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Central Steam System Decentralization to Localized Hot Water Systems

F E Pierce Jr - Oak Ridge National Laboratory

Agenda

- Introduction
- Advantages
- Disadvantages
- Example Feasibility Study
- Conclusions

Introduction

- Central steam generation systems and extensive distribution systems are used for facility heating
- Opportunities for energy efficiency improvements
  - Blowdown losses
  - Deaerator tank losses
  - Distribution system thermal losses
  - Flash steam from condensate receiver vents
  - Steam leaks and steam trap losses
  - Condensate loss
- In some cases inefficient central steam systems can be replaced with localized hot water systems

Advantages

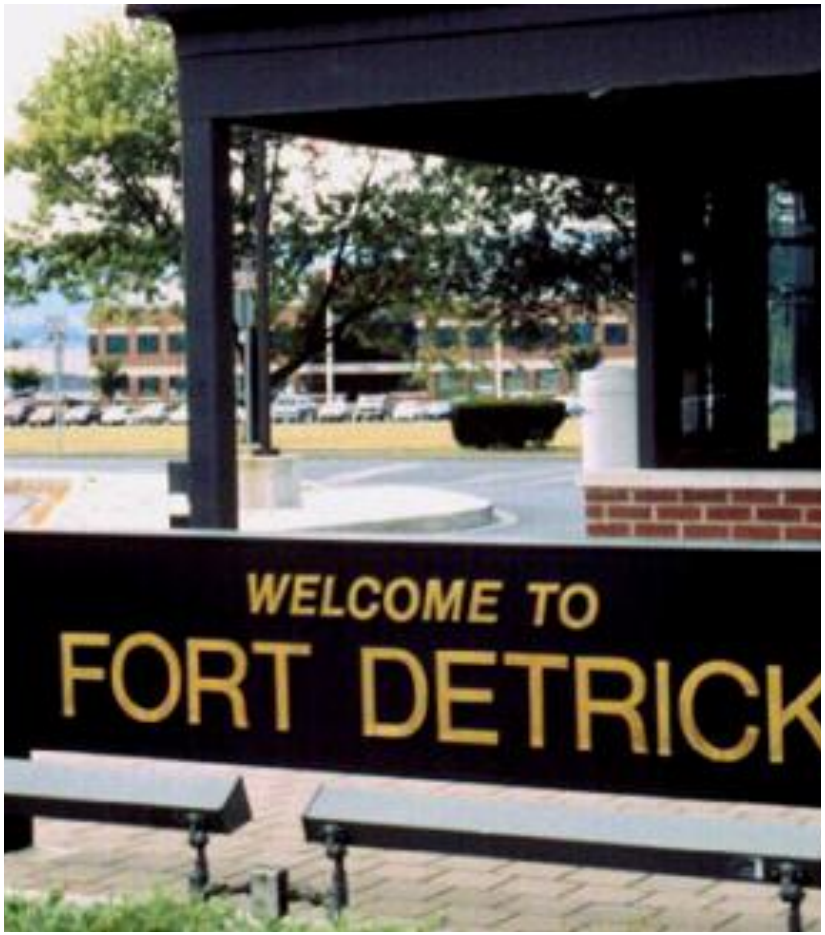
- Condensing hot water boilers can have efficiencies of up to 96% over their operating range
- Lower maintenance and operating cost
- A smaller installation footprint
- Better capacity modulation
- Elimination of all problems associated with steam traps.
- Code inspections and insurance liability requirements could possibly be reduced.

