IDEA Campus Energy Conference

UNIVERSITY of ROCHESTER

March 8, 2018

- Founded 1850 - Rochester, NY
- 9,470 Full Time Students + 3,000 Researchers
- 12+ MGSF (600+ acres), 9 MGSF connected to CU
- 800 bed Medical Center & Children's Hospital

Study Objectives

- ✓ **Identify buildings on River Campus still served by campus steam and annual steam consumption.**
- ✓ **Calculate energy and operating savings by converting River Campus steam users to hot water.**
- ✓ **Identify distribution system heat loss reduction converting to medium temperature hot water**
- ✓ **Calculate water treatment and make up costs associated with not returning condensate to plant in existing condensate return system.**
- ✓ **Calculate additional cogen plant electricity (kwhrs) that can be produced annually with additional hot water load.**
- ✓ **Identify Capital Costs to extend hot water system piping to buildings on steam.**
- ✓ **Identify Capital Costs to convert remaining 22 buildings to hot water.**
- ✓ **Identify Capital Costs to renew the aged steam distribution system**

Brief History of District Hot Water Heating at University of Rochester

1927 – Original Central Steam Plant built with coal fired boilers.

1998 – Steam boilers converted from coal to natural gas with oil backup

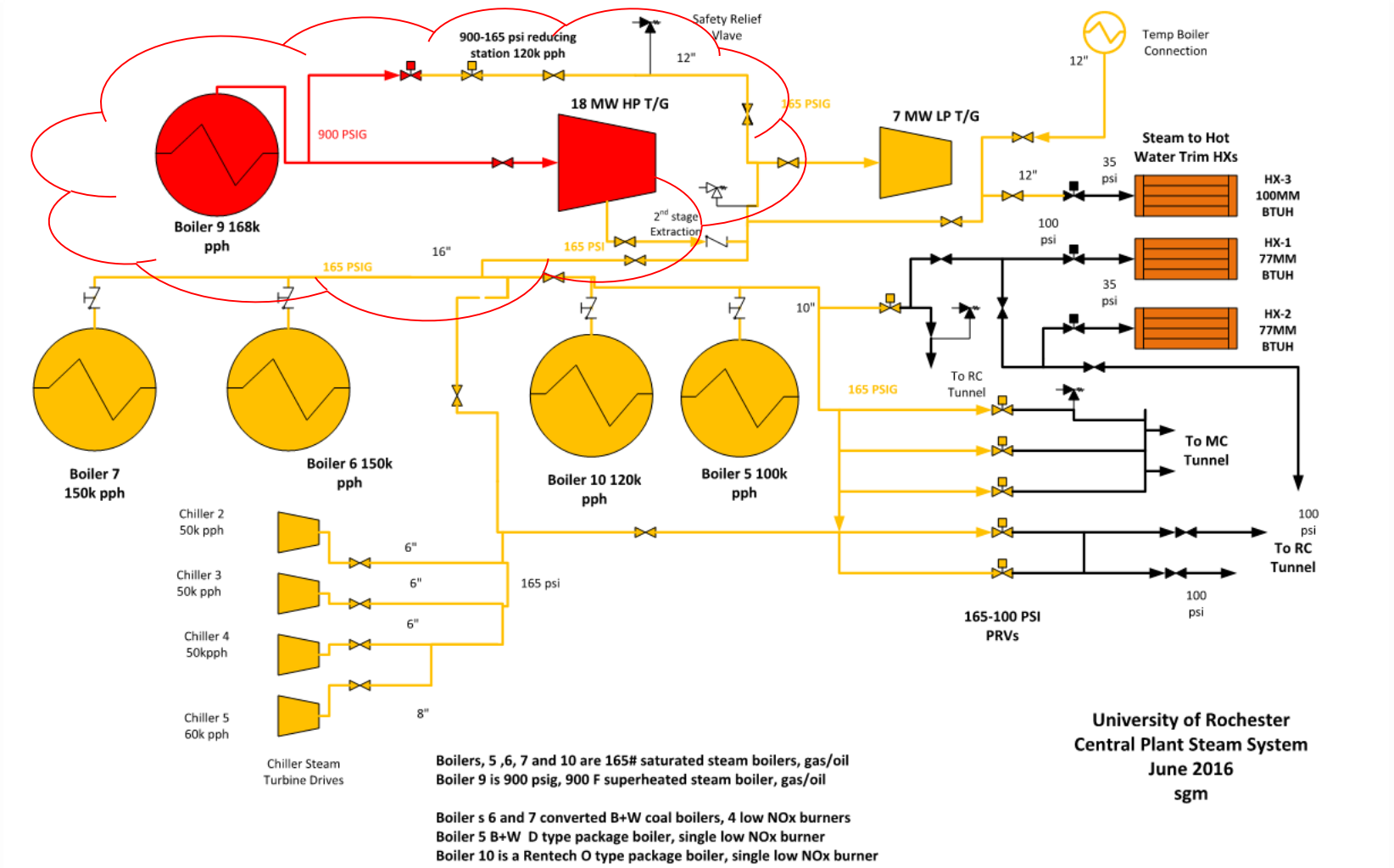
2005 - 25 MW Cogeneration Plant and Hot Water Distribution System Installed to Part of Campus

Central Utilities Overview

- 5 Gas Fired Steam Boilers (oil backup)
- 688,000 pph steam capacity
- 9 Chillers (5 Electric, 4 Steam)
- 34,000 tons CHW Capacity
- Steam, HW, CHW, electric, domestic water distribution systems

