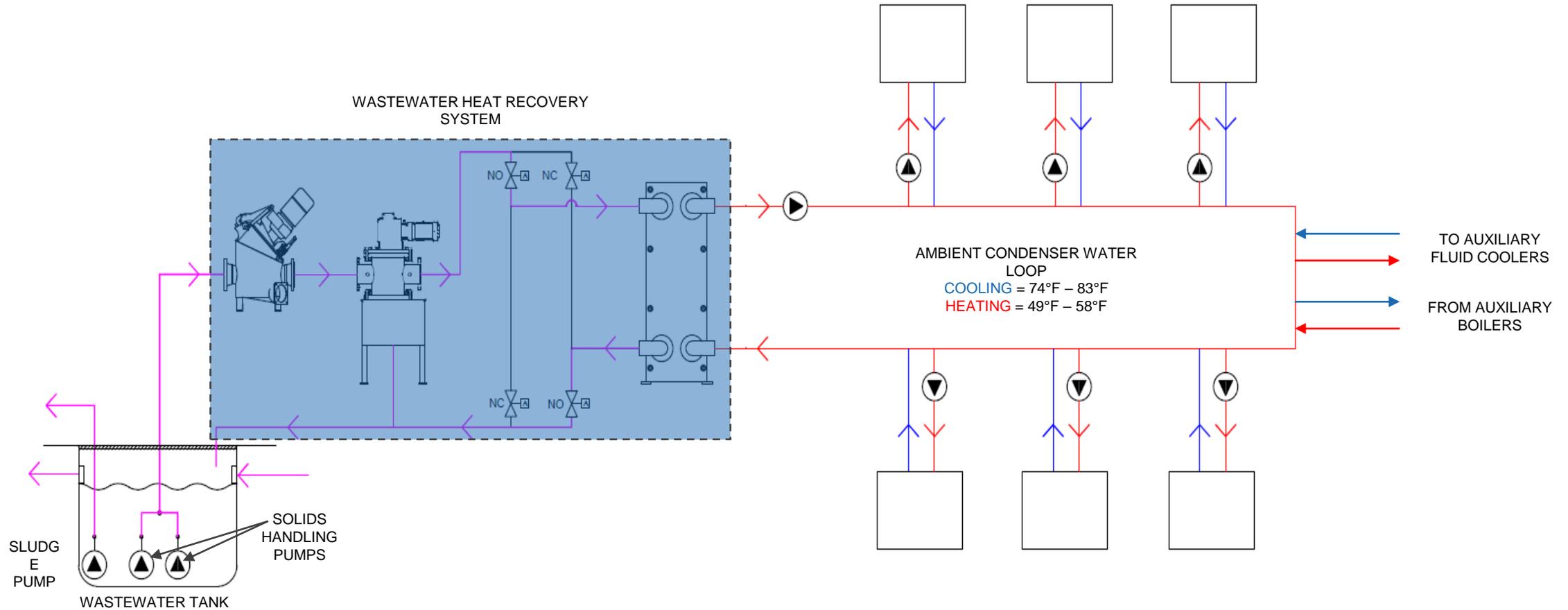
DISRUPTION



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AMBIENT WATER PIPES MOVE ENERGY



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SYSTEM IMPACTS

CARBON REDUCTION

- 2,600 metric tons of CO₂ emissions each year avoided
- Equivalent to 6.6 million vehicle passenger miles driven annually

WATER SAVINGS

- 3,168,000 gallons of fresh water saved each year
- Equivalent to 5-Olympic sized swimming pools

SUSTAINABILITY

- Helps Metro Wastewater reduce effluent temperatures to protect the Platte River eco system.
- Aligns with Denver's Broader Climate Action Plan Goals

