BOILER UPGRADE PROJECT MANCHESTER, NH WWTP

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Agenda

- Manchester Background
- Boiler Project Need
- Alternatives Analysis
- Basis of Design and Equipment Selections
- New Boiler System and Controls
- Air Handling Upgrades
- Hot Water Storage Tanks
- Boiler Operations
- Fuel Savings and Rebates
- NOx Reduction
- Questions

Background – City of Manchester

- Largest City North of Boston - 110,000 population
- Settled in 1725
- Evolved from Agricultural to Industrial: 1725 - 1815
- Amoskeag Mills: Largest single mill in the world 1915
- Post Industrial Depression: 1935 – 1980’s
- Revitalization: 1990 to Present

Environmental Protection Division

- Created in 1975
- Division of Manchester’s Department of Public Works
- An “enterprise”
- Staff of 43
- 15 acre campus at 300 Winston Street
- 10 buildings
  - Administration
  - Operations
  - Maintenance

Manchester's Wastewater Infrastructure – WWTP

- 1975 – 26 mgd
- 1994 – Upgrade to 34 mgd
- 2016 – Upgrade to 42 mgd
- Serves four communities
  - Bedford (4.37%)
  - Goffstown (4.11%)
  - Londonderry (10.16%)
  - Manchester (81.36%)
- Metro pop. – 172,000

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Boiler Project Need

- Existing Equipment
  - Three original 300 HP oil fired steam boilers built in 1973
  - They were 40 years old and in need of replacement
  - The original boilers were rated at 10 MMBtu each
  - The oil consumption was 1,200 gallons of No. 2 Fuel Oil per day
  - The boilers were turned on November 1st and shut off May 1st each year

Alternatives Analysis

- During the schematic design phase of the project four options were considered and analyzed:
  - Option #1: Non-Condensing Boilers with Thermal Mass Storage Tank
  - Option #2: Condensing Boilers with Thermal Mass Storage Tank
  - Option #3: Condensing Boilers and Water-to-Water Heat Pump (Using Wastewater) with Thermal Mass Storage Tank
  - Option #4: Biomass (Wood Chip) Boiler Plant
  - Potential Future Option: Biogas Fuel Cell utilizing potential future anaerobic digester.

Option #1: Non-Condensing Boilers with Thermal Mass Storage Tanks

- Gas-fired atmospheric non-condensing boilers (80% Efficient) with a supply water temperature of 200°F and a ΔT of 40°F to match existing building system.
- Primary/Secondary loop layout including new pumps and equipment.
- 4,000 Gallon storage tank (180°F Max. Temp.) supplied with heat exchangers to store thermal energy from the incinerator. Load side immersion heat exchangers for domestic hot water preheat and space heating.
- All existing hydronic terminal equipment to remain at 200°F inlet temperature.

