Maximize Boiler Heat Recovery with Condensing Economizers

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Presented by:
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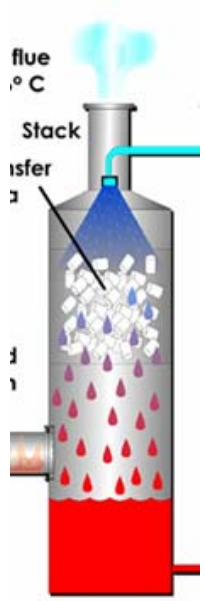
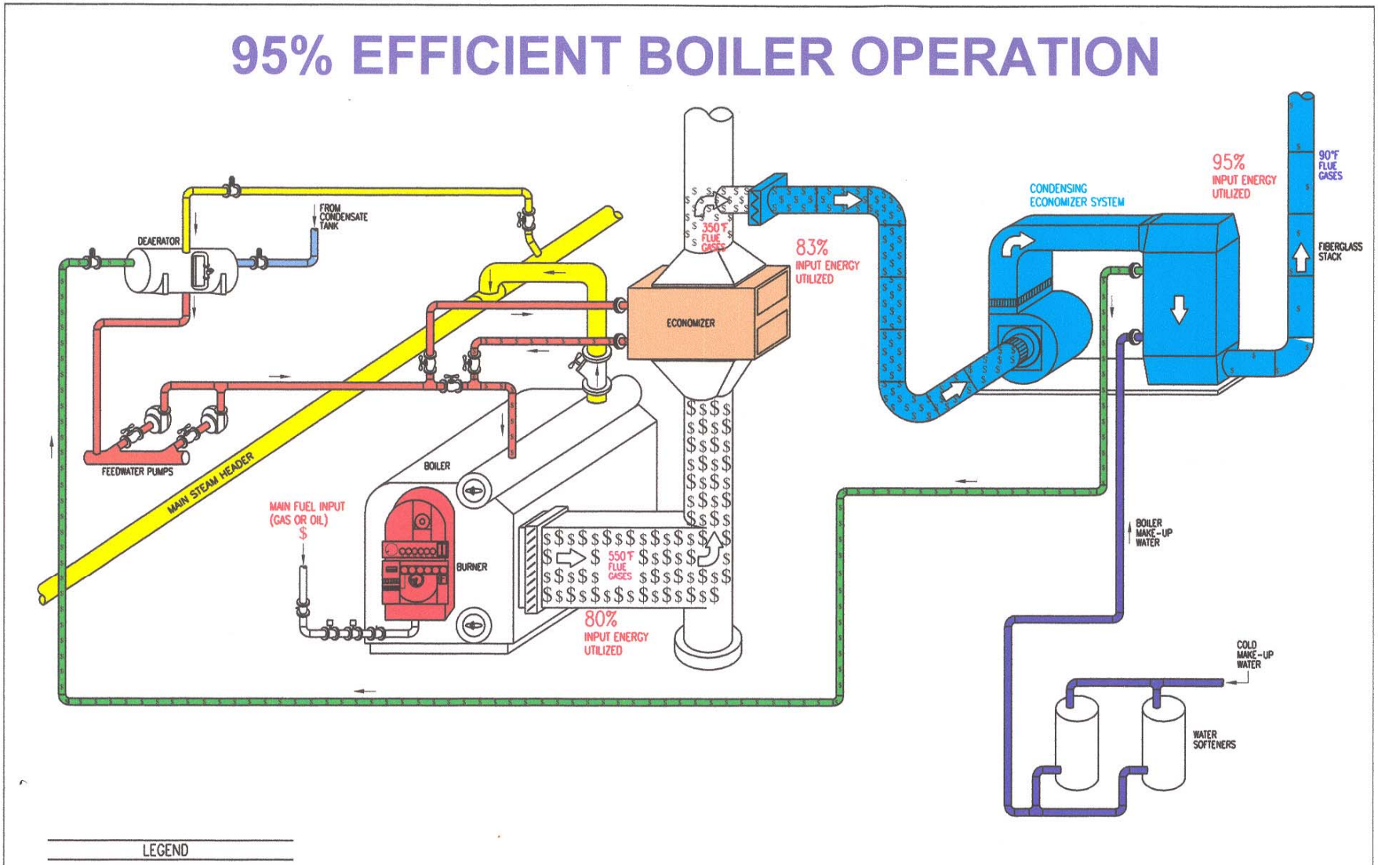


Outline

1. Review basic concepts of condensing heat recovery
2. Types of condensing economizers
3. Energy saving potential
4. Case studies
5. Potential applications
6. Key considerations
7. Major barriers to market penetration
8. Concluding remarks

Condensing Economizer Increases Boiler Efficiency Over 90%



Basic Concepts of Condensing Heat Recovery

When one molecule of CH4 is burned, it produces 2 molecules of H2O

$$CH_4 + 2O_2 + 7.52\ N_2 \rightarrow CO_2 + 2H_2O + 7.52\ N_2$$

16 lb

1 lb

36 lb

2.25 lb

One lb of CH_4 produces 2.25 lb of H_2O

One lb of Natural Gas (1005 Btu/ft3) produces 2.14 lb of water

Basic Concepts of Condensing Heat Recovery

- Water in products of combustion is vaporized due to heat of combustion
- Water vapors absorb about 10% of fuel input
- Energy lost to atmosphere with exhaust gases through stack
- Heat of vaporization can be recovered if flue gases are cooled below water dew point
- When water vapour condenses, it releases heat of vaporization
- Condensing economizer recovers both heat of condensation (latent heat) and sensible heat

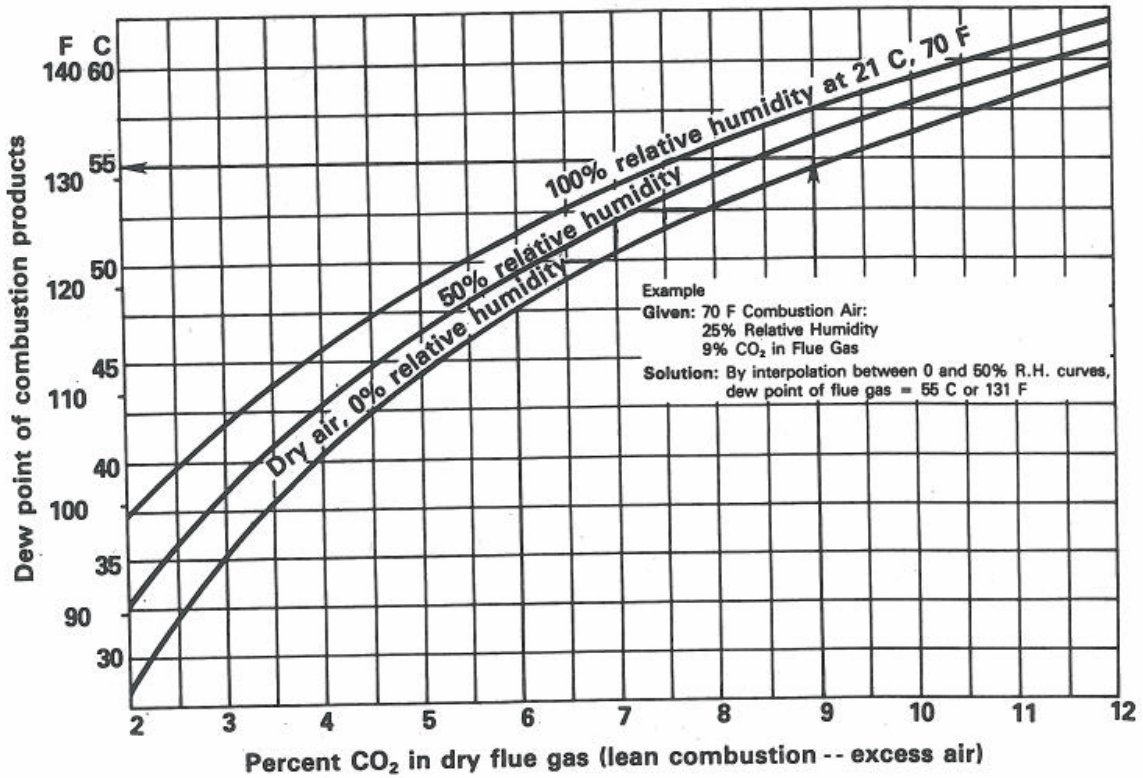
Condensation Starts Below Water Dew Point

Dew point varies with O2, CO2 and H2O in products of combustion

Example: For 4% O2, CO2 is 9.5%

Dew Point = 134 F

Figure 9.1. Dew points of products of combustion of natural gas, adapted from data courtesy of B.C. Hydro. Acid dew points may be appreciably higher.



