

# Heat Recovery from Flue Gas in Gas Fired Appliances





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# Heat Recovery

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1. What is waste heat recovery
2. History & Market Assessment of Boiler Waste Heat Recovery
3. Understanding today's heating systems
  - Efficiency Limitations
  - How can we improve them
  - Boiler replacement
4. Questions

# Part 1

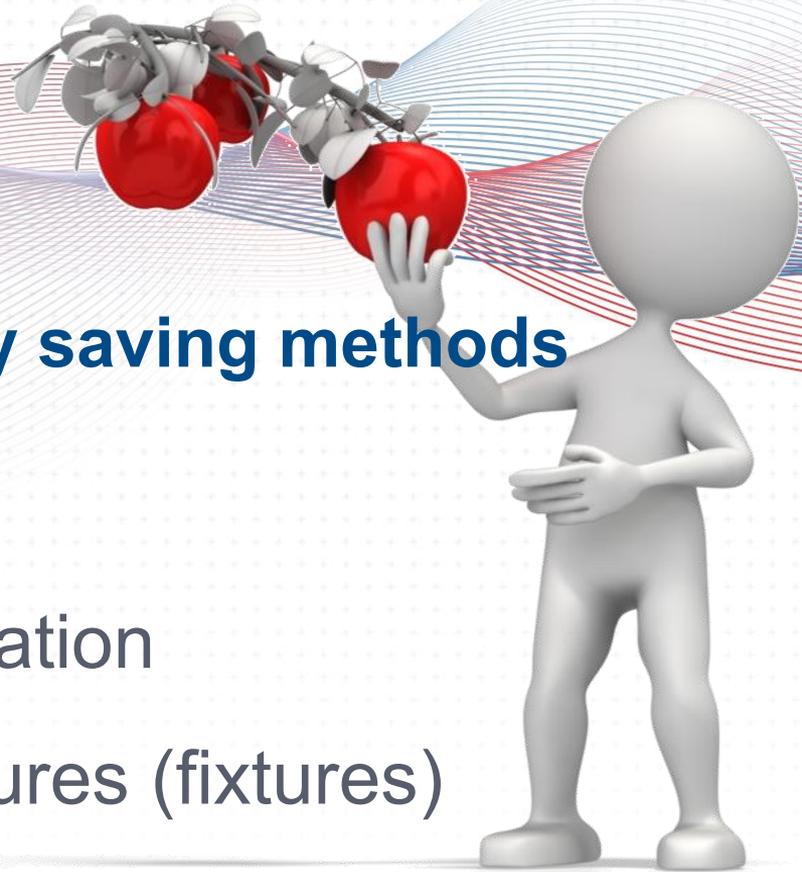
What do we mean by  
waste heat recovery?

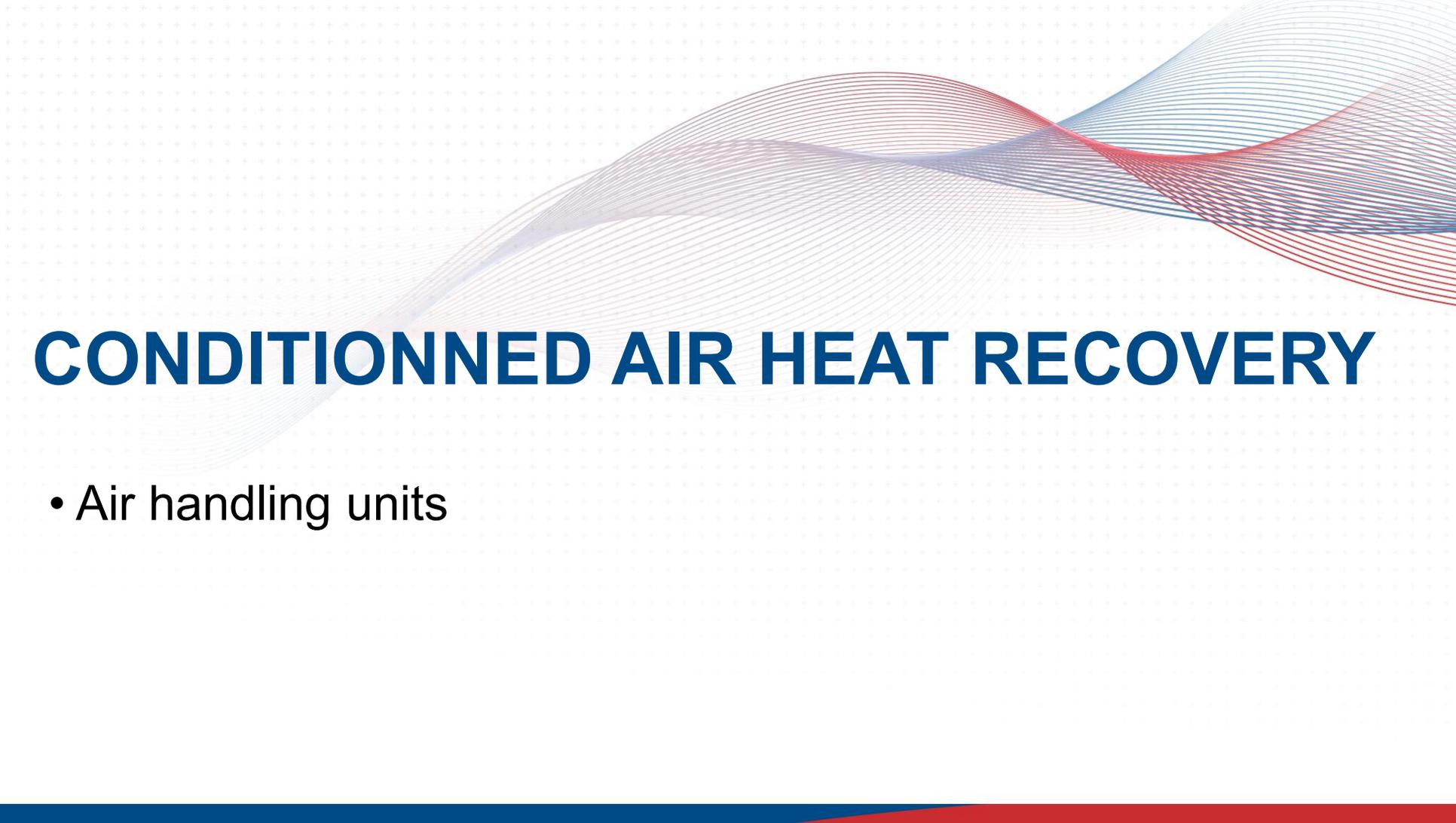


# LOW HANGING FRUITS

## First let's address current energy saving methods

- Lighting retrofit
- Upgrade windows, doors, insulation
- Hot water energy saving measures (fixtures)
- Controls retrofit (building automation, VFD'S, etc.)



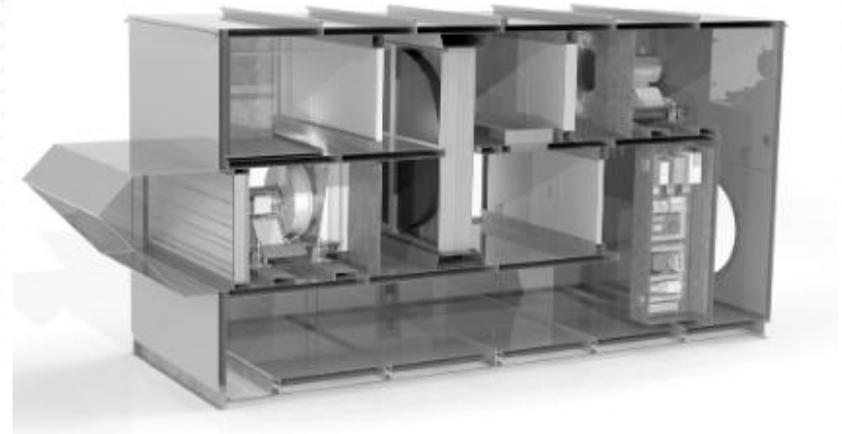
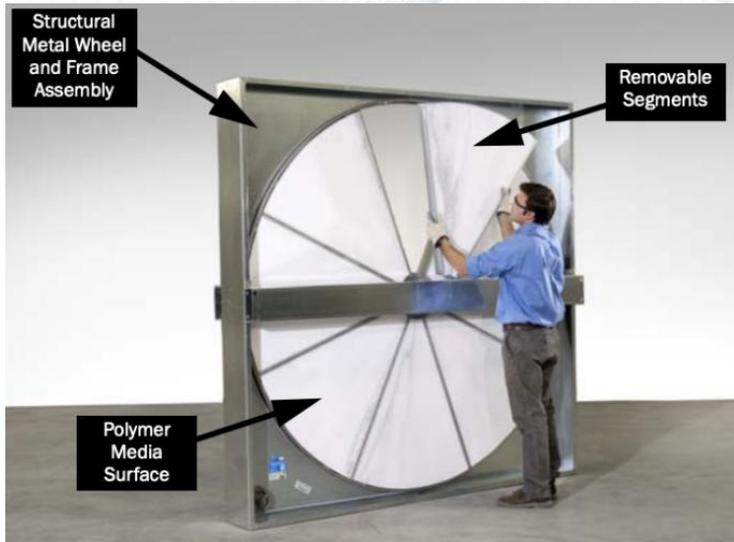


# CONDITIONNED AIR HEAT RECOVERY

- Air handling units

# CONDITIONED AIR HEAT RECOVERY

HEAT RECOVERY = Air Handlers, Heat Wheels, Dual Core



# Other Measures:

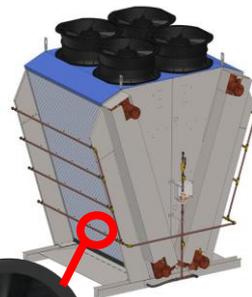
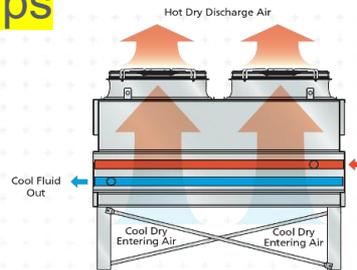
## → Chiller upgrade:

- Oil-free magnetic-bearing compressors
- High efficiency Inverter air/water heat pump
- Heat recovery chillers (6 pipes chillers)
- **New Hi-temp Air Source Boilers/Chillers/Heat Pumps**



## → Cooling tower upgrade:

- Evaporative/hybrid cooling towers
- Dry coolers
- Hybrid Adiabatic Cooling Systems



## → Boiler and water heater upgrades

- More efficient and modulating steam boilers
- Condensing water heaters and boilers
- Electrical boilers



# Flue gas thermo-pumping or waste heat recovery





# Part 2

## History and Market Assessment of “Boiler Waste Heat Recovery”

- The most dangerous phrase in business is: “We have always done it this way”

# Boiler stack economizers, the history

- The first boiler economizer was patented in 1845 by Edward Green.
- The first modern steam boiler design was patented in 1867 by George Babcock and Steven Wilco.
- Economizers capture heat from the exhaust flue and return it to the boiler by heating the incoming feedwater.

