

WASTE HEAT RECOVERY
...ADDING UP TO MORE THAN A DROP IN THE BUCKET

Technology for Boiler System Efficiency

Sponsor – Southern California Gas Company

**“Condensing Economizers and the
new DCI-HTR™ Technology”**

Bill Carson

Direct Contact Inc. (DCI)

May 28, 2008 – Downey, CA

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Heat Content of Flue Gas

**The heat exhausted from a boiler is
dependent on two factors:**

- Flue Gas Temperature (boiler specific)
- Water Vapor Content (humidity)

**The excess combustion air and type of fuel
burned determines the amount of water
vapor (humidity) in the flue gas.**

- hydrogen combustion generates only water vapor
- pure carbon combustion generates no water vapor
- Among hydrocarbons, methane combustion generates the most water vapor

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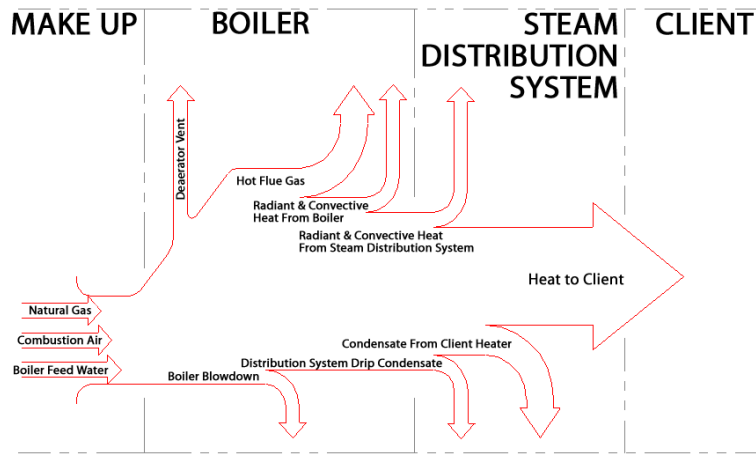
Combustion Energy

| FUEL | Higher Heat Value (BTU) | Lower Heat Value (BTU) | Latent Heat Water (BTU) | Heat Content In Water Vapor Exhausted (Part of Total) |
|----------|-------------------------|------------------------|-------------------------|---|
| HYDROGEN | 246335 | 208143.9 | 38191.1 | 15.50% |
| CARBON | 169256.9 | 169256.9 | 0 | 0.00% |
| METHANE | 191475.5 | 172389.9 | 19087.6 | 9.97% |
| ETHANE | 191475.5 | 175419.7 | 16336.7 | 8.55% |

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Heat Flow



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Heat Return Paths

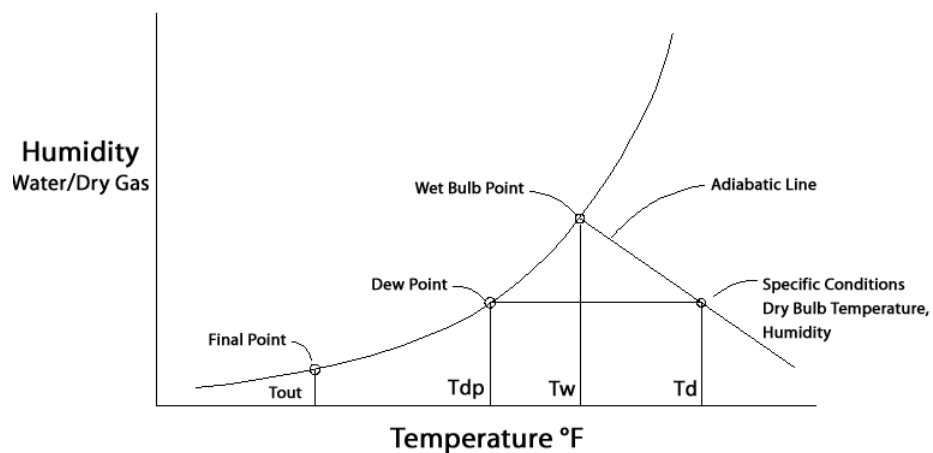
Captured Heat can be returned to the Boiler system by

1. Heating combustion air
2. Heating water make-up

Today's discussion focuses on the latter and we will examine

1. The heat removed above the Dew Point (via an *Economizer*)
2. The heat removed below the Dew Point temperature (via a *Condensing Economizer*)

Psychrometric Chart

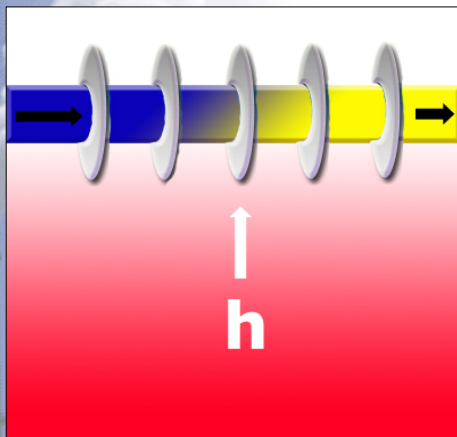


Heat Recovery

- Economizers
- Blow Down Heat Recovery
- Condensing Economizers & *DCI-HTR*TM
- DCI - Heat Transfer Specialists
 - Traditional Indirect Heat Transfer
 - Direct Contact Heat Transfer
 - 'Hybrid' Systems