PROVIDES CHOICES FOR THE DESIGN TEAMS



Water-to-Air Heat Pump

Forced Air Heating/Cooling



Water-to-Water Heat Pump

Radiant Heating/Cooling
Snowmelt
Pool Water Heating
Domestic Hot Water



Water-Source VRF

Wall-Mounted Fan Coils
Ceiling Concealed Cassettes
Ducted Fan Coils



Heat Pump Water Heater

Domestic Hot Water



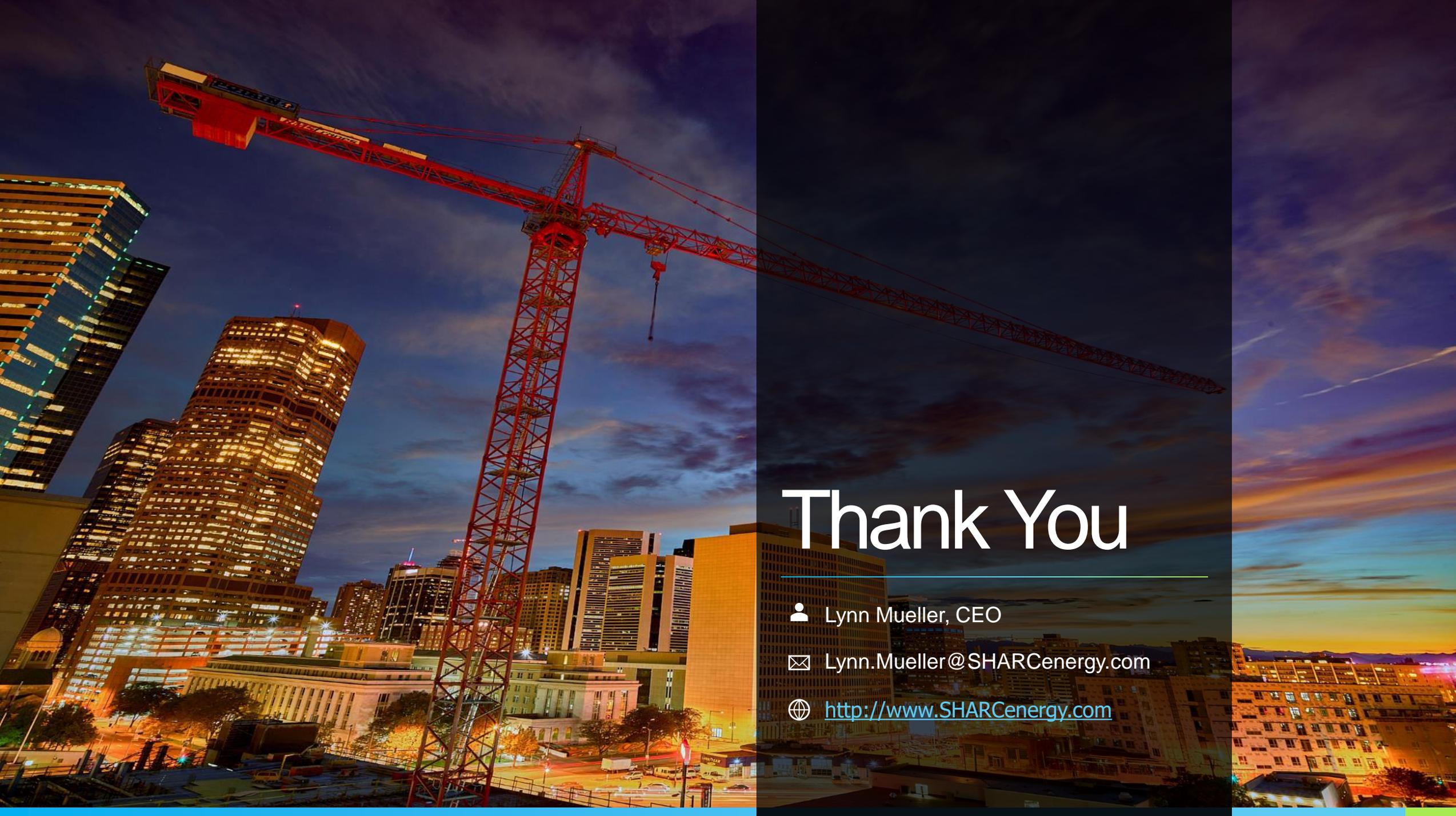
Heat Recovery Chillers

Hydronic Fan Coil Systems
Radiant Heating/Cooling
Snow Melt
Domestic Hot Water
Central Chilled/Hot Plant



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Thank You

👤 Lynn Mueller, CEO

✉ Lynn.Mueller@SHARCenergy.com

🌐 <http://www.SHARCenergy.com>