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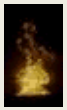

Energy Efficiency Strategies Waste Heat Recovery & Emission Reductions

TUR Continuing Education Conference

Sturbridge Host Hotel

April 14, 2010

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With fuel prices increasing and environmental pressure to reduce emissions, it makes sense to consider recovering exhausted energy from plant processes.

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Recovered energy from waste heat can be used for preheating process air and liquid streams as well as for HVAC applications.

Utilizing waste heat not only reduces fuel consumption, but helps to improve efficiency and reduce green house gas emissions.

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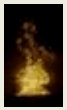

- For every 1 million BTU of natural gas burned there is approximately 118 pounds of CO2* Generated.

- Over an 8700 hour operating year, that is 1,026,600 Lbs (or 513 tons) of CO2 not emitted to our environment per million BTU recovered.

- Recovering one million BTU/Hr will release about 1000 lbs fewer Nitrogen Oxides into the atmosphere each year.

- Particulate matter and VOC emissions are also reduced by recovering waste heat to reduce total fuel burned.

*Source: Union Gas Ltd.

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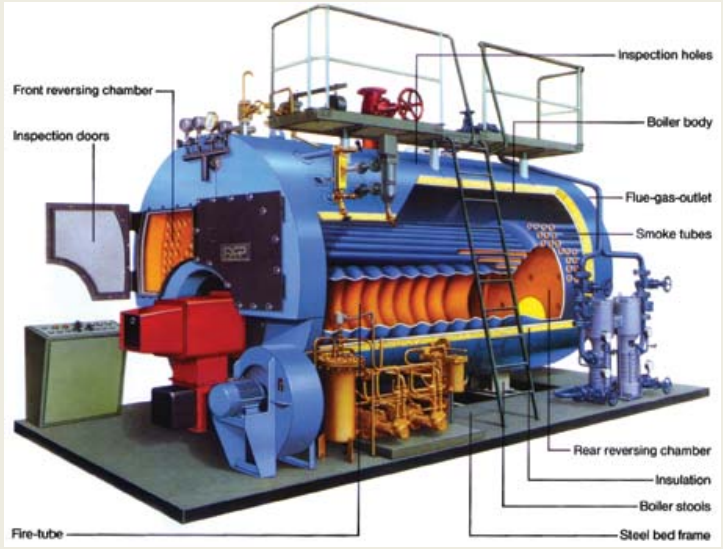

How Much Energy Is Lost in Exhaust Gases?

Application: Firetube Boiler

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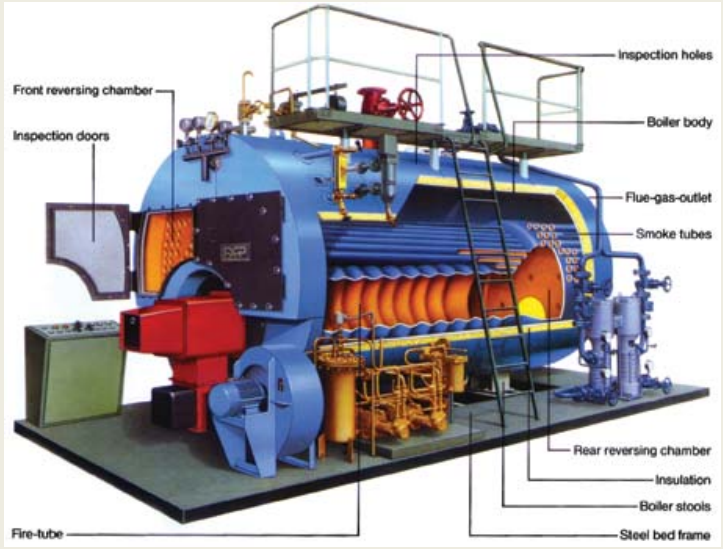

Application: Firetube Boiler

How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Boiler Size – 500 HP (16MMBTU/HR)

Gas Outlet Temperature = 350 ^{o}F

13,760 #/Hr Exhaust at 350 ^{o}F

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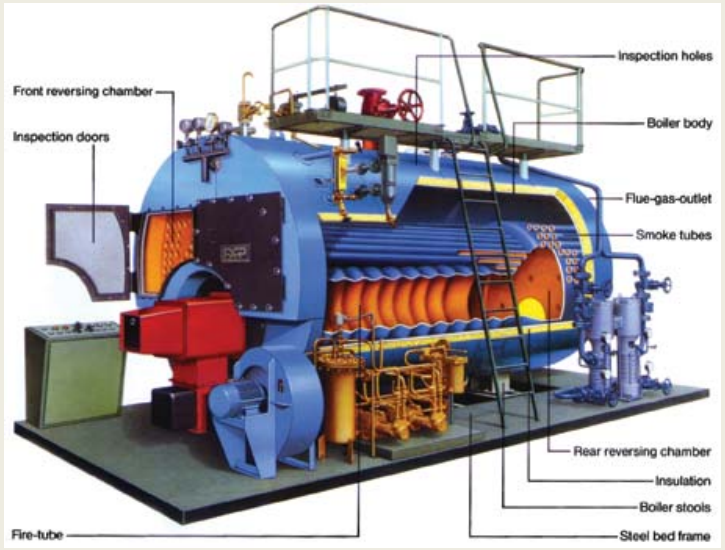

Application: Firetube Boiler

How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Boiler Size – 500 HP (16MMBTU/HR)

Gas Outlet Temperature = 350 ^{o}F

13,760 #/Hr Exhaust at 350 ^{o}F

1,000,000 BTU/Hr lost to atmosphere!

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Application: Dryer

How Much Energy Is Lost in Exhaust Gases?

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Application: Dryer

How Much Energy Is Lost in Exhaust Gases?

Assume 90 Degree Ambient Temp.

Process Exhaust Flow = 26,000 CFM

Gas Outlet Temperature = 196 ^{o}F

94,500 #/Hr Exhaust at 196 ^{o}F

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Application: Dryer

How Much Energy Is Lost in Exhaust Gases?

Assume 90 Degree Ambient Temp.

