

ACEEE 2018 Hot Water Forum

Condensing Humidified Air Recuperator

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 - > March 22, 2018

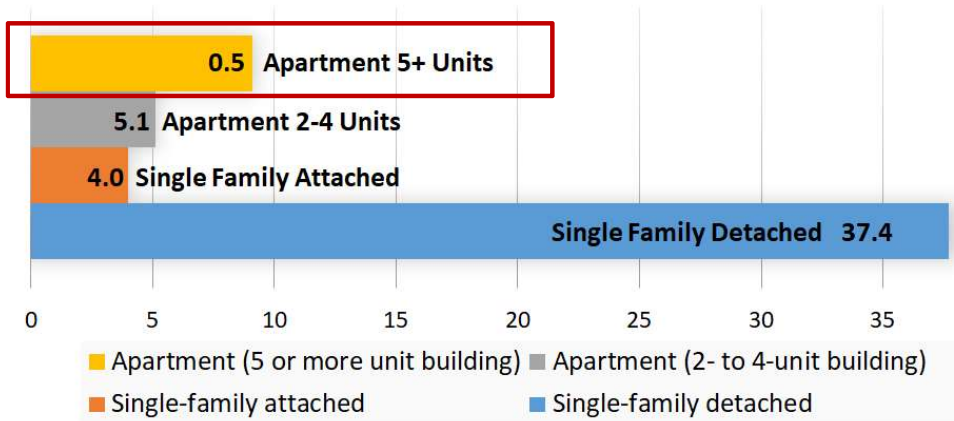
Overview

- The collective efficiency of the existing boiler population is somewhere between 58 and 70%.
- Boiler Life
 - Cast Iron: 25 to 50 years
 - Steel: 20 to 35 years
 - Cooper: 15 to 25 years
- To transform the efficiency of the existing boiler population requires both replacement and retrofit options.

Water Heating

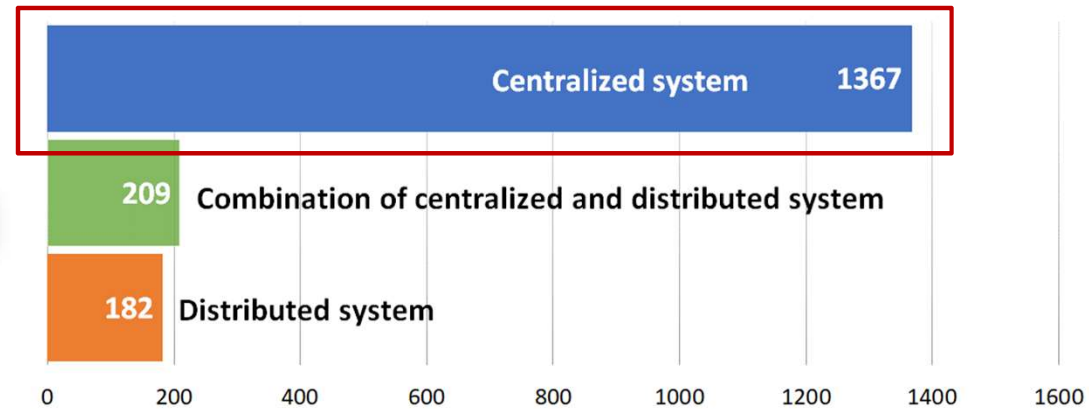
Residential

Gas Water Heating - 56.9 Million Units



Commercial

Gas Water Heating by Type - 1.8 Million Buildings



Boiler water heating population opportunity ~ 2 Million units

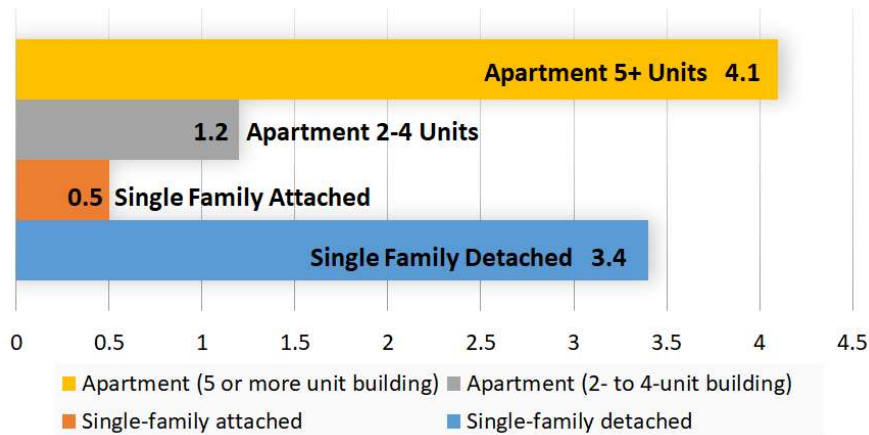
EIA Residential Energy Consumption Survey – 2015