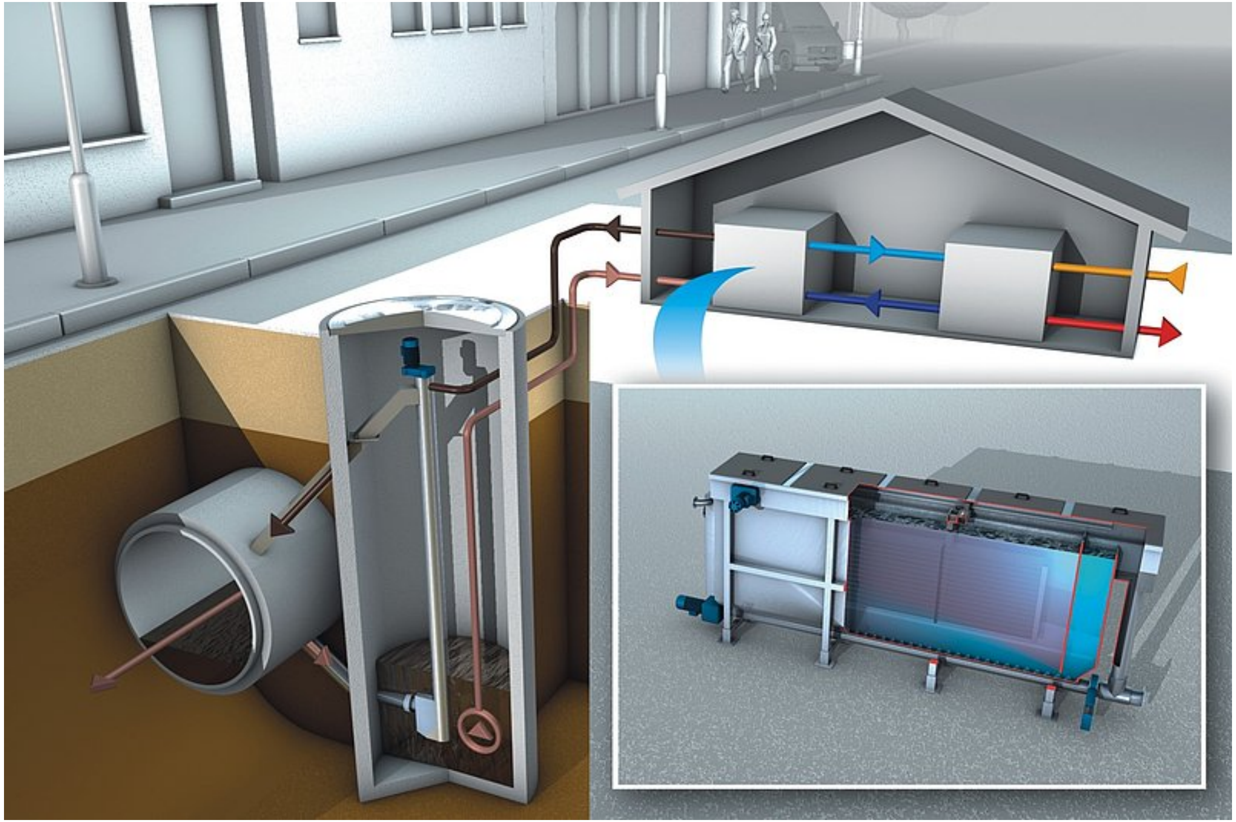
Option #2: Condensing Boilers with Thermal Mass Storage Tank

- Direct Vent Gas Condensing boilers (92% Efficient) with a supply water temperature of up to 180°F and a low temp. loop at 140°F supply temp.
- Primary/Secondary loop layout including new pumps and equipment.
- 4,000 Gallon storage tank (180°F Max. Temp.) supplied with heat exchangers to store thermal energy from the incinerator. Load side heat exchangers for domestic hot water and heating.
- All new hydronic heating equipment (coils, fin-tube, unit heaters, etc.) selected for 160°F supply and a ΔT of 40°F.

Option #3: Condensing Boilers and Water-to-Water Heat Pumps with Thermal Storage Tank

- Water-to-Water Heat Pumps utilizing the effluent water from the sewer as a heat sink for efficient operation of the heat pumps. The system shall provide hot and chilled water to the building.
- A gas fired direct vent condensing boiler plant shall act as a backup heating plant during the winter.
- 4,000 Gallon storage tank (180°F Max. Temp.) supplied with heat exchangers to store thermal energy from the incinerator and to pre-heat domestic hot water and space heating.
- All new hydronic heating equipment (coils, fin-tube, unit heaters, etc.) selected for 160°F supply and a ΔT of 40°F.

