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International District Energy Association

Thermal Distribution in District Energy and Cogeneration Systems

Presented by

William A. Liegois, P.E.

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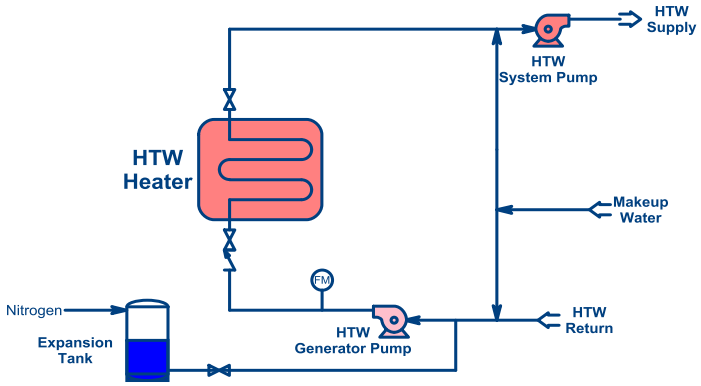
Topics

- Principles of Hot Water
- Conversion to Hot Water
- Hot Water and Cogeneration
- Advantages of Hot Water



Basic Thermodynamics

- Energy degrades into lower levels
- Only provide energy at the level required by the user
- Providing lower level energy saves money
  - Lower cost to produce
  - More options for heat recovery
- Design buildings to operate on lowest level energy possible

Hot Water Classifications

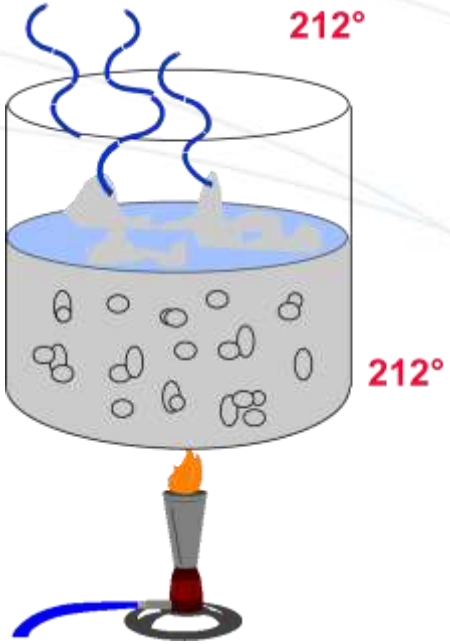
- Low Temperature Systems (< 225 °F)
- Medium Temperature Systems (226 to 350 °F)
- High Temperature Systems (351 to 450 °F)

Design Principles

- Pressurize System 15 to 25 psig
- Produce Water at a Design Temperature
- One-pump and Two-pump Systems
- Normal Differential Temperatures, 75 to 150 °F
- Unfired Pressure Vessels Make Steam for End Users
- Applications are Campus-type Services

HW Properties

- High Density
- High Specific Heat
- Low Viscosity
- Good Thermal Conductivity



Properties Materially Different than Steam

HW Properties (continued)

- Pressure Changes have Negligible Effect on
  - Density
  - Specific Heat
  - Thermal Conductivity
- Temperature Changes have only a Small Effect

HW Design Parameters

HTHW

- 300 lb class
- 425 °F Upper Temperature

LTHW

- 150 lb class
- 225 °F Upper Temperature

HW Design Parameters (continued)

- Heat Content of One Cubic Foot
  - Water from 400 °F to 250 °F = 7,266 Btu/ft^3
  - Water from 225 °F to 150 °F = 4,268 Btu/ft^3
  - Steam to Condensate at 400 °F = 373 Btu/ft^3
- Pressure Drops have Minimal Effect on HW Temperatures

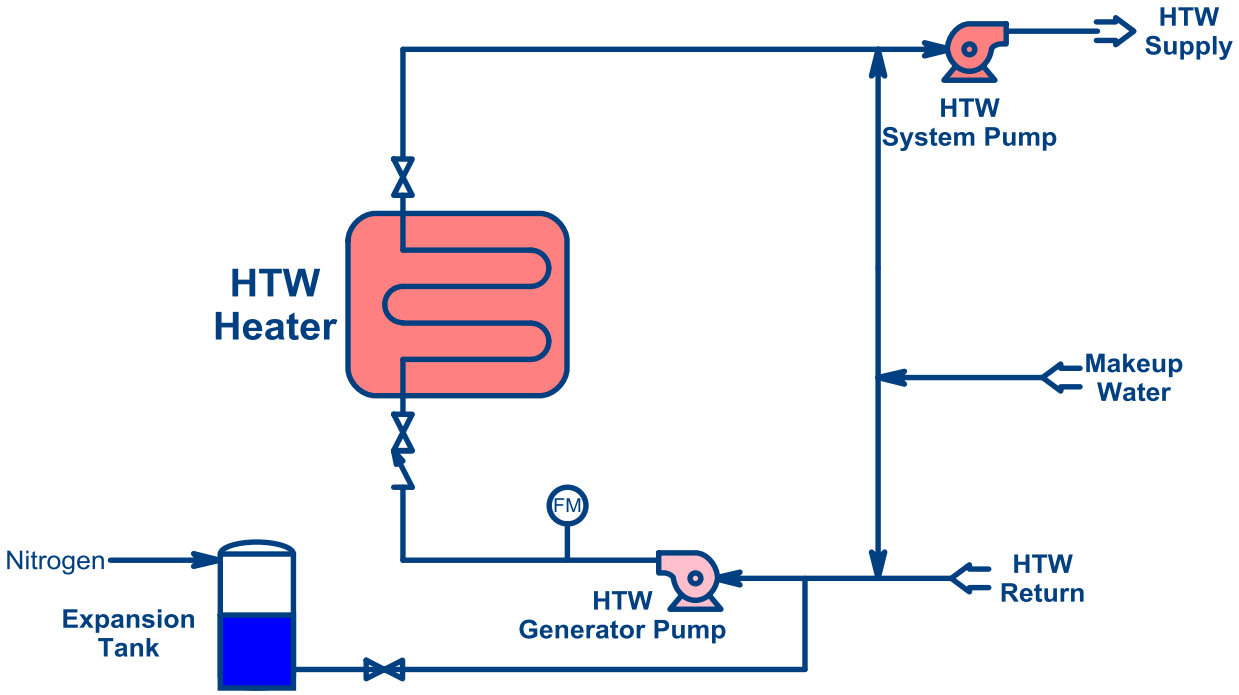
Heat Capacity Ratio
19.48
11.44

Typical Design Conditions

- High Temperature Hot Water (HTHW)
  - Supply Temperature, 375 – 400 °F
  - System Delta Temperature, 150 °F
  - Pressure, 250 – 275 psig
- Low Temperature Hot Water (LTHW)
  - Supply Temperature, 200 – 225 °F
  - System Delta Temperature, 50 - 75 °F
  - Pressure, 15 – 25 psig