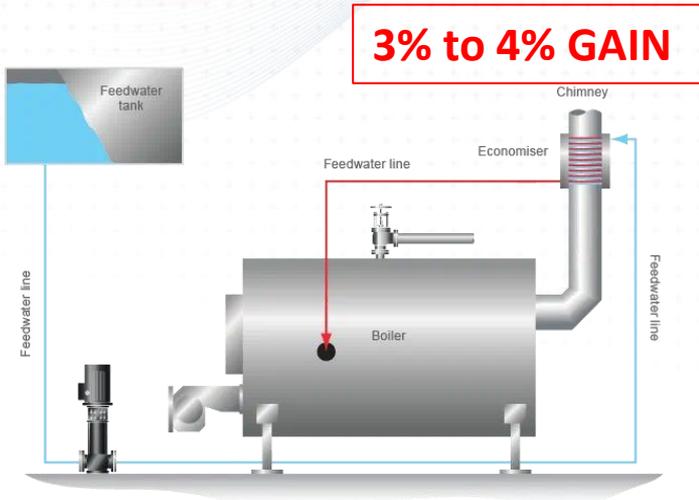
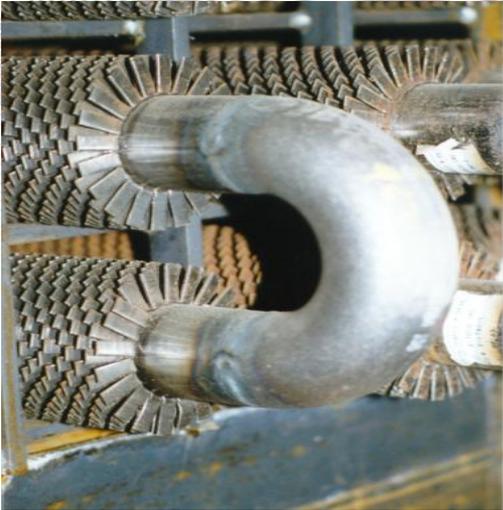


Fig. 3.4.3 A shell boiler with an economiser



# INDIRECT CONTACT TECHNOLOGY



# EXISTING INDIRECT CONTACT ISSUES

**Heavy and large, huge inertia issues**

**Economizer failures due to:**

- steaming/localized boiling
- stress caused by boiler cycling
- Unbalanced economizer flow distribution
- Stress corrosion cracking at welds

**Water chemistry:**

- Carbon steel subject to cold end corrosion & oxygen erosion and pitting
- Stainless Steel: Subject to chloride stress corrosion cracking

**Heat transfer limitations**

**Maintenance:** Almost unrepairable...



# LIMITATION OF FLUE GASES THERMOPUMPING MARKET

- Existing manufacturers are geared towards the large industrial.
- They are mostly born from the steam boiler world.
- The existing design build or heat recovery driven firms target the very large projects.
- All project are custom to each applications implicating a lot of engineering, custom controls, custom components leading to a lot of regulation hurdles.
- Lack of Knowledge of the HVAC Hydronic and low temperature applications and sizes...



# HVAC Market Assessment

1. New Building design get away from Inefficient steam systems.
2. Boiler capacities are going down.
3. Building heating system design incorporate different technologies and energy sources ( Hybrid systems).
4. Condensing boilers and water heaters have been widely accepted and integrated.
5. Steam boiler systems are still required but are generally a lot smaller in capacity.
6. Many industrial process plants have on staff decarbonizing team due to regulations.

# Boiler Waste Heat Recovery Market Assessment

1. Untapped Commercial, Institutional & Light Industrial market that require new solutions.
2. A solution that helps solve governmental regulatory pressures.
3. There are New Technologies on the market that need to adopted in the same way as condensing boilers have been accepted.
4. We need to integrate these new technologies with Electrification hybrid systems.



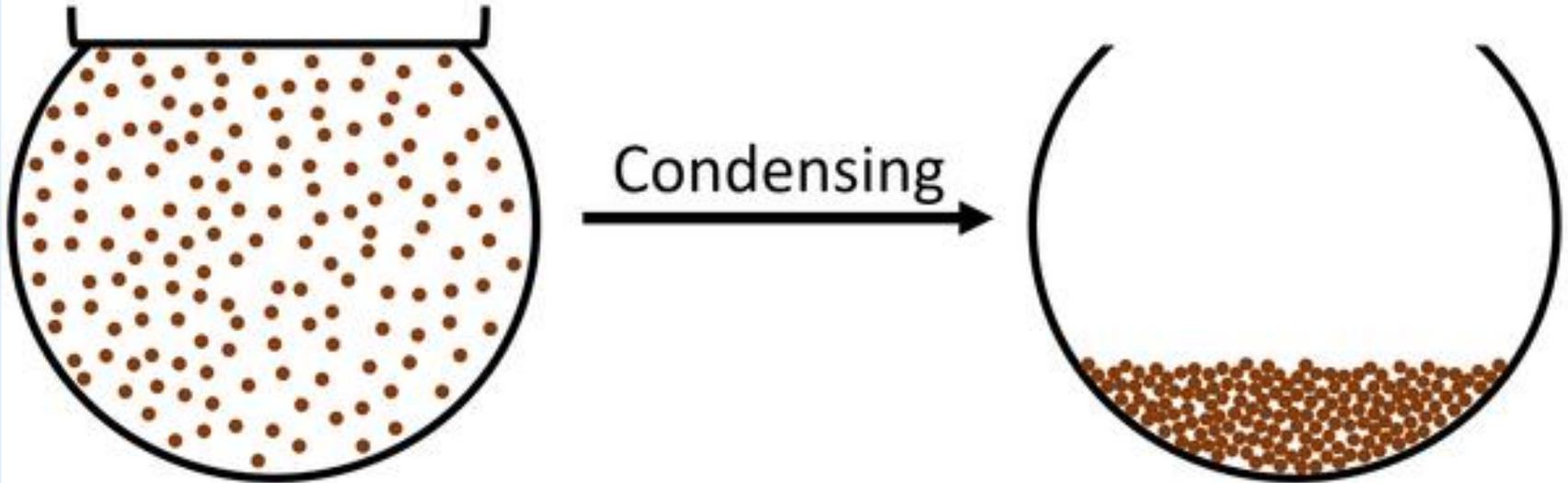


# **Part 3**

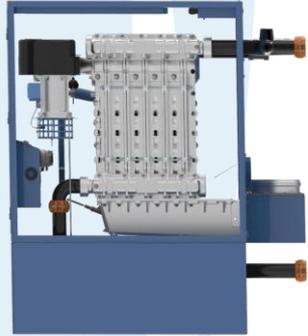
## **Education**

**Understanding today's heating systems Efficiency limitations and can we improve them?**

How exactly does a condensing boiler hit peak efficiencies?



Does that **NEED** to happen inside of the boiler?



**And let's not forget that sometimes we shouldn't condense at the boiler**

**But that doesn't mean we can't condense the flue.**



# 1. Hydronic Boiler Retrofit



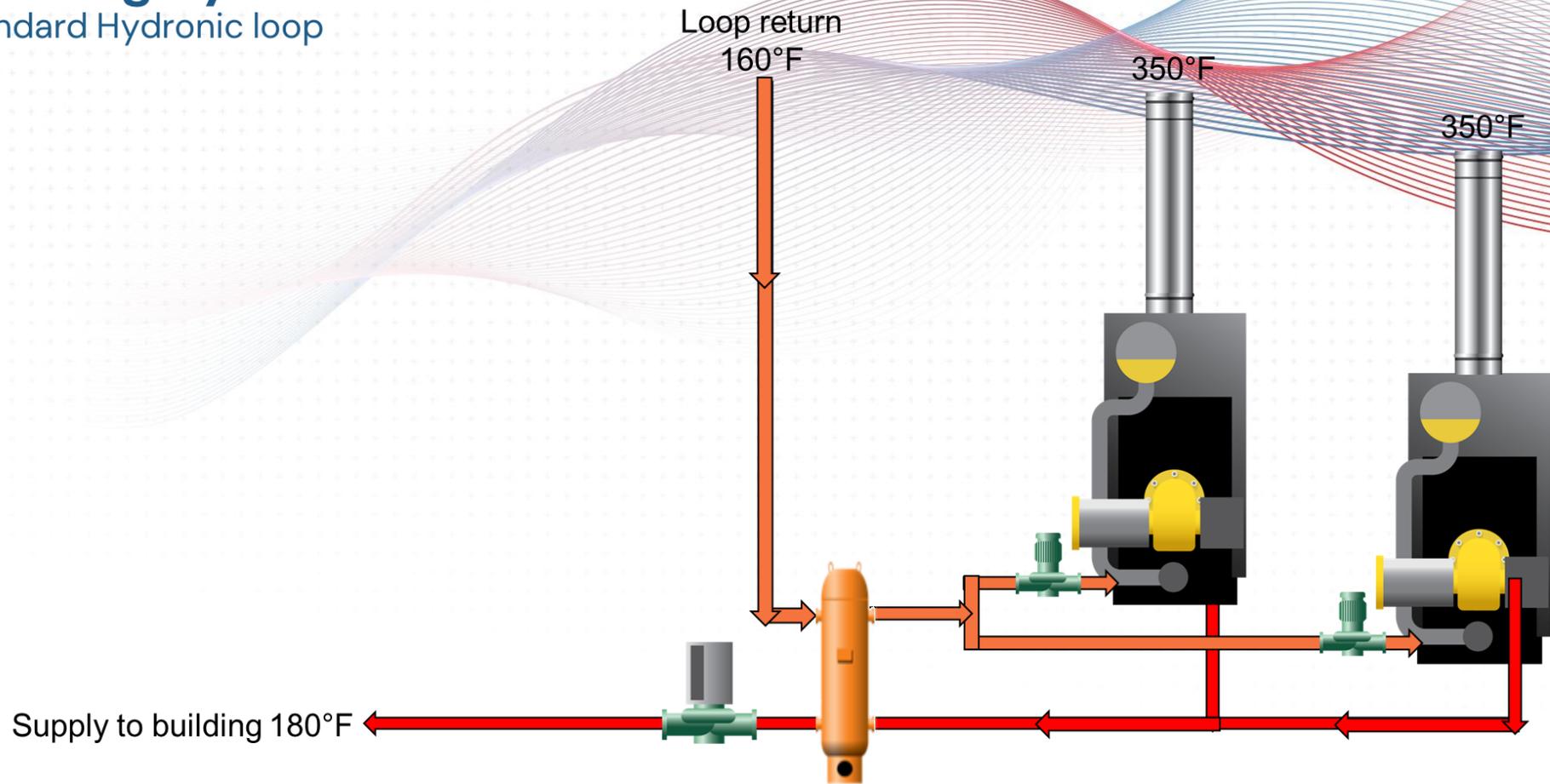
# Hydronic Boiler Retrofit

- 2 hot water “water tube boilers” @ 84% eff.
- 12,000,000 btu/HR INPUT each
- 100% redundancy
- Summer Average load is 25% of 1 boiler (reheat)
- Winter Average is 75% of 1 boiler
- Yearly average is 50% of 1 boiler
- Boilers equipped with Low Nox 10:1 micro modulating burners
- Natural Gas price: \$12.00/dKt
- Electrical cost: \$0.2014 / kWh