Process Exhaust Flow = 26,000 CFM

Gas Outlet Temperature = 196 ^{o}F

94,500 #/Hr Exhaust at 196 ^{o}F

2,400,000 BTU/Hr lost to atmosphere!

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How Much Energy Is Lost in Exhaust Gases?

Application: Thermal Fluid Heater

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How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Unit heat input = 7.5MMBTU/Hr

Gas Outlet Temperature = 500 ^{o}F

6,450 #/Hr Exhaust at 500 ^{o}F

Application: Thermal Fluid Heater

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How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Unit heat input = 7.5MMBTU/Hr

Gas Outlet Temperature = 500 ^{o}F

6,450 #/Hr Exhaust at 500 ^{o}F

704,000 BTU/Hr lost to atmosphere!

Application: Thermal Fluid Heater

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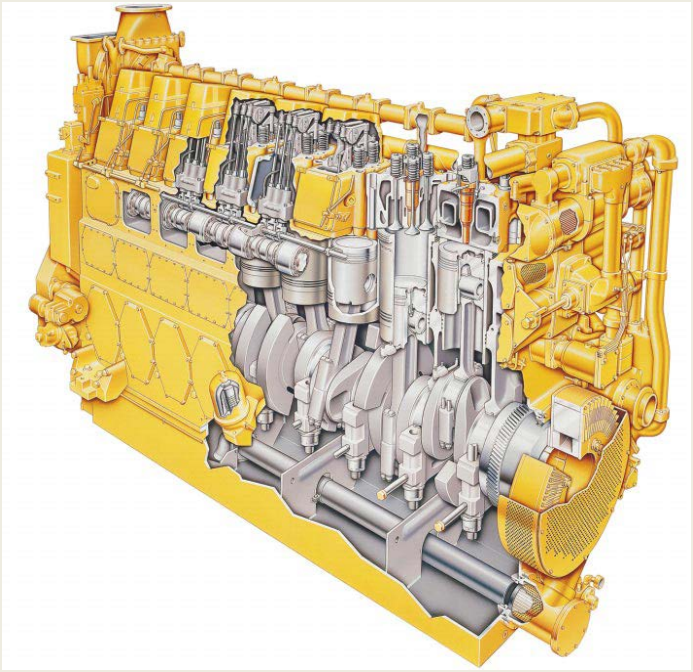

How Much Energy Is Lost in Exhaust Gases?

Application: Engine

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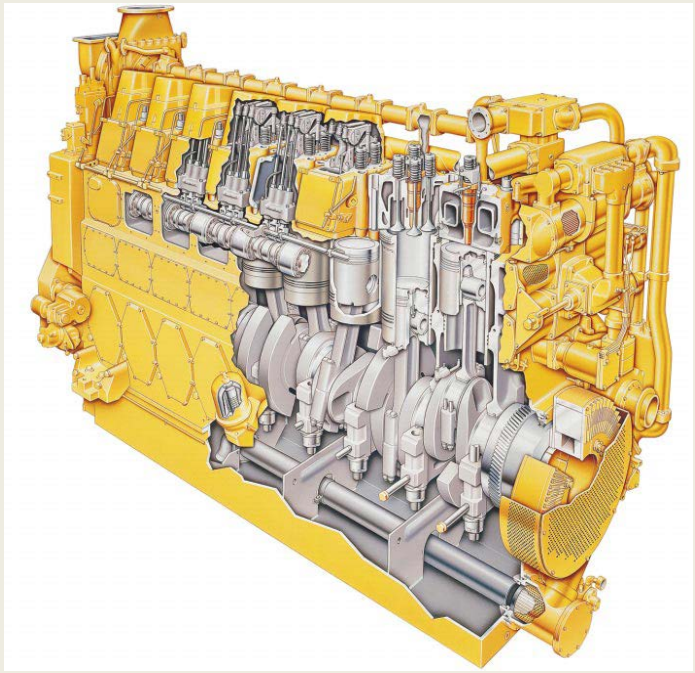

How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Exhaust gas flow = 775 CFM

Gas Outlet Temperature = 755 ^{o}F

Cooling water flow = 60 GPM

Cooling water outlet temperature = 183 ^{o}F

Application: Engine

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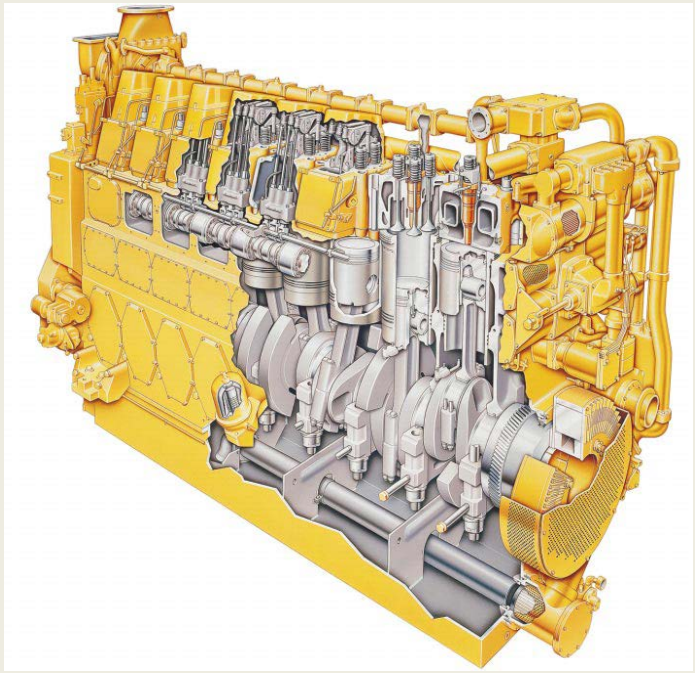

How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Exhaust gas flow = 775 CFM

Gas Outlet Temperature = 755 ^{o}F

Cooling water flow = 60 GPM

Cooling water outlet temperature = 183 ^{o}F

806,000 BTU/Hr lost to atmosphere!