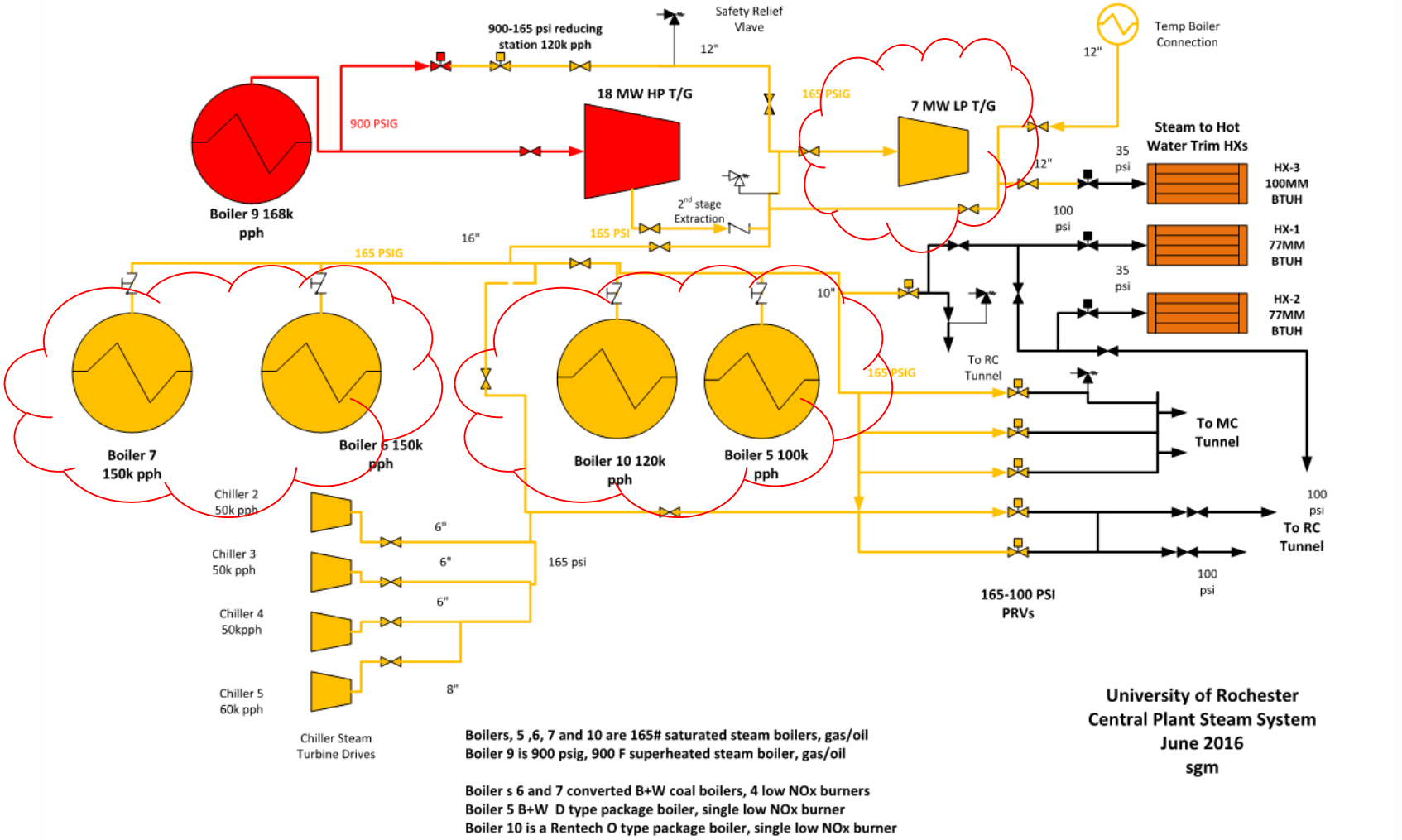
Steam System Overview

HP Boiler (900psi) & 18MW HP Turbine



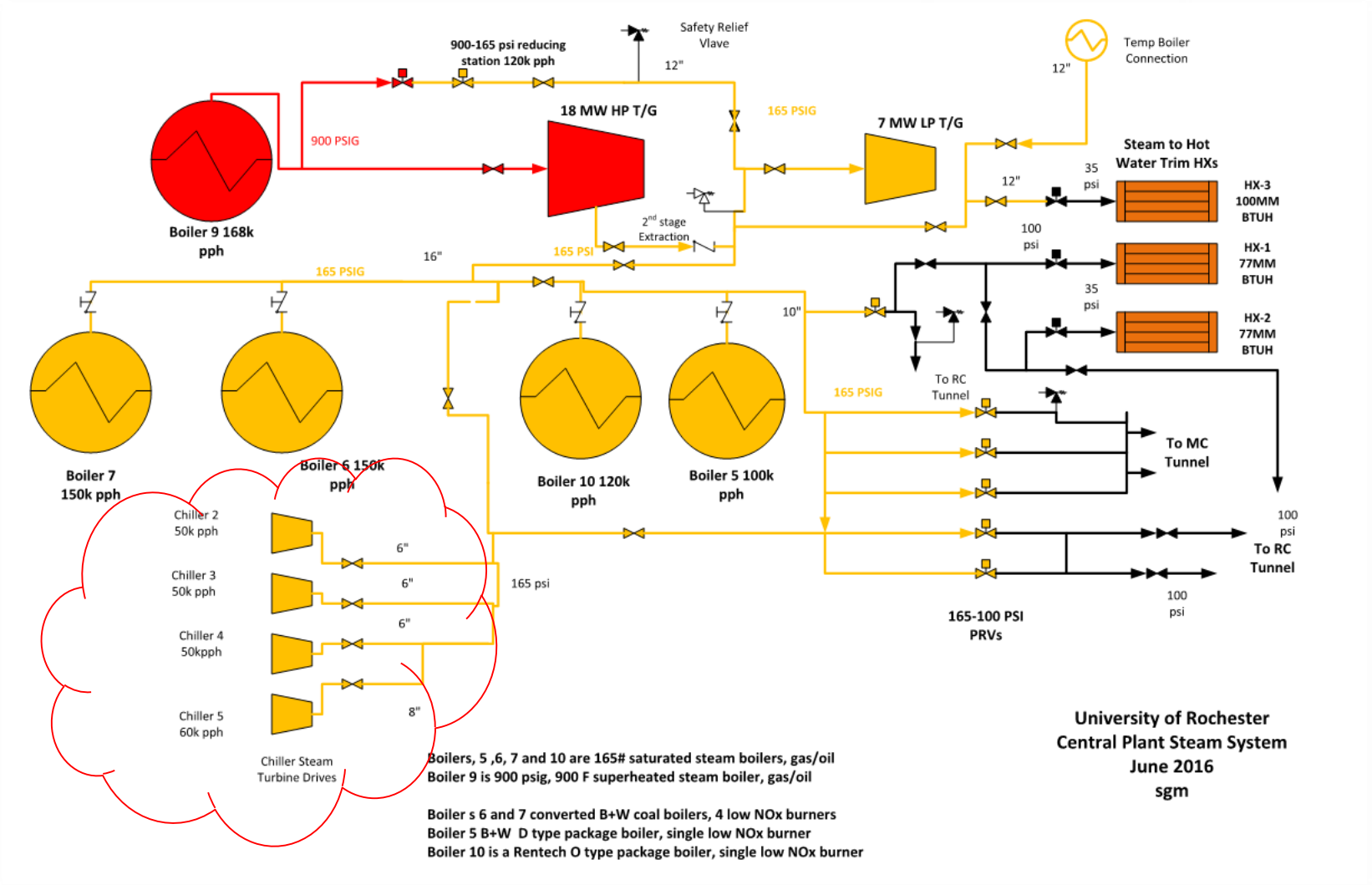
Steam System Overview