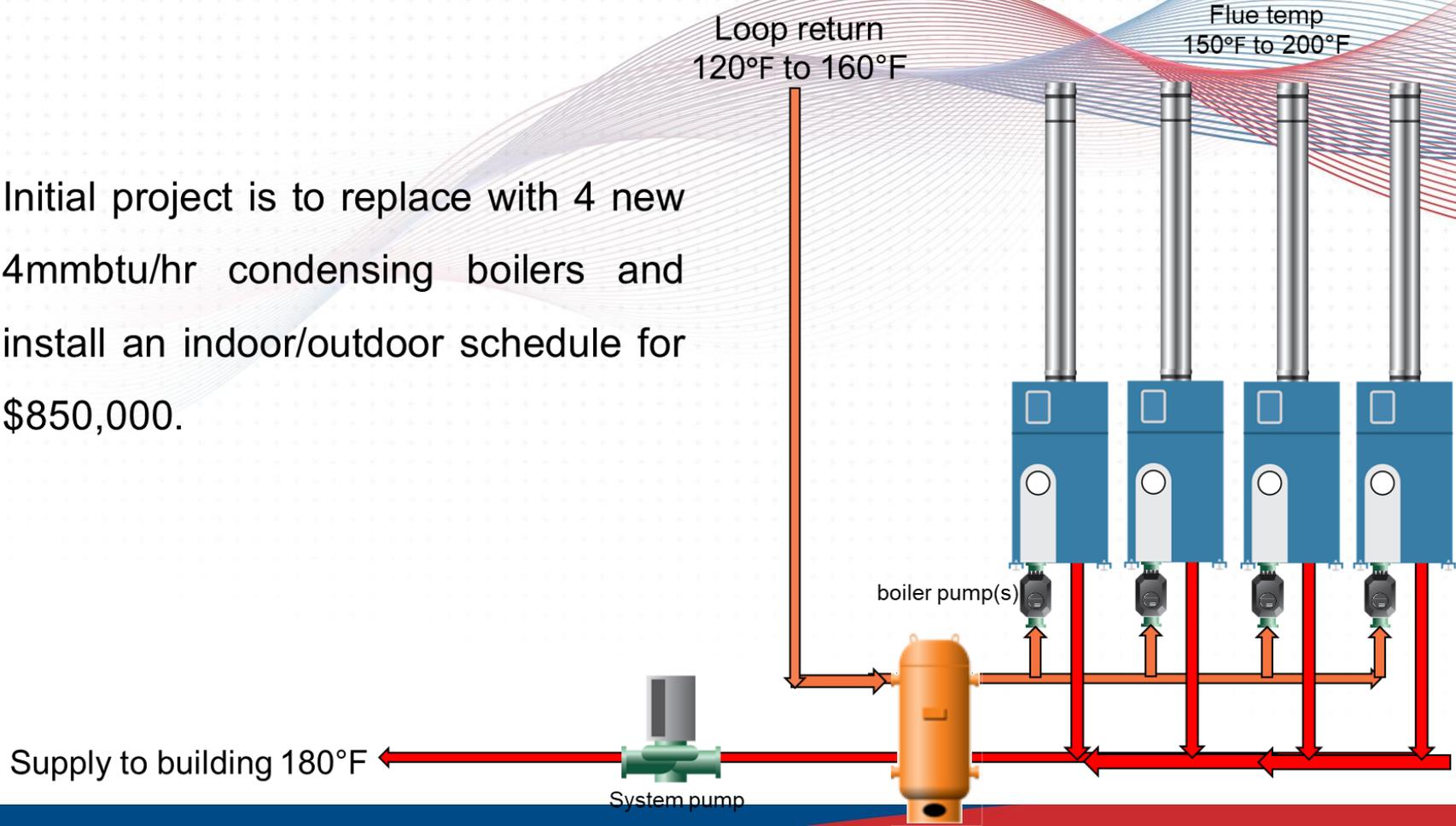
# Existing System

Standard Hydronic loop

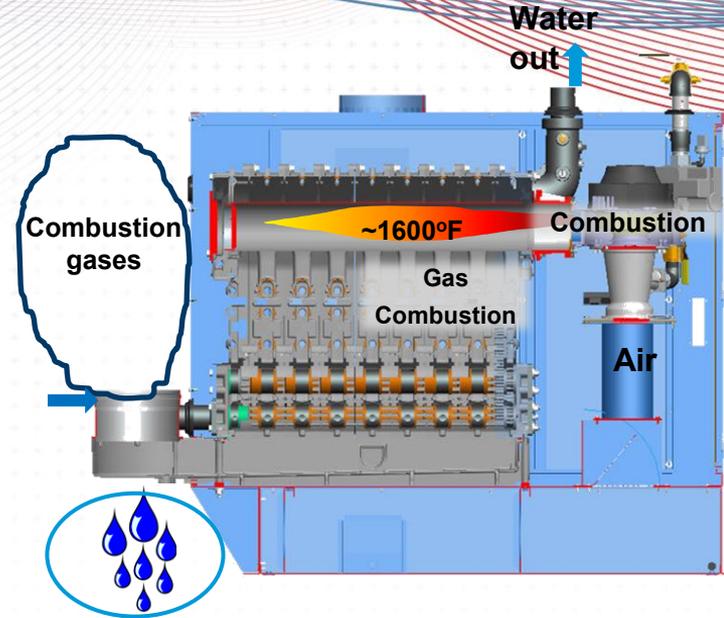
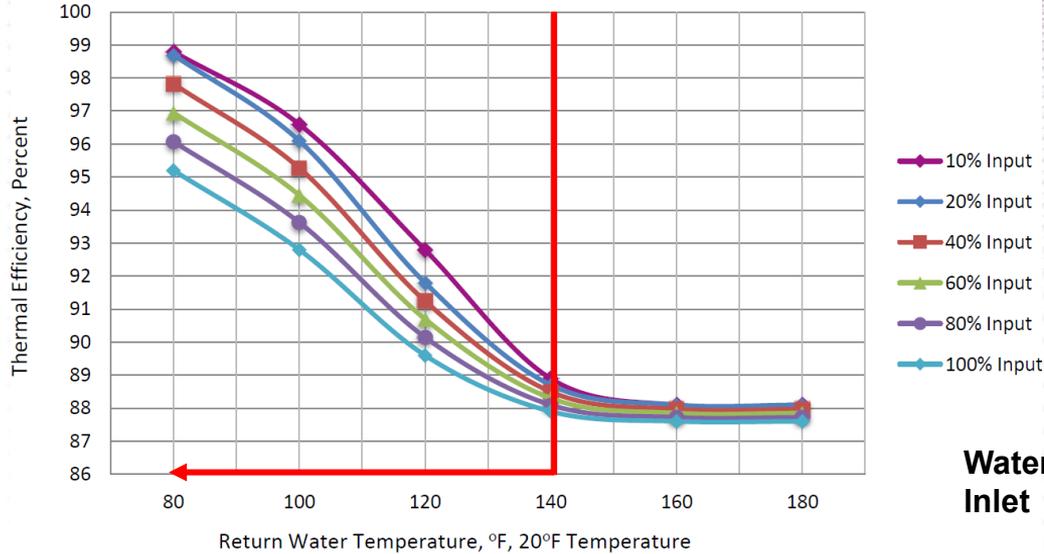


# Hydronic Boiler Retrofit

Initial project is to replace with 4 new 4mmbtu/hr condensing boilers and install an indoor/outdoor schedule for \$850,000.