Application: Engine

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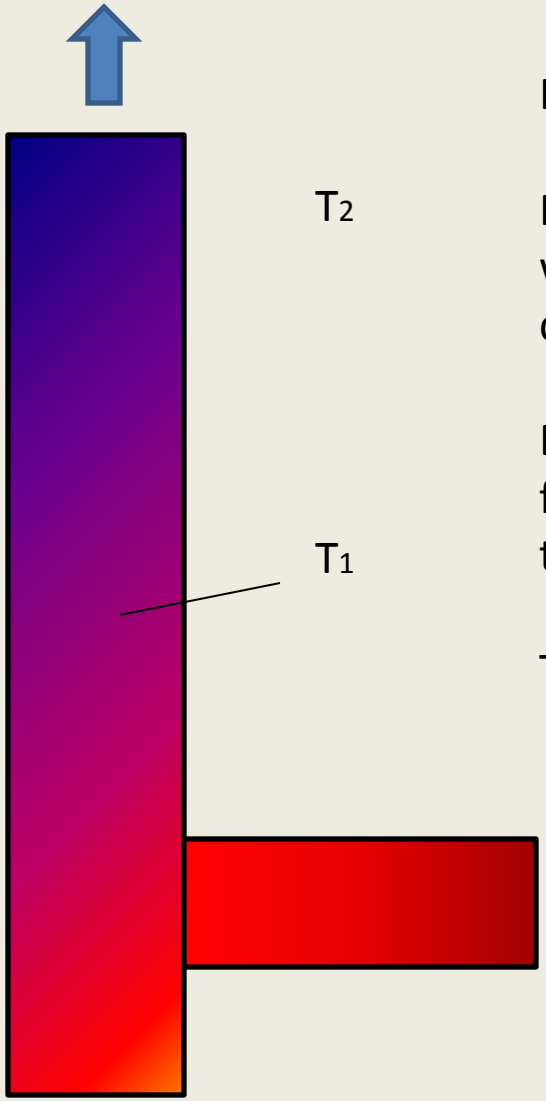

Not all exhausted energy is practical to recover

Recovery equipment becomes very large and costly when trying to drop exhaust temperatures down close to ambient temperatures.

Exhaust gases must maintain enough heat to allow for buoyancy with a positive flow and plume through the stack effect.

T1 (stack temperature) > T2 (ambient temperature)

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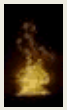

What to look for in your plant

Heat Sources

- Boilers
- Thermal Fluid Heaters
- Gas Turbines
- Ovens
- Dryers
- Engines
- Incinerators
- Fume Hoods

Heat Sinks

- Building Make Up Air
- Make Up Water
- Process Water/Fluids
- Clean Up Water
- Domestic Hot Water
- Swimming Pool
- Combustion Air Preheat
- HVAC Heating
- HVAC Cooling
- Electricity Generation

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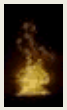

Heat sources from natural gas combustion are most effective for energy recovery.

Dryer exhaust with entrained moisture are also good heat sources.

Must be careful of exhaust streams with sulfur or other corrosive materials at reduced temperatures. Special materials and/or coatings are required.

Particulate in the gas stream may limit the type and efficiency of the recovery equipment.

Must keep in mind the pressure requirements of the system.

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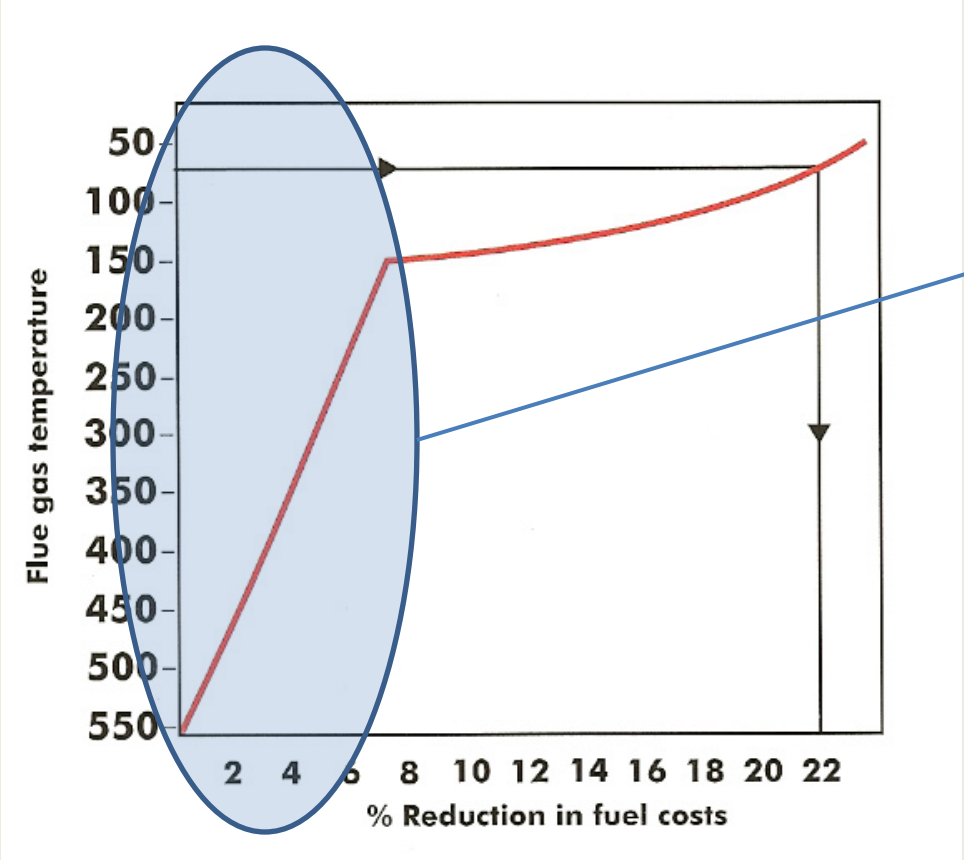
Sensible and Latent Heat



Air to Air Heat Exchangers, Energy Wheels & Standard Economizers utilize *Sensible* Heat Recovery

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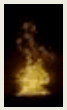


