Life Cycle Value Analysis - Revisted

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Agenda

Life Cycle Value Analysis

Cooling LCCA Example

Seasonal Boiler Efficiency Debate

Heating LCCA– Work in Progress

Questions & Discussion

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Life Cycle Cost Value Analysis


Inside Insights

Benefits of Economic Analyses (part 1):

$#*! my dad taught me

Steve Traiforos, PE, Vice President of Energy Services, Sydia Hennessy Group

Inside Insights

Benefits of Economic Analyses (Part 2):

Real-world examples

- Most multi-million dollar decision deserve more attention than a back of the napkin analysis
- A Net Present Value analysis using Life Cycle Cost methodology is the best vehicle in obtaining a rational decision
- Many value driven issues must be addressed in a more detailed manner to highlight all the issues and decision parameters – ***quantitative*** and ***qualitative*** (non-quantifiable)

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Quantifiable Parameters

Simpler to put prices to these items

- Capitol Costs of heating or cooling plant and interconnection
- Energy and Utility Costs
- Operations and Maintenance Costs

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Qualitative or Non-Quantifiable Parameters

But how do you put a price to these items?

- Reuse of space for other purposes
  - Rentable area
  - Roof garden
- Visual architectural and environmental impacts
  - No plume from cooling towers or boiler stacks
- Cost stability
- Reliable service
- Less green house gas (carbon) emissions
- Freeing up maintenance staff
- Sleep at night factor

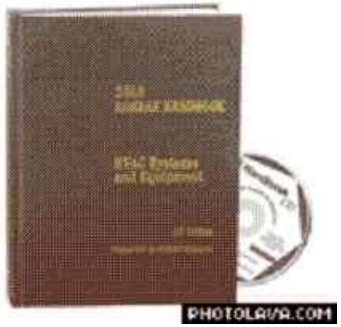
Additional Items for Consideration

- System reliability & availability
- Make-up water
- Only pay for energy used.
- Water treatment chemicals
- Refrigerant storage and management
- Maintenance & operations labor (quantity, expertise & training)
- Administration & management
- Overtime premiums
- Spare parts & supplies
- Electricity rates – demand reduction
- Natural gas rates – firm supply, volatility
- Regulatory compliance and emissions reporting
- Fees, permits & licenses
- Insurance

ASHRAE Handbook & DHG/DCG LCCA Example

District Cooling vs. Self Generation Example

- Peak Cooling Load = 2,400 tons
- Annual cooling load = 6,240,000 ton-hrs
- Study Period = 25 years
- Discount rate = 5.5%
- Escalation rate = 3.5% for all but water/sewer
  which is at 10% per year
- Sewer Water Charges = $4/1000 gallons
- Blended Electrical Rate = $0.10/kWh
- Reduced Electrical Rate due to DC = $0.0875/kWh
- Operator Salary = $70,720 * 1.4 benefits = $99,000
- Cost Insurance = 0.75% of construction cost



LCCA Example (Continued)

Alternative 1 – District Cooling

- Capacity charge = $285 ($/ton/year)
- Consumption Charge = $0.13 ($/ton-hr)
- Interconnection charge = $289,500

  (recovered in invoice over life of contract)

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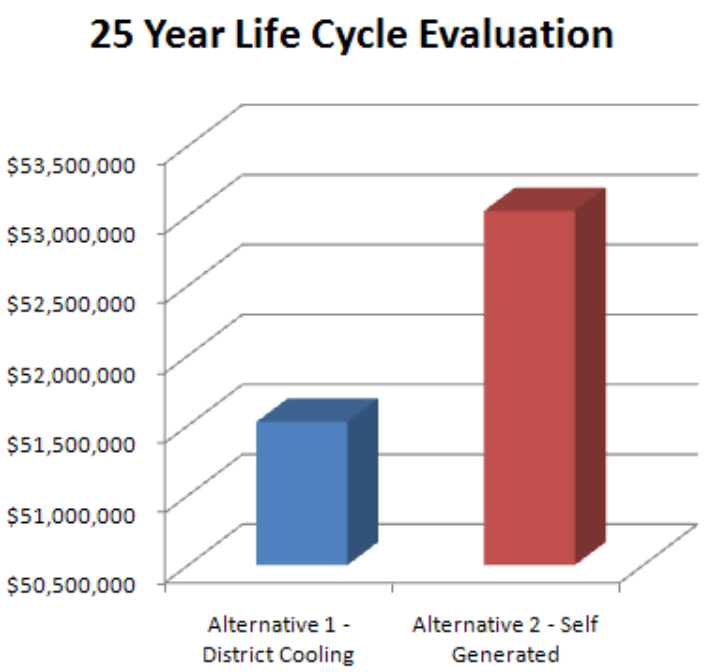
LCCA Example (Continued)