Two Pump System

- Nitrogen Pressurization



Installed Piping Comparison

Basis of Design:

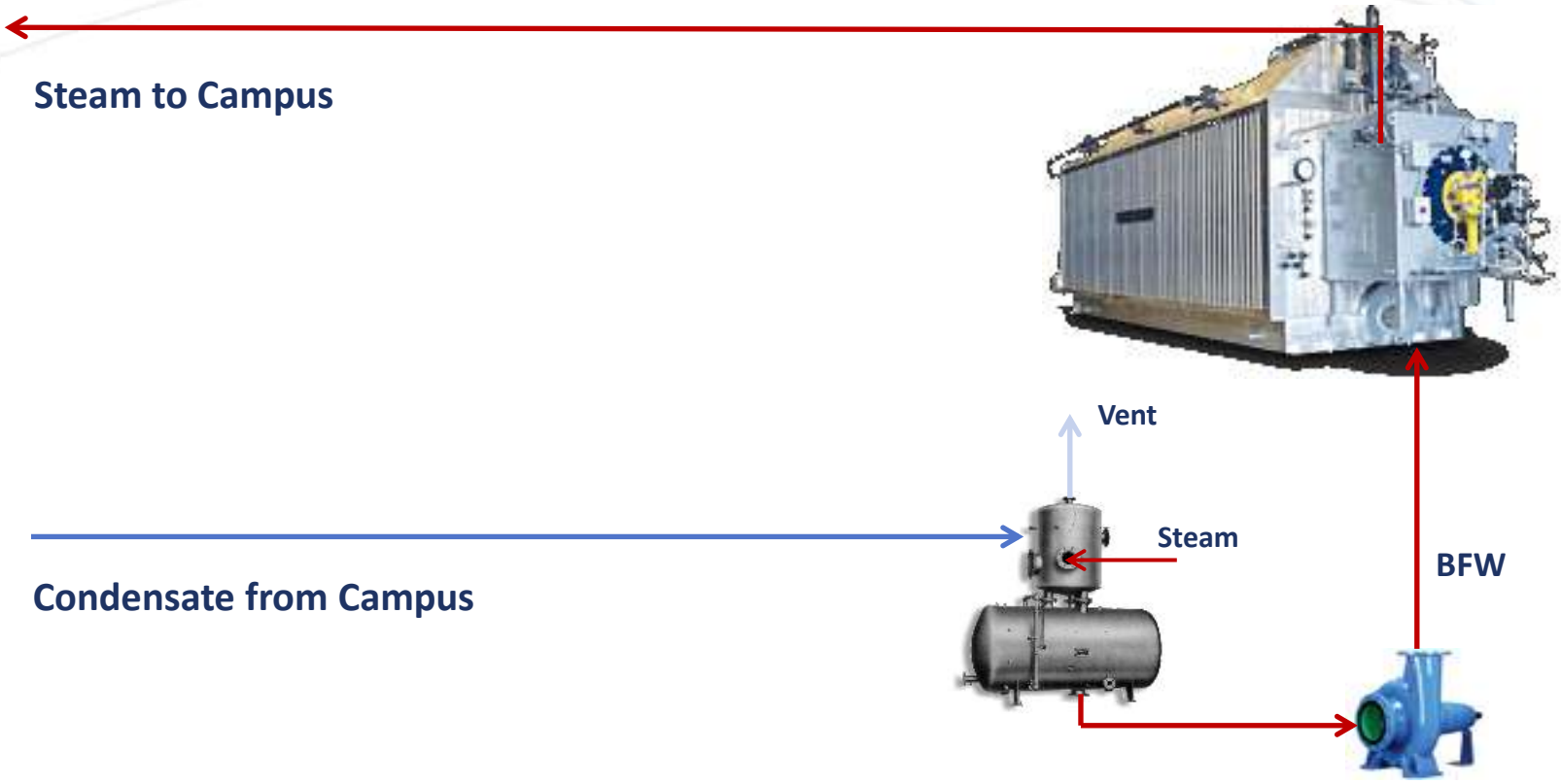
100 MMBtu/hr of heat in 1,000 feet of pipe with expansion joints and fittings.

Steam Piping, 14 inch steam 4 inch condensate.		HTHW, 8 inch supply & return.		LTHW, 10 inch supply & return.	
Excavation	10%	Excavation	15%	Excavation	20%
Pipe Installation	75%	Pipe Installation	70%	Pipe Installation	60%
Surface Repair	15%	Surface Repair	15%	Surface Repair	20%
Basis Cost	100 units	Basis Cost	90 units	Basis Cost	60 units

Piping Conversions

- All new distribution system or system expansion and building conversions.
- New and renovated buildings designed for hot water, remaining on steam distribution.
- Convert some or all distribution to hot water.
- Convert the Heating Plant to hot water or cogeneration.