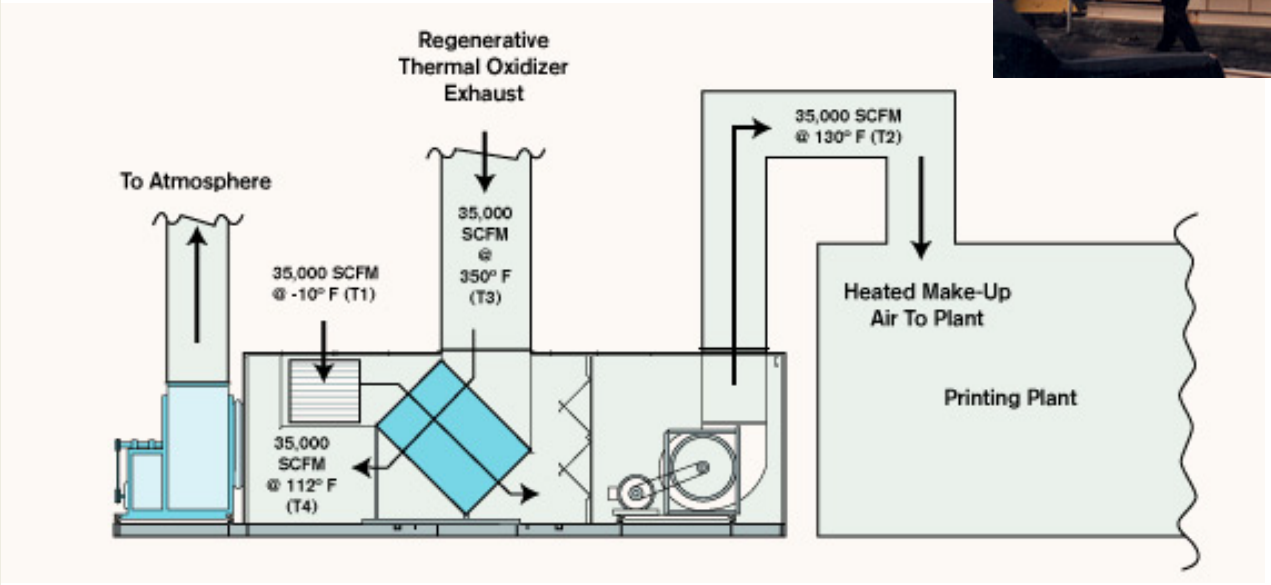
Heat Recovery Applications

Make Up Air

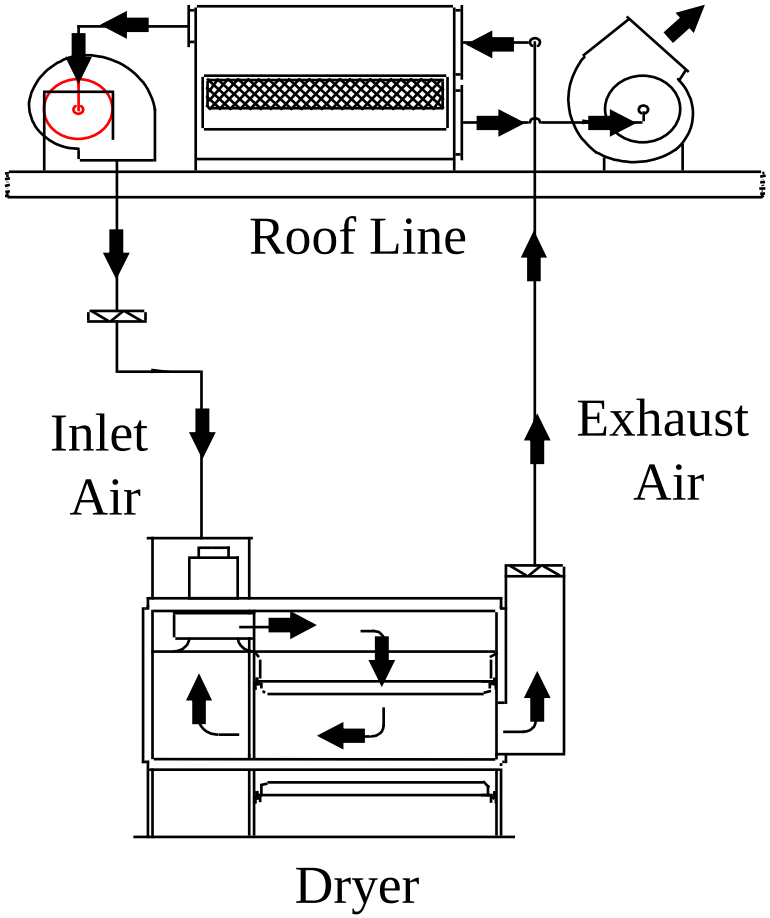
Vs

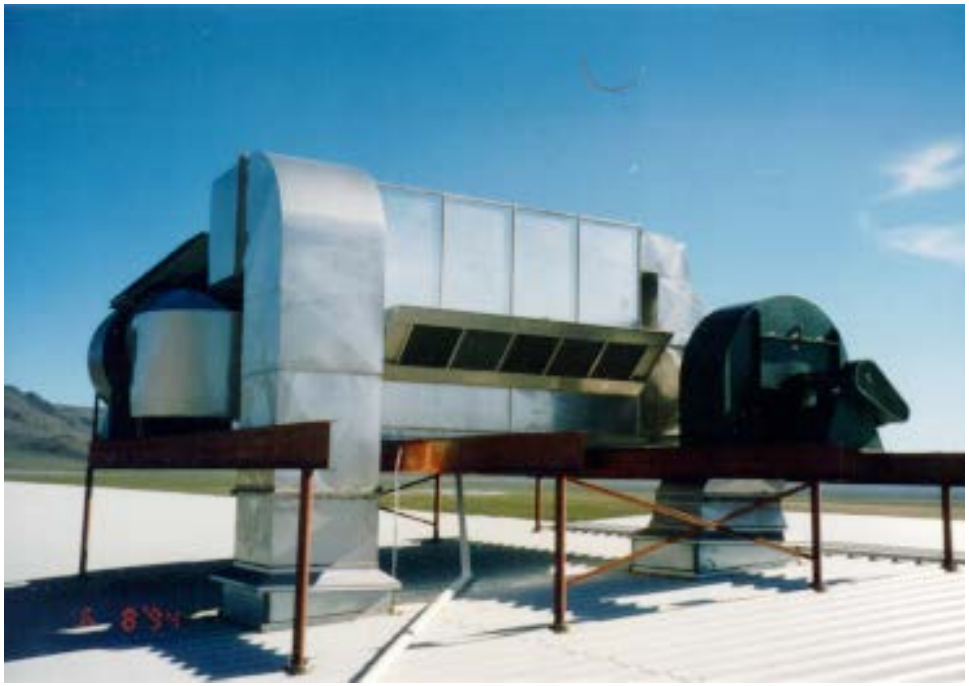
Process

Typical MAKEUP Heat Recovery System



Typical PROCESS Heat Recovery System





Comparison: Process and Make Up

When considering Air to Air Energy Recovery look at all your options and make the best decision. The process application also offsets the make-up air requirements saving an additional 750,000 BTU/Hr.

	PROCESS	BUILDING MAKE-UP
Installed Cost	$165,000.	$125,000
Operating Hrs	4,377 Hrs/Yr	2,958 Hrs/Yr (Winter)