Source: North American Combustion Handbook

Available Heat Varies with FG Temperature Leaving Economizer

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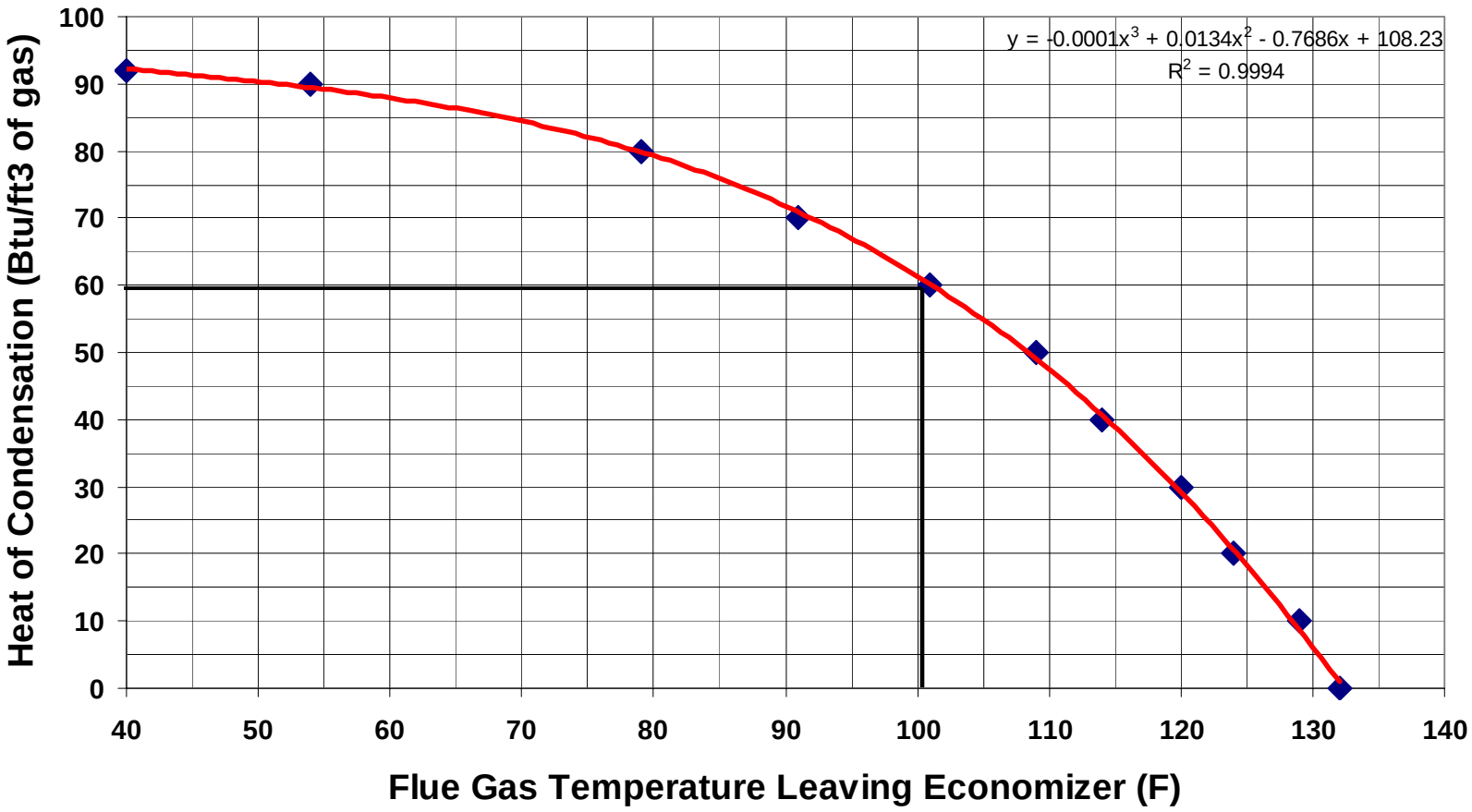
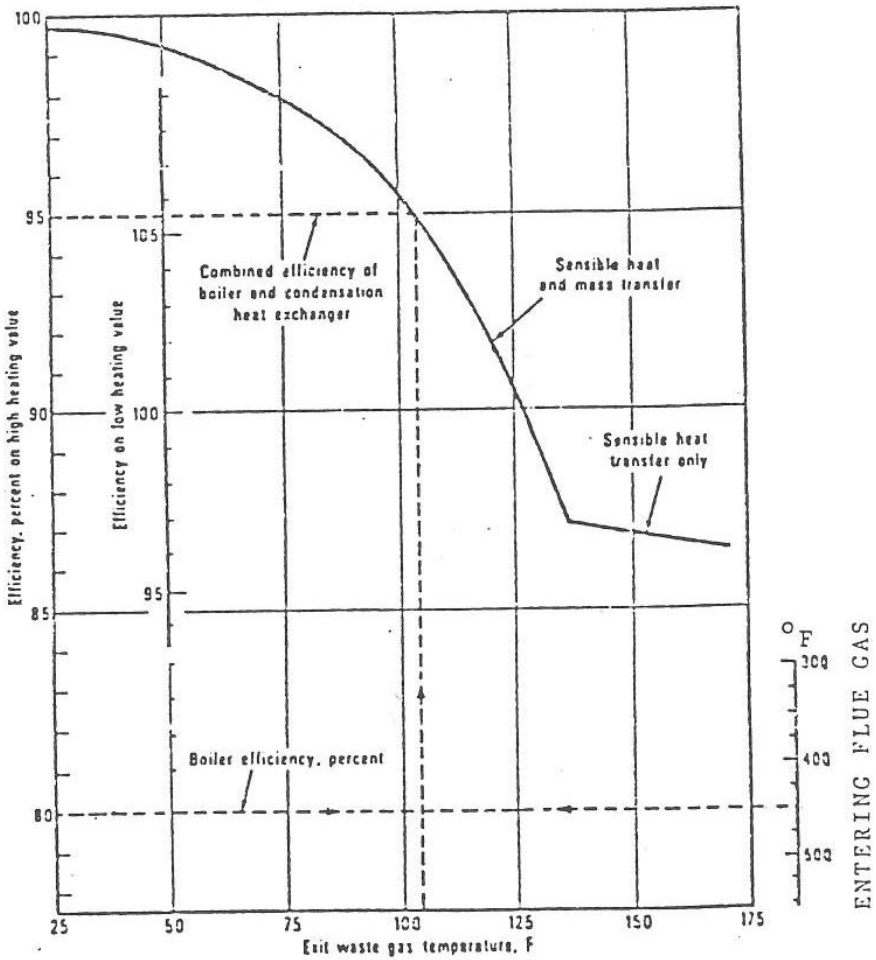
Heat of Condensation vs. Flue Gas Temperature
(Source: Sofame)



Efficiency Varies with FG Temperature Leaving Economizer

- X-axis: Exit Flue Gas Temp
- Y-axis: Efficiency – percent of high heating value
- Latent heat transfer starts at 137 F
- Excess air 15%
- Entering flue gas temp 450 F
- Exit Flue gas temp 105 F
- Efficiency w/o economizer 80%
- Efficiency with condensing economizer 95%