# Condensing Boilers: You've got to get lower...

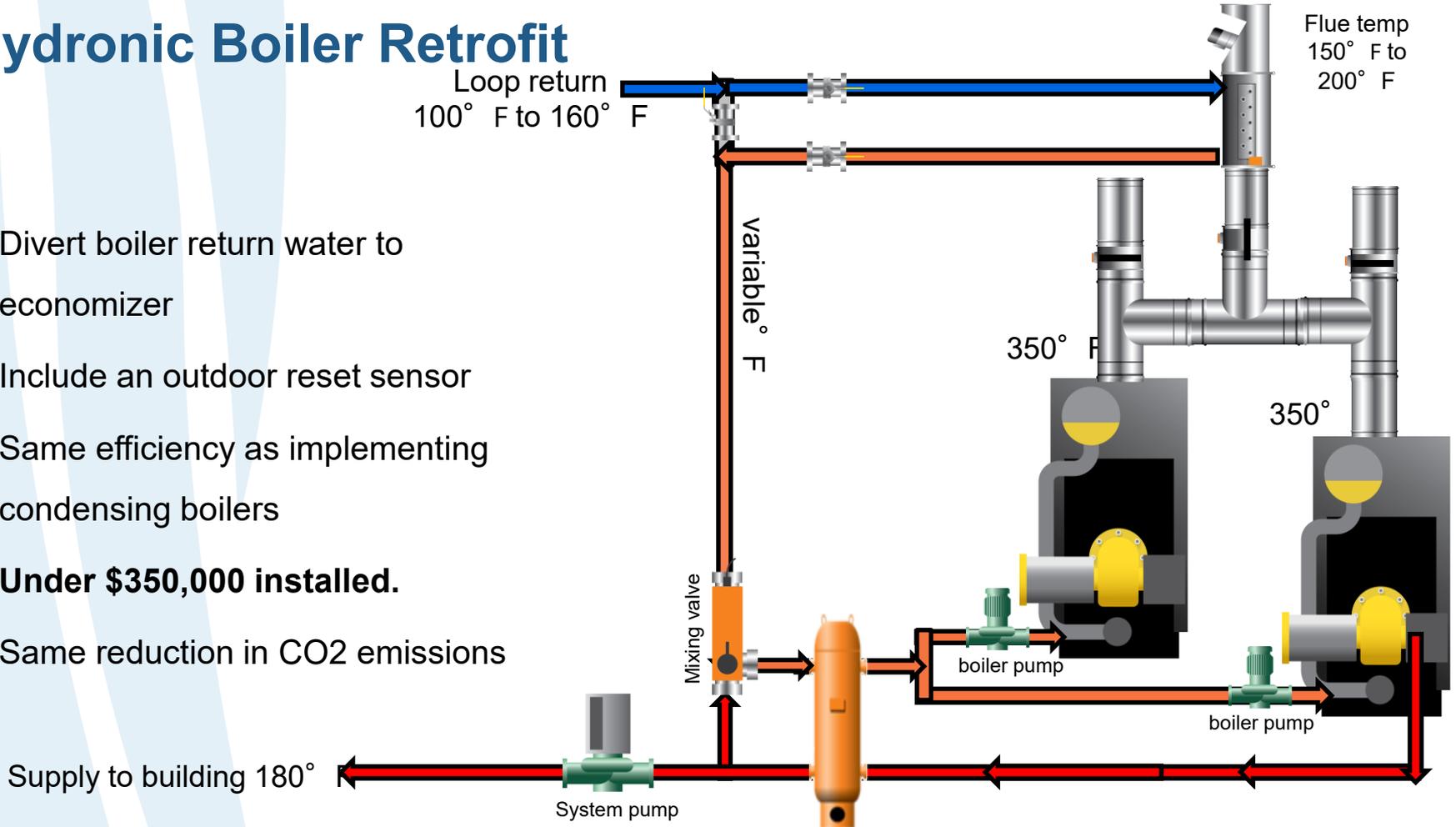


Lower flue temp below dew point

▪ Latent Energy (970 BTU/1 lb)

# Hydronic Boiler Retrofit

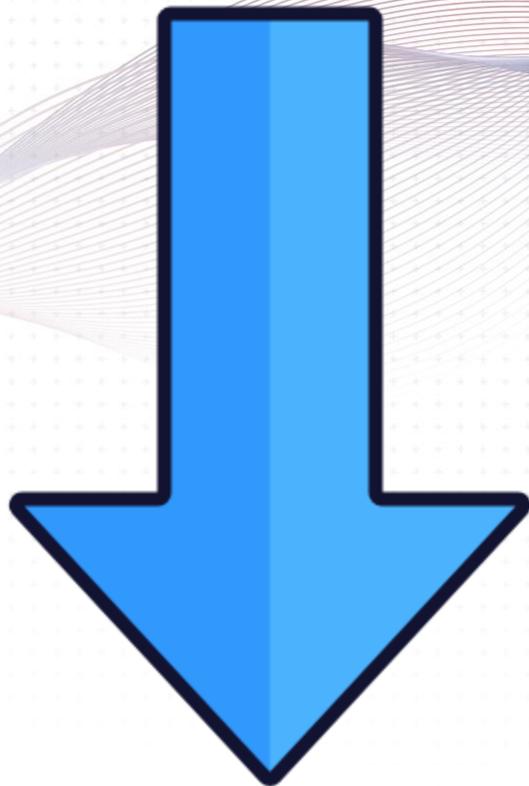
- Divert boiler return water to economizer
- Include an outdoor reset sensor
- Same efficiency as implementing condensing boilers
- **Under \$350,000 installed.**
- Same reduction in CO2 emissions

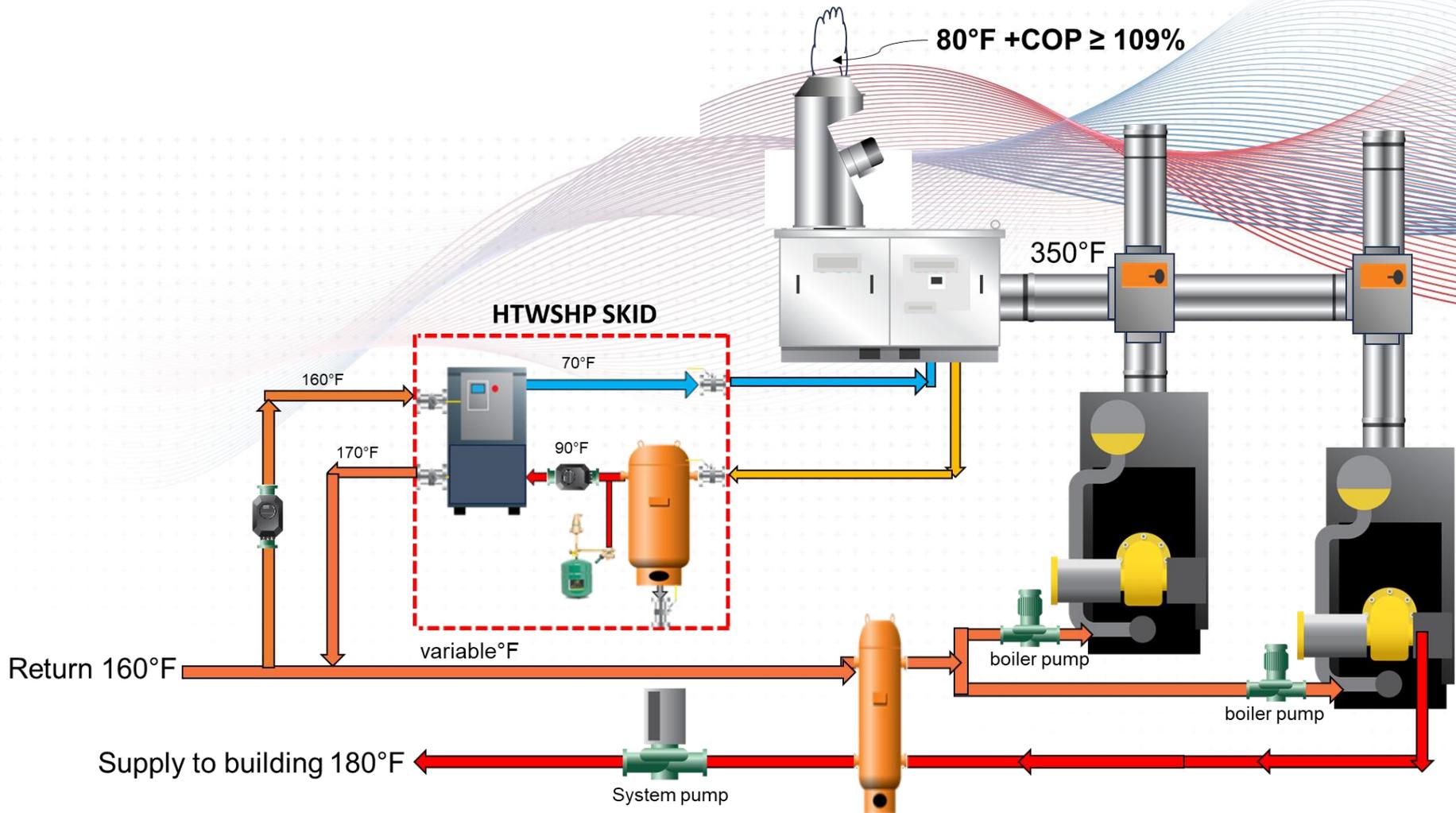


# *Waste Heat Recovery Solution PayBack/ROI*

So, what is the ROI on this?....

We saved \$500,000 in Capital Investment





# “Boiler Only” vs “Boiler + High-Temp Heat Pump” (Peak = 12.0 MMBtu/hr)

Metric	Before (Boiler Only @ Peak)	After (Boiler + 1 HP @ Peak)	How It's Calculated
Boiler gas input	12.00 MMBtu/hr	9.24 MMBtu/hr	$B_{new} = \frac{10.08 - 2.32}{0.84}$
Boiler heat to building	10.08	7.76	$Q_{boiler} = 0.84 \times 9.24$ or $10.08 - 2.32$
Heat pump heat to building	0.00	2.32	$Q_{HP} = 2.32$
Total heat to building	10.08	10.08	Constant load
Stack loss produced	1.92	1.48	$Q_{stack} = 0.16 \times Input$
Flue heat recovered by HP	0.00	1.36	$Q_{recovered} = 1.36$
Unrecovered stack loss	1.92	0.12	$1.48 - 1.36$
% of stack recovered	0%	92%	$1.36/1.48$
Overall thermal efficiency	84.0%	109.1%	$\eta_{app} = 10.08/9.24$
Gas reduction vs baseline	—	23.0%	$(12.00 - 9.24)/12.00$

The combined system reduces peak boiler firing from 12.0 → 9.24 MMBtu/hr while maintaining 10.08 MMBtu/hr building heat (23% gas reduction, 109% thermal efficiency).

## Other Advantages

- We keep existing boilers that the operators know.
- We avoid expensive condensing boilers maintenance VS standard boiler technology (burner clean ups, heat exchanger cleanup, etc).
- We avoid any nuisance alarm that are common with mesh murners, thus also avoiding *costly gas tech visits*.
- *We can offset the cost of Air Source Boilers/Heat Pumps that poorly perform at low ambient temperatures.*
- *We take advantage of the WWSHP C.O.P. 24/7/52!!!!*
- *This solution is 100% in line with electrification hybrid systems.*

# “How much MORE gas do we reduce vs just changing boilers?”

## Average Load (50%) — Gas Input & Savings in Btu/hr

Case @ 50% avg load	Gas Input (MMBtu/hr)	Gas Input (Btu/hr)	Gas Saved vs Baseline (MMBtu/hr)	Gas Saved vs Baseline (Btu/hr)	% Gas Reduction
Baseline (84% boiler)	6.00	6,000,000	—	—	—
Option 1: Condensing boilers (89%)	5.66	5,662,921	0.337	337,079	5.6%
Option 2: Heat recovery + heat pump system	4.62	4,620,000	1.38	1,380,000	23.0%

What does this mean:

Extra gas saved (vs 89% boilers)