Alternative 2 – Electric Centrifugal Plant

- Configuration = (3) 700 Ton Chillers = 2,700 tons
- Estimated Cost of Chiller Plant = $8,981,000
- Percent Financed = 90%
- Escrow for Chiller Plant Overhaul= $400/ton/yr
- Chiller Plant Maintenance = $6/ton
- Cost of Water Treatment = $0.0025/ton-hr
- Blended Electrical Rate = $0.10/kWh
- Annual Chiller Plant Electric Usage = 4,389,950 kWh
- Annual Makeup Water = 16,181,000 gallons
- Annual Blow down to Sewer = 3,773,000 gallons
- Water & Sewer charges = $8.00/1000 gallons

What Alternative is the best solution?

LCCA Example – Results



Results:

- **Alternate 1 NPV (District Cooling): $51,525,000**
- **Alternate 2 NPV (Self Generated): $53,035,200**

District Cooling has a 25 Year LCC Savings of

$1,510,000!!!

But don't get too excited, that is still pretty close for 25 year study (2.8%)

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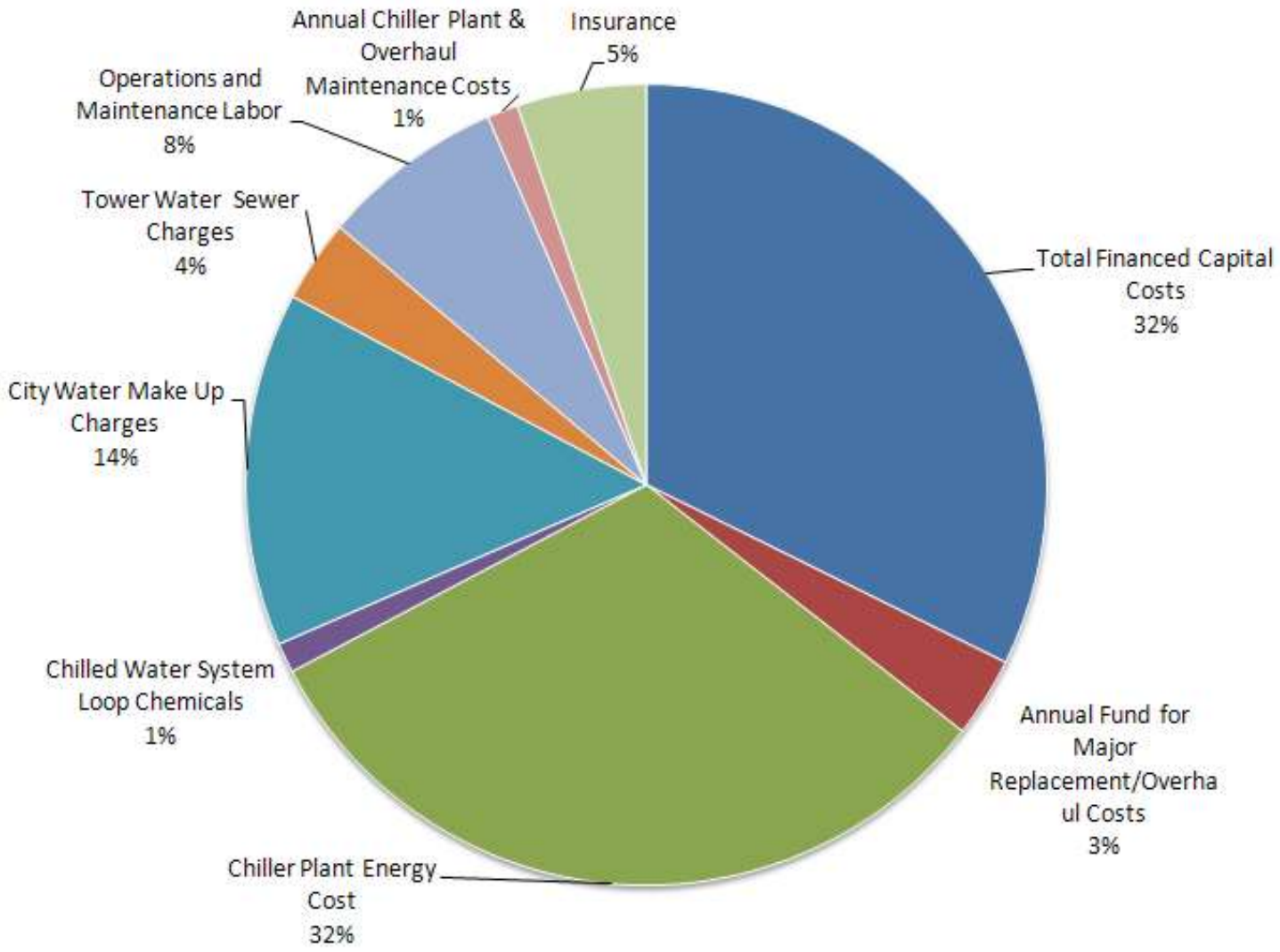
LCCA Example – Alternative 2 Breakdown