Traditional Steam Distribution



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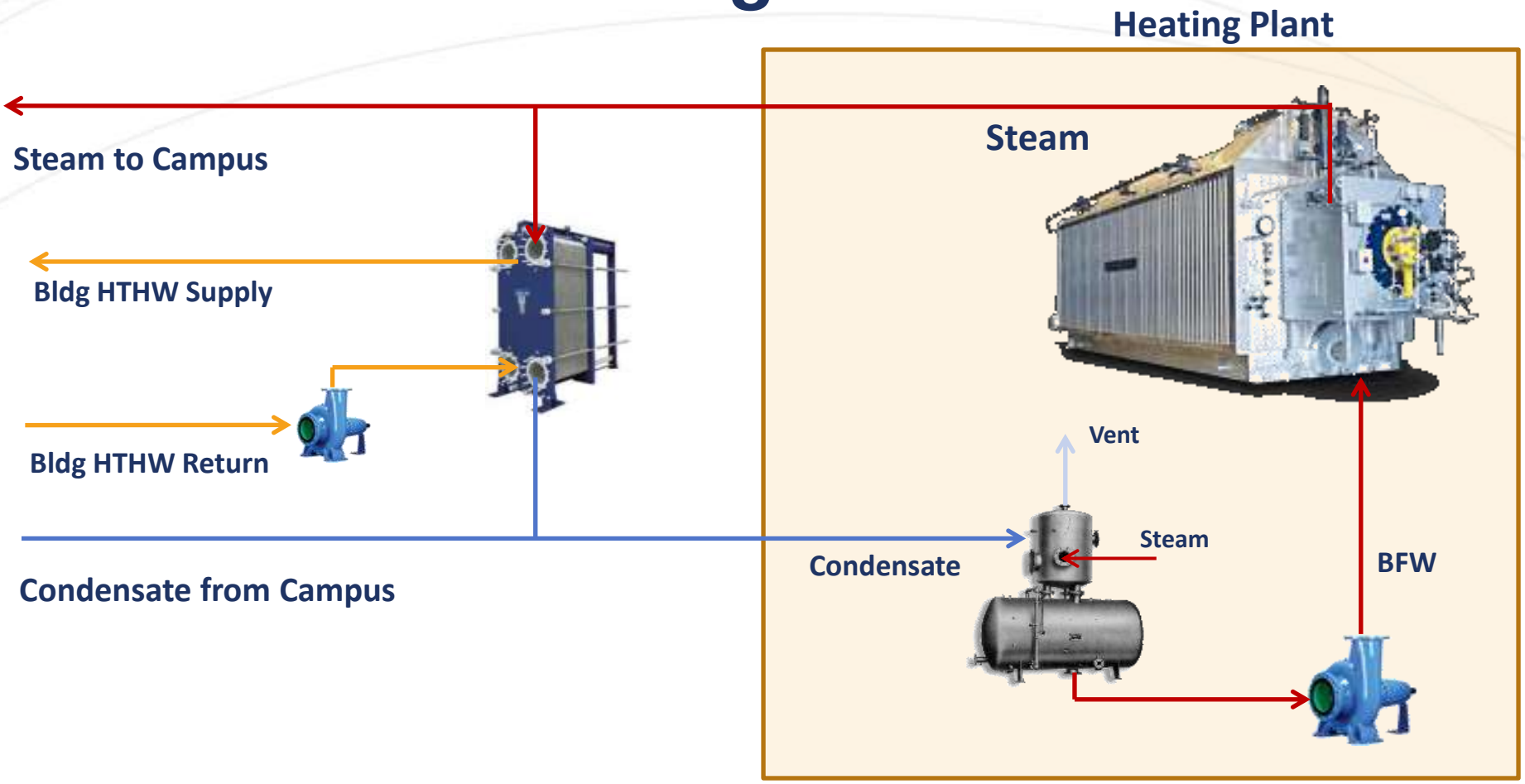
Conversion from Steam to HW

- Renovate by area, if possible, so distribution loops can be converted to HW.
- Re-use steam pipe and install a second line for hot water return.
- Take advantage of other construction activities.

Steam Generation with Steam Dist. & Hot Water Buildings



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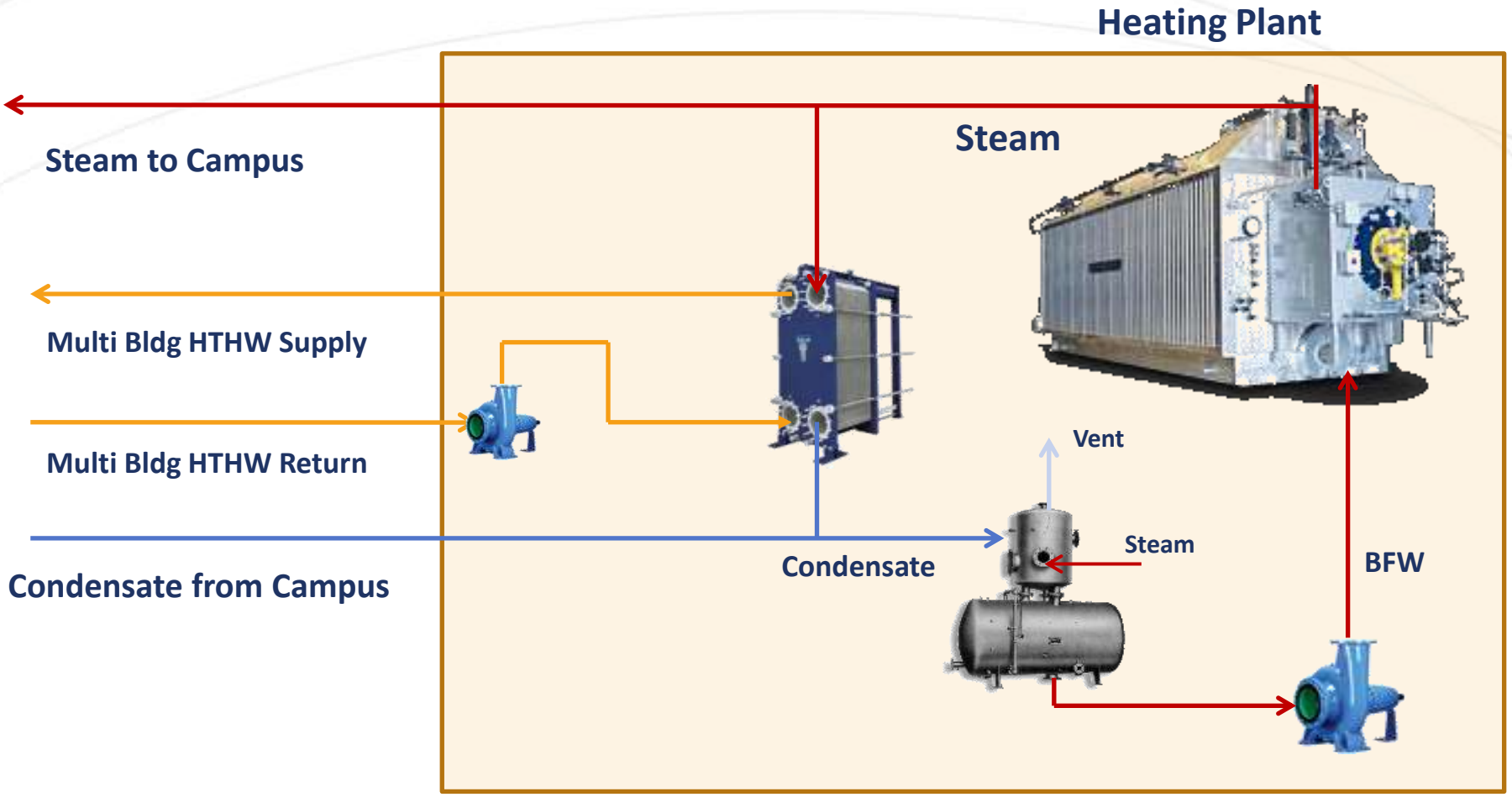
Steam Generation with Steam & Hot Water Distribution