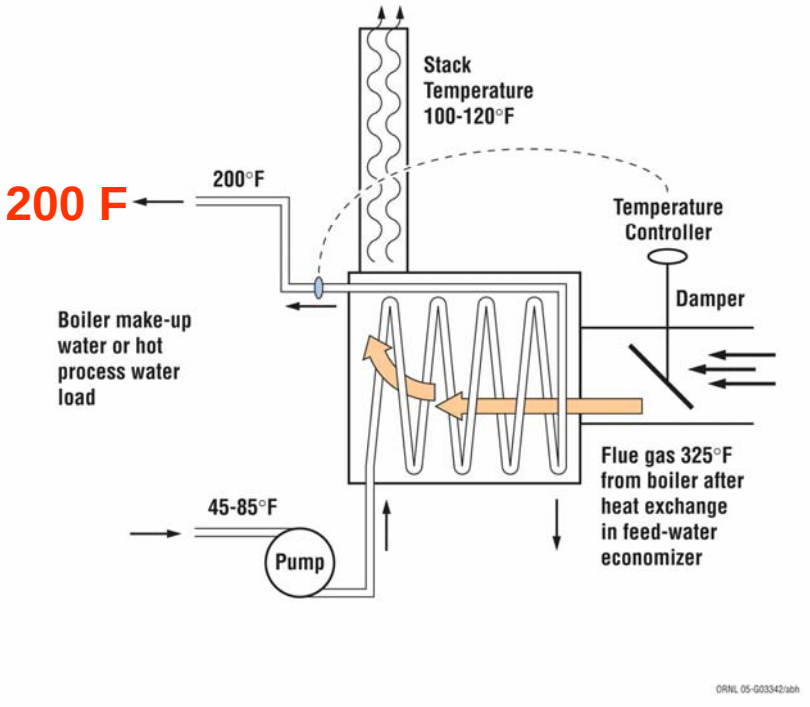


2 Condensation heat exchanger performance in terms of exit waste gas temperatures. Based on natural gas from the Lacq source in France burned with 15 percent excess air.

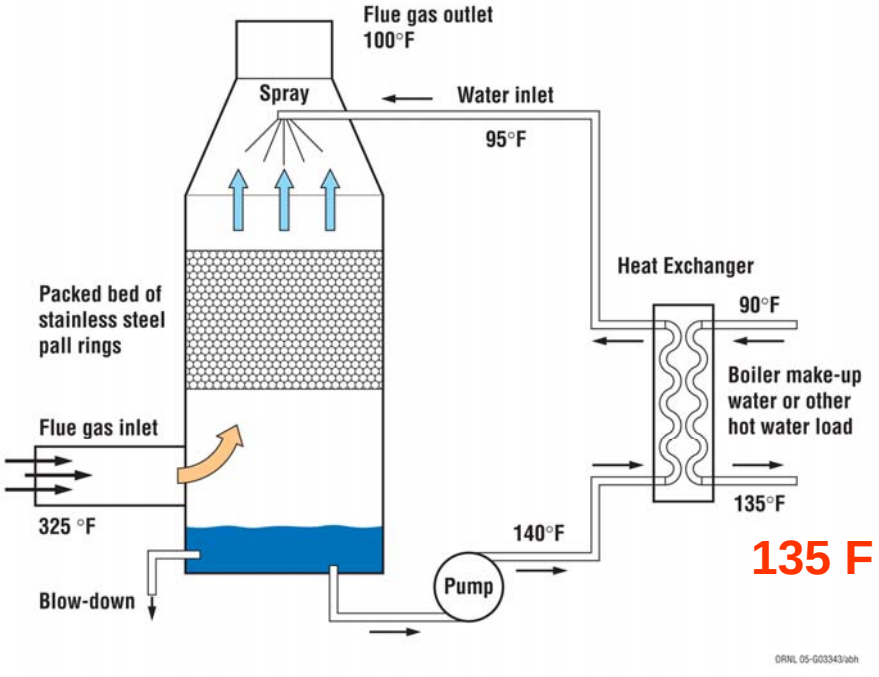
Heating/Piping/Air Conditioning, October 1974