BTU's Saved/Yr	13,942,517,453	7,517,034,070
Dollars Saved/yr	$117,410.	$63,301.
Payback	**1.44 Years**	**2.29 Years**

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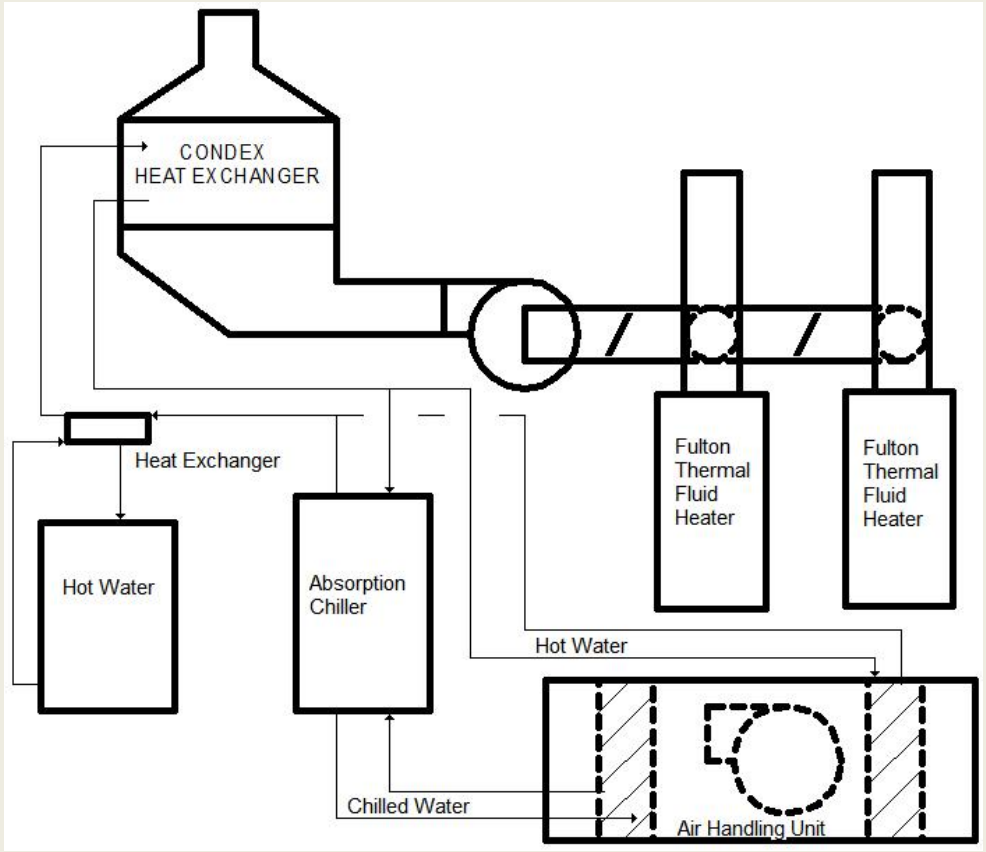
An Example of Year Round Energy Recovery for HVAC



Average Yearly Energy Recovered = 600,000 BTU/Hr

Offsets gas fired space heating in the winter and electric costs for air conditioning in the summer.

Reduced stack temperatures from 500F to 130F

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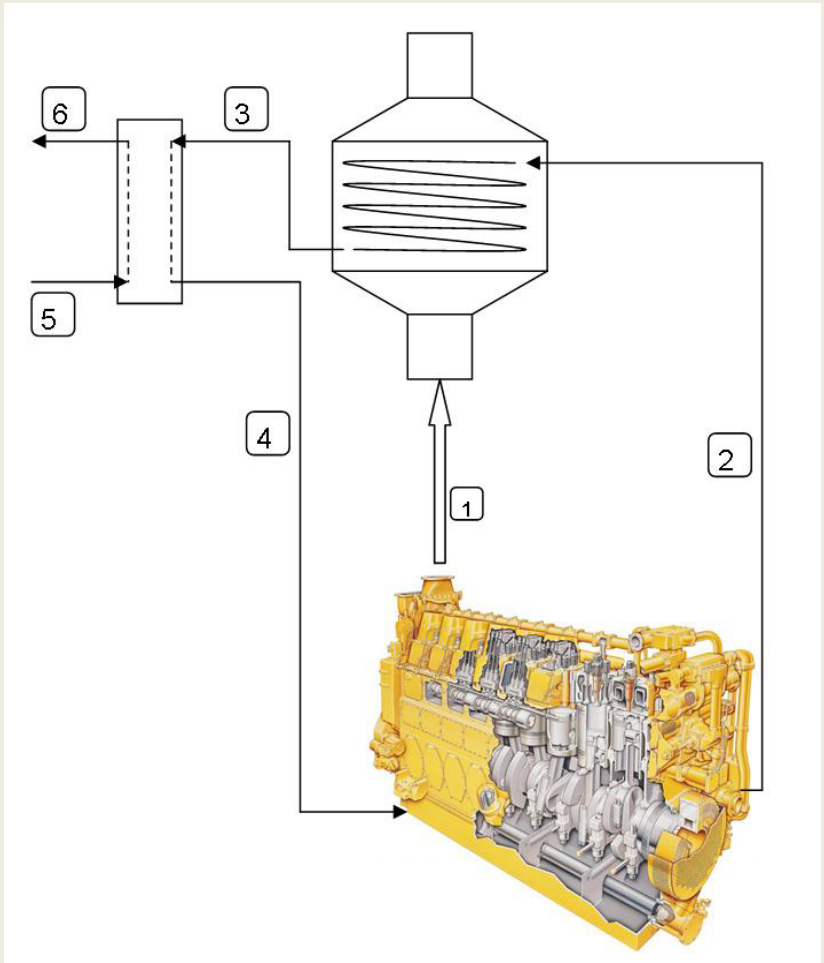
An Example of Year Round Energy Recovery for Domestic Hot Water