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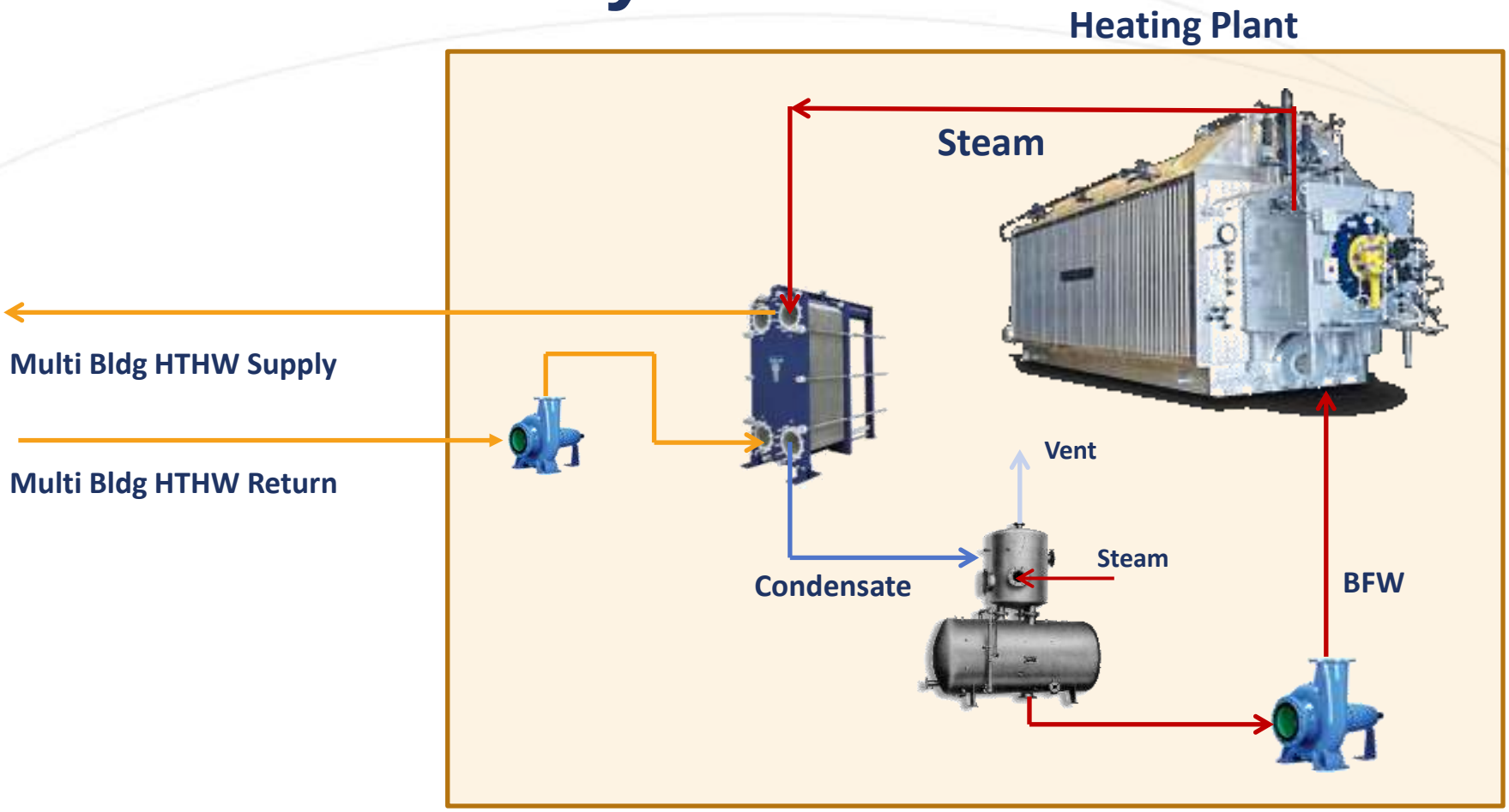
Steam Generation with Hot Water Distribution Only



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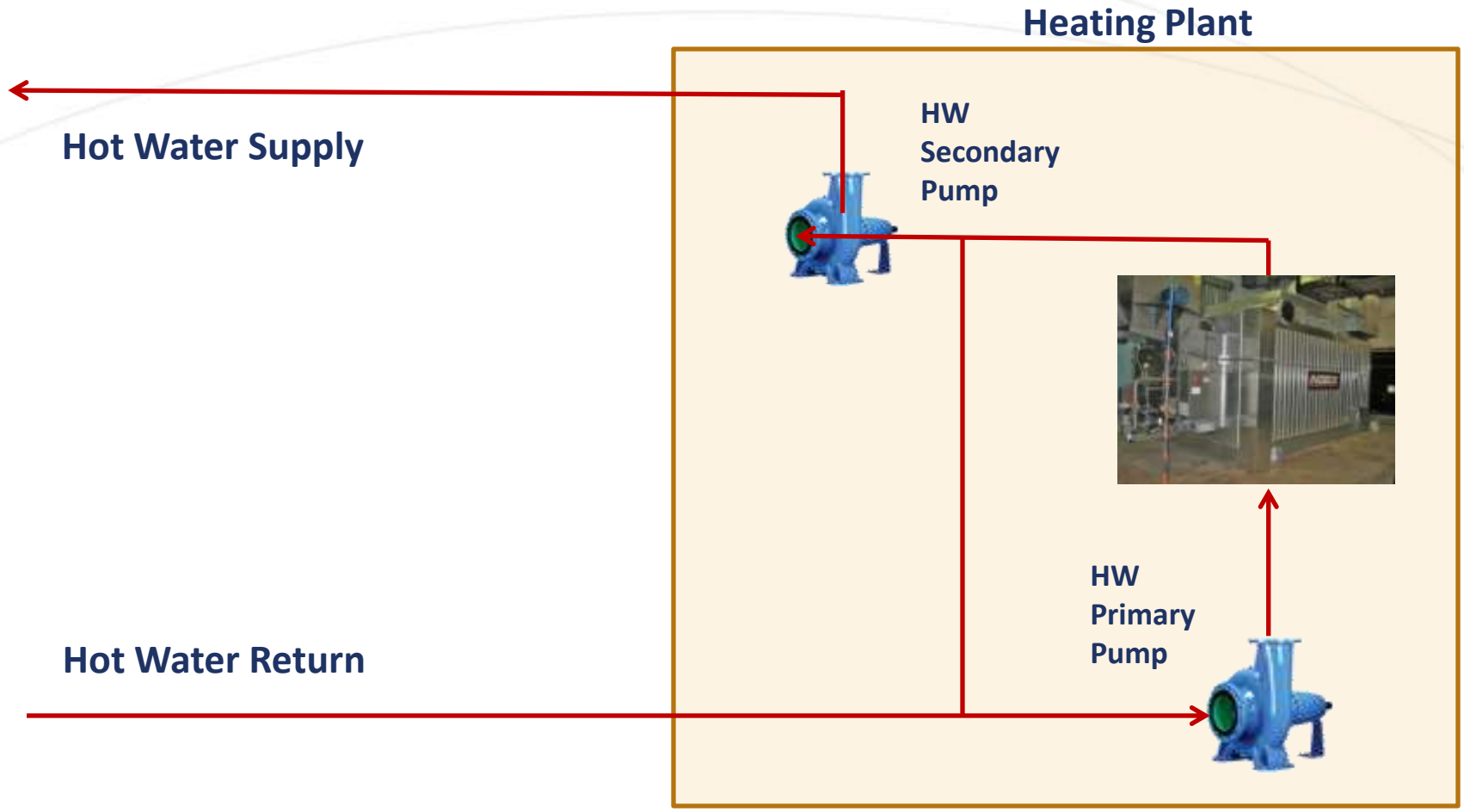
Hot Water Generation with Hot Water Distribution