LP Boilers (165psi) & 7MW LP Turbine



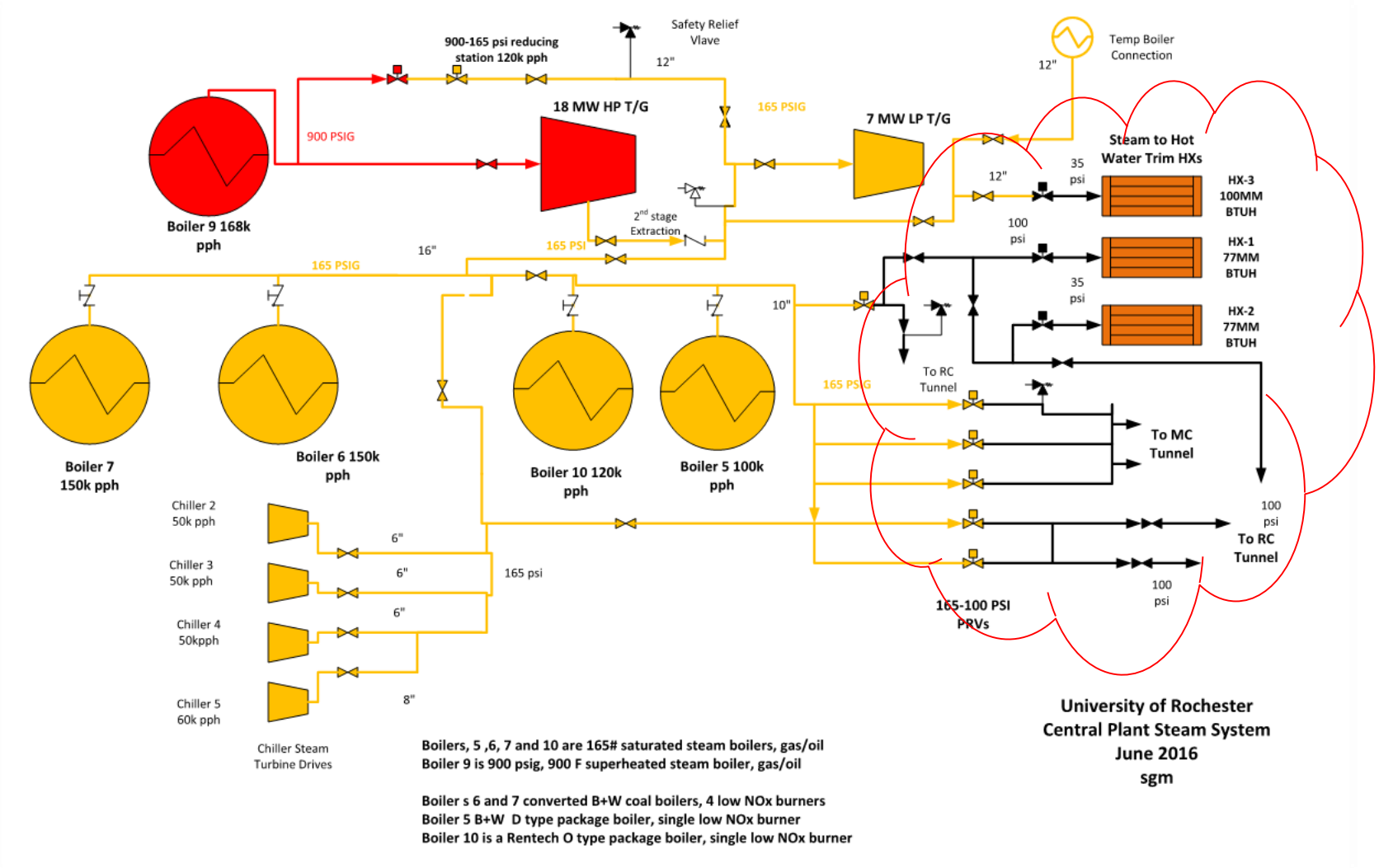
Steam System Overview

Steam Driven Chiller Turbines (20k tons)



