# 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





### Life Cycle Cost Value Analysis

### **Benefits of Economic** Analyses (part 1): \$#\*1 my dad taught me

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### Benefits of Economic Analyses (Part 2):

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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)



### **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







## **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

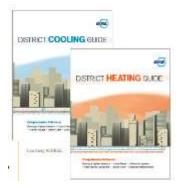
### **District Cooling vs. Self Generation Example**

- Peak Cooling Load =
- Annual cooling load =
- Study Period =
- Discount rate =
- Escalation rate = which is at 10% per year
- Sewer Water Charges =
- Blended Electrical Rate =
- Reduced Electrical Rate due to DC =
- Operator Salary = \$70,720 \* 1.4 benefits =
- Cost Insurance =



2,400 tons 6,240,000 ton-hrs 25 years 5.5% 3.5% for all but water/sewer

\$4/1000 gallons \$0.10/kWh \$0.0875/kWh \$99,000 0.75% of construction cost







## LCCA Example (Continued)

### **Alternative 1 – District Cooling**

- Capacity charge =
- Consumption Charge =
- Interconnection charge =

\$285 (\$/ton/year) \$0.13 (\$/ton-hr) \$289,500 (recovered in invoice over life of contract)





## LCCA Example (Continued)

### **Alternative 2 – Electric Centrifugal Plant**

- Configuration = (3) 700 Ton Chillers =
- Estimated Cost of Chiller Plant =
- Percent Financed =
- Escrow for Chiller Plant Overhaul=
- Chiller Plant Maintenance =
- Cost of Water Treatment =
- Blended Electrical Rate =
- Annual Chiller Plant Electric Usage =
- Annual Makeup Water =
- Annual Blow down to Sewer =
- Water & Sewer charges =

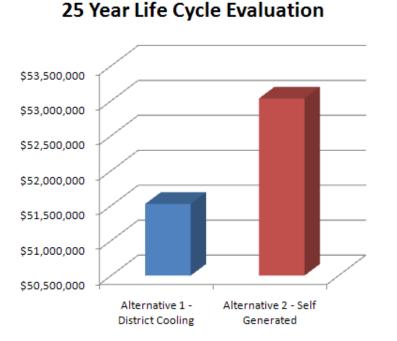
2,700 tons \$8,981,000 90% \$400/ton/yr \$6/ton \$0.0025/ton-hr \$0.10/kWh 4,389,950 kWh 16,181,000 gallons 3,773,000 gallons \$8.00/1000 gallons

### 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!!!

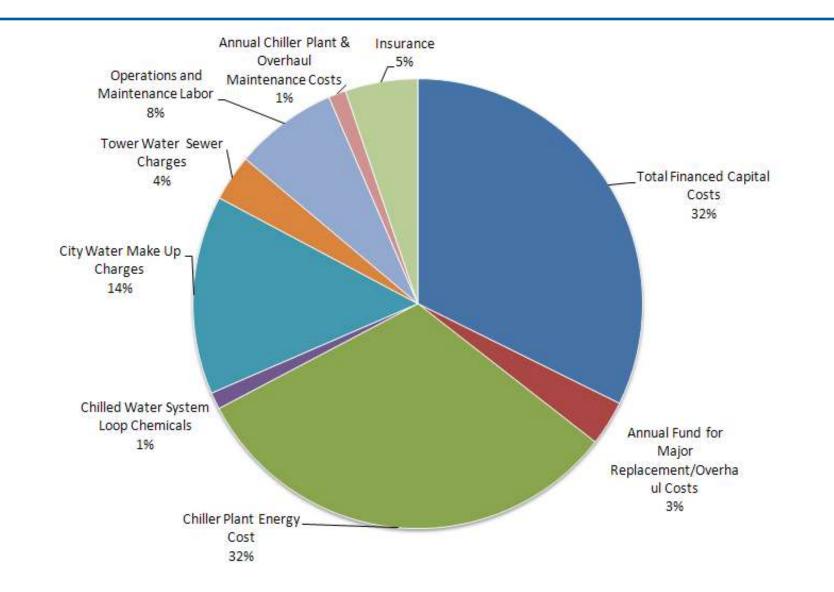


But don't get too excited, that is still pretty close for 25 year study (2.8%)





### LCCA Example – Alternative 2 Breakdown







### **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

but is the actual overall seasonal efficiency that an engineer can report from a minimity new and officieta natural gas-fired steam boller plant? Most registers have an opinion and many offen are an owned somotal efficiency needer to make every rate comparaces and equipment selections. Inst, not many organoers have been able to test and monitor the actual efficiency of multiple existing. In the marge of 0.3% to 5%, I gas-fired boilers operating under widely varying load conditions with real-world installation and realizes and practices.

hollors to district stream. This conversion pervided the opportunity to establish the true seasonal efficiency of natural gas-freed assamisolars 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 gasfired boller plant will be. The published information that is and able primarily describes construction efficiency and furl-to-strains must be selected to handle the peak load on the coldest day of the

ASPIRAE deflace combustion efficiency as (mergy) input minus stack (thirtury) icon, divided by (manys) input. ASHIRAE positions the constituation efficiency of most belien to be in the 75% to 86% range.' This definition makes contrastion efficiency just a measure of the performance of the gas horser and heat exchange mpacky of the bolist.