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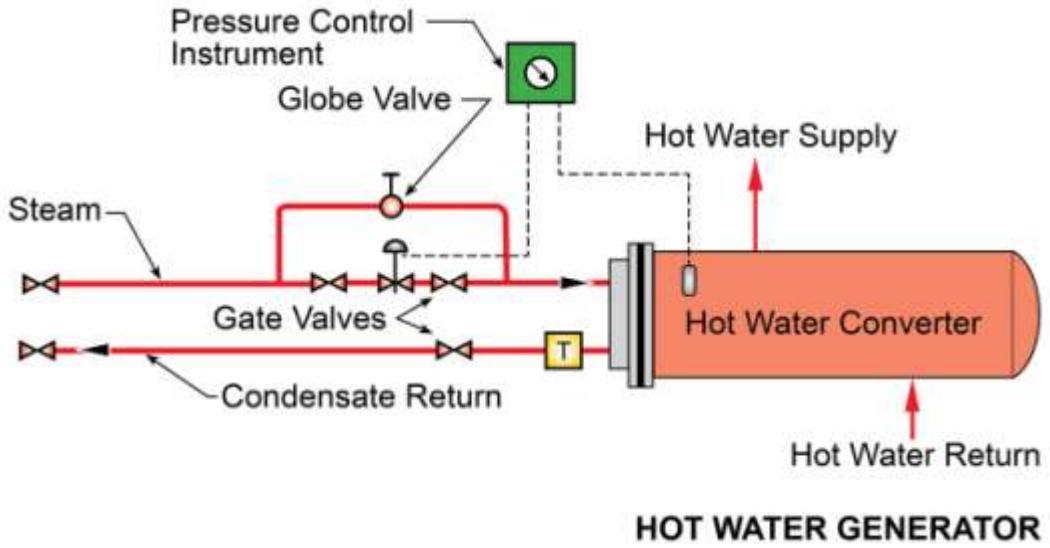
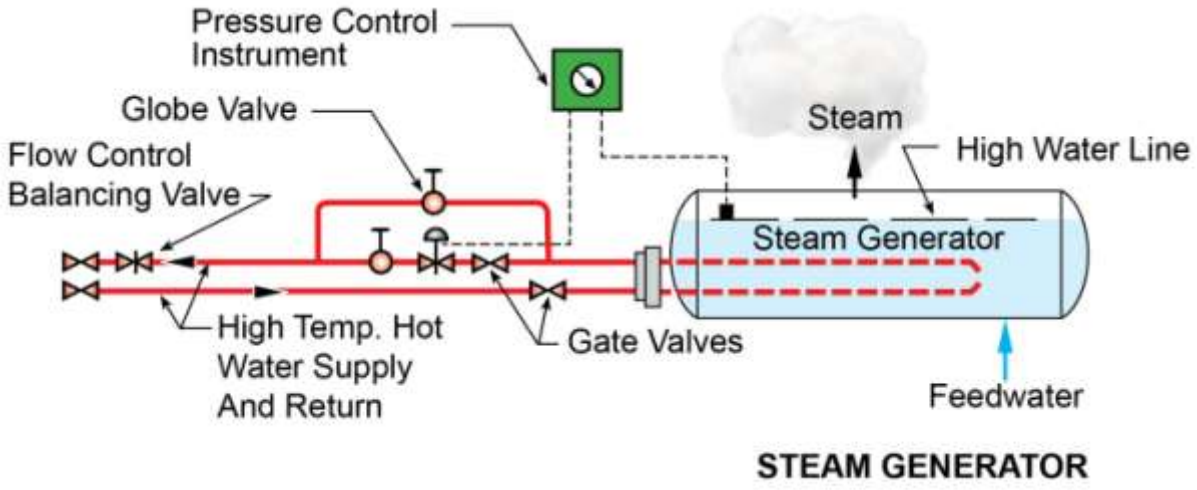
Building Conversions

New Buildings Designed for hot water or renovated buildings now designed for hot water but on a steam system.



Building Conversions

Old Buildings Designed for steam but on a HTHW supply system.