Steam System Overview

100Psi distribution & Trim Hex's



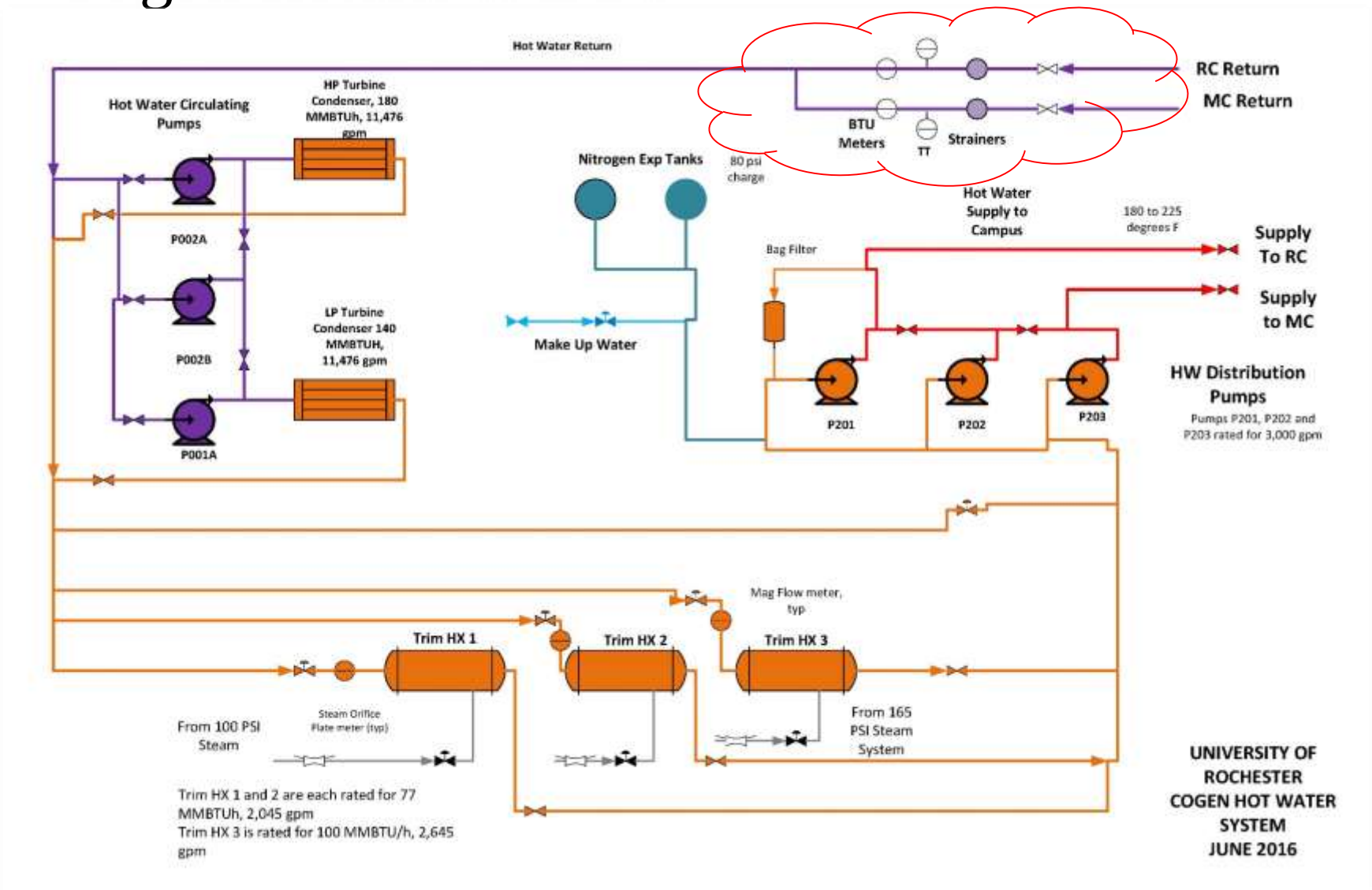
Hot Water System Specifics

- Medium Temperature Hot Water System - 100 psig distribution pressure and 180-230 degrees F distribution supply temperature, 50-60 degrees delta T.
- Direct Buried Pipe Installed using EN-253 standard
- Brazed Plate or Plate and Frame Heat Exchangers – double wall for Domestic or Glycol
- Not Every River Campus Building connected to hot water in 2005, operating dual steam and hot water distribution systems. 22 out of 62 Bldgs still utilize steam.