Gas fired engines used to drive chillers for the ice rink generate hot gas and hot engine cooling fluid.

The waste heat from the engine is used to heat domestic hot water for the adjacent High School.

Three engines provide 500,000 BTU/Hr of waste heat each, that is transferred to the domestic water.

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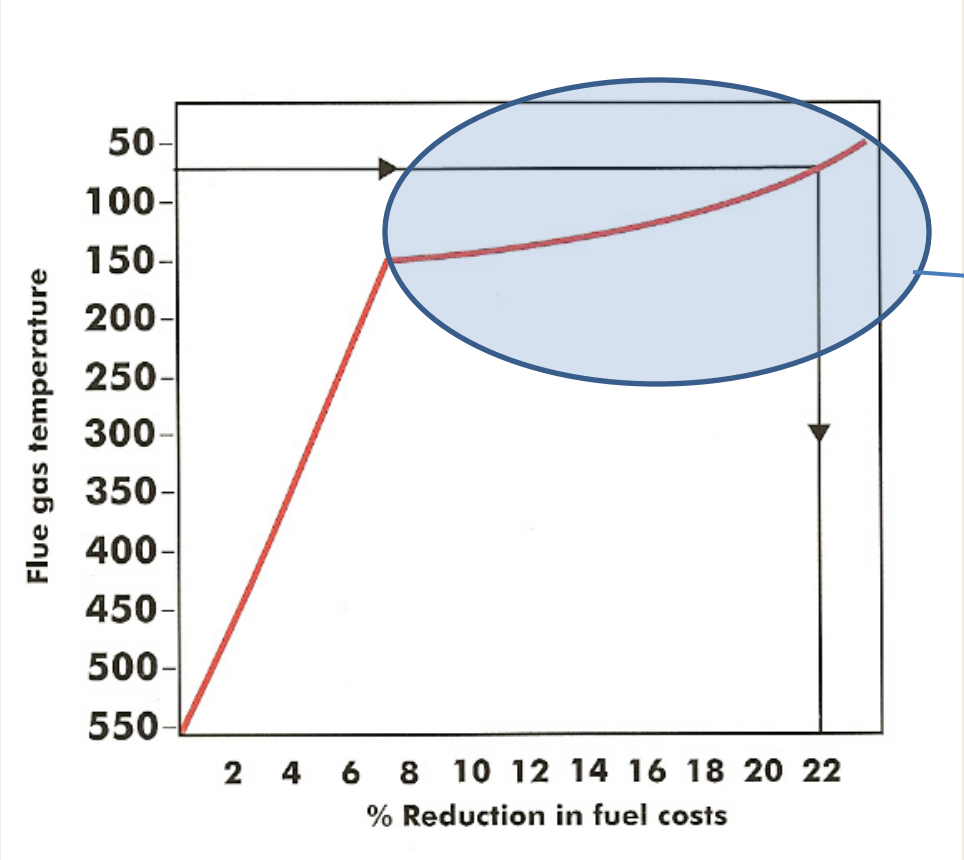


Condensing Economizers are designed to take advantage of latent heat recovery by condensing the water out of flue gases.

Condensing Heat Recovery Systems: The Energy Bonus!

- The normal combustion process of natural gas combines hydrogen and oxygen chemically to form water, which is instantly vaporized by the heat of combustion.

- This process absorbs approximately 17% of the total heat released by the fuel and it is normally lost to the atmosphere with the boiler exhaust gases.

Condensing Heat Recovery Reduces This Loss!