Boiler Efficiency Studies

Real-World Seasonal Efficiency of Gas-Fired Steam Boilers

A field study used actual metered data from existing buildings to establish the true seasonal efficiencies of gas steam boilers

By Tim M. Tierney and Charles J. Fishman
ASHRAE Member

What is the actual overall seasonal efficiency that an engineer can expect from a relatively new and efficient natural gas-fired steam boiler plant? Most engineers have an opinion and many often use an assumed seasonal efficiency number to make energy rate comparisons and equipment selections. But, not many engineers have been able to test and monitor the actual efficiency of multiple existing gas-fired boilers operating under widely varying load conditions with real-world installation and maintenance practices.

A district steam utility company in St. Louis has converted 14 different buildings from operating with in-house gas-fired steam boilers to district steam. This conversion provided the opportunity to establish the true seasonal efficiency of natural gas-fired steam boilers operating years after their original installation.

Background

There is no existing conclusive published information on what the actual overall seasonal efficiency of an operating natural gas-fired boiler plant will be. The published information that is available primarily describes combustion efficiency and fuel-to-steam efficiency.

ASHRAE defines combustion efficiency as (energy) input minus stack (chimney) loss, divided by (energy) input. ASHRAE predicts the combustion efficiency of most boilers to be in the 75% to 86% range.[1] This definition makes combustion efficiency just a measure of the performance of the gas burner and heat exchange capacity of the boiler.

Fuel-to-steam efficiency is an efficiency measure often used in boiler manufacturers' catalogs. This is a measure of the ratio of Btu output divided by Btu input; it takes into account some of the radiation and convection losses as well as the combustion efficiency.

However, combustion efficiency and fuel-to-steam efficiency are not appropriate for use as overall seasonal efficiency. This is because neither of these two measures of boiler efficiency takes into account:

- The effects of a varying load on efficiency;
- The effects of boiler plant age and design on efficiency; and
- The effects of average commercial boiler maintenance and boiler water treatment programs on efficiency.