EIA Commercial Building Energy Consumption Survey – 2012

Space Heating

Residential

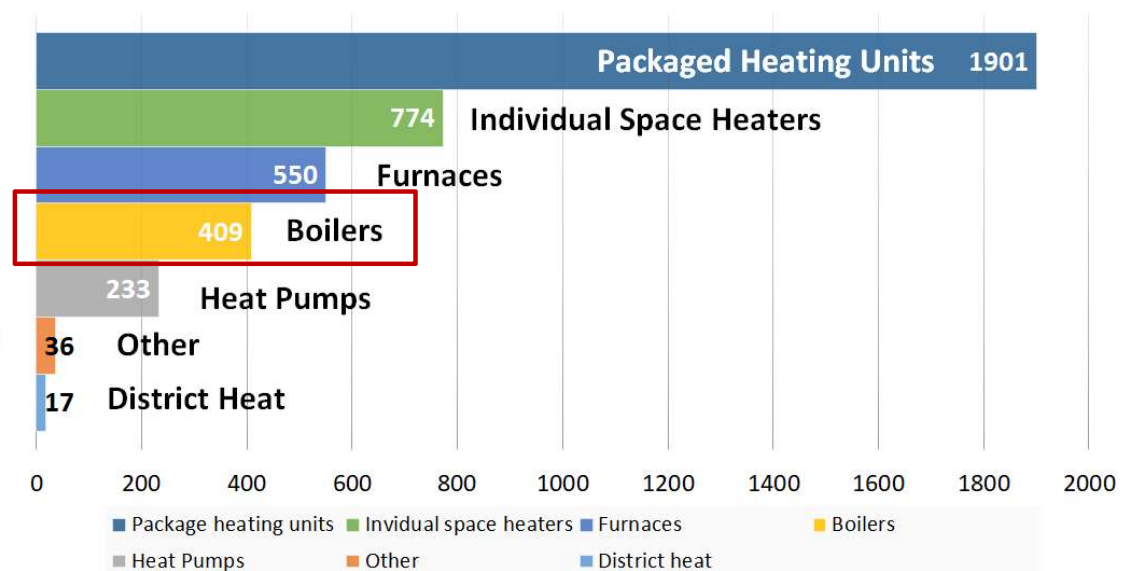
Residential Boilers - 9.3 Million Units



EIA Residential Energy Consumption Survey – 2015

Commercial

Gas Space Heating - 3.9 Million Buildings



EIA Commercial Building Energy Consumption Survey – 2012

Boiler space heating population opportunity ~ 4.5 Million units

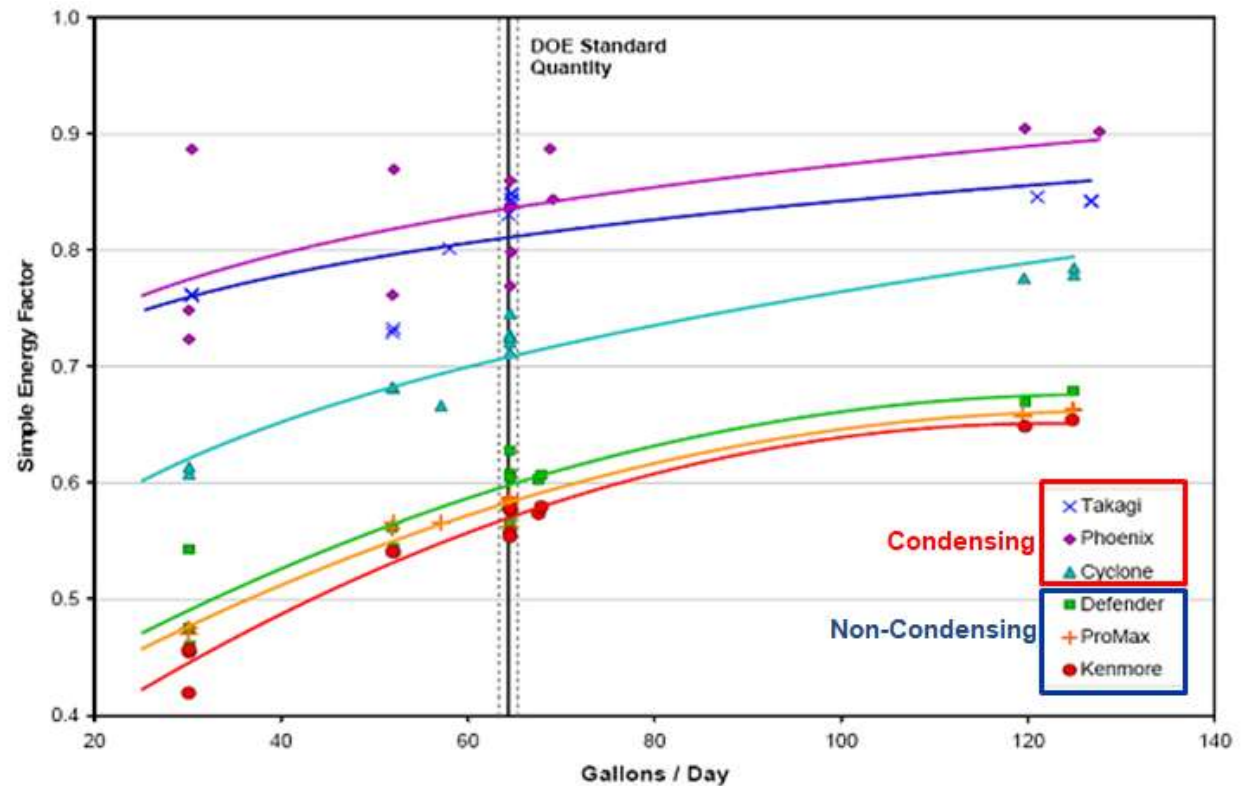
Project Objectives