Main Disadvantages

- Process loads requiring steam will have to be met by installing small, packaged steam generators
- A steam system delivers more energy per pound of working fluid than hot water.
- Steam boilers can be configured to utilize different fuels
- Steam heating coils must be replaced with hot water heating coils

Example Feasibility Study

- An economic feasible study - evaluate an alternative to replace the building 190 central steam plant
- Funded through American Recovery and Reinvestment Act (ARRA)
- Conducted by ORNL and Geo-Marine Inc
- Alternative - high efficiency, condensing type hot water boilers
- Data sources - site survey and a previous steam system evaluation report



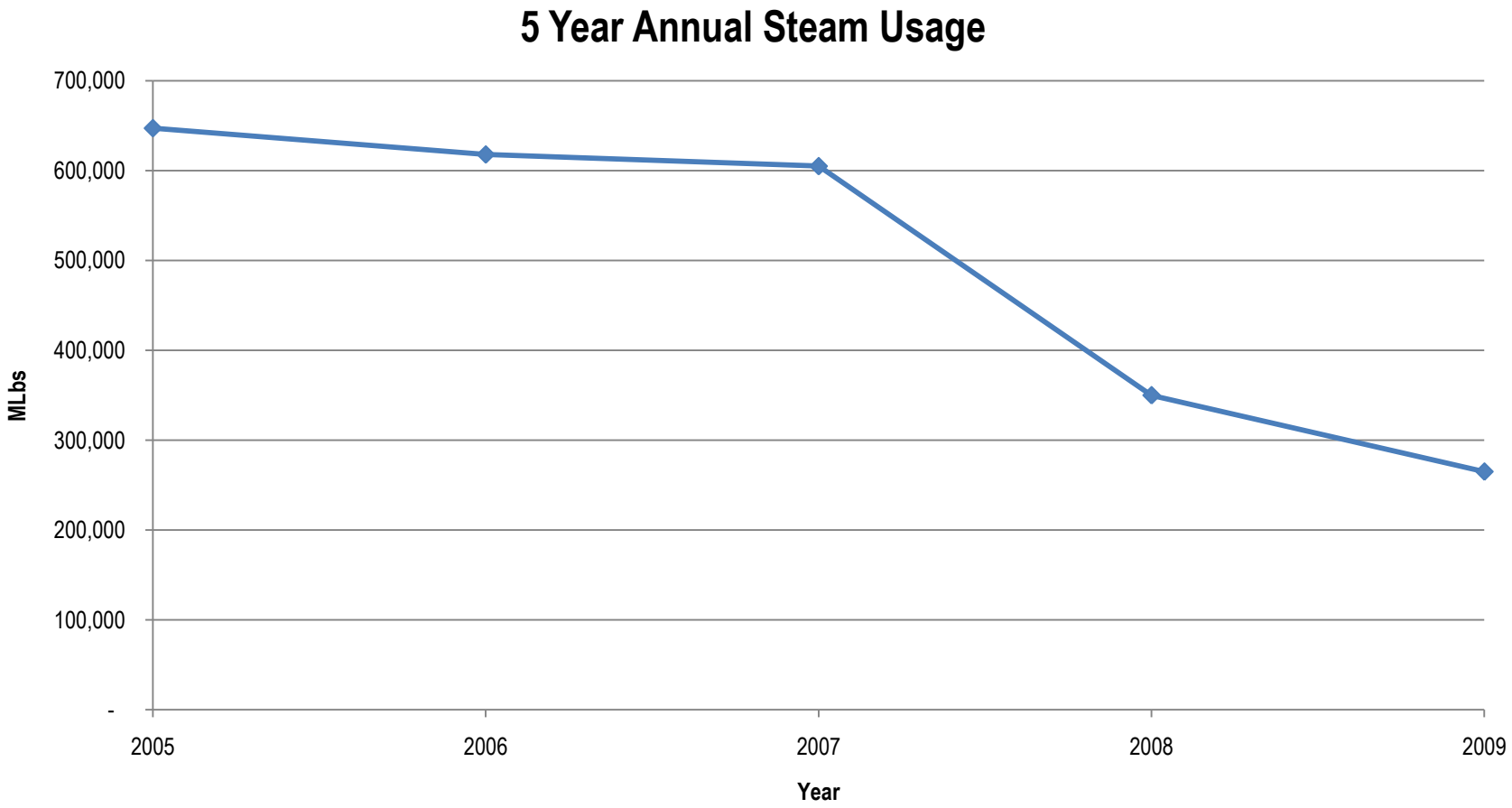
Site Survey Observations

- Forty- Four buildings (approx 594,000 ft^2) served by building 190 steam system
- Thirty-three buildings (approx 323,000 ft^2) would be served by alternative heating system
- All were visited for the purpose of gathering information
- Steam being reduced from the 112.5 psig distribution pressure to 15 - 30 psig
- A few buildings have process loads that use steam at a higher pressure
- Central steam plant consists of six boilers
  - Each boiler has a rated capacity of ~65,000 lbs/hr
  - Yielding a total plant capacity of 390,000 lbs/hr.
  - The boilers were installed over a period of time (1953-2004)
  - All boilers are capable of operating on No. 6 fuel oil or natural gas.
  - Efficiency – 84.7%