Types of Condensing Economizers

Indirect Contact

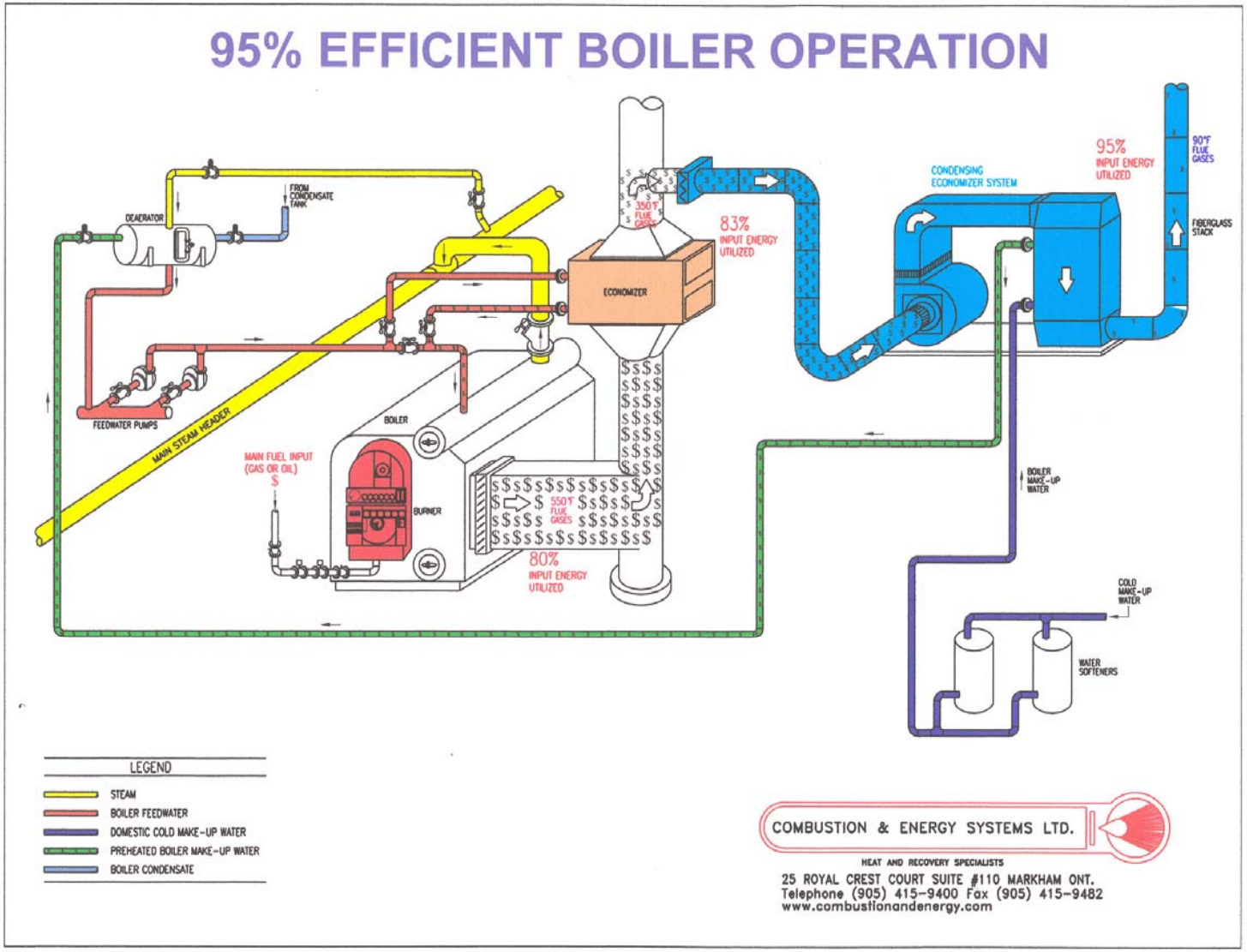


Direct Contact



Source: DOE Condensing Economizers Tip Sheets

Indirect Economizer



Direct Contact Economizer

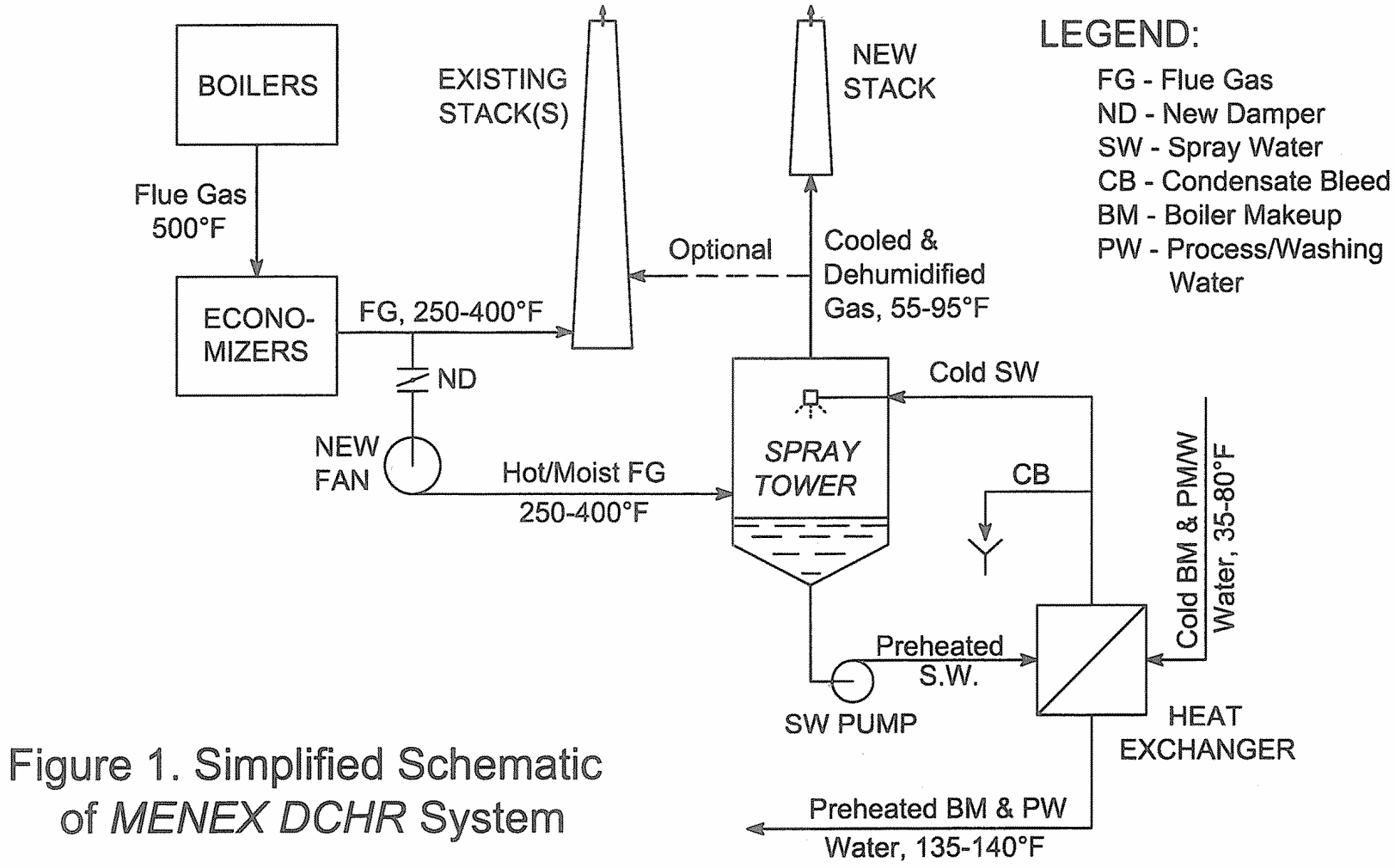
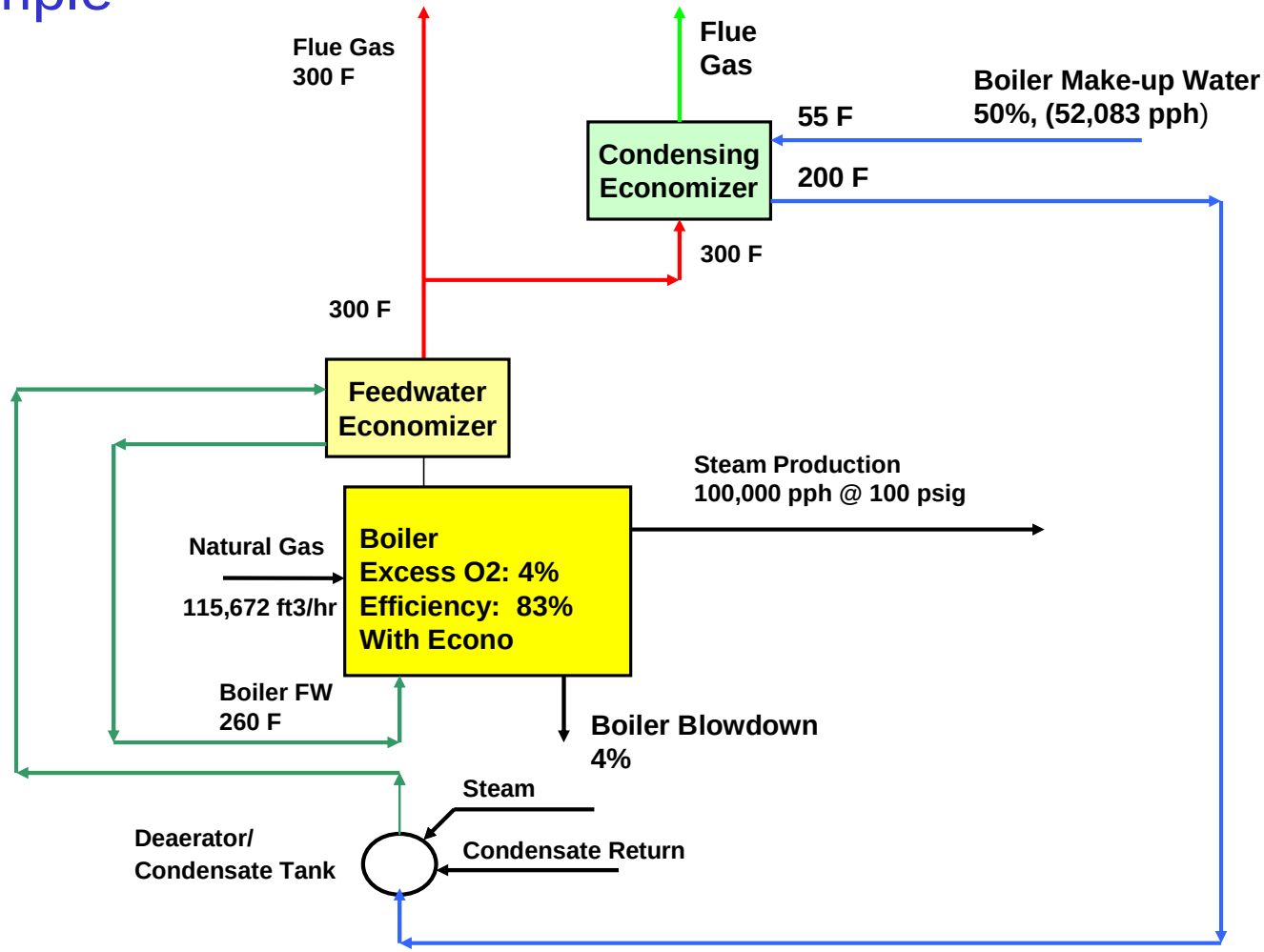