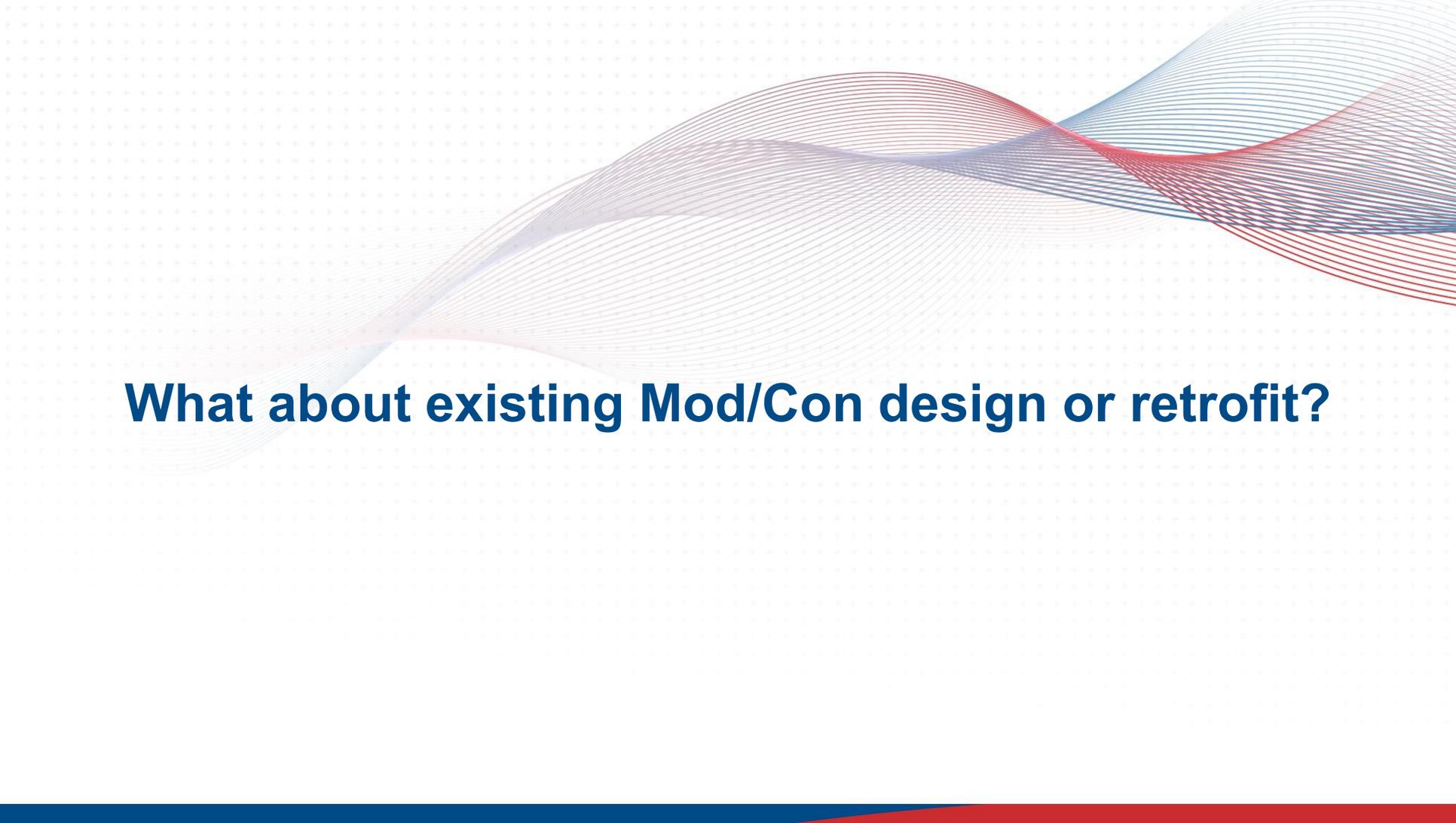
1.043 MMBtu/hr

Extra % gas reduction

23.0% – 5.6% = 17.4 points

Relative improvement

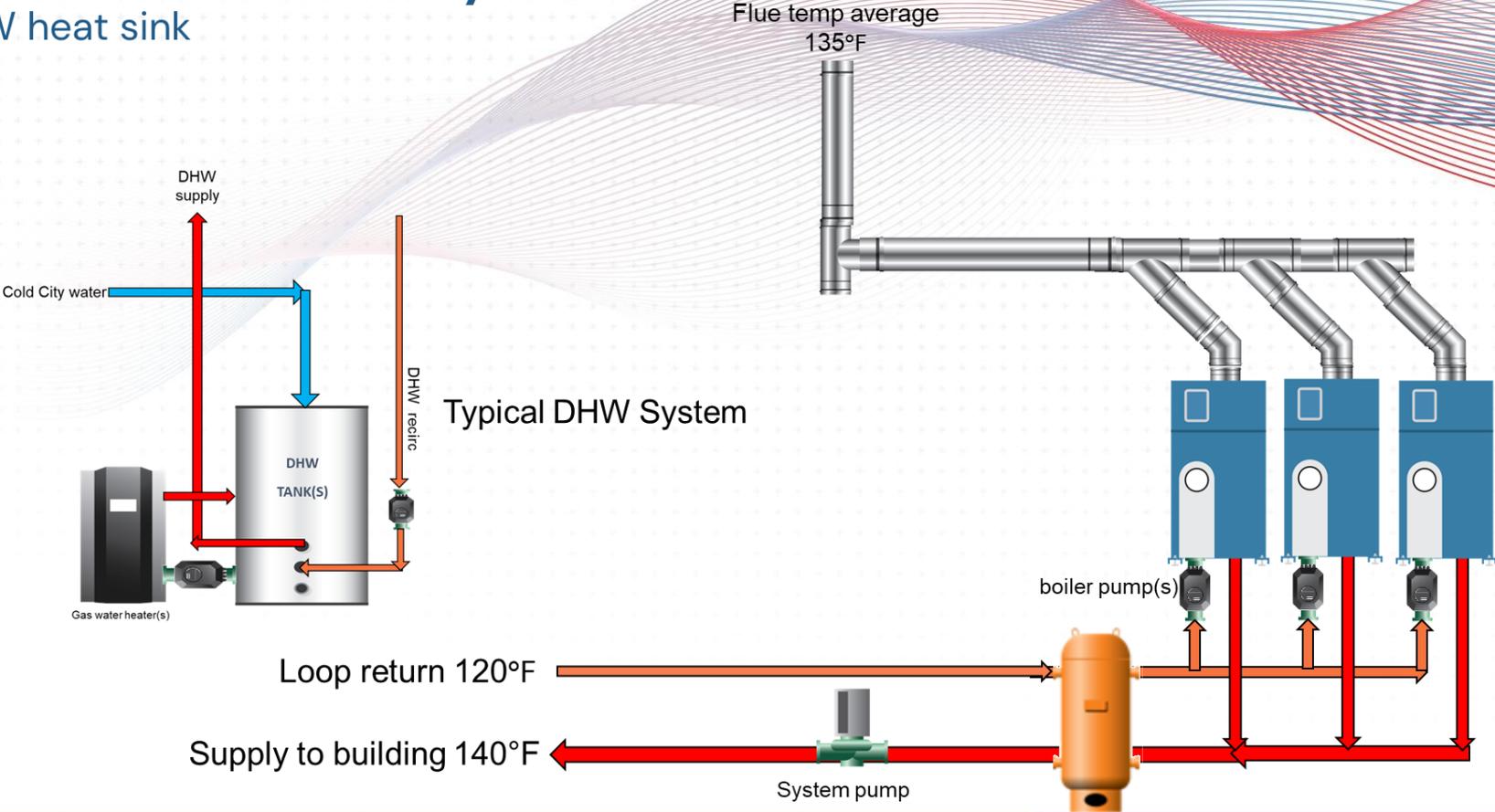
~4.1× more gas reduction



**What about existing Mod/Con design or retrofit?**

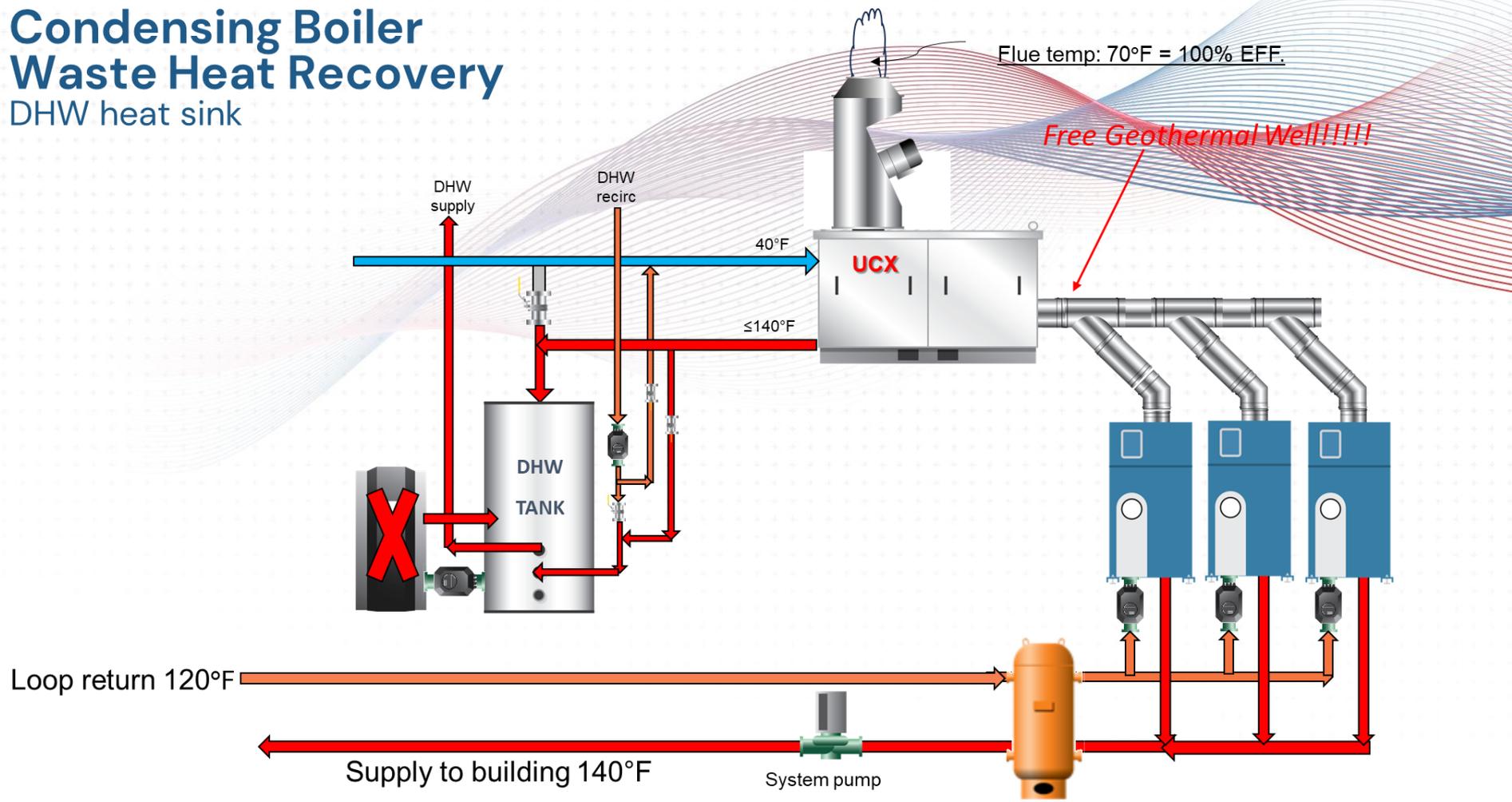