Radiation losses in a single boiler with the boiler operating at high firing levels are in the range of 0.1% to 2%.[2] As the load on the boiler is reduced, the amount of radiated heat loss stays about the same. Therefore, the radiation losses as a percent of heat output increase as the load on a boiler drops off. Radiation losses for the same boiler operating at an average of 50% of full load will be in the range of 0.3% to 6%.[3]

Combustion efficiency and fuel-to-steam efficiency are generally available from boiler manufacturers. However, these efficiencies are established when the boilers are new. Therefore, it stands to reason that the efficiency of boilers operating in a building's basement or penthouse over a five-year period would average something less than the original manufacturer's test results.

It also stands to reason that a boiler plant's design will affect its overall seasonal efficiency. The selection of the quantity and capacity of each boiler in a boiler plant and the actual load profile that the boiler must operate under will certainly affect overall boiler plant seasonal efficiency.

In a commercial boiler plant with one large boiler, the boiler must be selected to handle the peak load on the coldest day of the year plus a safety factor. In this case, the boiler cannot operate at maximum efficiency under light loads in the spring and fall. Under light loads, the boiler will cycle on for a few minutes and then cut off for several minutes, resulting in significant energy losses due to the loss of useful heat out of the boiler plant during the off-cycle.

About the authors

Tim M. Tierney is the director of marketing at Trigen-St. Louis Energy Corp. in St. Louis, Missouri. He has a BS in mechanical engineering from the University of Missouri, Columbia. Tierney is a member of ASHRAE TC 6.1 (Hydronic and Steam Equipment Systems), TC 6.2 (District Heating and Cooling) and GPC 9P (Energy Cost Allocation for Multiple-Occupancy Residential Buildings).

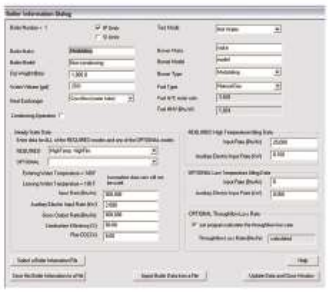
Charles J. Fishman is the president of Trigen-St. Louis Energy Corp. He has a BS (physical engineering from Purdue University), a master's degree in engineering from the University of California, Berkeley, and a master's degree in business administration from the University of Chicago. Fishman is a member of the International District Energy Association.

Publications

- **1994 ASHRAE Journal – Real-World Seasonal Efficiency of Gas-Fired Steam Boilers** (Tim Tierney & Charles Fishman)
  - 14 Building Study on St. Louis Trigen System
  - ASHRAE predicted the combustion efficiency of most boilers between 75% and 86% (days before condensing boilers)
  - Losses:
    - Age
    - Stack loss
    - Radiation losses
    - Blowdown
    - Too much excess air
  - Maintenance factors
    - Chemical treatment and scale

Results of study – average 56%!!!

Boiler Efficiency Studies



New Software for

Calculating Seasonal Efficiency for Boilers

By David C. Bixby, Member ASHRAE; **Martha J. Hewett,** Member ASHRAE; and **Ron M. Nelson,** Ph.D., PE., Member ASHRAE

A user-friendly, Windows-based software tool has been developed to calculate the application seasonal efficiency (ASE) of commercial space heating boiler systems, based on the tests and calculation procedures specified by ASHRAE Standard 155P, *Method of Test for Rating Commercial Space Heating Boiler Systems*.

The standard, which is nearing completion by Standard Project Committee (SPC) 155P, is unique in that the tests and calculation procedures result in an application-specific seasonal efficiency rating for a particular system configuration in a particular building type and climate location. This represents a first in North America for any kind of commercial heating system.

Why the Software?

The software was developed to facilitate the standard's application-specific approach. Given the complexity of commercial boiler systems and the resulting complexity of Standard 155P, only the most experienced could be expected to use the standard without this software. The software will greatly facilitate determination of boiler system energy input and ASE for commercial buildings by manufacturers' representatives, design engineers, utility staff and others to compare options for building owners. It also will help boiler manufacturers use the standard in sensitivity analyses for designing new boiler products and control strategies.