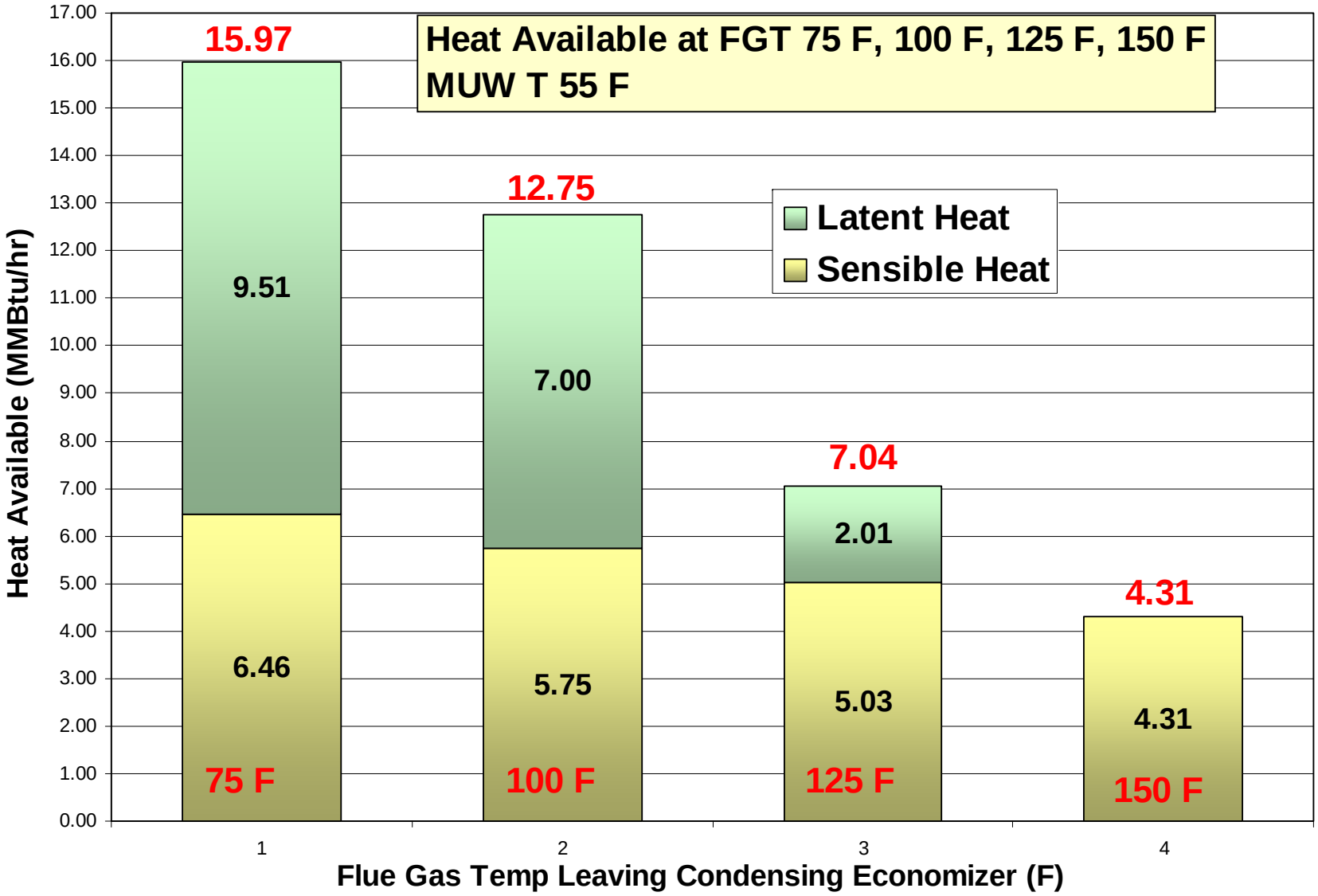
Figure 1. Simplified Schematic of *MENEX DCHR* System

Energy Saving Potential with Condensing Economizer

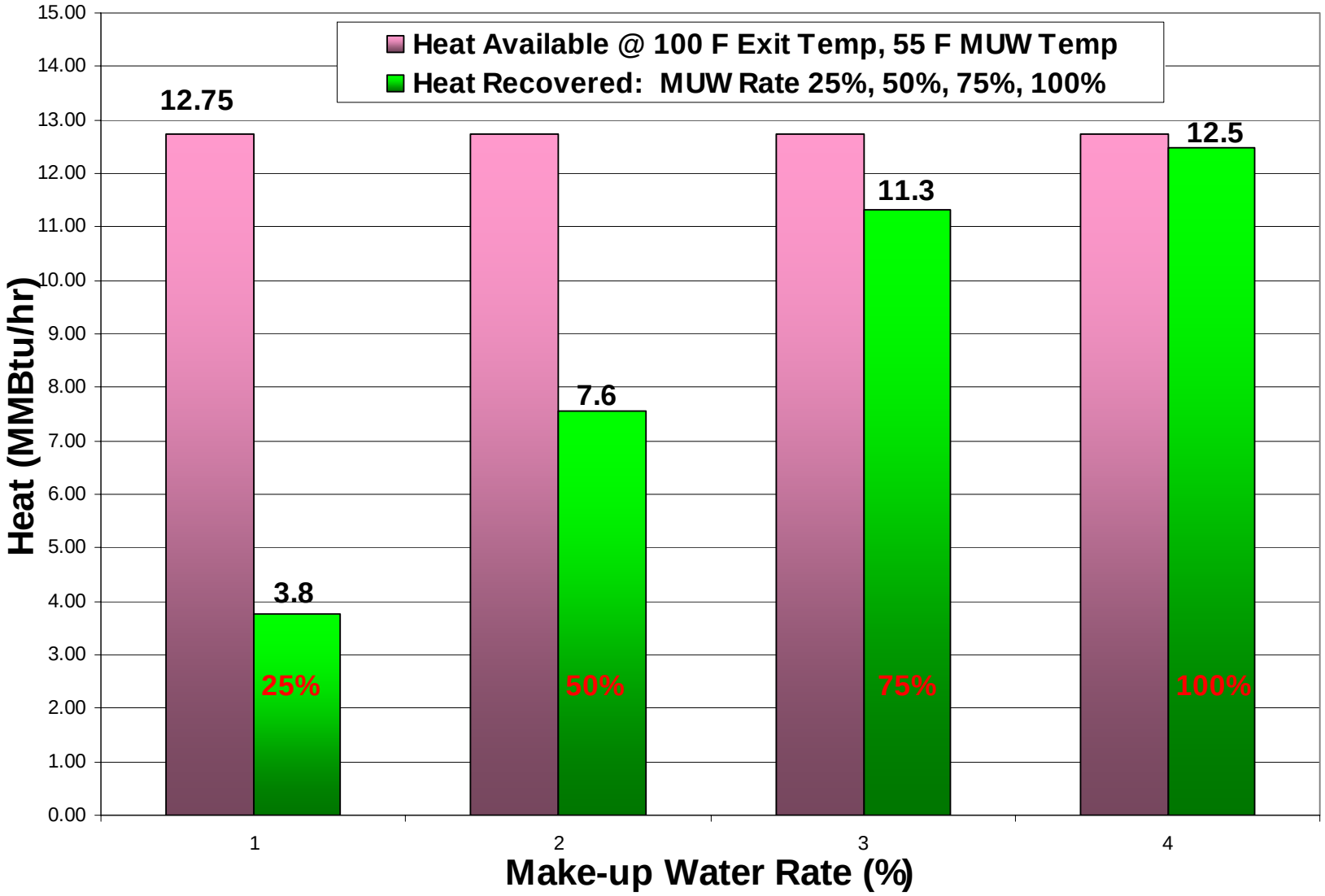
Example



Available Heat Varies with FG Temp Leaving Condensing Economizer



Recovered Heat Depends on Heat Sink Size



Gas Saving Potential

Steam production	100,000 pph
Make-up water flow rate	50%
Make-up water temperature entering condensing economizer	55 F
Make-up water temperature leaving condensing economizer	200 F
Flue gas temperature leaving condensing economizer	100 F
Energy recovered	7.55 MMBtu/hr
Boiler operating hours	8000 hrs
Gas cost	$8/MMBtu
Energy cost savings	$582,000