Water to Water Heat Pump



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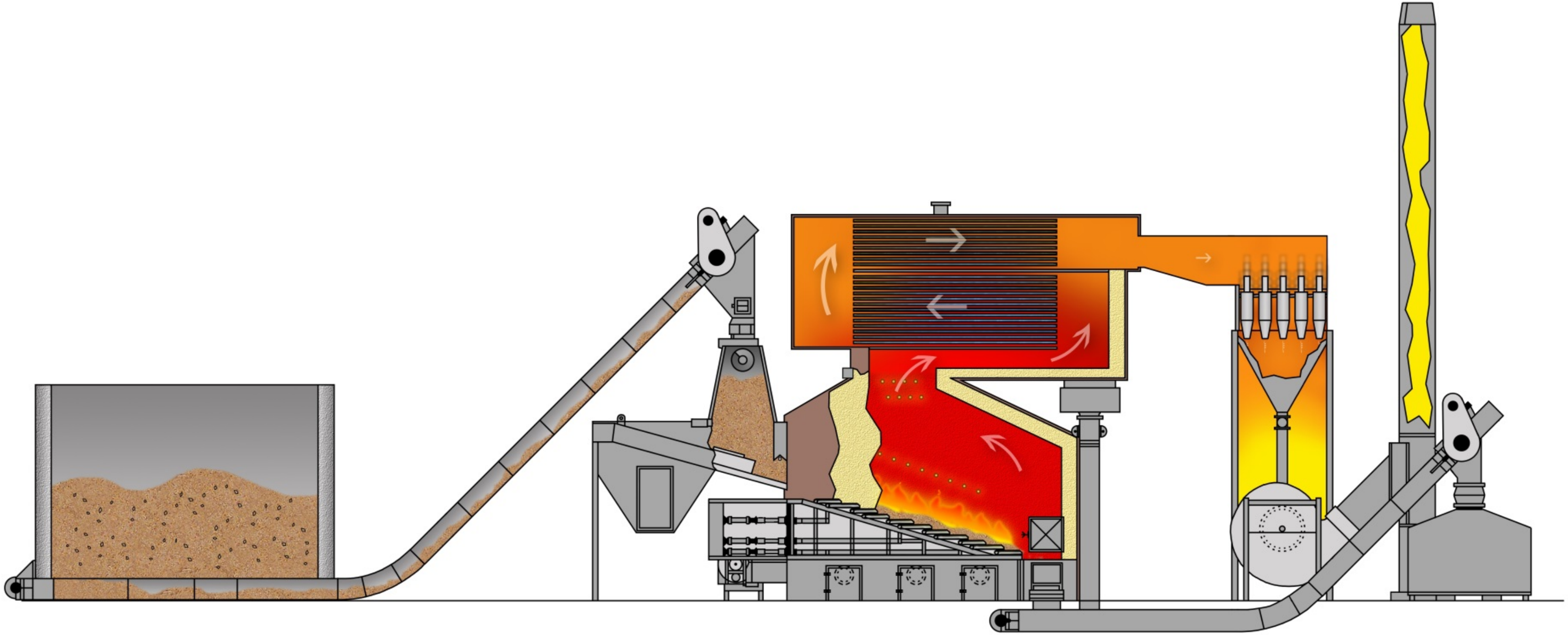
Option #4: Biomass (Wood Chip) Boiler Plant

- The existing boilers would be removed and replaced with a biomass (wood chip) boiler plant.
- It would require an addition for the delivery and storage of wood chips.
- A conveyor system would bring the chips from the storage bins to the biomass boilers. And a lift to bring the ash to street level.
- The boiler plant would have a 200°F supply and a ΔT of 40°F .
- It would require a new primary / secondary piping layout and it would be connected to our hydronic system.