The research project that resulted in the software was recommended by SPC 155P, and sponsored by ASHRAE TC 6.1, *Hydronic and Steam Equipment and Systems*. Ron Nelson, Ph.D., P.E., Member ASHRAE, of Iowa State University is the project's contractor.

How "Friendly" Is It?

Designers can use the software's user-friendly interface to:

- Select building load profiles from the library by building type and climate location;
- Import customized load profile data from one or more common file formats;

About the Authors

David C. Bixby is manager, Technical Services, with the Gas Appliance Manufacturers Association, in Arlington, Va., and a member of ASHRAE SPC 155P. **Martha J. Hewett** is assistant director of research & engineering with the Center for Energy and Environment, Minneapolis, and chair of SPC 155P. **Ron M. Nelson, Ph.D., PE.,** is professor of mechanical engineering at Iowa State University in Ames, Iowa, and the principle investigator on RP-1196.

- ASHRAE Standard 155P, Method of Test for Rating Commercial Space Heating Boiler Systems
- ASHRAE Research Project RP-1196
- This effort has been going on for over 17 years
- 2004 Journal article stating that the project was near completion
  - The research project ran into issues and never was fully completed. Its completion is still outstanding, however, it has not died yet
  - Effort is ongoing and the standards committee still meets at all society meetings

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Boiler Efficiency Studies

Boiler System Efficiency

By Thomas H. Durkin, P.E., Member ASHRAE

When natural gas cost $0.40 per therm* (1999), even a poorly designed boiler system would have positive payback. Hurricane Katrina changed that.

According to the Energy Information Administration (www.iea.doe.gov), the cost of natural gas has increased 50% in the U.S. since last fall (due to Hurricane Katrina) and 200% in the last seven years. Electricity has increased only 20% in the same time frame (central Indiana). Winter 2006 natural gas cost as much as $1.40 per therm (100,000 Btu) and electricity costs around $0.07/kWh (3,413 Btu). The electric cost equates to $2.05 per therm.

In the simplest terms, if the boiler cannot deliver heat to the space at an efficiency of at least 68%, then the boiler has zero payback vs. straight resistance electric heat, which is (theoretically) 100% efficient. This represents a large shift in engineers' approach to heating systems.

Some would argue, probably correctly, that the entire national energy picture is in flux, and that the cost of electricity is artificially low compared to natural gas. Conversely, the cost of natural gas may be artificially high because of the hurricane damage to the gas drilling rigs in the Gulf of Mexico. In Indiana, most of the new electric power generation is gas-fired peaking plants, which likely will create a ripple effect on electric costs.

This snapshot makes it seem that gas-fired boilers are a marginal investment, and that boilers burning fuel oil at $2.80 per gallon (139,000 Btu/$2.01 per therm) or propane at $2 per gallon (91,600 Btu/$2.18 per therm) will cost significantly more than straight resistance electric heat. In all fairness, while several

About the Author

Thomas H. Durkin, P.E., is director of engineering at Veazey Parrott Durkin & Shoulders in Indianapolis.

*Therm = 105.5 MJ, generally rounded to 100 MBtu, equal to 100 ft³ of natural gas.

July 2006 ASHRAE Journal 51

- 2006 Journal article.
- Mentioned the pending completion of Standard 155P (a little premature)
- Warning on using published boiler efficiency for condensing boilers if low return water temperatures are not achieved.

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Boiler Efficiency Studies

PG&E's Emerging Technologies Program ET11PGE5272

Boiler Research Project - ASHRAE Standard 155P – Phase II

ET Project Number: ET11PGE5272

(Sample picture of product/technology

Project Manager: Ed Elliott
Pacific Gas and Electric Company

Prepared By: Al Beliso
Eddie Huestis
Manny D'Albora
PG&E – Applied Technology Services
3400 Crow Canyon Rd.
San Ramon, CA 94583