Site Survey Observations (continued)

- The supply and condensate return piping system is spread out over the campus
  - Over 8 miles of overhead and underground piping.
  - Most underground piping is in excess of 30 years old
- The plant is significantly underutilized
  - Declining customer base
  - 33 facilities would be served by the steam plant in the future
  - The maximum steam demand on the plant - 48,628 lbs/hr
  - 12.5% of peak capacity.
- Utility Rates:
  - Electric Power - $0.0959 per KWH
  - Natural Gas - $1.00 per therm,
  - No.6 Fuel Oil - $1.32 per gallon
  - Water - $12.24/1000 gallons

Historical Steam Usage



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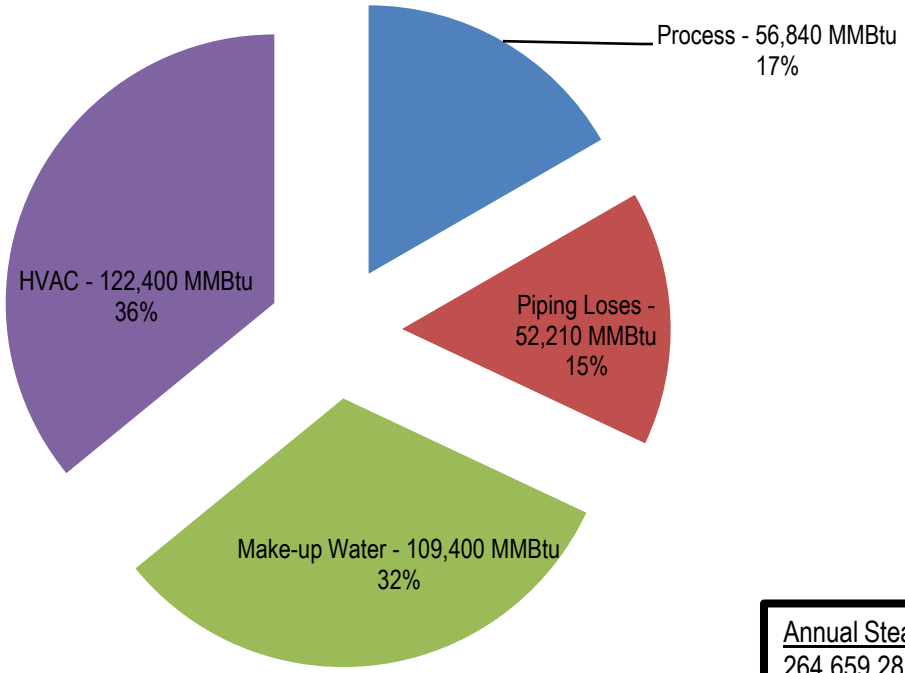
Site Survey Observations (continued)

Boiler Plant Fuel Usage

Annual Energy Input
Natural Gas - 204,900 MMBtu
#6 Fuel Oil - 135,900 MMBtu



Annual Steam Output
264,659,289 Lbs

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Existing Steam Plant Operating Cost

Operating Cost Category	$
Labor/Supervision	923,083
Make-Up Water	163,333
Chemicals (water treatment)	36,516
Electric Power	162,201
Natural Gas	2,049,467
#6 Fuel Oil	1,198,922
Maintenance	577,766
Total	5,111,288

