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International District Energy Association
Campus Conference
February 13, 2020
Agenda

• Why temperature matters
• District hot water temperatures coming down
• Design trade-offs
• Building conversion costs
• Conclusions
Why temperature matters

- Broader array of energy sources with lower temperature hot water
- Better heat pump COP at lower temperatures
- Reduced heat losses
Why temperature matters

- COP is strongly affected by temperature “lift”.
- Generally, the maximum practical output temperature of a heat pump is about 170°F.
- Usually heat pump systems are designed for lower temperatures if possible.

- Graph shows representative values for the COP of a heat pump driven with a heat source of 50°F for a range of heat output temperatures.
Hot water temperatures coming down

- Strong trend toward reducing hot water temperature
- “Generations” of district heating

![Evolution of District Heating](chart.png)
Hot water temperatures coming down

- Swedish DH system temps have been dropping
- Most systems are now in 3rd or 4th generation
- We are now moving to a next generation – 120°F or below

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It’s not just plants and pipes!

- Building conversion costs are often given insufficient scrutiny when a hot water temperature scheme is considered.
Design trade-offs

- Life-cycle analysis of cost trade-offs is critical!!
- Assess the impact of alternative Hot Water District Heating (HWDH) supply and return temperatures on:
  - Conversion of building systems
  - Dispatch of heat sources
  - Distribution piping materials
- Phased approach to hot water temperatures may facilitate capital cost reductions
New buildings

- New buildings can and should be designed for temperatures of 120°F or lower.
- Special efforts are required to prevent Legionella problems if a supply temperature lower than 140°F is contemplated.
Retrofit of buildings

- Retrofit of existing buildings is more complex and more expensive.
- Typical North American building HVAC systems are designed for 180-200 °F.
- If lower temperatures are delivered to terminal equipment than the units were designed for, heat output capacity is reduced or “derated”.
- It is sometimes necessary to reduce heating requirements through envelope improvements (insulation of roofs and/or walls, window replacements, etc.).
Building systems conversion

Bummer

All steam equipment; lots of process load

Nirvana

Existing HXs convert steam to low temp HW; no process load

Typical Reality

Low cost

High cost

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Building systems

• What are the characteristics of the building systems?
  – Steam to hot water (HW) heat exchangers
  – Steam or HW perimeter heat
  – Steam or HW reheat coils
  – Steam pre-heat coils
  – Process loads

• Useful to classify HVAC systems into
  – Steam
  – Hot water
  – Hybrid
Conversion costs

• Following data based on schematic designs for a range of campus and government buildings
• Significant scatter in data due to wide variation in building-specific circumstances
• Generalizations:
  – Smaller buildings are most costly per kW thermal load
  – Steam systems most costly
  – Hot water systems least costly
  – Hybrid systems in the middle
Example conversion costs by HVAC type vs load

- Steam
- Hybrid
- Hot Water

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Conversion costs

• **Temperatures matter!**
  • If client goal is cost-effectiveness and heat production is fuel-based, recommend minimizing terminal equipment replacement
  • With existing steam systems, must often replace terminal equipment, so these systems can run on lower temperatures
  • Existing hot water systems can be converted more cost-effectively if higher temperatures are acceptable
  • Conversion costs are very building-specific
Example conversion costs by temperature vs load

- 140F supply
- 150-160F supply
- 170-180F supply
Conclusions

• How low can you go?
  – Technically, very low, considering space heating air temperature set points, with consideration of DHW issues

• Easier to optimize with new buildings

• Economics are driven by high heat transfer area surface area

• Retrofits present additional challenges and higher costs

• Optimization analysis must consider heat production, distribution system and building system design or retrofit
Conclusions

• Must also consider evolution or revolution

• Phasing district heating temperature reductions can take advantage of building renewal cycles

• Ultimately, most appropriate design depends on client goals

• In municipal settings, policy is critical
Thanks for your attention!

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45 Years of Experience in Sustainable District Energy Systems