District HW Pipe installation examples

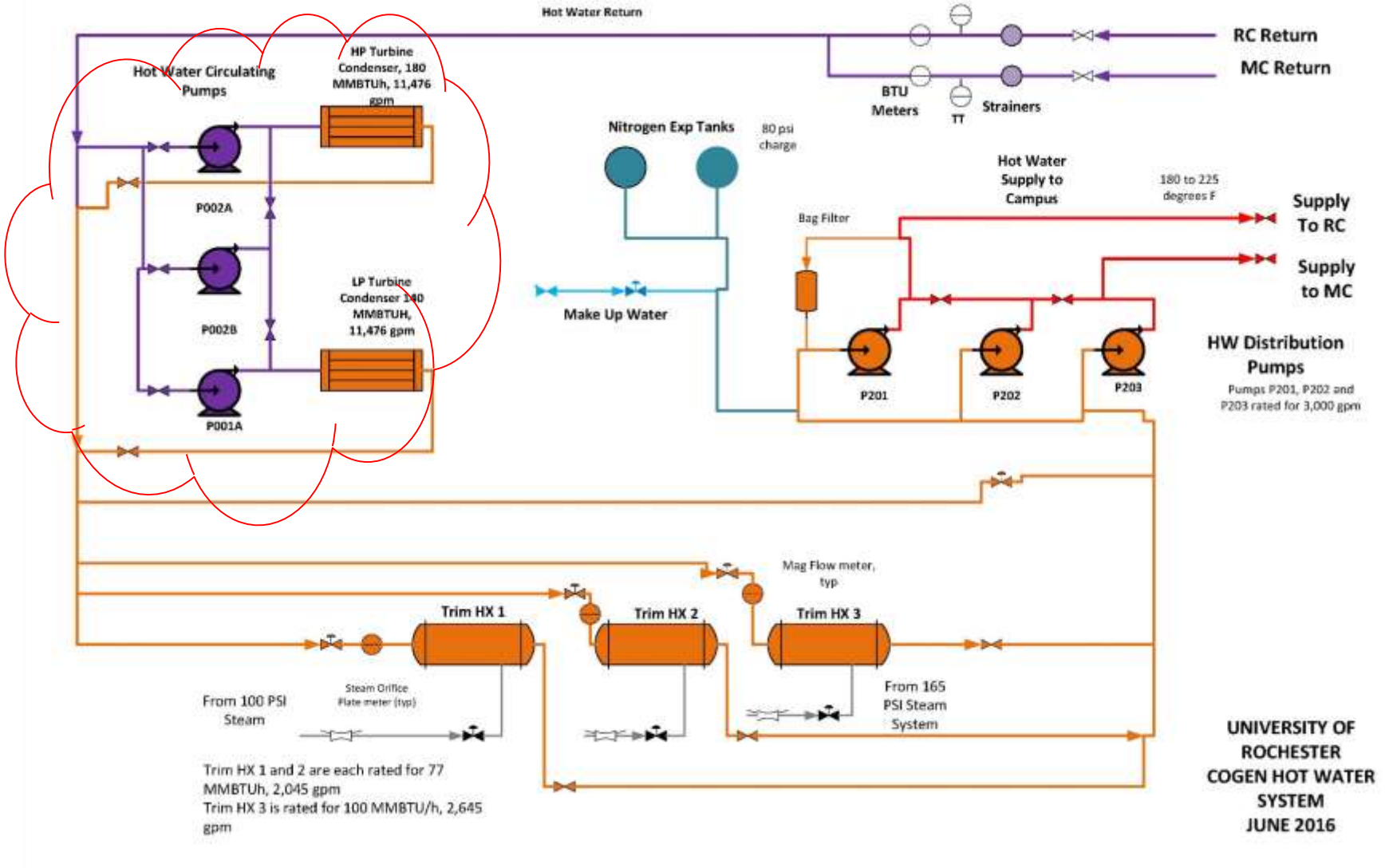
Cogeneration Plant HW System Overview

Cogen Return & BTU



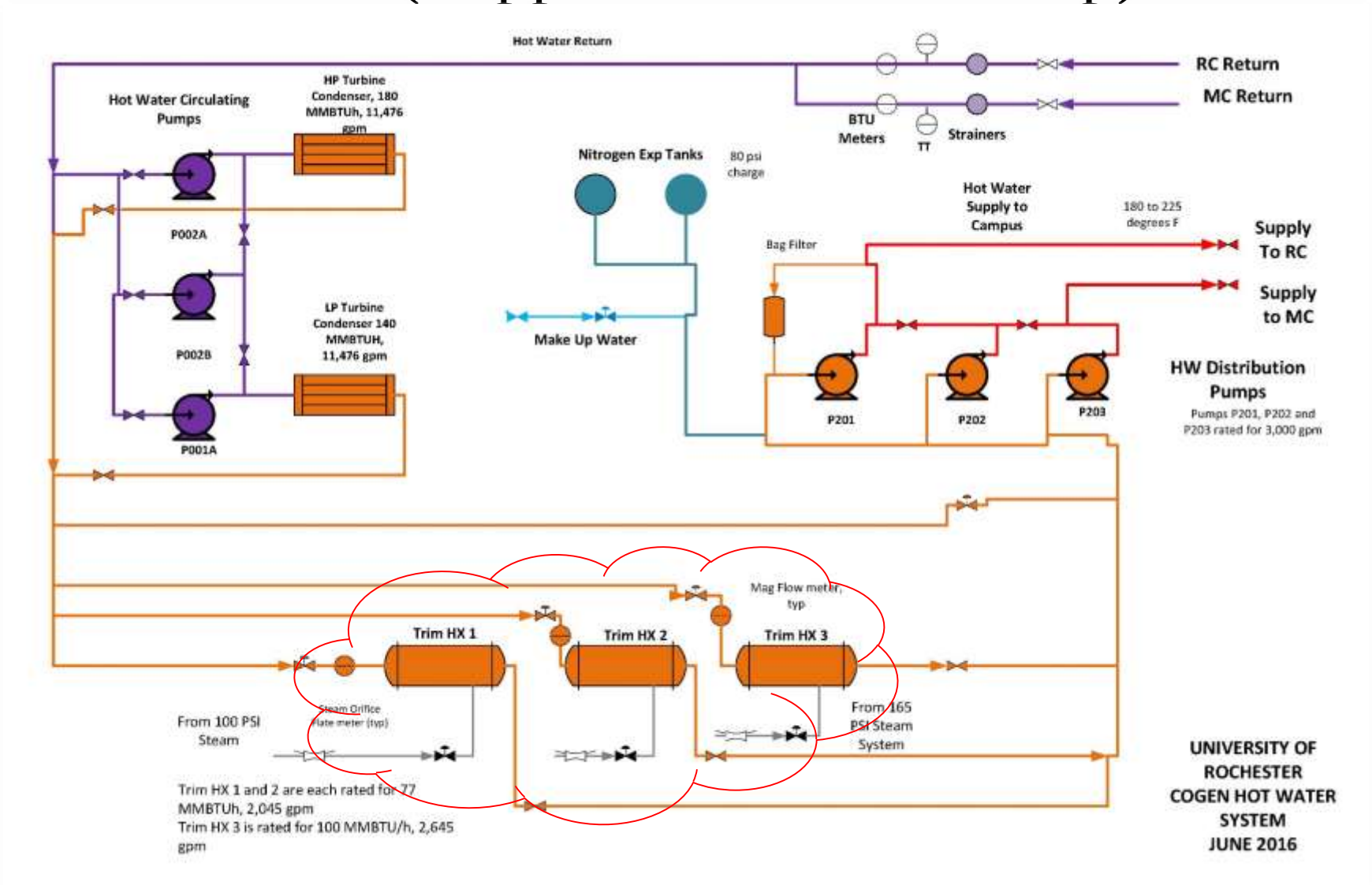
Cogeneration Plant HW System Overview

Primary HW Pumps & Turbine Condensers



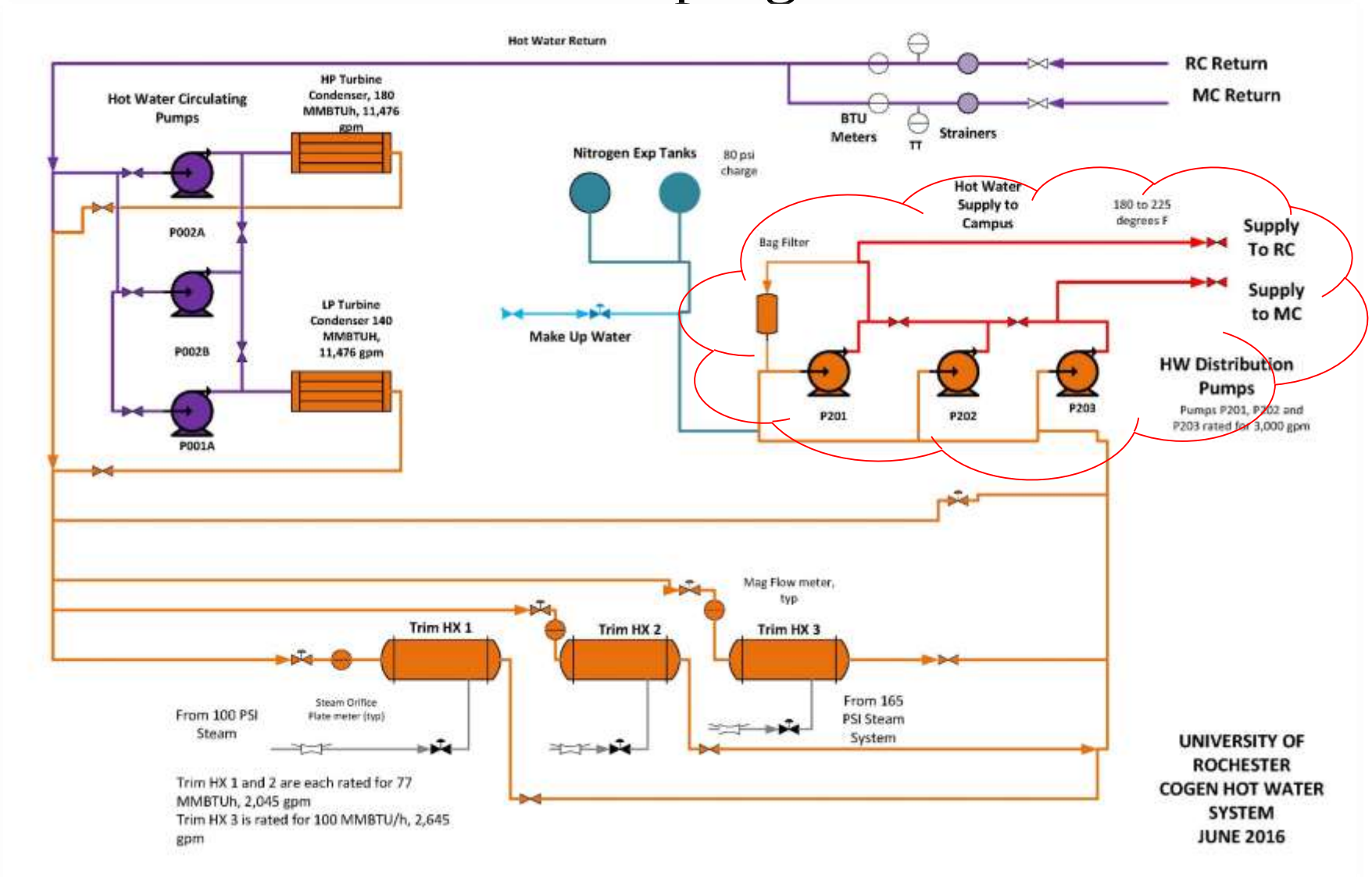
Cogeneration Plant HW System Overview

Trim Hex's (Supplemental & Backup)



Cogeneration Plant HW System Overview

HW Distribution Pumping



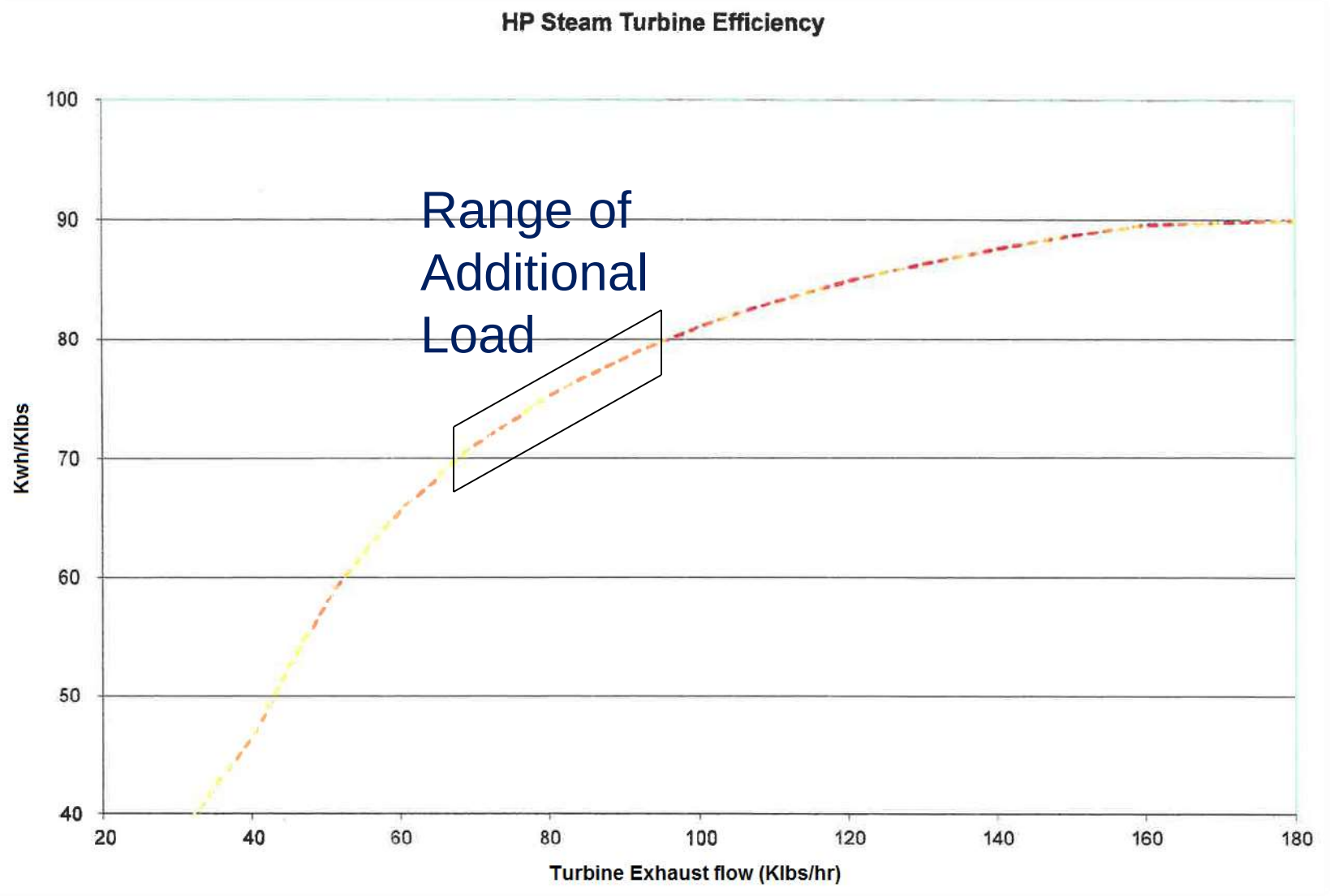
River Campus Thermal Distribution

- River Campus 3.7 MGSF connected (FY16)
- FY16 – 235,722 MMBTU combined steam & HW consumption
  - Current Hot Water system
    - 2.2 Mgsf service for 47 buildings connected w/9,838 ln ft of piping
    - FY16 – 158,994 MMBTU consumption (67%)
  - Current Steam system
    - 1.5 Mgsf service for 22 buildings connected w/ 8,400 ln ft piping
    - FY16 – 76,728 MMBTU consumption (33%)
  - Future Steam to Hot Water
    - 1.5 Mgsf to be converted
    - 22 bldgs. w/ 4,775 ln ft new piping

Condensate Return Losses & Costs

- FY16 data from Central Utilities Steam Plant
  - 64,262 klbs steam delivered to River Campus
  - 7.7 MM Gallons of condensate generated (derived from steam delivered)
  - 76% condensate lost from direct sewering and system losses
  - 5.8 MM Gal makeup water
  - $55k dollars in chemicals treatment and water/sewer costs based on makeup water
  - Additional 6,808 MMBTU of heat required for makeup water, $27k @ $4/MMBTU

Cogeneration Plant Steam Turbine Efficiency



Estimated Incremental Cogen Electrical Generation with Increased Hot Water Load

- Use 70-80 kwh/klbs steam turbine efficiency
- Assume 80% of incremental steam passed through steam turbine
- 64,262 klbs * 70 kwh/klbs * 0.8 = 3,598,672 kwh
- FY16 Cogeneration 61,246,157 kwh (prev record)
- FY17 Cogeneration 61,994,638 kwh (record)
- 5% increase in annual electric production
- At $0.06 per kwh avoided cost, $216k annual savings