Condensing Heat Recovery Systems

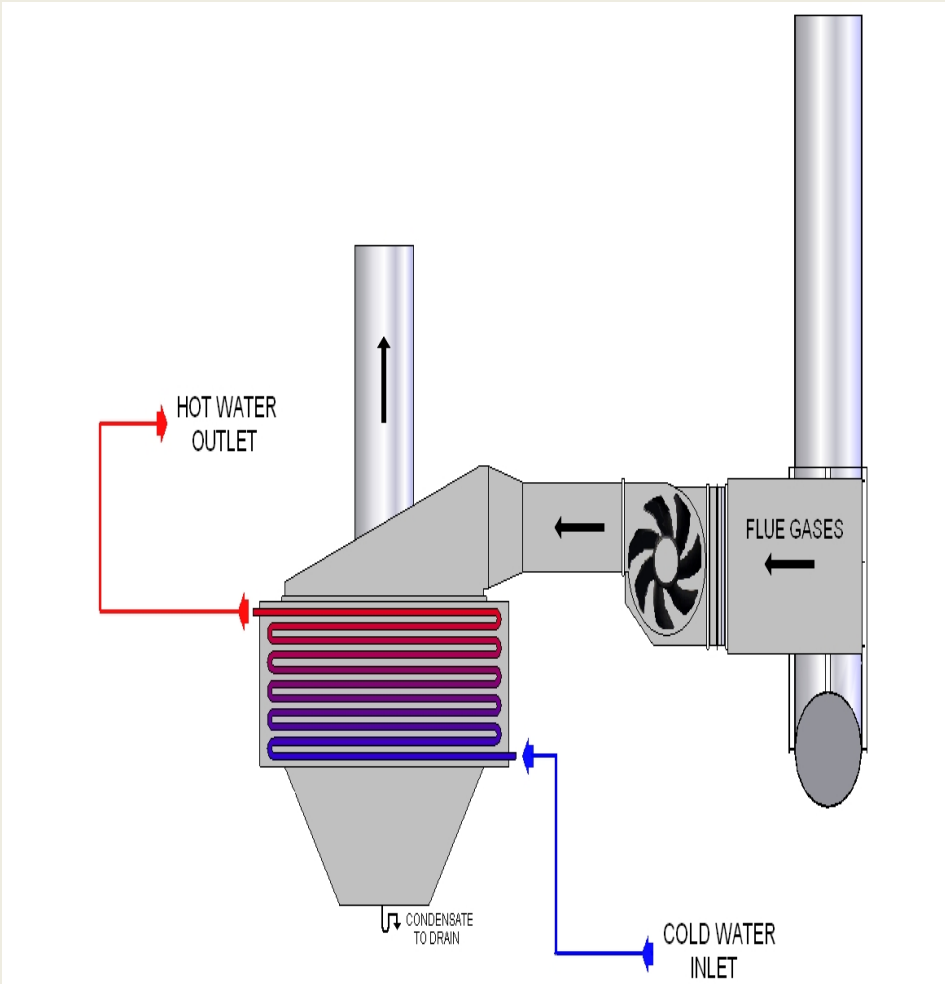
A condensing economizer improves heat recovery by recovering energy well below the dew point of the flue gas.

Standard heat recovery systems can reduce boiler stack temperatures to about 250 F, and are designed to avoid condensation of the flue gas.

The Goal: Recover the maximum amount of usable heat possible from your exhaust gas – you paid for it, you might as well use it!

HOW CONDENSING HEAT RECOVERY WORKS:

- Incoming cold fluid enters the Condensing exchanger
- Some of the tube and fin temperatures are below gas dew point and cause the vapors to condense out.
- The flue gas and heated liquid are not in contact (indirect contact heat exchange) with each other and the water remains pure.



WATER RECOVERY FROM EXHAUST GAS

- Condensed water recovery rates vary from 4 – 60 Gallons Per Minute, depending on the application.

- Water is reusable in many applications such as boiler make up water or process water.

Reduce Greenhouse Gas Emissions Through Energy Recovery

- For every 1 million Btu of natural gas burned there is approximately 118 pounds of CO2*
- Over an 8700 hour operating year, that is 1,026,600 lbs (or 513 tons) of CO2 not emitted to our environment per million Btu recovered!
- In addition to the efficiency effect, in the ConDex process CO_2 in the flue gas absorbs into the condensed water vapor, reducing gas emissions directly from the stack. Typical CO_2 gas reduction rate through the ConDex is 2.3 lb/hr

*Source: Union Gas Ltd.

CASE HISTORY

William Osler Hospital

- Dual stage ConDex System heats boiler make up water and domestic hot water for the hospital.
- Average energy recovery rate: 5,100,000 Btu/hr
- Capitol payback rate: 4 months.
- Greenhouse gas emission reduction: 3,200 tons /year!
- NOx emissions reduction: 2.11

Case Study

Graphic Packaging – Santa Clara, CA

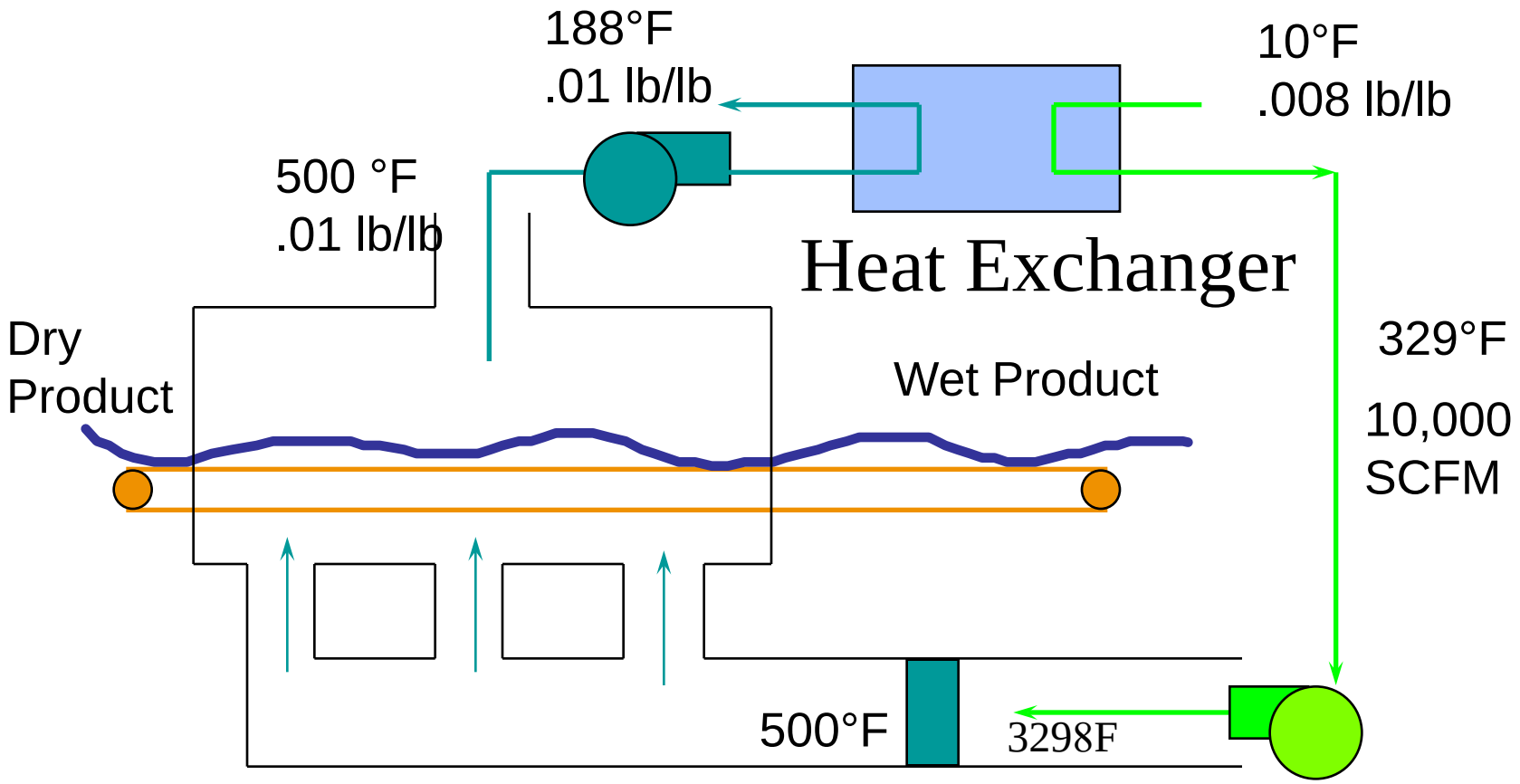
- **ConDex System Recovers waste heat from gas turbine / HRSG exhaust.**
- **Heats 1,300 GPM of process water to 180 deg F**
- **Recovers 25,000,000 Btu/hr at average load.**
- **At peak load, ConDex System recovers up to 28 GPM of water from the exhaust gas!**