# Condensing Boiler Waste Heat Recovery

DHW heat sink

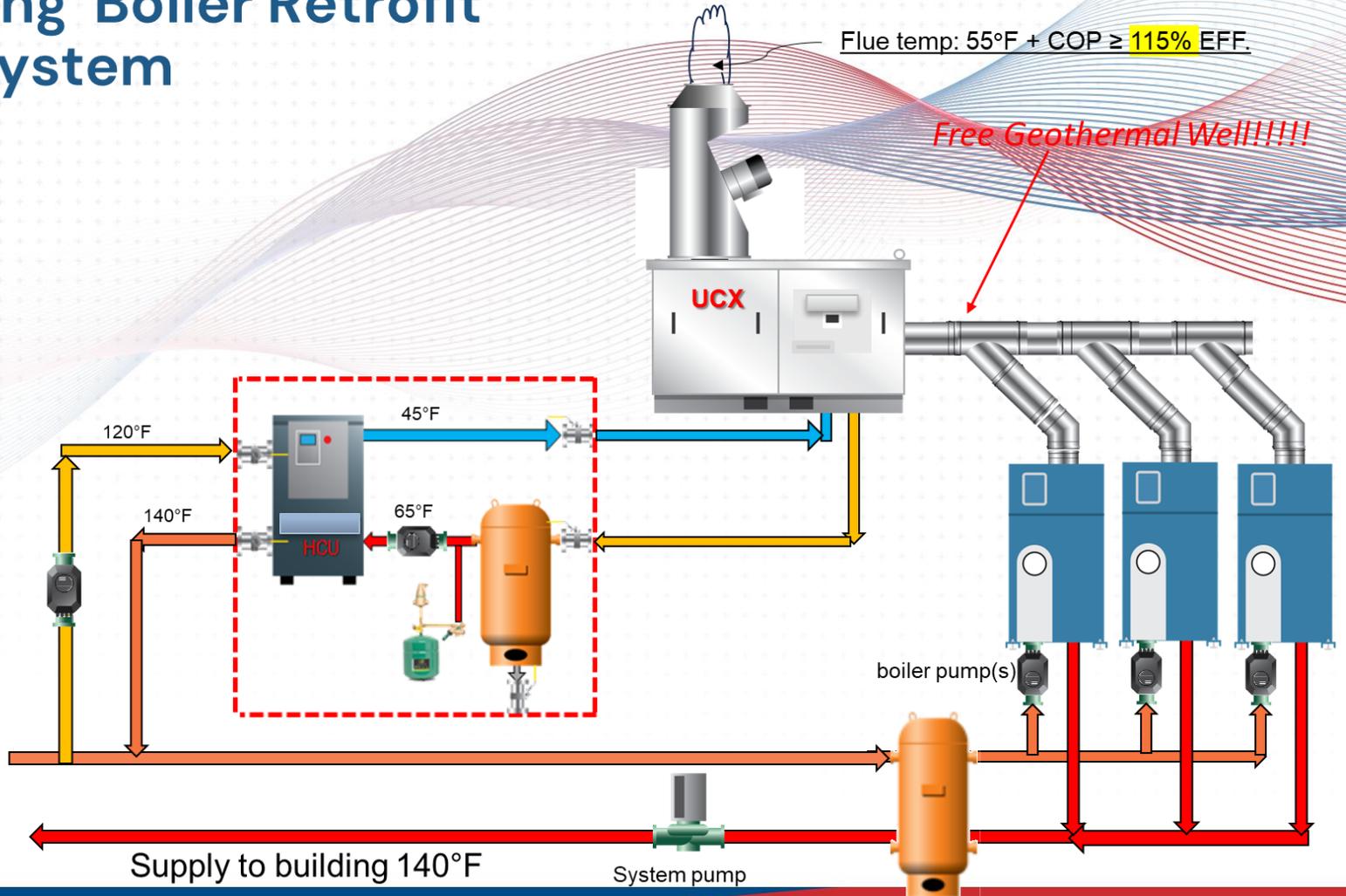


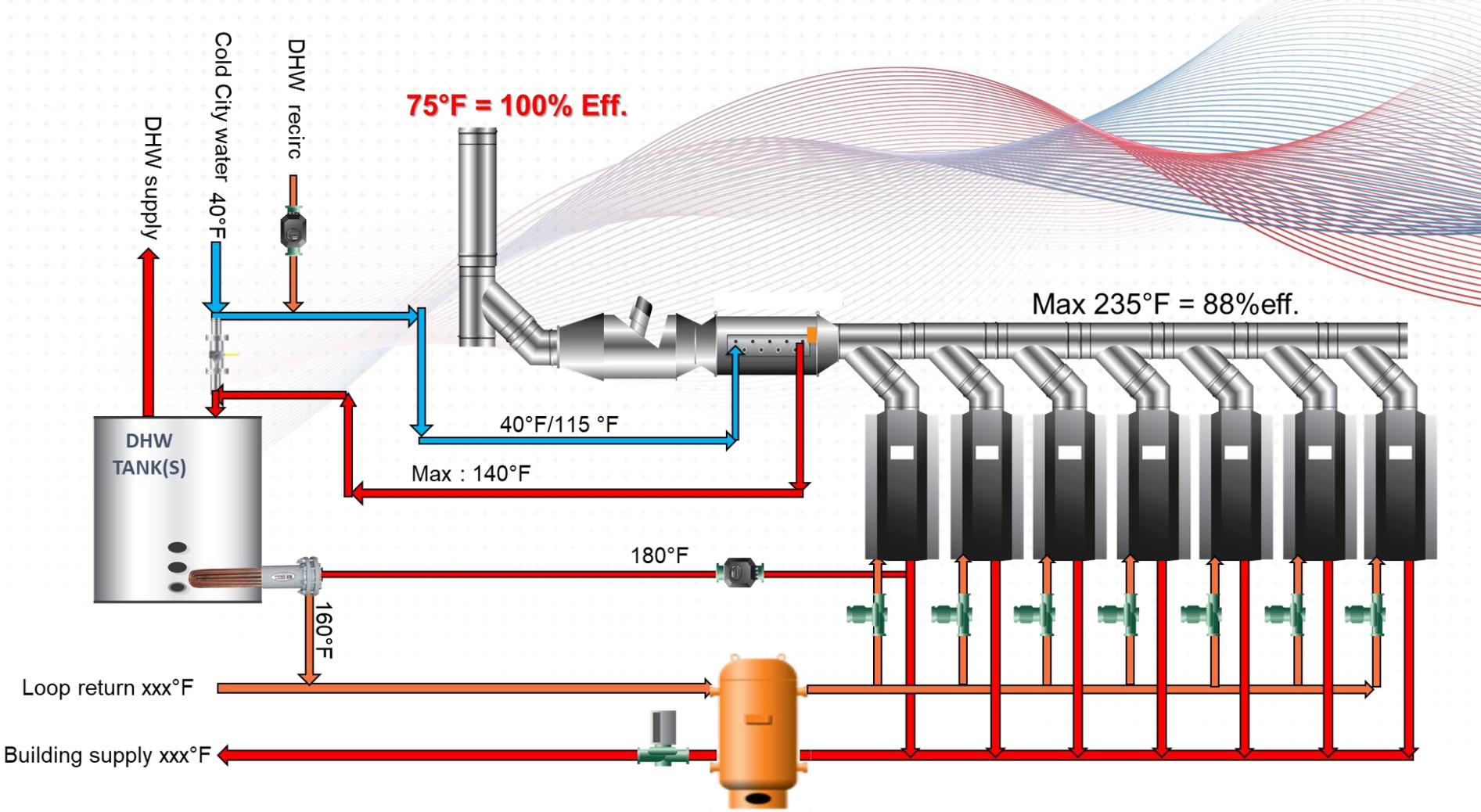
# Condensing Boiler Waste Heat Recovery

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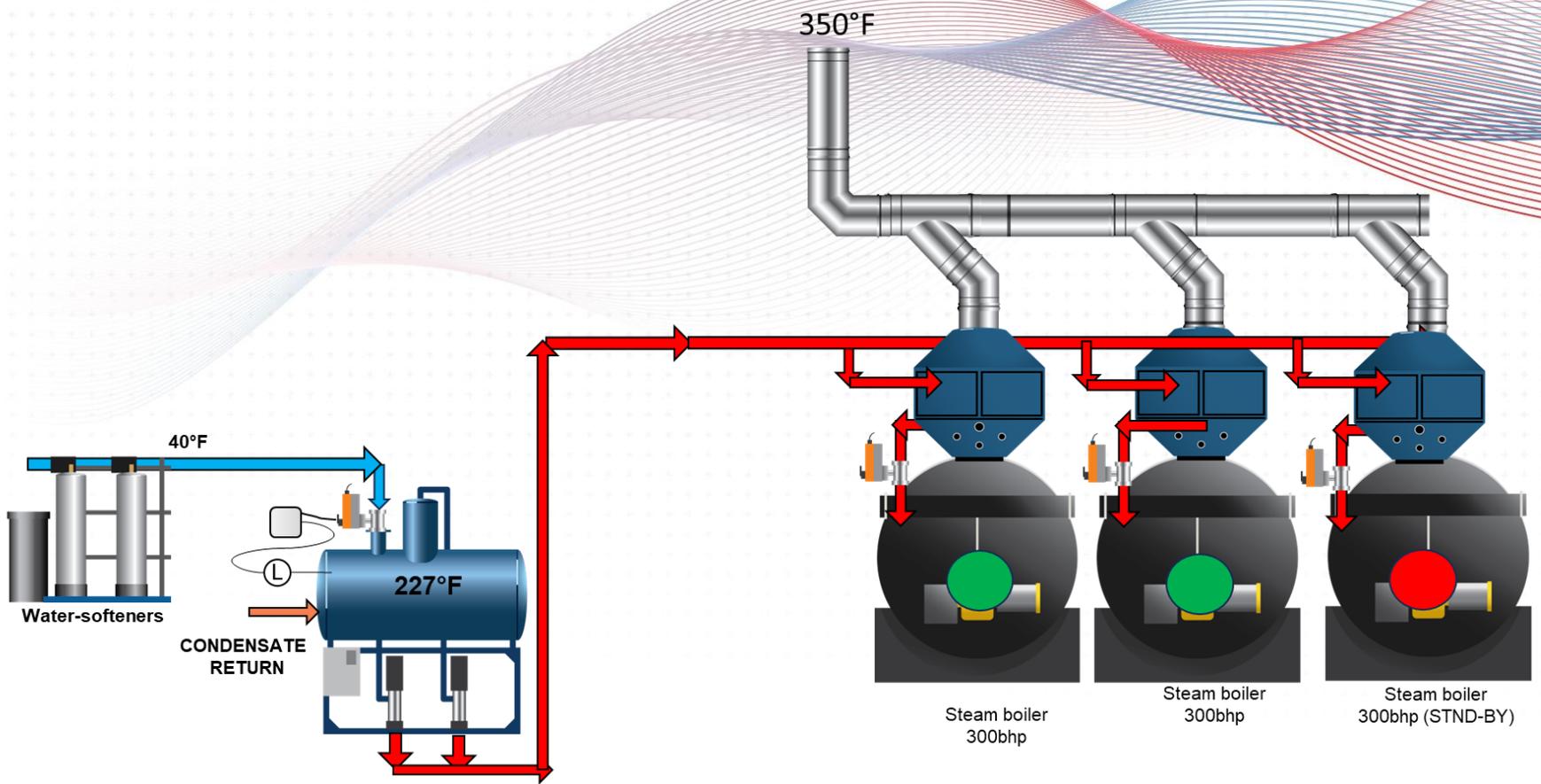