University of Rochester Options

- Option 1 – Full River Campus Conversion of Existing Steam to DHW
- Option 2 – Renew Existing Steam piping and continue servicing two heating systems
- Option 3 – Business As Usual, Repairs as Needed to Existing Steam System

Option 1 Building Conversion from Steam to DHW Costs

Building	Approx Construction Costs	Notes
Wallis Hall	$91,250	Partial DHW/Steam Use
Hylan Hall	$23,850	Partial DHW/Steam Use
NYS OPTICS	$501,750	Partial DHW/Steam Use
Fauver Stadium	$485,150	Full Steam
Wilson commons	$612,000	Full Steam
Rush Rees Library (New Part)	$377,250	Full Steam
Goergen Athletics	$433,500	Partial DHW/Steam Use
Spurrier Gym	$1,500,000	Full Steam
Harkness Hall	$376,000	Partial DHW/Steam Use
Melioria Hall	$207,000	Partial DHW/Steam Use
Hutchison Hall	$219,100	Partial DHW/Steam Use
Todd Union	$429,250	Full Steam
Strong Auditiorum	$425,650	Full Steam
Lattimore Hall	$148,000	Full Steam
Morey Hall	$534,745	Partial DHW/Steam Use
Dewey Hall	$398,715	Full Steam
Hoyt Hall	$287,935	Full Steam
B+L Hall	$1,073,235	Full Steam
Rush Rees Library (Old Part)	$1,122,000	Full Steam
Gavett Hall	$849,845	Full Steam
Taylor Hall	$255,615	Full Steam
BioMed/Optics	$408,250	Partial DHW/Steam Use
Sub-Total	*$10,800,000*	
Contingency and Escalation at 25	*$2,700,000*	
Owners Costs	*$1,500,000*	
Total	***$15,000,000***	
2018 Conversion Projects		

Option 1 - Costs to Convert Building Heating System from Steam to Hot Water

- 22 Buildings on River Campus for Conversion
- $10.8M construction estimate
- $2.7M Owner's Contingency
- $1.5M Project Management/Commissioning

- $15M Estimated Conversion Project Cost

Option 1 - Cost to Extend Hot Water Piping to Remaining RC Buildings

- 3” to 10” Nominal Pipe Diameters
- European Direct Buried EN253 Class Pipe
- Construction Cost $4.8M (4,775 lf at $1k/lf)
- Design and PM fees @10% = $500k
- $5.3M Estimated Underground Piping Costs

Option 1 - Annual O&M Savings with Hot Water

- **Water Treatment & Make Up Water Costs Reduction -** $55k
- **Makeup Water Heat Reduction** – $27k
- **Steam Trap Losses -** $32k (est 5% of annual steam usage @ $10/klb)
- **Steam Maintenance Reduction -** $160k (1 FTE mech & $100k mat)
- **Piping Thermal Loss Reduction -** $5k
- **Additional Pumping Costs** – ($5k) est
- **Increased Cogen Output -** $216k per year electric savings
- **Total Estimated O&M savings -** $490k / Year

Cost Summary Option 1- Convert Remaining Buildings to Hot Water

- Annual O&M Cost Savings with HW: - $490k. PW Value over 30 years 5% = ($7.5M)
- Capital Expenditures to Extend Hot Water Distribution Piping: $5.3M
- Capital Expenditures to Convert Remaining Building Heating Systems to Hot Water: $15M
- $12.8M - Total Present Value

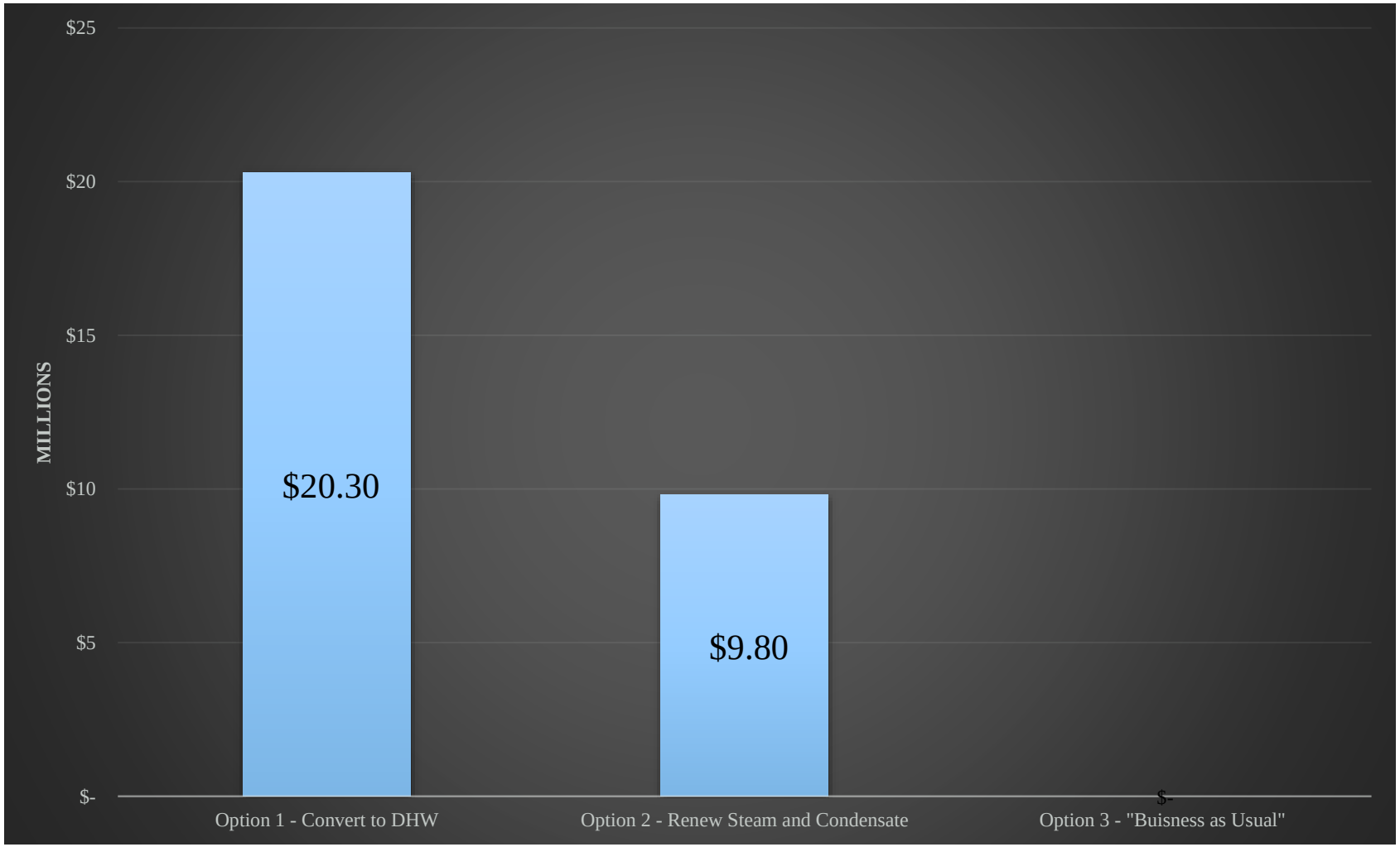
Option 2 - Renew Existing Steam Piping and Continue Servicing Two Heating Systems