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Economizers/Air Preheaters



- Recover heat from the flue gas at temperatures far above the gas's dew point temperature.
- Utilize only the *Sensible Heat* contained in the flue gas

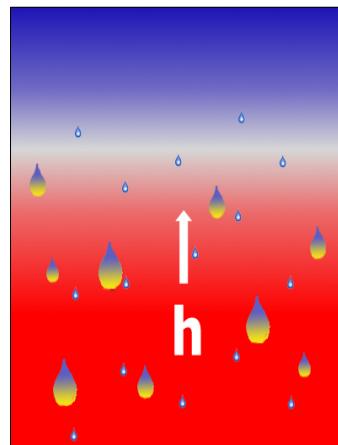
DCI-HTR[™] Provides New Heat Recovery Opportunities

- Very High Heat Transfer Coefficient
- Non-Fouling - Extremely High Heat Transfer Surface Area
- Low Gas Side Pressure Drops

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DCI-HTR[™] System

- Recovers heat directly from the flue gas, cooling it below its dew point temperature
- Utilizes mainly the *Latent Heat of Vaporization* contained in the flue gas
- Can be used with Economizers



Assumptions Used in Mass and Energy Balance

- Boiler produces 6,000 pounds per hour of steam at 100-psig saturated
- Combustion air, fuel and makeup water are all at inlet temperature 60°F
- Combustion air dew point is at a temperature of 40°F
- Fuel is 100% methane, combustion air is 10% excess, and the combustion efficiency is 100%
- The boiler has 0% blow down and negligible heat is lost from the deaerating heater vent
- The boiler's radiant and convective heat losses are at 2% and no heat is lost from the distribution piping
- Inefficiencies of rotating equipment are negligible
- Flue gas enters economizer at 530°F and leaves the economizer at 320°F
- 51% flue gas passes through the condensing economizer leaving at 113°F
- The condensing economizer gas exhaust and hot flue gas, directly from the economizer, combine to produce a stack exhaust temperature of 219.2°F

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Heat Available

Total Heat in Flue Gas leaving Boiler

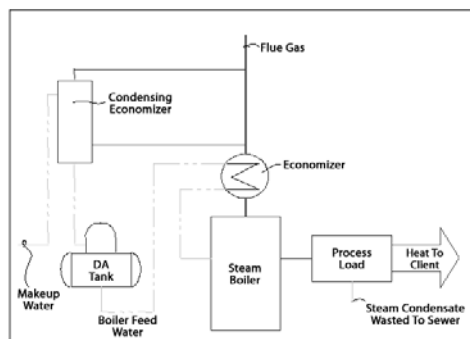
1,742,160 BTU/hr
 100%

Heat captured in the Economizer

428,240 BTU/hr
 24.6%

Heat captured in the Condensing Economizer

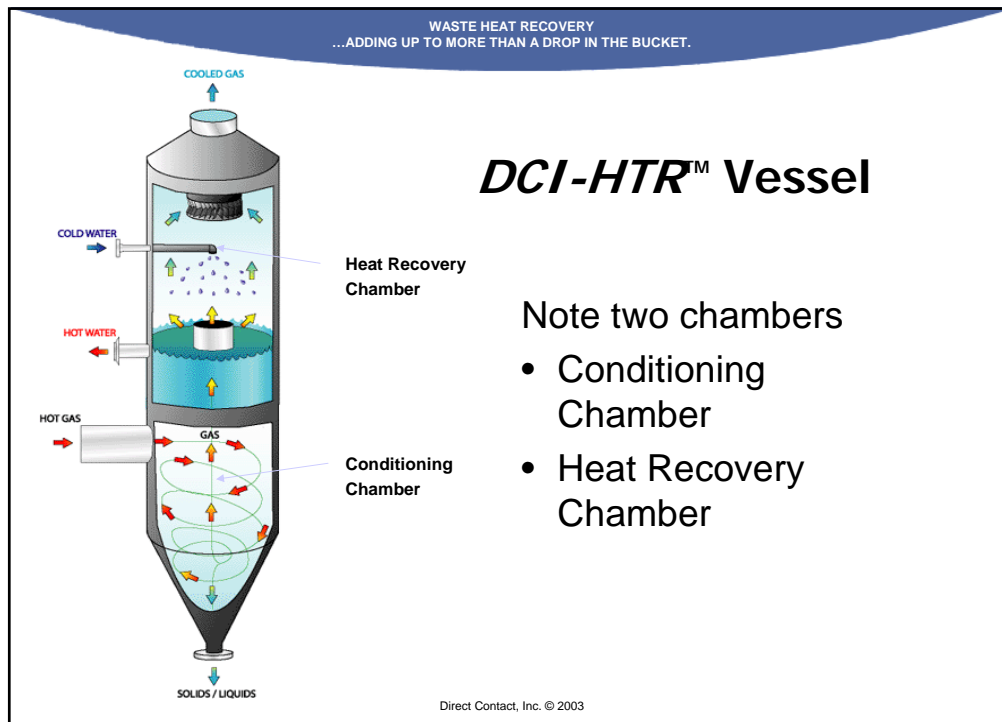
390,000 BTU/hr
 (**Additional** 22.4%)