# Condensing Boiler Retrofit Existing system

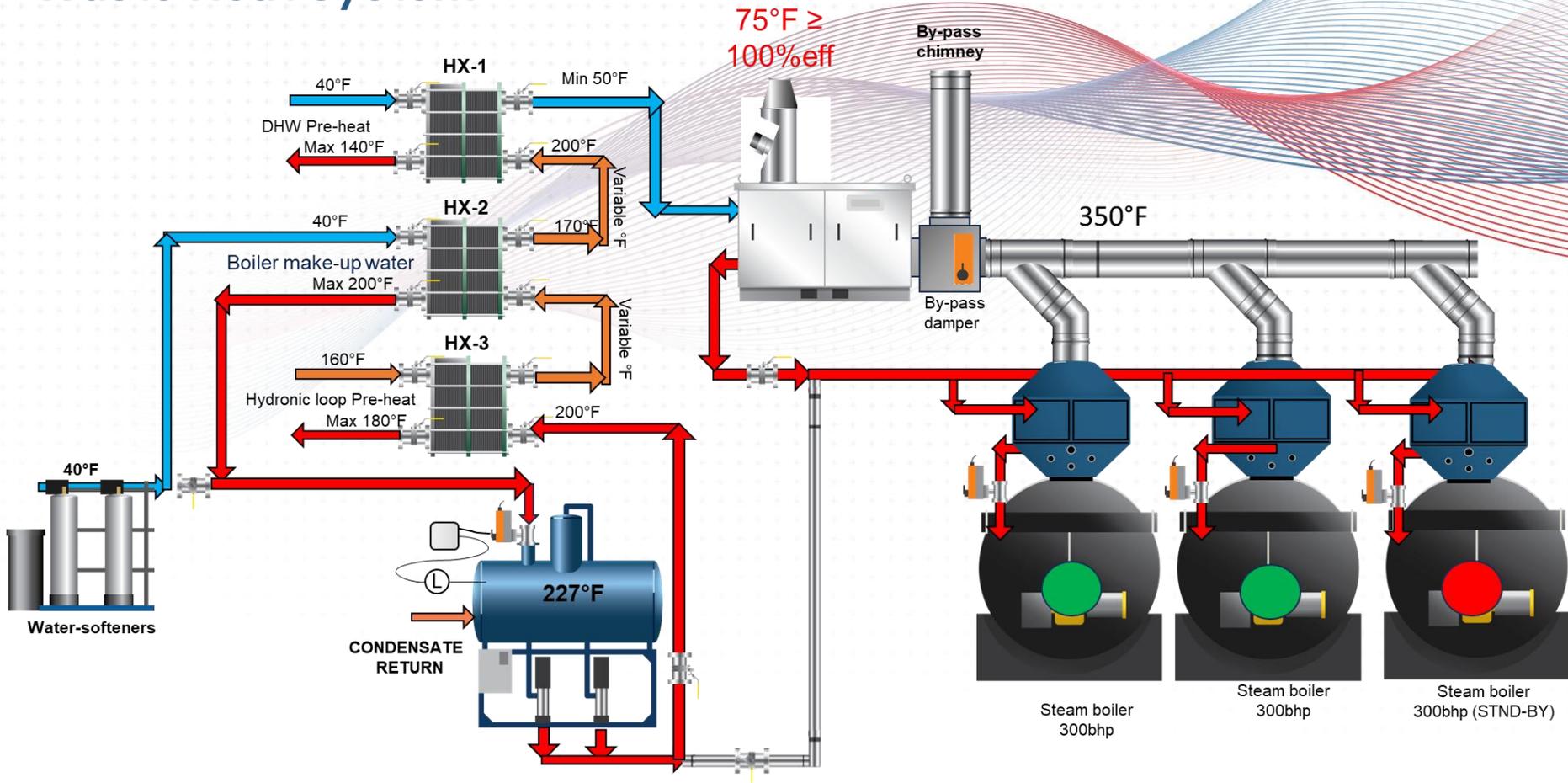




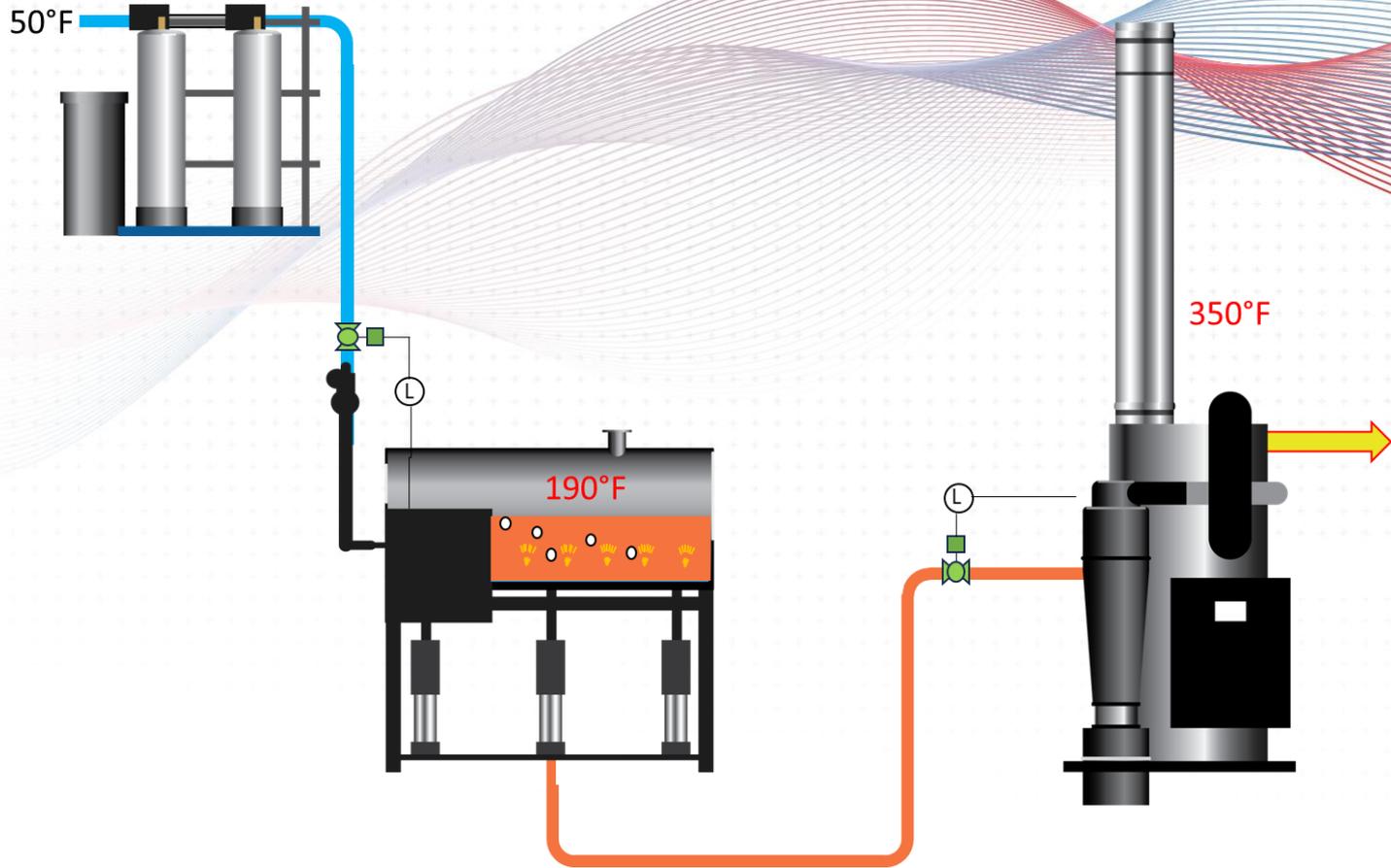
# Typical Steam System with Existing ICE's