- Steam Cost Calculation
  - Steam Generated – 264,659,289 Lbs
  - Total Cost - $5,111,288
  - $19.31/kLb
- Fiscal year 2009 operation and maintenance costs
  - Approximately 70% of the operating cost is attributable to variable inputs (fuel, water, chemicals, power, etc.)
  - Approximately 30% was dependent on fixed charges (labor and most of the maintenance)

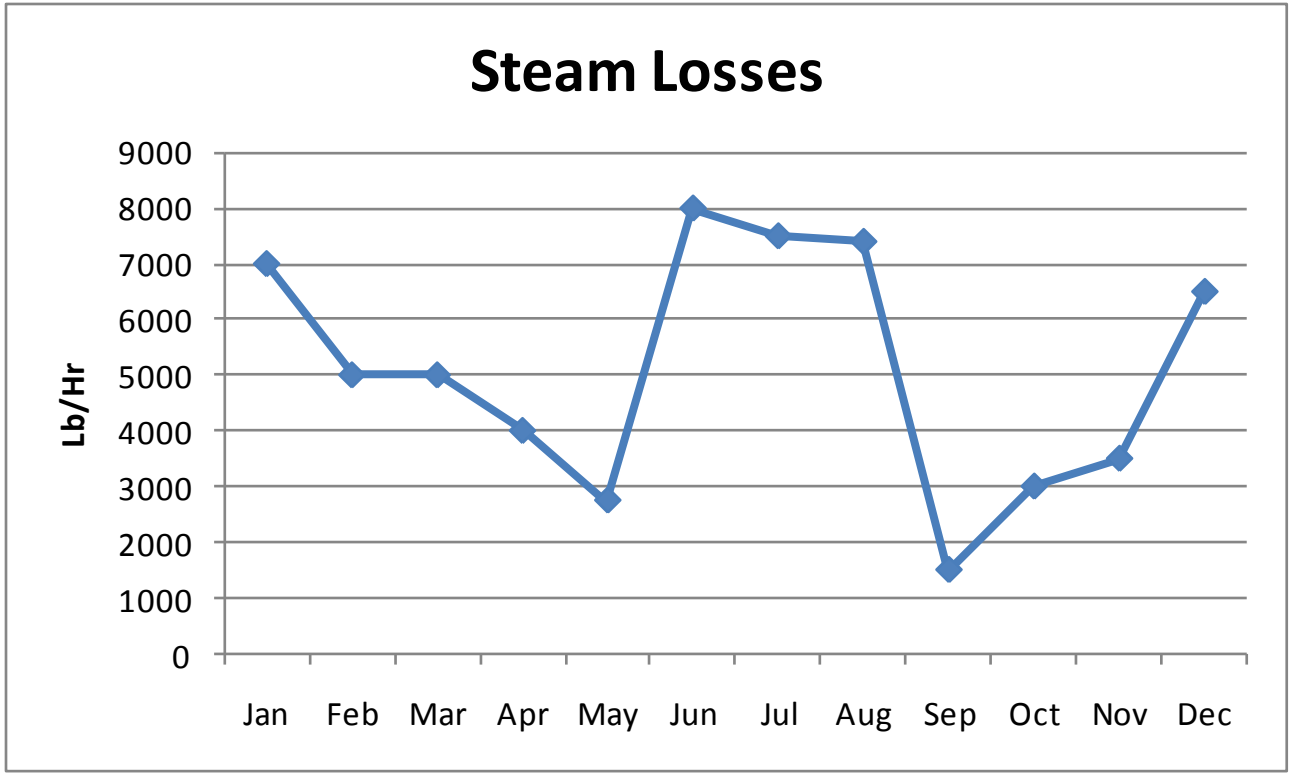
Typical Losses Associated with Centralized System

- Annual Condensate Cost
  - Loss – 40%
  - 105,863,821 Lbs (12,708,823 gallons)
  - Heat Loss - $588,727
  - Water Cost - $155,555
- Distribution System Losses (thermal, flash steam, and steam trap)
  - Estimated to average 5000 lbs/hr
  - 43,800,000 Lbs/year
  - $845,778/Yr
- Boiler Blow-Down Water Cost
  - Assume 2% water loss
  - 635,436 gallons
  - $7,778
  - Cost of heat is included in plant energy cost

