- 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 (900 psi) & 18MW HP Turbine

Boilers, 5, 6, 7 and 10 are 165# saturated steam boilers, gas/oil
Boiler 9 is 900 psi, 900 F superheated steam boiler, gas/oil

Boiler 5 is a B&W D type package boiler, single low NOx burner
Boiler 7 is a Rentech 0 type package boiler, single low NOx burner

University of Rochester
Central Plant Steam System
June 2016
sgm
Steam System Overview

LP Boilers (165psi) & 7MW LP Turbine

Boilers, 5, 6, 7 and 10 are 165# saturated steam boilers, gas/oil
Boiler 9 is 900 psig, 900 F superheated steam boiler, gas/oil
Boiler s 6 and 7 converted B+W coal boilers, 4 low NOx burners
Boiler 5 B+W D type package boiler, single low NOx burner
Boiler 10 is a Rentech 0 type package boiler, single low NOx burner
Steam System Overview

Steam Driven Chiller Turbines (20k tons)

Boilers, 5, 6, 7 and 10 are 165# saturated steam boilers, gas/oil
Boiler 9 is 900 psig, 900 °F superheated steam boiler, gas/oil

Boiler 5, 6 and 7 were converted B+W coal boilers, 4 low NOx burners
Boiler 5 B+W D type package boiler, single low NOx burner
Boiler 10 is a Rentech O type package boiler, single low NOx burner
Steam System Overview

100Psi distribution & Trim Hex’s

Boilers, 5, 6, 7 and 10 are 165# saturated steam boilers, gas/oil
Boiler 9 is 900 psig, 900 F superheated steam boiler, gas/oil

Boiler 6 and 7 converted B+W coal boilers, 4 low NOx burners
Boiler 5 B+W D type package boiler, single low NOx burner
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University of Rochester
Central Plant Steam System
June 2016
sgm
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
Primary HW Pumps & Turbine Condensers
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

HP Steam Turbine Efficiency

Range of Additional Load

Kwh/Klbs

Turbine Exhaust flow (Klbs/hr)
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
- \[ 64,262 \text{ klbs} \times 70 \text{ kwh/klbs} \times 0.8 = 3,598,672 \text{ kwh} \]
- 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
<table>
<thead>
<tr>
<th>Building</th>
<th>Approx Construction Costs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallis Hall</td>
<td>$91,250</td>
<td>Partial DHW/Steam Use</td>
</tr>
<tr>
<td>Hylan Hall</td>
<td>$23,850</td>
<td>Partial DHW/Steam Use</td>
</tr>
<tr>
<td>NYS OPTICS</td>
<td>$501,750</td>
<td>Partial DHW/Steam Use</td>
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<tr>
<td>Fauver Stadium</td>
<td>$485,150</td>
<td>Full Steam</td>
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<tr>
<td>Wilson commons</td>
<td>$612,000</td>
<td>Full Steam</td>
</tr>
<tr>
<td>Rush Rees Library (New Part)</td>
<td>$377,250</td>
<td>Full Steam</td>
</tr>
<tr>
<td>Goergen Athletics</td>
<td>$433,500</td>
<td>Partial DHW/Steam Use</td>
</tr>
<tr>
<td>Spurrier Gym</td>
<td>$1,500,000</td>
<td>Full Steam</td>
</tr>
<tr>
<td>Harkness Hall</td>
<td>$376,000</td>
<td>Partial DHW/Steam Use</td>
</tr>
<tr>
<td>Melioria Hall</td>
<td>$207,000</td>
<td>Partial DHW/Steam Use</td>
</tr>
<tr>
<td>Hutchison Hall</td>
<td>$219,100</td>
<td>Partial DHW/Steam Use</td>
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<tr>
<td>Todd Union</td>
<td>$429,250</td>
<td>Full Steam</td>
</tr>
<tr>
<td>Strong Auditorium</td>
<td>$425,650</td>
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<tr>
<td>Lattimore Hall</td>
<td>$148,000</td>
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<tr>
<td>Morey Hall</td>
<td>$534,745</td>
<td>Partial DHW/Steam Use</td>
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<tr>
<td>Dewey Hall</td>
<td>$398,715</td>
<td>Full Steam</td>
</tr>
<tr>
<td>Hoyt Hall</td>
<td>$287,935</td>
<td>Full Steam</td>
</tr>
<tr>
<td>B+L Hall</td>
<td>$1,073,235</td>
<td>Full Steam</td>
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<tr>
<td>Rush Rees Library (Old Part)</td>
<td>$1,122,000</td>
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<tr>
<td>Gavett Hall</td>
<td>$849,845</td>
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<tr>
<td>Taylor Hall</td>
<td>$255,615</td>
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<tr>
<td>BioMed/Optics</td>
<td>$408,250</td>
<td>Partial DHW/Steam Use</td>
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<tr>
<td>Sub-Total</td>
<td>$10,800,000</td>
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<tr>
<td>Contingency and Escalation at 25%</td>
<td>$2,700,000</td>
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<tr>
<td>Owners Costs</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$15,000,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1 - Convert to DHW</td>
<td>$20.30</td>
</tr>
<tr>
<td>Option 2 - Renew Steam and Condensate</td>
<td>$9.80</td>
</tr>
<tr>
<td>Option 3 - &quot;Buisness as Usual&quot;</td>
<td>$5</td>
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</tbody>
</table>
Present Net worth Cost Comparison
UR River Campus Heating Options

Option 1 - Convert to DHW
Option 2 - Renew Steam and Condensate
Option 3 - "Buisness as Usual"
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