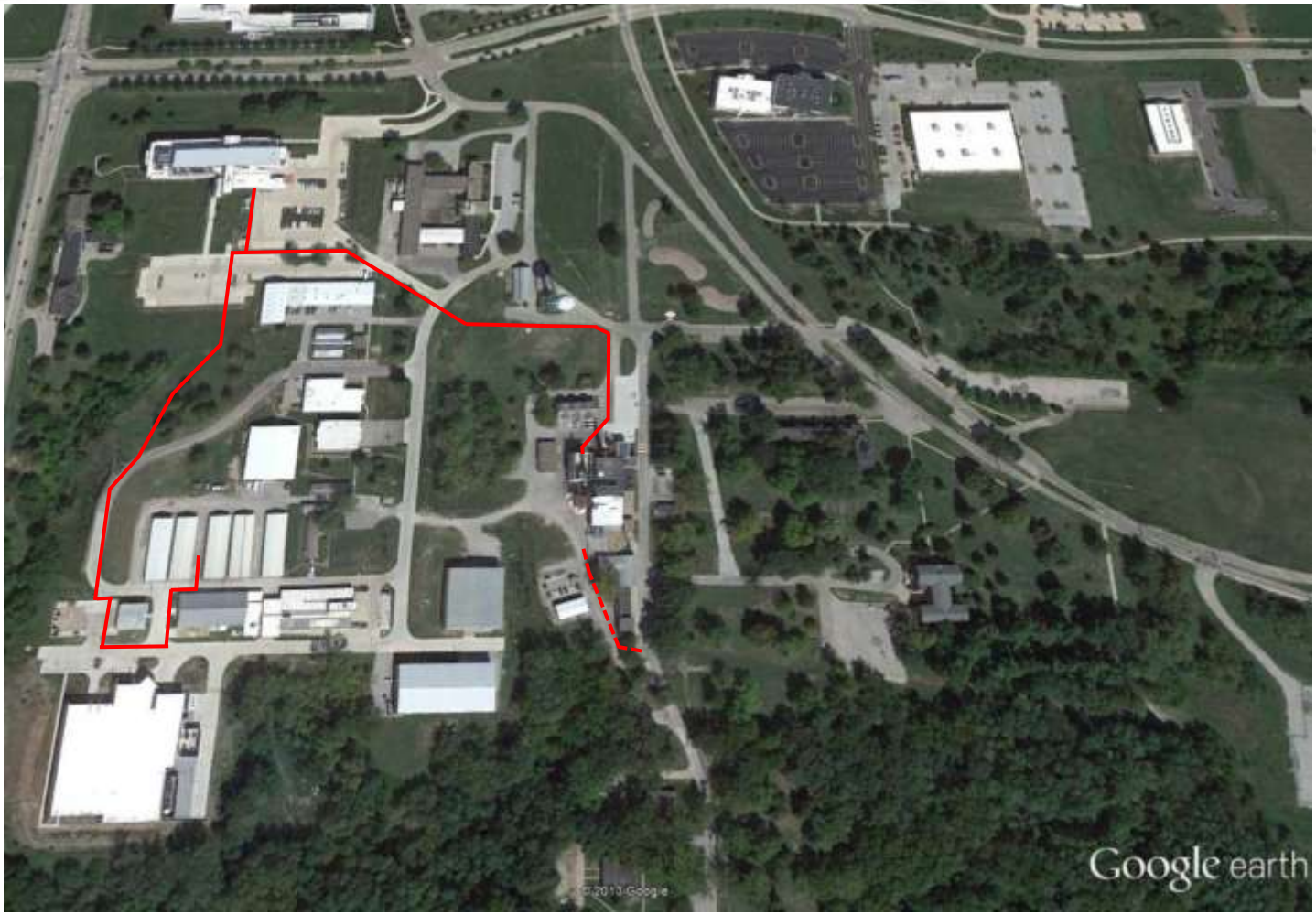


Hot Water and CHP

Reciprocating Internal Combustion Engine (RICE)

- LTHW
  - Recover Exhaust and Jacket Water
  - Aux firing is an option to increase heat recovery
- HTHW
  - Exhaust heat recovery only
  - JW, LO, and AC heat are wasted to air or cooling tower

University of Iowa Research Park Campus



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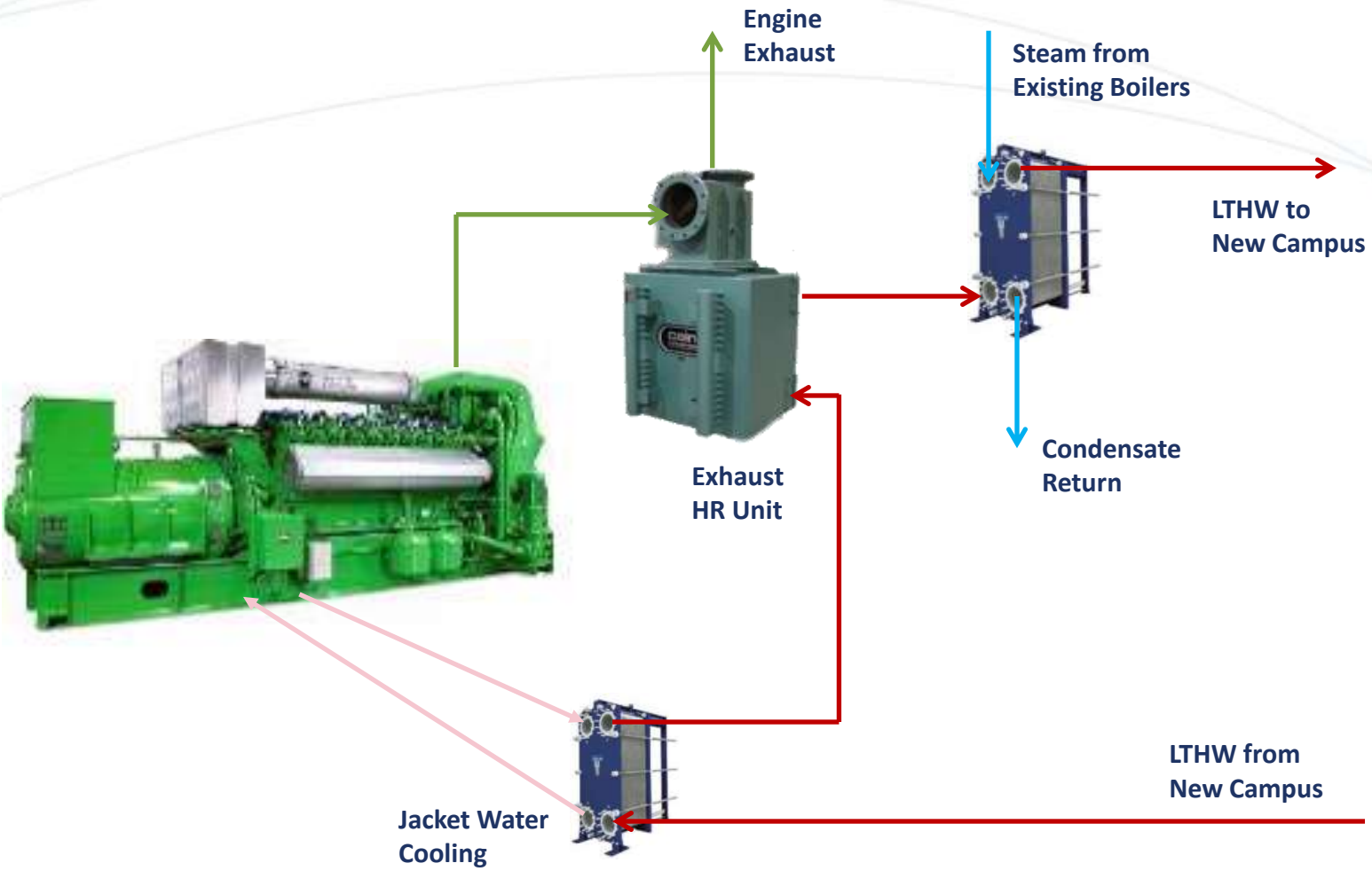
UI Research Park Simplified Schematic