- Estimated Cost to 'renew' 4,165 lf existing steam and condensate piping ($2,043/lf) - $7.0M
- Demolition of tunnel piping and vaults - $1.0M
- ACM Contingency - $500k
- Design Fees, Project Management and Inspections- $1.3M
- Construction cost $9.8M
- Plus Bldg HVAC Control & Deferred Maint – est $3.7M
- Plus Present Value of O&M – $2.1M
- Total $15.6M

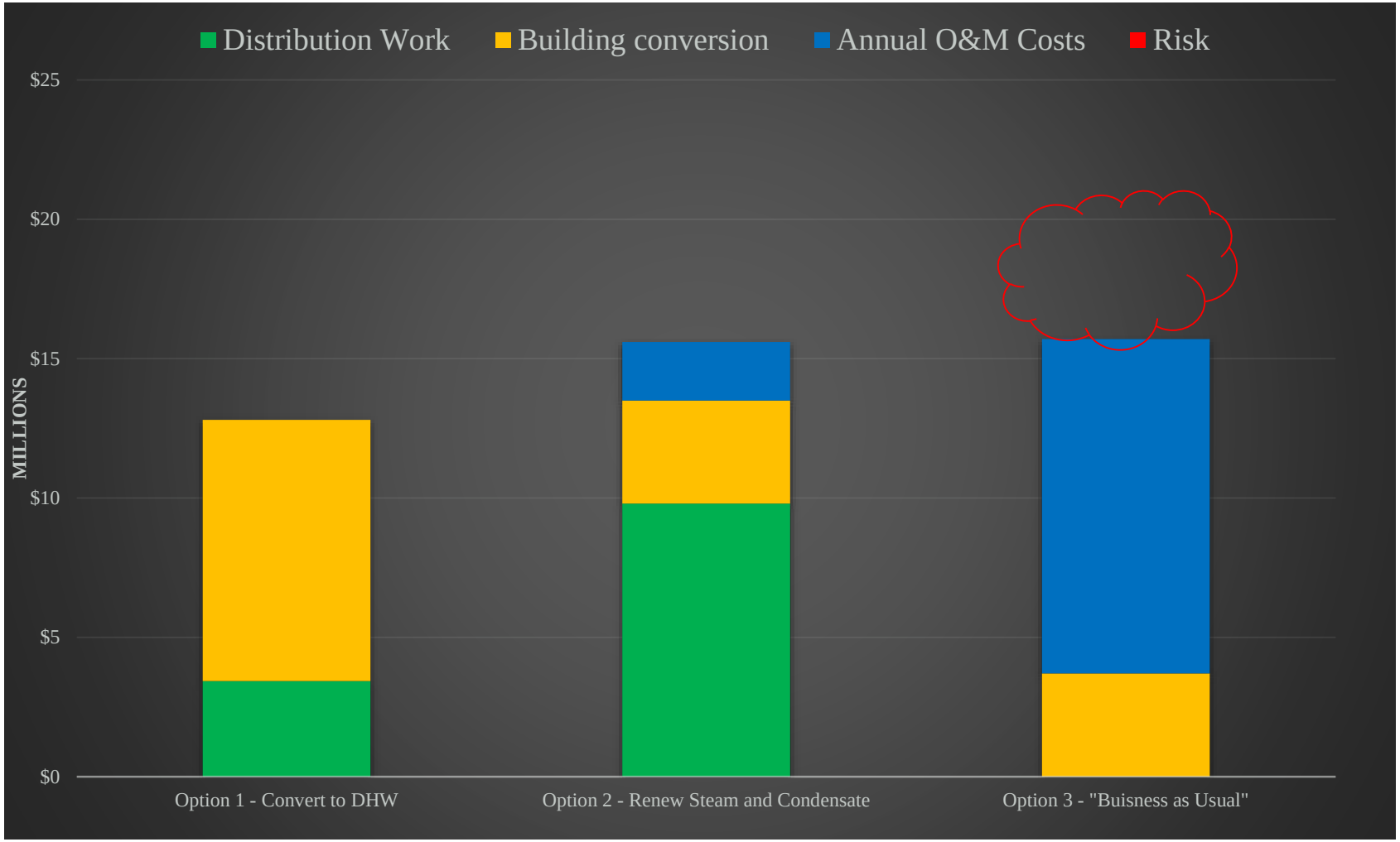
Option 3 – "Business as Usual", Repairs as Needed to Existing Steam System

- Budgeted Annual Repair Costs to Steam System $500k/yr
- Annual Steam System Maintenance Labor -$160k/yr
- Annual Make Up Water and Treatment Costs - $81k/yr
- Annual Estimated System Heat Loss- $12k/yr
- Annual estimated Steam Trap Loss- $32k/yr
- Annual Total Estimated Cost - $785k/yr
- $12M – Present Value (30 Years @ 5%)
- Plus Bldg HVAC Control & Deferred Maint – est $3.7M
- Total $15.7M
- Plus Risks w/ operating system beyond life

First Cost Comparison
UR River Campus Heating Options



Present Net worth Cost Comparison
UR River Campus Heating Options



Conclusions

- NPV Review Supported Selection of Option 1
- Capital Plan submitted to convert 22 Campus Buildings from Steam to Hot Water $20.3M needed
- $490k annual O&M savings converting to hot water from current conditions with steam
- Building steam coils, steam piping, condensate pumps and terminal heating devices at end of useful life
- Operate one heating distribution system with a medium temperature hot water system, no steam maintenance