Biomass (Wood Chip) Boiler Plant



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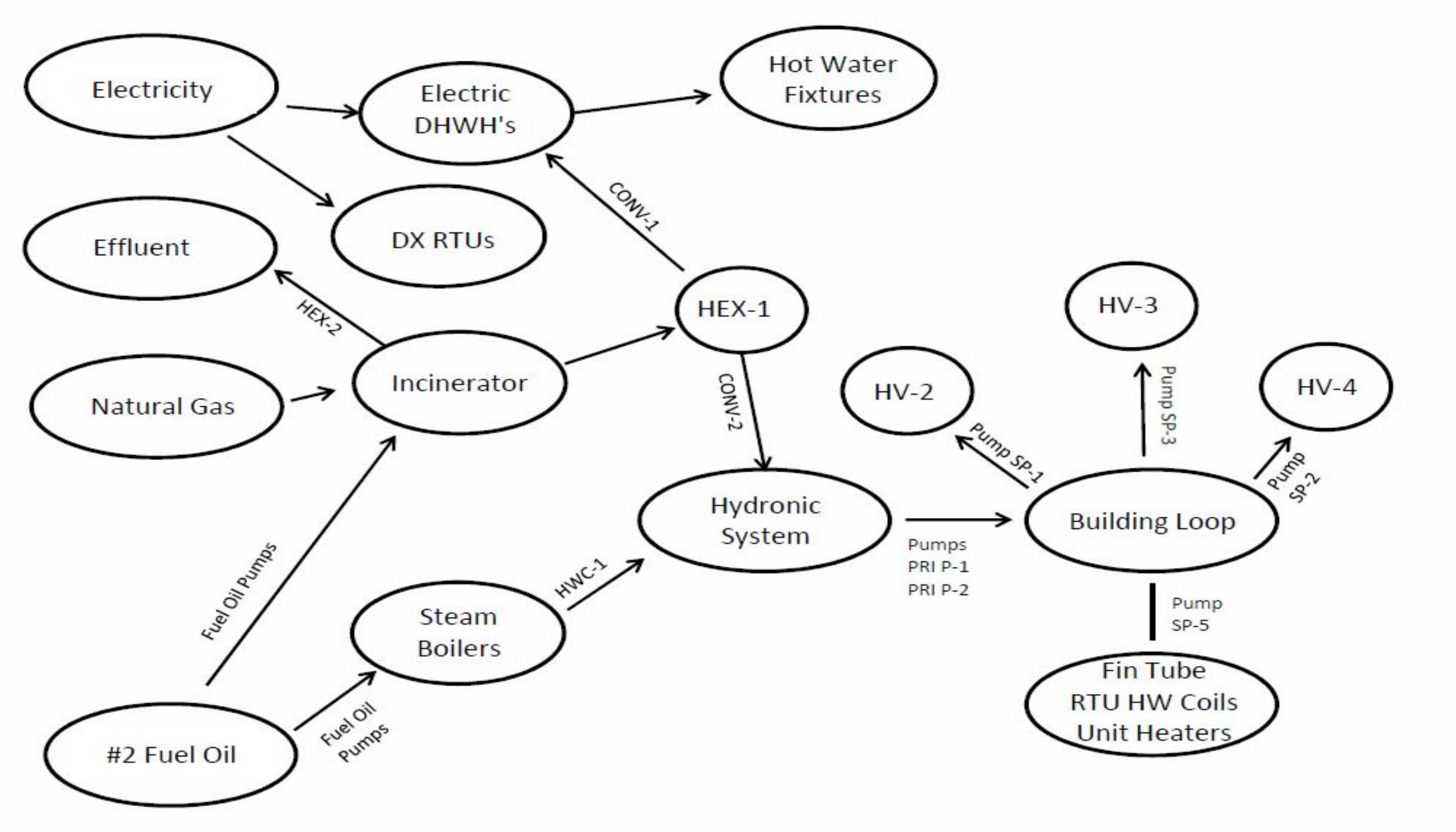
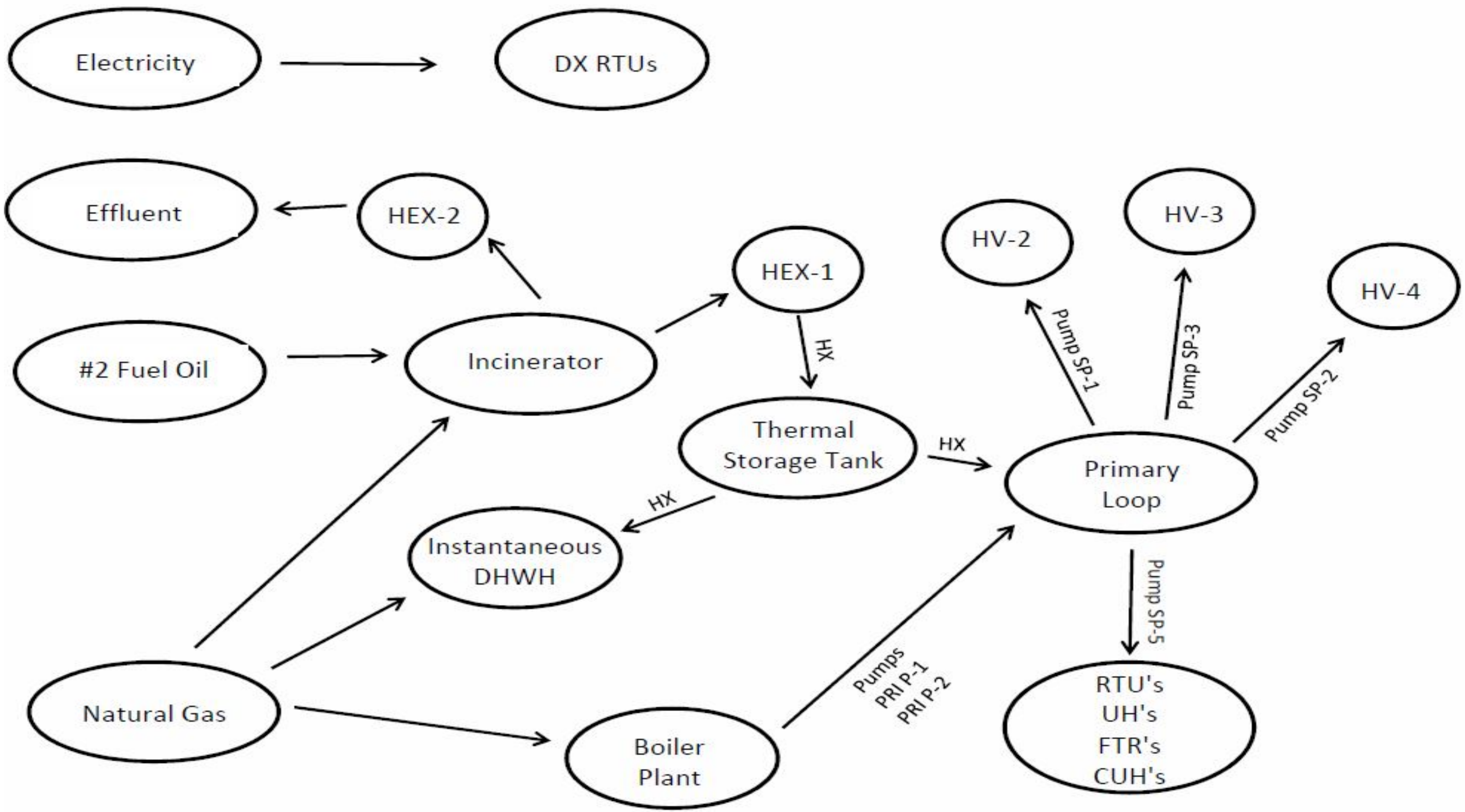
Future Option: Biogas Fuel Cell