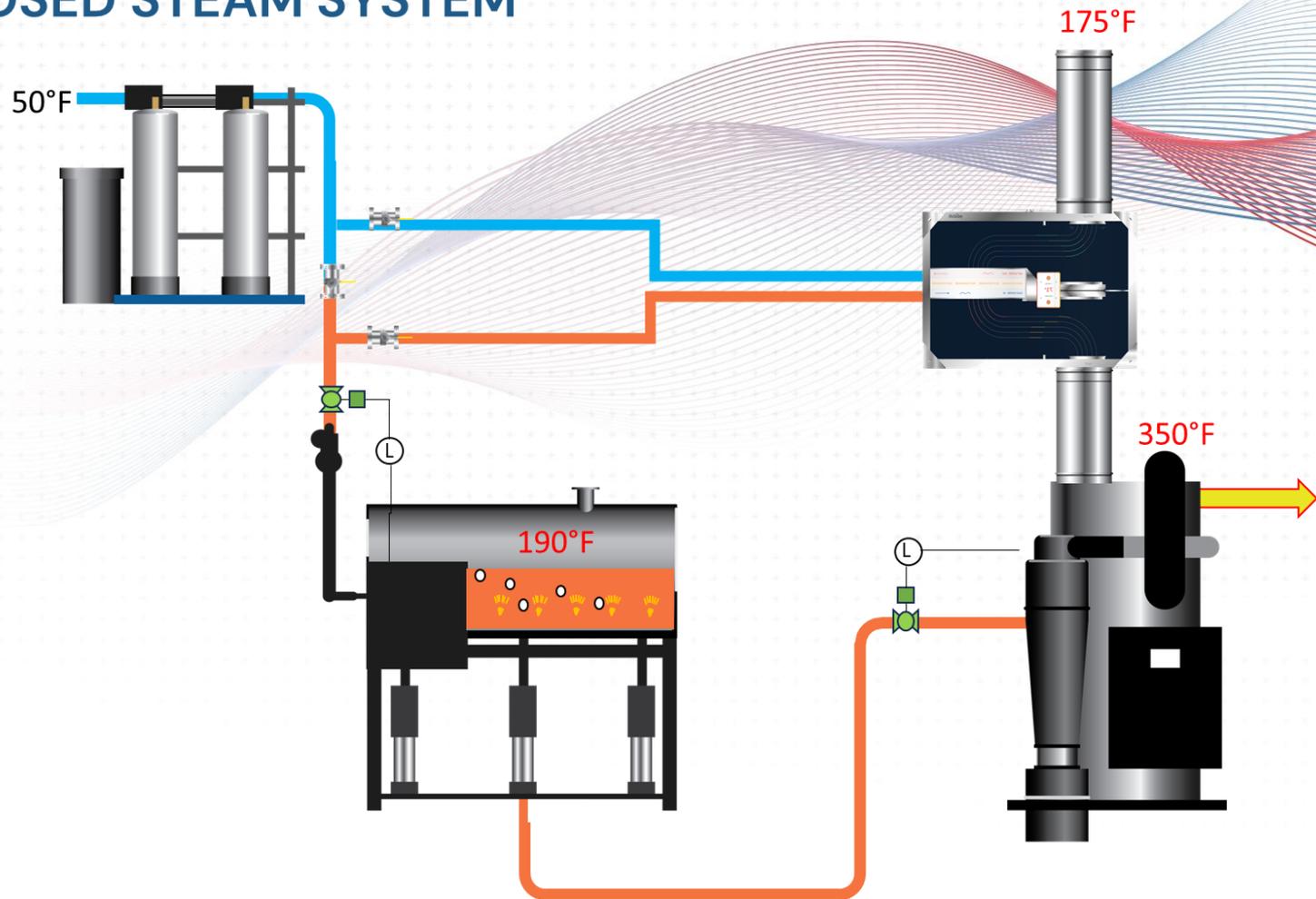
# Waste Heat System



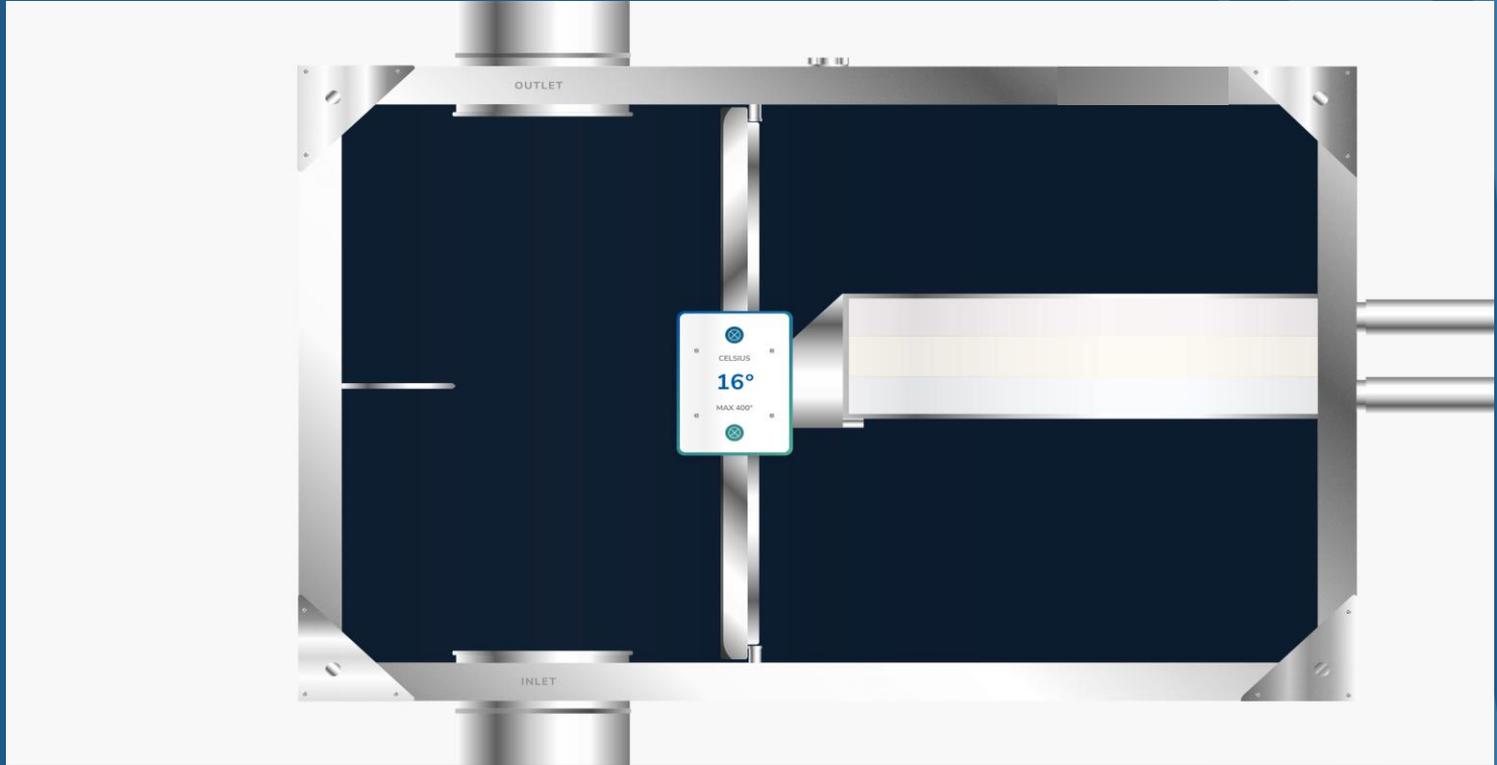
# EXISTING STEAM SYSTEM



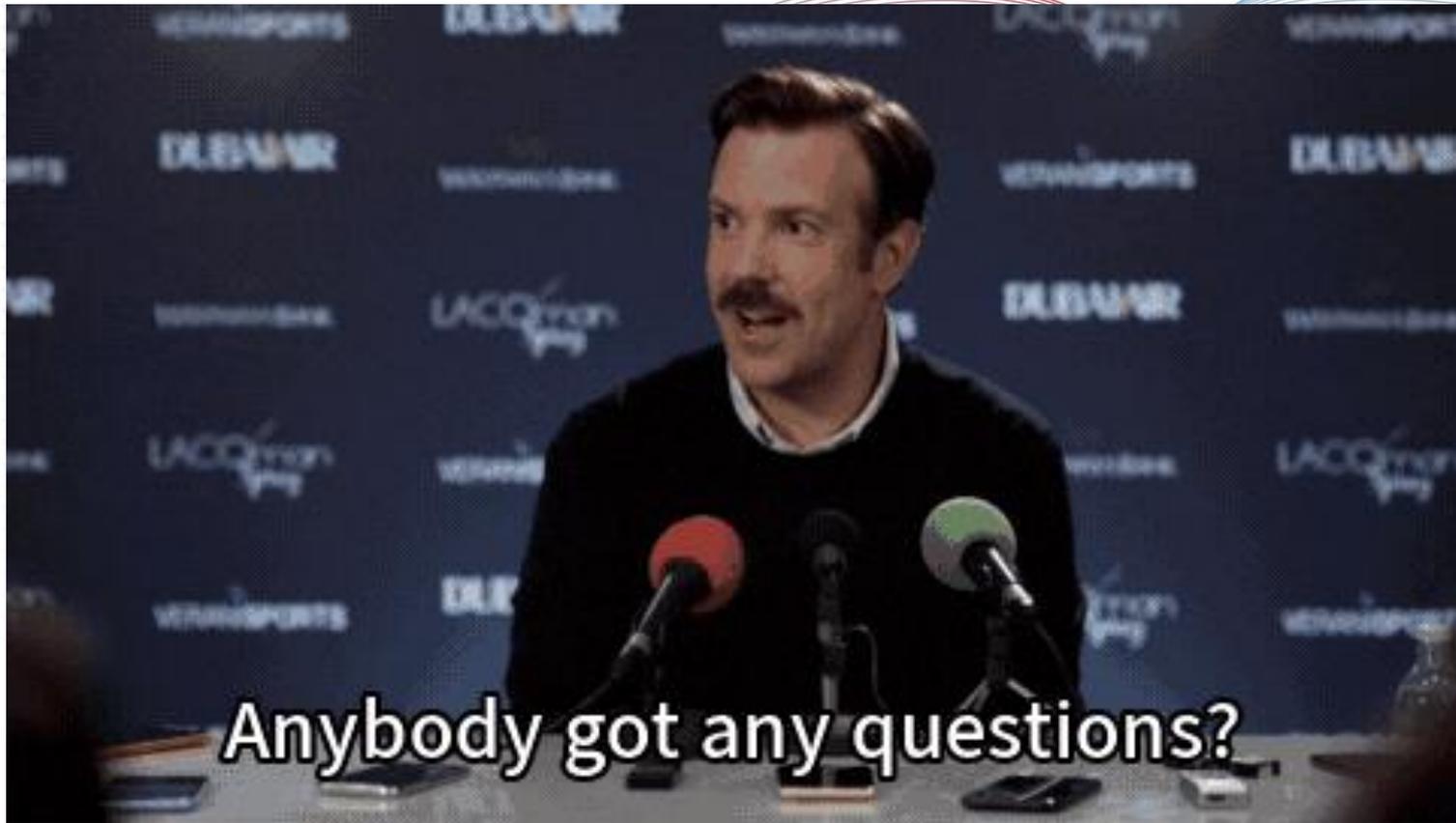
# PROPOSED STEAM SYSTEM



# Plate Bypass Function – 140 F/60 C







Anybody got any questions?



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*Thank  
you!*