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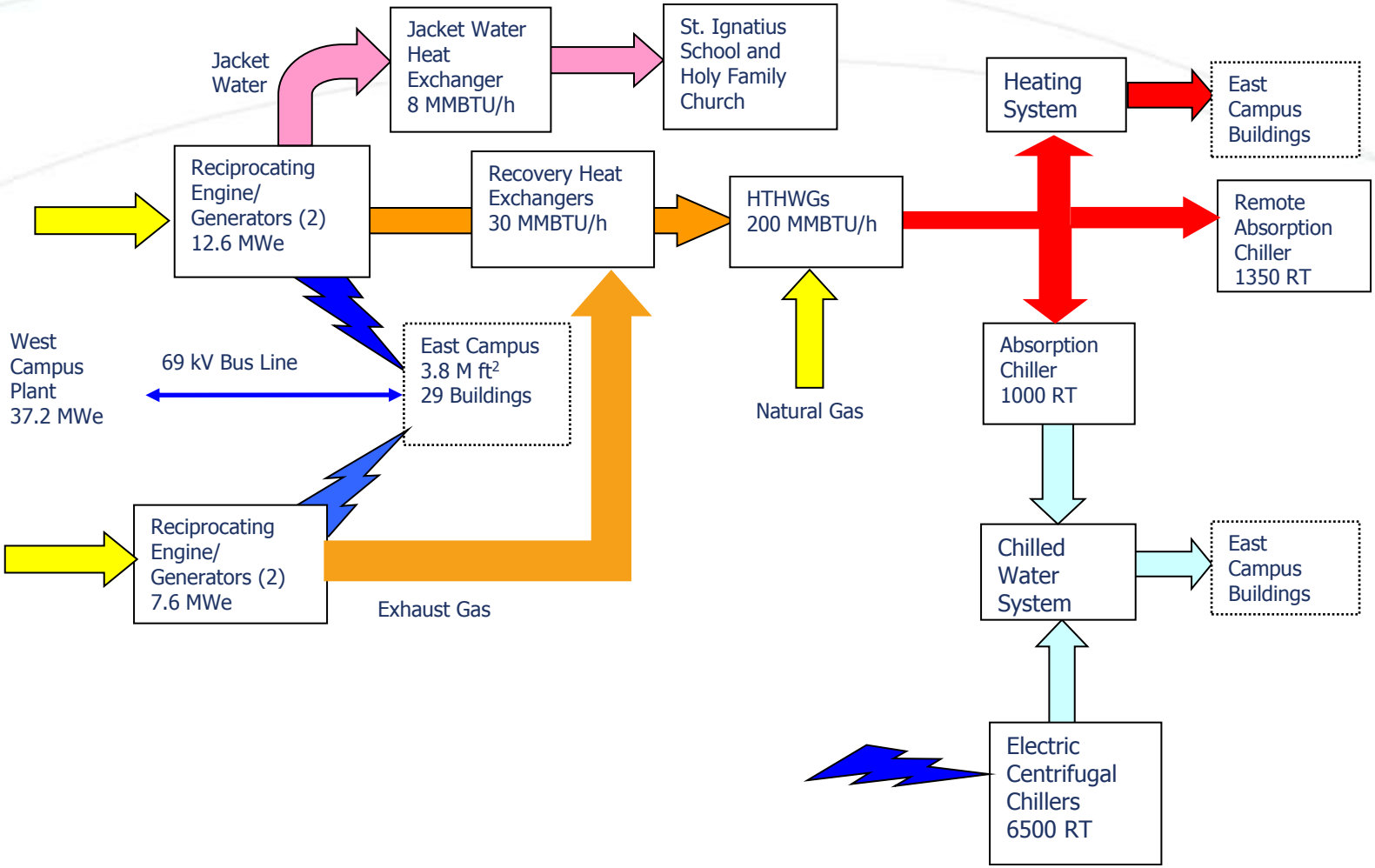
UIC RICE CHP Operation



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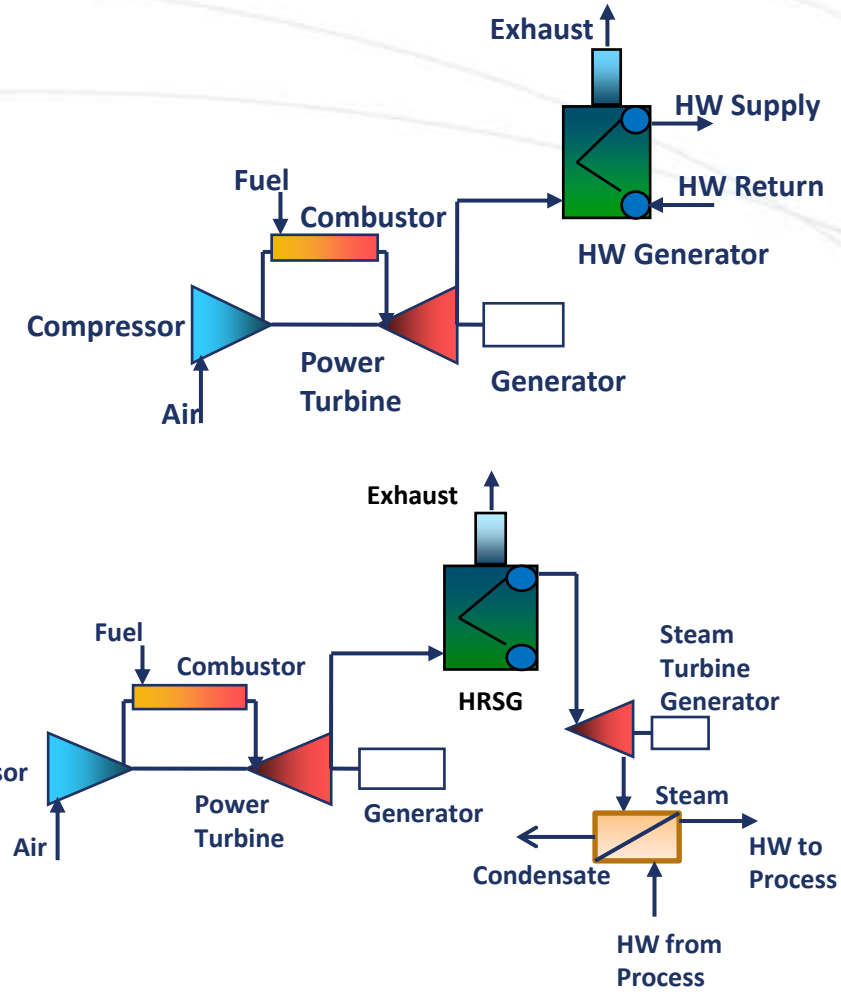
Hot Water and CHP