Typical Applications

- **Industries with steam boilers, requiring large amount of hot water such as make-up, washing, process, DHW**
- **Best Candidates:**
  - **Textile, commercial laundries**
  - **Food and beverage**
  - **Breweries**
  - **Non-integrated paper mills**
  - **Chemicals**
  - **District heating**
  - **Large hospitals**
  - **Green houses**

Case Study: Indirect Condensing Economizer

Menu Foods – Pet Food Mfg , Toronto

Enbridge Customer

- Two 350 HP coil tube boilers, 105 psig saturated steam
- 100% boiler make-up water
- 5 day x 24 hr operation
- ConDex condensing economizer system installed on roof
- Pull exhaust from two stacks into one common duct feeding Condex

Case Study: Indirect Condensing Economizer

Menu Foods – Pet Food Mfg , Toronto

Enbridge Customer

System heats boiler make up water from 65 F up to 165 F

At maximum load the system recovers 2,541,000 Btu/hr

Projected Gas savings: $190,000

Payback: 1.4 yrs

Case Study: Indirect Condensing Economizer

W.O. Hospital, Greater Toronto Area
Enbridge Customer

ConDex Economizer installed to recover waste heat from 3 x 450 HP firetube boilers.

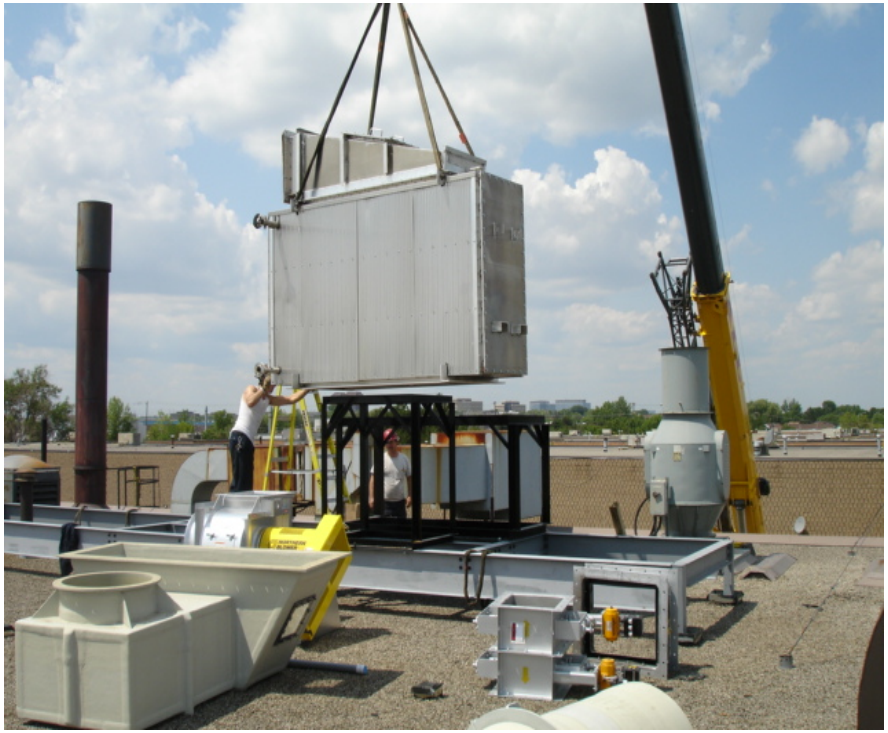
Two Stages of separate heat recovery sections heat:

- bldg heating loop water (160 to 190 F)
- boiler make up water (45 up to 175 F)

Energy saving: 4,293,800 Btu/hr

Annual cost savings: $421,900

Installed payback: 8.5 months

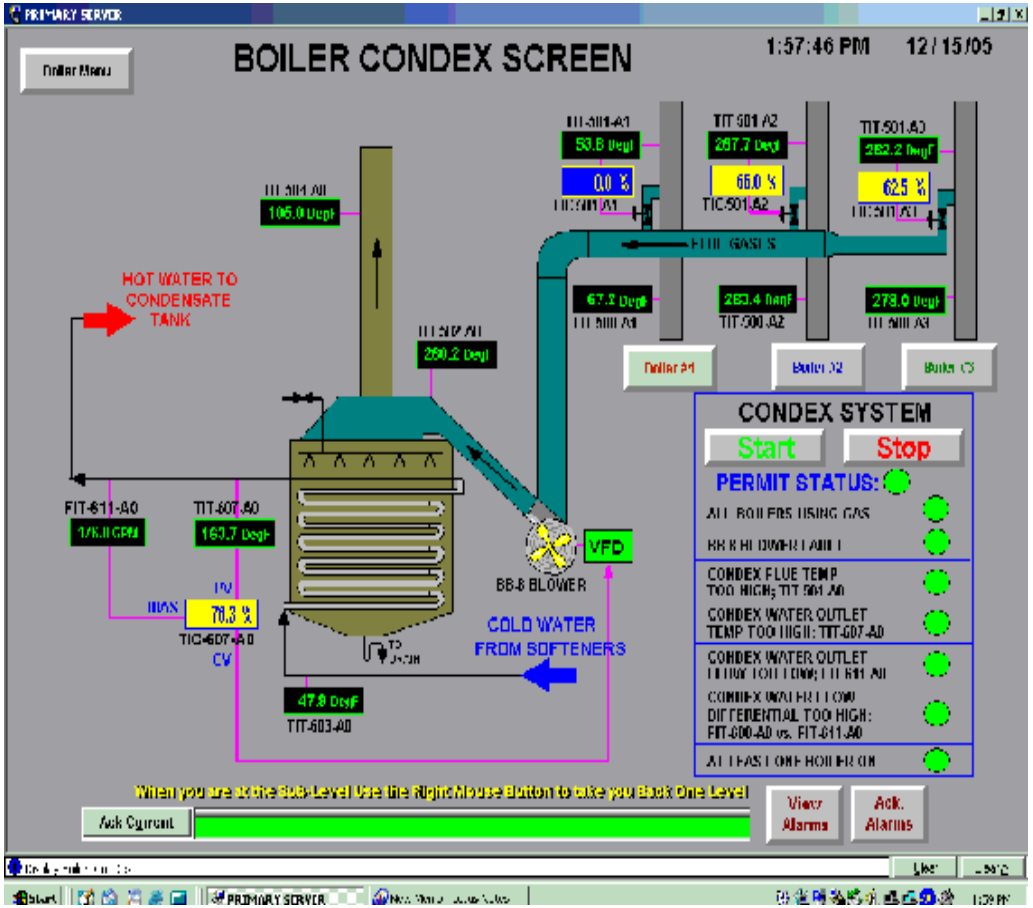


Case Study: Indirect Condensing Economizer

Bunge North America, USA

- **ConDex System heats 183 GPM of boiler make up water from 60 F up to 185 F.**
- **Exit flue gas temperature cooled to 105 F.**
- **System recovers avg. 11,200,000 Btu/hr**
- **Annual savings delivered:**

  $ 1,035,000.00
- **Fuel saving: 8.75% of fuel cost**
- **Payback less than 6 months**