CASE HISTORY

Heinz Inc – Stockton, CA

- Cylindrical In-Stack Condensing Economizer Installed on a 350 HP boiler.
- Recovers 1,264,000 Btu/hr.
- Yearly savings $105,900.00
- Annual CO2 Emissions reduction: 732 Tons/year
- Annual Water Recovery: 544,530 Gallons per year

Thermo Z on Oven Application



Without Heat Recovery 5,316,500 BTU's/Hr Consumed
With Heat Recovery ….1,883.009 BTU's/Hr Consumed
Savings …….. **3,433,491 BTU's/Hr Saved**

Munters

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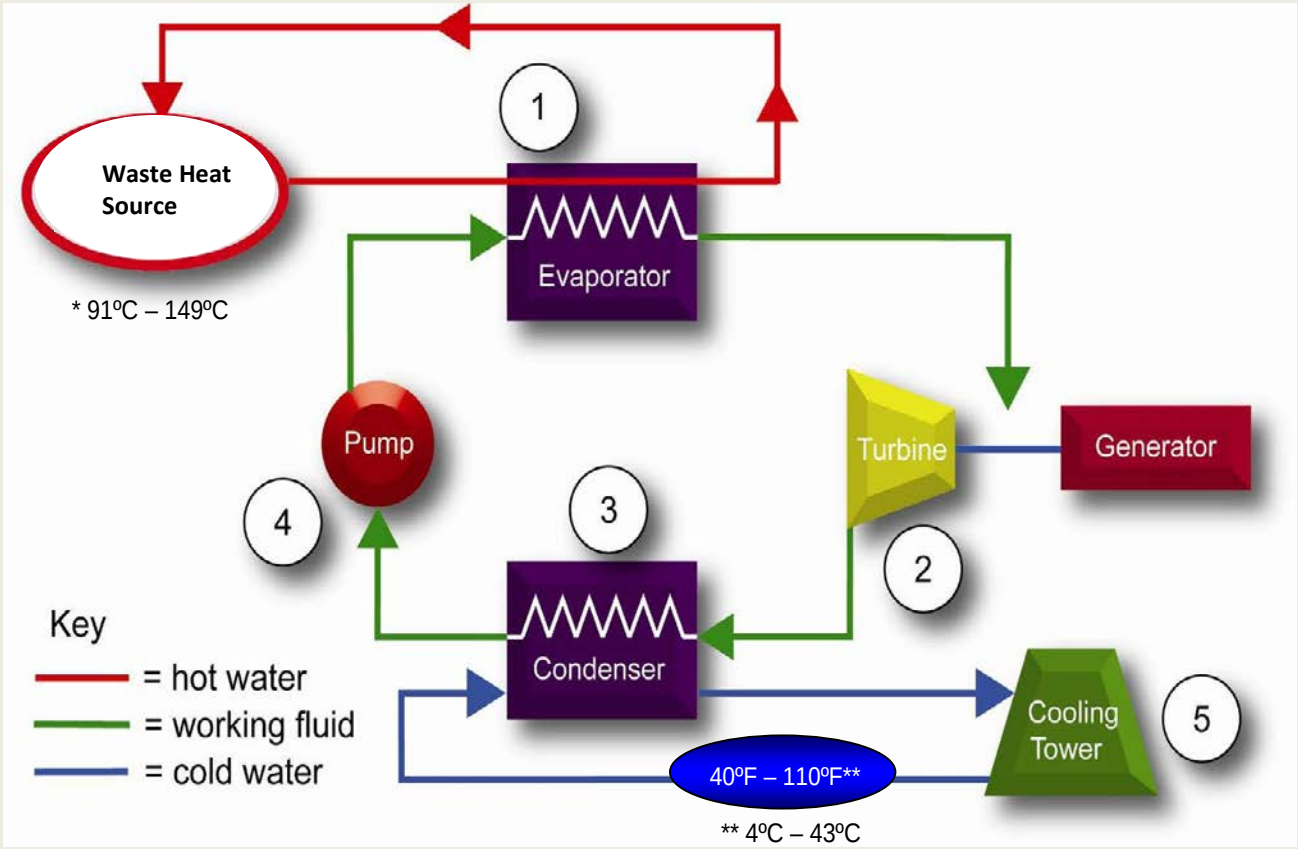
Electricity Generation from Waste Heat – The Organic Rankine Cycle



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Many Benefits of Waste Heat Recovery

- Fuel Savings = Increased profits
- Efficiency gain
- Reduced greenhouse gas Emissions
- Recovery of substantial amounts of water from flue gas (condensing)
- Reduced thermal emissions
- Increased plant capacity
- Positive plant image