Jeff Stein / Kathleen Matthews
Taylor Engineering

Issued: December 21, 2012

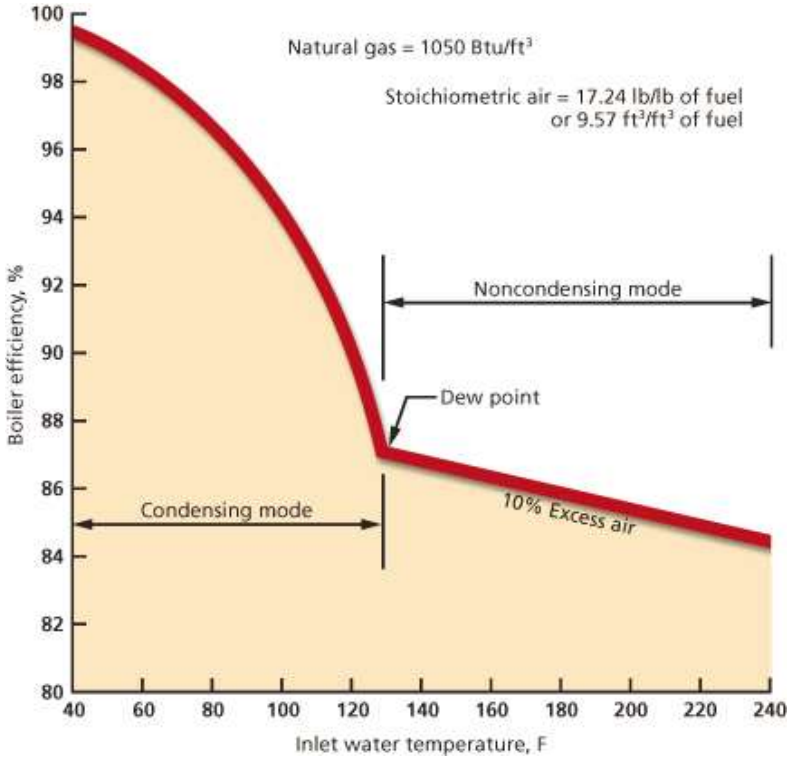
Pacific Gas and Electric Company®

Page 1

- Results will be used to support testing in ASHRAE Standard 155P
- PG&E Applied Technical Services (ATS)
- Phase I of the boiler research at ATS was completed in late 2011 in support of Standard 155P.
  - Phase I focused on identifying any fundamental flaws in the test methodology, calculation procedures and report forms.
  - No fundamental flaws were identified but several minor flaws and recommendations were identified, such as the need to address stratification
- Phase II published in December 2012
  - More of a how to on testing and calculating boiler efficiency
  - Boiler tests were conducted on two boilers (conventional and condensing) to establish testing uncertainties, etc.

Boiler Efficiency Studies

CONSULTING - SPECIFYING
engineer



June 2012 CSE article - Boiler systems: Economics and efficiencies

Engineers can meet a building's hot water needs with today's boiler systems

Dominic Tabrizi, PE, Environmental Systems Design, Chicago

"…the seasonal efficiency, which is the overall effectiveness of the boiler over the entire season, for today's noncondensing boilers is roughly at 70% to 75%, compared to 84% to 92% for new condensing boilers."

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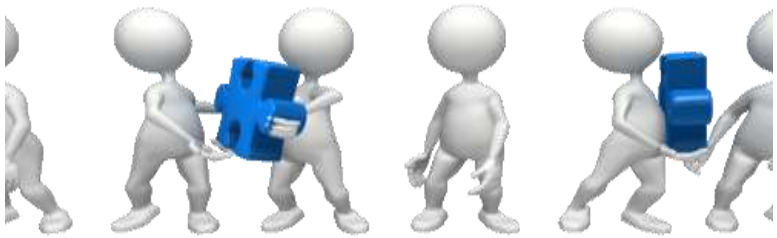
Next Steps????



- Need a similar LCC analysis for district heating comparison
  - Spreadsheet was started, then stopped
- Similar to the cooling model, it requires additional real world information from ***district energy providers***
- Continue research & support of real world boiler efficiency studies

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Questions & Discussion

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Thank You!

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