Source: Combustion and Energy System, Canada

Case Study: Direct Contact Condensing economizer
Dial Corporation, Chicago area

- Menex system installed on two 75,000 pph 800 psig saturated steam boilers

- Steam Production
  - 95,000 pph summer
  - 130,000 pph winter
- Installed after existing FW economizer
- Preheat boiler make-up water to 135 F
- Installed cost: $600,000
- Annual savings: $400,000
- Payback: 1.5 yrs

Source: Menex Inc., Canada

Case Study: Direct Contact Condensing Economizer
Dial Corporation, Chicago area

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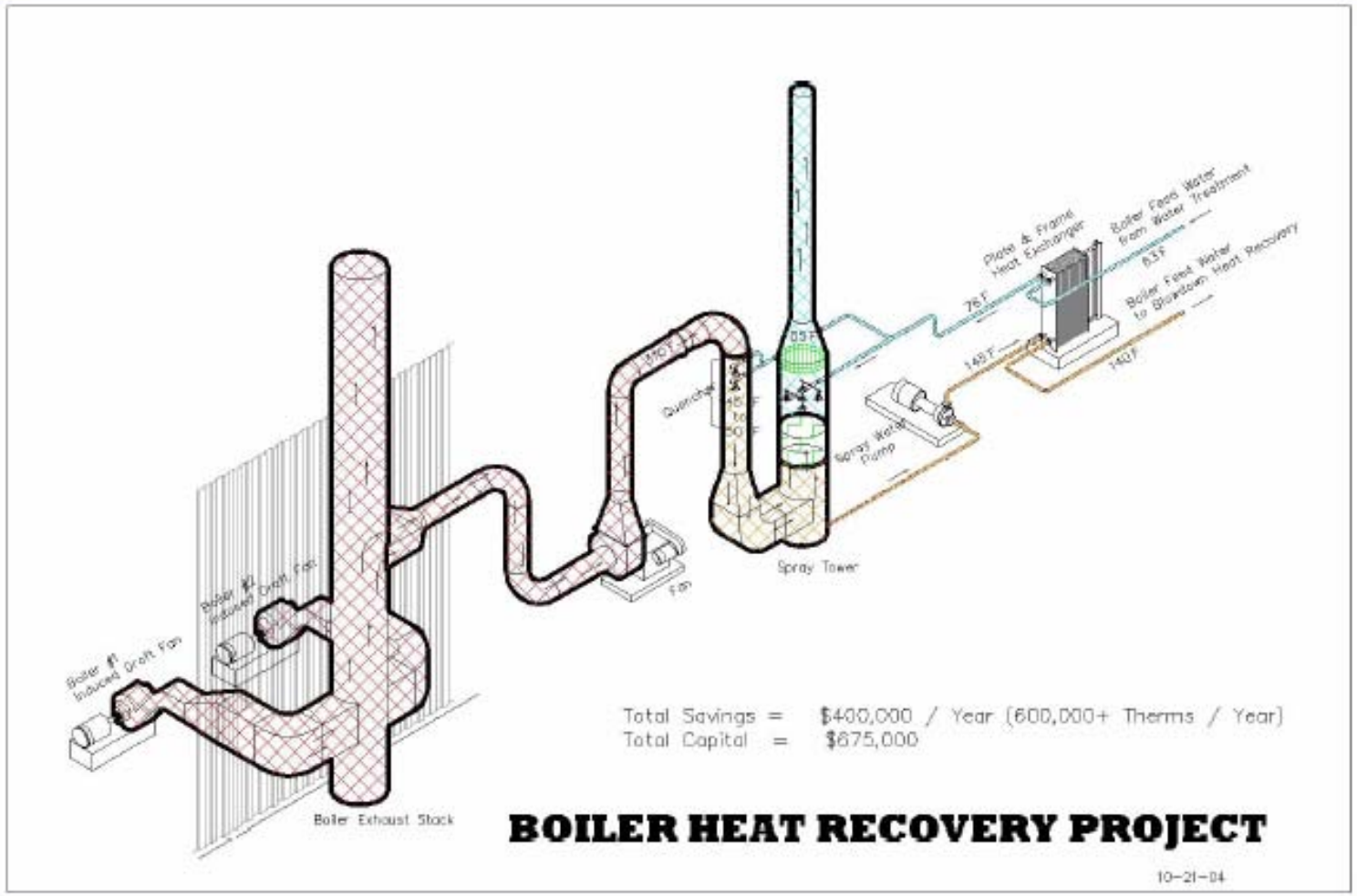


Source: Menex Inc., Canada

Key Considerations

- **Establish how much heat is available**
  - **Existing FW economizer, Flue gas temp, excess O2, steam production, gas consumption, hours of operation**
- **Is there sufficient heat sink available**
  - **Boiler make-up water,**
  - **Domestic hot water**
  - **Process water**
- **Entering temperature of heat sink must be below dew point to cause condensation**
- **Evaluate impact on existing system including blow down, flash steam, DA, water treatment etc.**
- **Fuel used**

Key Considerations

- Space for installation, stacks, icing due to plume impingement, indoor outdoor installation etc.
- Cost savings, installed cost, payback
- Direct versus Indirect?
  - site specific
  - customer preference
  - Cost
  - temp requirement
  - Application
  - heat sink etc.

Major Barriers for Market Penetration

- Not an “off-the-shelf” technology. Each application is an engineered solution
- Requires good understanding of technology and its application
- Needs a suitable heat sink. Small amounts of make-up water (25%) capture only a small portion of available heat
- Project approval faces same issues as any other steam and boiler energy efficiency related projects. Steam is considered a “necessary evil” and does not get same attention as production and product quality
- Initial work conducted in 80’s carries stigma related to Sulfur induced corrosion which is not an issue with natural gas

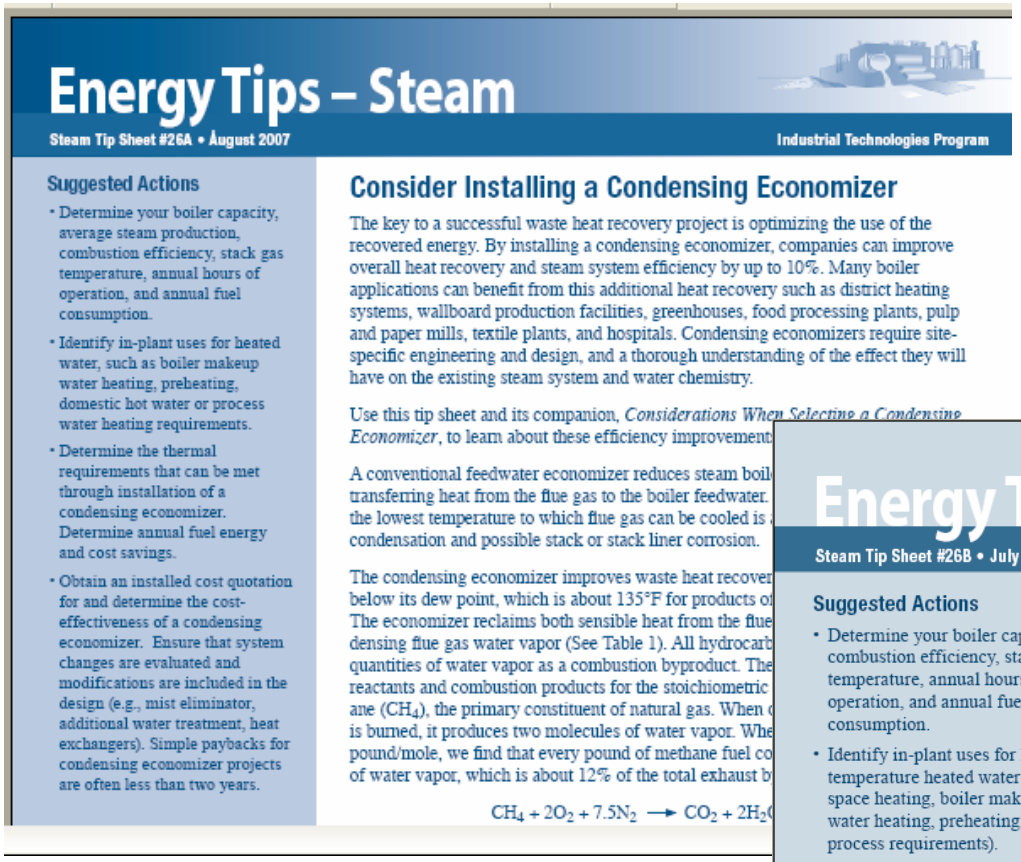
Concluding Remarks

- Condensing heat recovery is a proven, commercially available cost effective technology
- Offers significant un-tapped energy saving potential for boiler applications. Could be applied to recover latent heat from paper machine hoods, dryers and gas turbine/HRSG exhaust.
- Natural gas prices above $5 per MMBtu offer attractive payback
- Need to increase awareness of technology and its applications.