Typical Losses Associated with Centralized System (continued)

- Boiler Stack Losses
  - Stack Energy Loss - % 0f Fuel Input
    - Natural Gas – 19.9%
    - #6 Fuel Oil – 15.0%
  - Stack Loss $
    - Natural Gas – $407,751
    - #6 Fuel Oil - $ 179,388
- Boiler Shell Losses – 0.5% of Fuel Input (Typical)
  - Energy Loss
    - Natural Gas – 10,245 therms
    - #6 Fuel Oil – 13,590 therms
  - Cost
    - Natural Gas – $10,245
    - #6 Fuel Oil – $5,980

Estimated Distribution System Steam Losses



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Proposed System

- Replace the heating function in 26 of the 33 facilities with high efficiency condensing type hot water boilers
- Seven buildings of the thirty-three to be heated using natural gas unit heaters rather than distributive hot water boiler systems
  - They are primarily smaller shop or warehouse type facilities.
- Install small packaged steam generators for buildings that have process steam requirements

Key Assumptions

- Existing steam plant and associated infrastructure, including the distribution system, would be abandoned in place.
- Capping and abandonment of existing steam and condensate piping in-place
- Direct replacement of existing air supply system steam coils with hot water coils or abandonment of the steam coils in-place and duct-mounting new hot water coils.
- Assumed the existing supply fan could overcome the additional static pressure of the hot water coils.
- Installation of a complete hot water boiler distribution piping system, including: pump(s), valves, controls, etc.

Operating Cost for Proposed System

Operating Cost Category	$
Labor/Supervision	-
Make-Up Water	-
Chemicals (water treatment)	-
Electric Power	33,012
Natural Gas	665,594
#6 Fuel Oil	-
Maintenance	5,000
Total	703,606

- Operating Cost Summary
  - Centralized Steam System - $5,111,288
  - Proposed System- $703,606
  - Savings - $4,407,682
- Energy Cost Savings - $2,711,984
- Non-Energy Cost Savings - $1,695,698

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Proposed System Energy Costs

- Pumping Power for Localized Boilers
  - Pumping head and efficiency are assumed values
    - Head – 100 ft
    - Efficiency 65 %
    - Heating Season - 210 days
    - $33,012
- Building Heating - Natural Gas
  - Base line heating energy rate 206,265 Btu/ft^2
  - Proposed system will heat 322,689 ft^2
  - 665,594 therms
  - $665,594

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Hot Water Boilers Required

- SYSTEM # QUANTITY AND SIZE OF BOILERS
  - #1 - *2 @ 3 MMBtu
  - #2 - 2 @ 2.5 MMBtu
  - #3 - *2 @ 1.5 MMBtu
  - #4 - 1 @ 1.5 & 1 @ 2 MMBtu
  - #5 - 2 @ 2 MMBtu
  - #6 - 1 @ 1.5 MMBtu
  - #7 - 1 @ 1 & 1 @ .75 MMBtu
  - #8 - *2 @ 0.9 MMBtu
  - #9 - 2 @ 1.5 MMBtu
- Total # - 17
- Total Capacity – 29.55 MMBtu (Approximately 883 boiler HP)

Economics

- Energy Saved Therms/Yr – 2,731,448
- Energy Cost Saved - $ 2,711,984
- Total Annual Cost Savings, - $ 4,407,682
- Cost to Implement, - $ 3,785,510 to $ 6,165,969
- Payback Years Based on Total Cost Savings- < 1 to 1.4
- Payback Years Based on Energy Cost savings – 1.4 to 2.3

Conclusions

- Central steam system was energy intensive and expensive to maintain and operate
- Central system was not efficient source of heating energy
  - The steam system is underutilized
  - Facilities served are not closely grouped and has an extensive distribution system
  - The process requirements are not a significant proportion of the load
- Distributed hot water systems were better in this case, because:
  - Condensing Hot Water boilers are more efficient
  - Distribution system losses are eliminated
  - Condensing hot water boilers are cheaper to maintain and operate
- Facility is proceeding with project