Gas Turbines

- Make HTHW /LTHW directly
- Make High Pressure Steam
  - 600 – 800 psig
  - Aux Firing is an option to increase heat recovery
  - Convert to HTHW/LTHW for distribution



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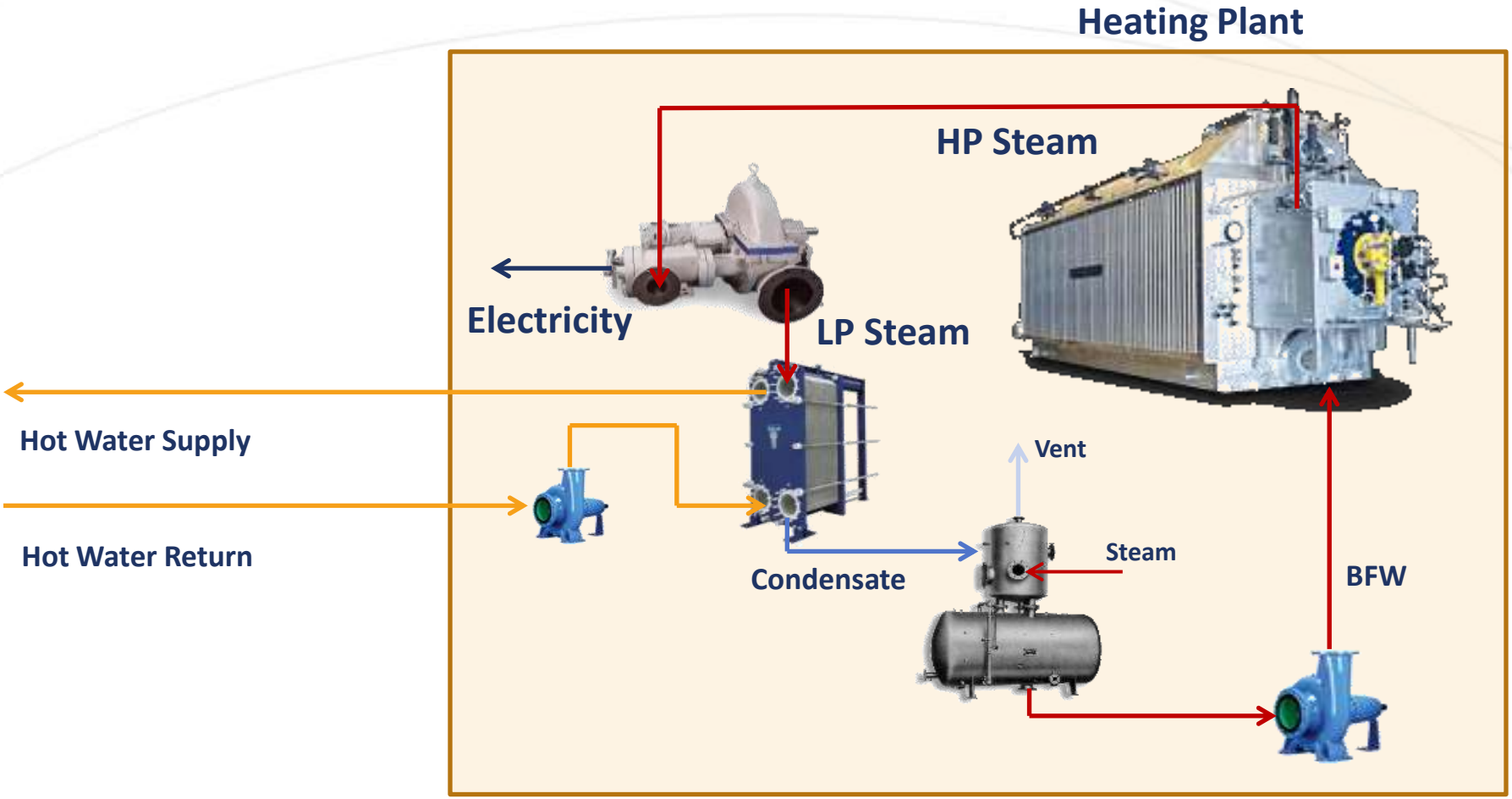
Hot Water and CHP

Steam Boilers

- Backpressure steam turbine for power generation.
- Heat Exchanger for conversion to HW for distribution.

Steam and Electric Generation with Hot Water Distribution



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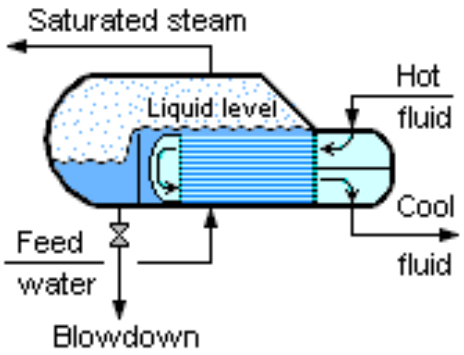
Additional Services Requiring Steam

- Sterilizers
- Kitchens
- Laundries



Advantages of HW

- Minimum Leakage and Makeup Water
  - Pump Seals and Valve Packing
  - 0 to 1 Percent Makeup
- Elimination of Corrosion and Scaling
  - In Generators and Heat Transfer Equipment
  - In Valves, Piping and Fittings
  - *No Condensate Line Corrosion*
- Negligible Water Makeup Requirements
  - No Blowdown
  - No Heating or Chemical Treatment of Makeup Water

Advantages of HW (continued)

- No losses from Flash-off (Typically 15 to 25% for Steam)
- Flexibility in pipe routing
- Reduced pipe expansion with LTHW
- No Losses from Lack of Condensate Return (Typically 10 to 25% in Campus Distribution)
  - Leaking System
  - Malfunctioning Traps

Advantages of HW (continued)

- Reduced Water Treatment Equipment
  - No Blowdown
  - Closed Loop (100% Return)
- Low Head/High Volume Pumps Replace Boiler Feedwater Pumps
- Improved Heat Storage in System

Hot water normally results in improved overall system efficiency at installed costs similar to or less than a steam system.

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Thank you