Concluding Remarks

- Need to include condensing economizer as part of a standard steam plant assessment
- Organizations such as ESC, DOE, NRCan, natural gas utilities can help increase awareness
- ESC workshops and DOE condensing economizer tip sheets offer significant help to increase awareness

DOE Best Practices Steam Tip Sheets



Energy Tips – Steam

Steam Tip Sheet #26A • August 2007

Industrial Technologies Program

Suggested Actions

- Determine your boiler capacity, average steam production, combustion efficiency, stack gas temperature, annual hours of operation, and annual fuel consumption.
- Identify in-plant uses for heated water, such as boiler makeup water heating, preheating, domestic hot water or process water heating requirements.
- Determine the thermal requirements that can be met through installation of a condensing economizer. Determine annual fuel energy and cost savings.
- Obtain an installed cost quotation for and determine the cost-effectiveness of a condensing economizer. Ensure that system changes are evaluated and modifications are included in the design (e.g., mist eliminator, additional water treatment, heat exchangers). Simple paybacks for condensing economizer projects are often less than two years.

Consider Installing a Condensing Economizer

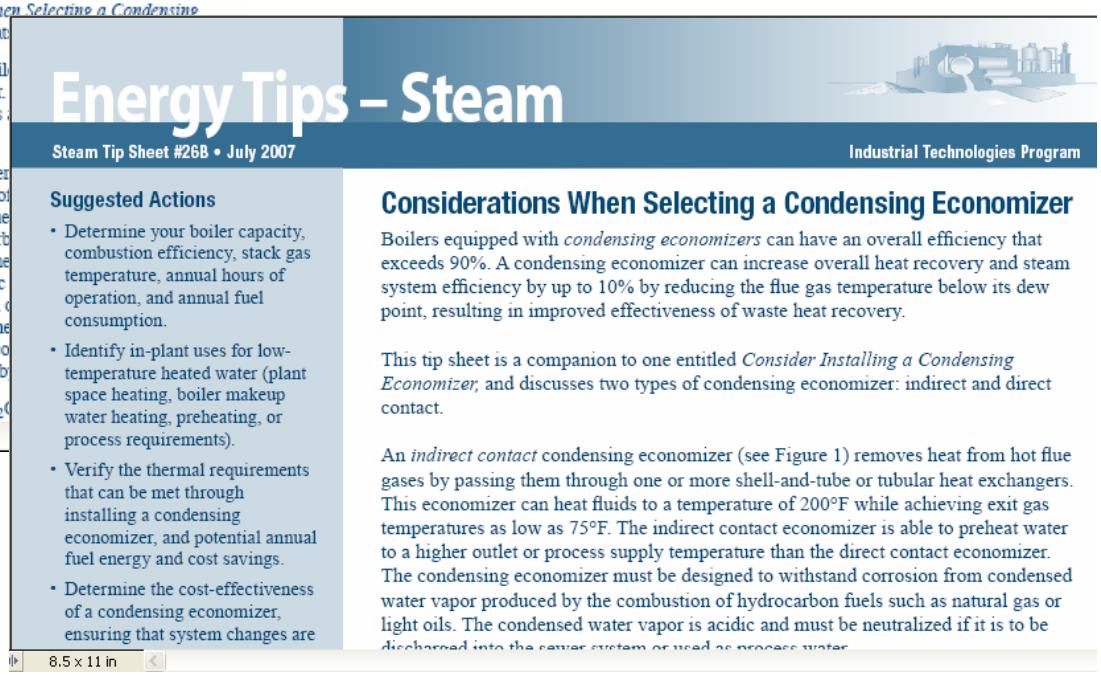
The key to a successful waste heat recovery project is optimizing the use of the recovered energy. By installing a condensing economizer, companies can improve overall heat recovery and steam system efficiency by up to 10%. Many boiler applications can benefit from this additional heat recovery such as district heating systems, wallboard production facilities, greenhouses, food processing plants, pulp and paper mills, textile plants, and hospitals. Condensing economizers require site-specific engineering and design, and a thorough understanding of the effect they will have on the existing steam system and water chemistry.

Use this tip sheet and its companion, *Considerations When Selecting a Condensing Economizer*, to learn about these efficiency improvement

A conventional feedwater economizer reduces steam boil transferring heat from the flue gas to the boiler feedwater. the lowest temperature to which flue gas can be cooled is condensation and possible stack or stack liner corrosion.

The condensing economizer improves waste heat recover below its dew point, which is about 135°F for products o The economizer reclaims both sensible heat from the flue densing flue gas water vapor (See Table 1). All hydrocarb quantities of water vapor as a combustion byproduct. The reactants and combustion products for the stoichiometric ane (CH_4), the primary constituent of natural gas. When is burned, it produces two molecules of water vapor. Whe pound/mole, we find that every pound of methane fuel co of water vapor, which is about 12% of the total exhaust b

$$CH_4 + 2O_2 + 7.5N_2 \longrightarrow CO_2 + 2H_2$$



Energy Tips – Steam

Steam Tip Sheet #26B • July 2007

Industrial Technologies Program

Suggested Actions

- Determine your boiler capacity, combustion efficiency, stack gas temperature, annual hours of operation, and annual fuel consumption.
- Identify in-plant uses for low-temperature heated water (plant space heating, boiler makeup water heating, preheating, or process requirements).
- Verify the thermal requirements that can be met through installing a condensing economizer, and potential annual fuel energy and cost savings.
- Determine the cost-effectiveness of a condensing economizer, ensuring that system changes are

8.5 x 11 in

Considerations When Selecting a Condensing Economizer

Boilers equipped with *condensing economizers* can have an overall efficiency that exceeds 90%. A condensing economizer can increase overall heat recovery and steam system efficiency by up to 10% by reducing the flue gas temperature below its dew point, resulting in improved effectiveness of waste heat recovery.

This tip sheet is a companion to one entitled *Consider Installing a Condensing Economizer,* and discusses two types of condensing economizer: indirect and direct contact.

An *indirect contact* condensing economizer (see Figure 1) removes heat from hot flue gases by passing them through one or more shell-and-tube or tubular heat exchangers. This economizer can heat fluids to a temperature of 200°F while achieving exit gas temperatures as low as 75°F. The indirect contact economizer is able to preheat water to a higher outlet or process supply temperature than the direct contact economizer. The condensing economizer must be designed to withstand corrosion from condensed water vapor produced by the combustion of hydrocarbon fuels such as natural gas or light oils. The condensed water vapor is acidic and must be neutralized if it is to be

Major Manufacturers

Indirect Contact Economizers

Combustion and Energy System, Toronto, Canada
www.combustionandenergy.com

CHX Corporation, Clifton Park, NY
www.chx.com

Sidel System USA, California
www.sidelsystems.com

Direct Contact Economizers

Direct Contact Inc. Renton, WA
www.dciheat.com

Kemco System
www.kemcosystems.com

Menex, Toronto, Canada
Ph: (905) 276-1774

Sofame, Montreal, Canada
www.sofame.com

Thermal Energy System, Ottawa, Canada
www.thermalenergy.com