Pad-to-mean efficiency is an efficiency measure offers and in heller standardaters' catalogs. This is a measure of the ratio of Bits output divided by Bits input; it takes into account assess of the radiation and convection locaes as well as the communico effi-**Sistery** 

However, constantiant efficiency and hiel-to-steam efficiency are not appropriate for use as overall seasonal efficiency. This is because address of these two measures of holler efficiency takes into AGO/MARC

- . The effects of a varying load on efficiency;
- · The effects of boller plant age and design on efficiency and
- · The effects of average commandial bother maintenance and holes water treatment programs on efficiency.

ASWRAS Journey September 1999

Radiation losses in a single boller with the holler operating at high firing levels are in the range of 0.1% to 2%.2 As the load on the boller is reduced, the appoint of radiated hear 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

Combustion efficiency and fusi-to-tonan efficiency an generally available from boller manufactures. However, these efficien-A district means at hty company is St. Loose has concerted 14 cites are established when the bodiers are new. Therefore, it attends different buildings from operating with in-income gas-first stoam to major, that the efficiency of boilers operating in a building's basement or perchouse over a five-year period would average evenething loss than the original manufacturer's cost results.

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

In a commercial boiler place with our large boller, the boiler your plus a solvry faince. In this case, the botler carnesi 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, rendting in significant energy lowes due to the lass of useful limit out of the boiler plant during the off-cycle.

#### About the authors

The M. There is the doctor of marketing in Tapes W. Long-Downs. Comparish Loost Minson Webs within new anich restorance here the Leaseners of Mission, Colored & Densy is a months of ADDRAR UP & OTOPOLOGIC and Logic Logic Systems), We all Order History and Corpus and GUC P (Energy Con Adventure) for Multiple-Occupanty Aronaphial Survivation Charled Follows other providence Theory St. Loss (Note: Corp. Be have \$5 in call of givening thes Purker Supervise, a matery depth 11, magineting fermitter Departury of California, Radiolog, and a master's surpra to has some administration from the Univer-Charges Walnuts in a member of the Interactional District Energy Amouree

### **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%!!!**





### New Software for

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# **Efficiency for Boilers**

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

user-friendly. Windows-based software tool has been develsoftware was recommended by SPC  $oldsymbol{A}$  oped to calculate the application seasonal efficiency (ASE) of 6.1, Hydronic and Steam Equipment and commercial space heating boiler systems, based on the tests and is the project's contractor. calculation procedures specified by ASHRAE Standard 155P, Method of Test for Rating Commercial Space Heating Boiler Systems. How "Friendly" Is It?

heating system.

#### Why the Software?

tate the standard's application-specific control strategies. approach. Given the complexity of com-

July 2004

The standard, which is nearing comple- mercial boiler systems and the resulting tion by Standard Project Committee complexity of Standard 155P, only the . Select building load profiles from the (SPC) 155P, is unique in that the tests and most experienced could be expected to calculation procedures result in an appli- use the standard without this software. cation-specific seasonal efficiency rating The software will greatly facilitate de- . Import customized load profile data for a particular system configuration in a termination of boiler system energy inparticular building type and climate lo- put and ASE for commercial buildings cation. This represents a first in North by manufacturers' representatives, de-America for any kind of commercial sign engineers, utility staff and others to compare options for building owners. It also will help boiler manufacturers

use the standard in sensitivity analyses The software was developed to facili- for designing new boiler products and The research project that resulted in the

cal engineering at lows State University in Ames, lows, and the principle investigator on RP-1196. ASHRAE Journal

55

155P, and sponsored by ASHRAE TC

Systems. Ron Nelson, Ph.D., P.E., Mem-

ber ASHRAE, of Iowa State University

Designers can use the software's user-

library by building type and climate

from one or more common file formats;

David C. Bixby is manager, Technical Services, with

the Gas Apolance Manufacturers Association. In

Arlington, Va., and a member of ASHRAE SPC 155P

Martha J. Howett is assistant director of research & engineering with the Center for Energy and En-

vironment, Minneapolis, and chair of SPC 155P. Ron

M. Nelson, Ph.D., PE., is professor of mechani-

friendly interface to:

location:

About the Authors

- 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







# **Boiler System Efficiency**

#### By Thomas H. Durkin, RE., Member ASHRAE

en natural gas cost \$0.40 per therm\* (1999), even a poorly designed boiler system would have positive payback. Humicane 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 electric heat, which is (theoretically) cannot deliver heat to the space at an 100% efficient. This represents a large has zero payback vs. straight resistance 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 ratural 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 bollers are a marginal investment, and that boilers burning fael off at \$2.80 per gallon (139,000 Btu/\$2.01 per thorm) or propane at 52 per gallon (91,60) Bhu \$2.18 per therm) will cost significantly more than straight resistance electric heat. In all fairness, while several

#### About the Action

Thomas H. Durkin, P.E., is director of engineering at Wapey Parrott Durion & Shoulders in efficiency of at least 68%, then the builter shift in engineers' approach in heating them a 1853% georaly market in 1869% and to 100 h<sup>2</sup> of retard gas

**July 2006** 

**ASHRAE** Journal

51

NATIONA ICT ENERGY

- 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.



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

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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.





100 Natural gas = 1050 Btu/ft<sup>3</sup> 98 Stoichiometric air = 17.24 lb/lb of fuel or 9.57 ft3/ft3 of fuel 96 94 Boiler efficiency, % 92 Noncondensing mode 90 Dew point 88 86 10% Excess air Condensing mode 84 82 80 40 60 80 100 120 140 160 180 200 220 240 Inlet water temperature, F

**CONSULTING - SPECIFYING** 

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."





## 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 <u>district energy</u> providers
- Continue research & support of real world boiler efficiency studies





# **Questions & Discussion**





# Thank You!\_\_\_\_\_

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