- With the potential of a future anaerobic digester being installed on site a Biogas Fuel Cell for production of electricity was discussed.
  - Biogas reclaimed from the digester would be fed to a 1.4 megawatt Fuel Cell for energy production.
  - Fuel cell requires 55% methane for proper operation and would provide electricity as well as low and high grade waste heat for use in the building.
  - Configured for Co-Gen operation the total thermal efficiency nears 90%.
  - Low quality heat gets returned to the digester and high quality heat is transferred to the thermal storage tanks for use by the building systems.

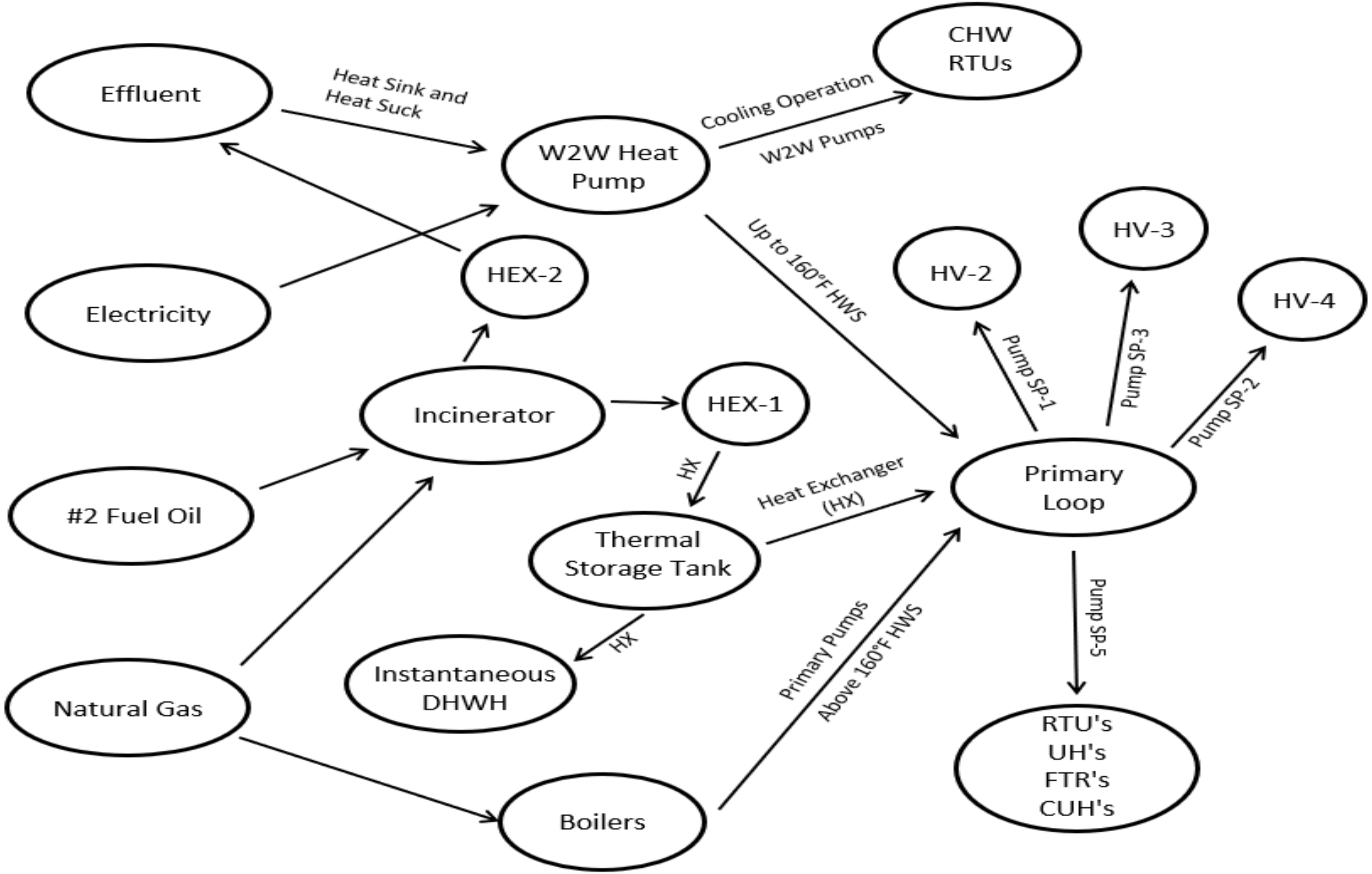
Energy Flow Diagram - Existing



Energy Flow Diagram – Options 1 & 2



Energy Flow Diagram – Option 3



System Comparisons

- Existing Boiler System with DX Rooftops
  - Fuel Oil: 136,000 gallons
  - Electricity: 76,682 kWh
  - Annual Energy Cost: $385k
- Option #1: Non-Condensing Boilers with DX Rooftops
  - Natural Gas: 170,000 Therms
  - Electricity: 76,000 kWh
  - Annual Energy Cost: $199k
- Option #2: Condensing Boilers with DX Rooftops
  - Natural Gas: 159,000 Therms
  - Electricity: 76,000 kWh
  - Annual Energy Cost: $187k
- Option #3: W2W Heat Pumps with Condensing Boilers
  - Natural Gas: 32,000 Therms
  - Electricity: 1,164,000 kWh
  - Annual Energy Cost: $160k

Basis of Design

- The option determined to best fit the economical and operational needs of the facility was that outlined in Option #2 as follows:
  - Gas fired, direct vent condensing boiler plant with dual temperature returns. Min. of 20% return water below 130°F required for condensing operation with an efficiency of 93%.
  - Two 2,000 Gallon ASME rated thermal storage tanks including heat exchangers for incinerator, domestic hot water, process hot water, and space heating.
  - Low Temp supply to new heating coils in RTU's and perimeter heating to ensure 20% low temp return water.
  - Refurbishment of HV units including new fans, hydronic coils, and pumps.
  - New direct digital control (DDC) BMS from JCI to replace existing pneumatic controls in the building.
  - Test and Re-Balance of the buildings air and water systems.

Equipment Selections

- Boilers: Cleaver Brooks Model CFC 3300
- Draft Inducer: Enervex RSV 400
- Plate and Frame Heat Exchangers: Alfa Laval
- Circulation Pumps: Grunfoss CRE & VLSE type
- Administration RTU Coils: Trane DSWB type
- HV Heating Coils: Carrier
- Thermal Tanks: Fabricated by Steel-Pro
- DDC BMS: Johnson Controls Incorporated

New Boiler System and Controls

- Four new energy efficient gas fired dual temp return hot water condensing boilers
- The new boilers are 3.3 MMBtu each
- New piping and air handling equipment

New Boiler System and Controls

- Project Completed 2017
- Project Cost $2.5 Million
- The project was completed on time and on budget

Air Handling Upgrades

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Hot Water Storage

- 4,000 Gallons of Hot Water Storage
  - The Economizer (air to water heat exchanger) from the Fluidized Bed Incinerator converts hot air to hot water.
  - The hot water was once only used as it was produced. With these tanks we are able to capture and retain 4,000 gallons to be used later.

Boiler Operations

- The new boilers are operated year round
- The year round operation allows the WWTP to have hot process water even when the incinerator is not in operation
- This helps improve cleaning operations
- It also allows us to have heat before November 1st and after May 1st when the old boilers were not in operation

Fuel Savings and Rebates

Annual Average Savings of $100K

Rebates of $200K

NOx Reduction

90%

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Acknowledgements

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Thank You…