Condensing Economizer Only

444,000 BTU/hr
 25.5%

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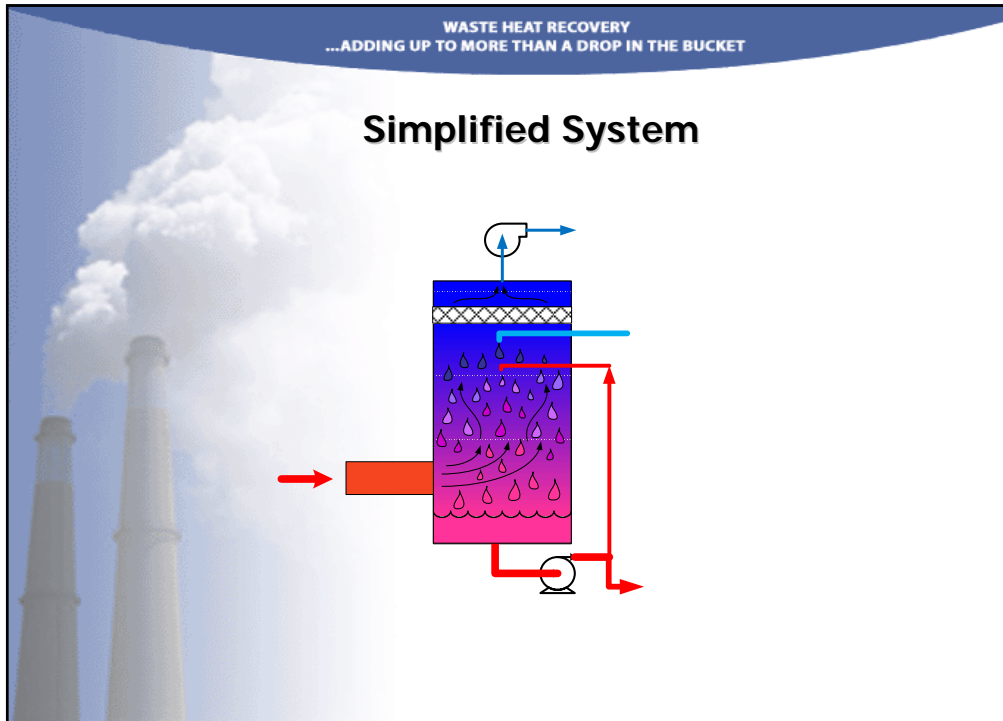
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Low Grade Heat

- A Heat Repository (or “Heat Sink”) is required to cool exhaust gas.
- Finding a “home” for the hot water you create can be challenging...
- ...but if you can use this heat, and replace virgin energy, the project can turn into a net “money maker.”
- Good Examples: Boiler Feed Water, Domestic Hot Water, Process/Wash Water

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Simplified System



Economic Justification

- Typical Yardsticks for DCI projects to date have averaged a 2-3 year 'simple payback' or less; a 24-36% ROI (using the '72-rule')
- PG&E Incentive
 - Example: NRG-San Francisco; \$300,000 Rebate
- Other Incentives
 - Federal Energy and Security Act (Dec. 2007)
- "A Good Return on Investment is great, but a carbon credit today is priceless"

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Direct Contact Inc. Heat Recovery System NRG – San Francisco

- ~13 MBTU/hr saved
- >8 million gallons/yr. water was recovered
- >8,000 tons/yr. less CO₂ was generated
- Average fuel savings >\$2000/day
- < 1.3-yr payback



WASTE HEAT RECOVERY
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Direct Contact Inc. Heat Recovery System Seattle Steam Company

- ~14 MBTU/hr saved
- >9 million gallons/yr. water was recovered
- >9,000 tons/yr. less CO₂ was generated
- Average fuel savings >\$2000/day
- < 2-yr payback



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**Direct Contact Inc.
Heat Recovery System
Pactiv Corporation**

- ~5 MBTU/hr saved
- >2 million gallons/yr. water was recovered
- >3,000 tons/yr. less CO₂ was generated
- Average fuel savings >\$500/day
- < 2-yr payback



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**Direct Contact Inc.
Heat Recovery System
James Hardie Gypsum**

- ~10 MBTU/hr saved
- >9 million gallons/yr. water was recovered
- >6,000 tons/yr. less CO₂ was generated
- Average fuel savings >\$1200/day
- < 2-yr payback



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Direct Contact Inc. Heat Recovery System Northwest Groundwood Refiner



- 1st Unit of this design was installed in 1985 and is still performing
- 2nd unit was installed at the same mill in 1991
- 3rd system has been installed on a Hog Fuel Boiler Exhaust and is capturing >25 MBTU/hr

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Why lose all this **heat**?



Consider a



Heat Recovery System

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