The Condensing Humidified Air Recuperator (CHAR) was developed to transform boiler market by:

1. Providing a method that allows water heaters and boilers to condense more fully.
2. Using flue gas latent heat and condensate to preheat and humidify air for combustion for efficiency gains and reduced emissions.
3. A design that can be used in retrofit and new applications.

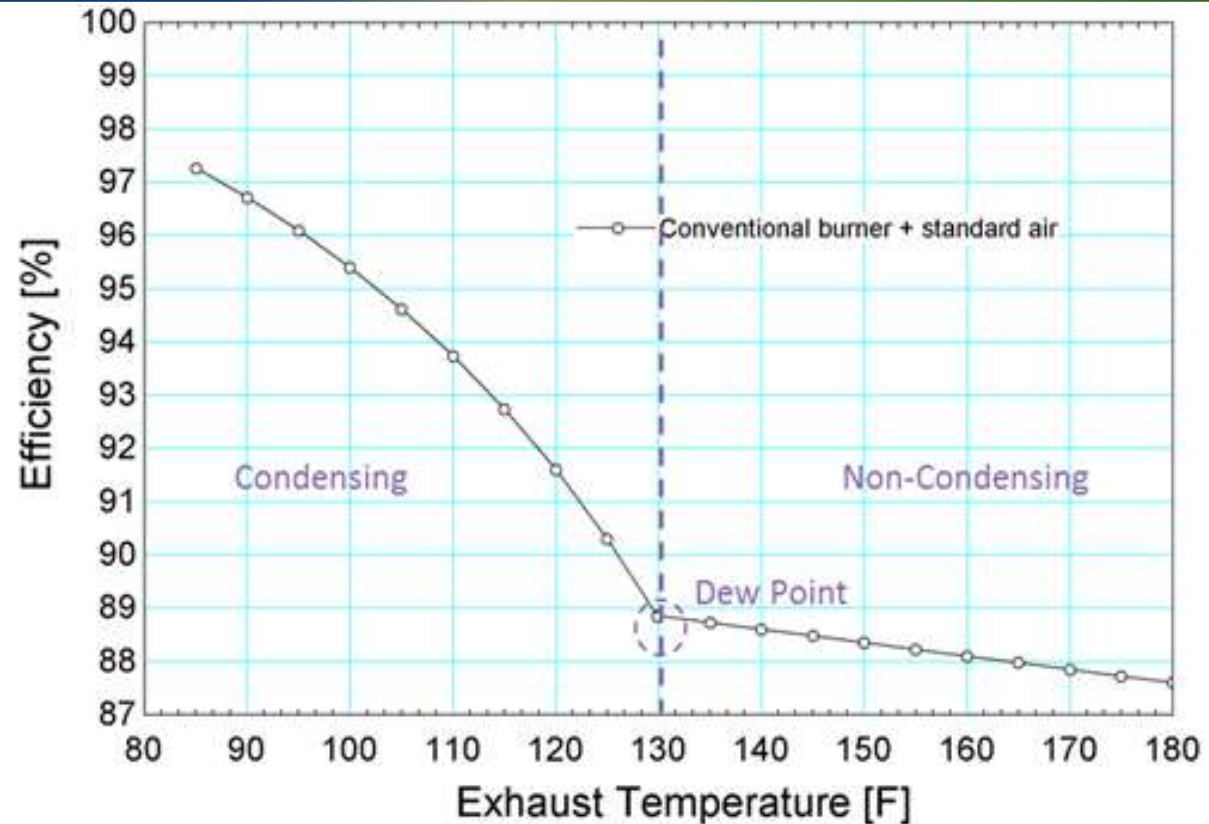
Condensing

- Condensing is more efficient than non-condensing.
- Condensing water heaters and boilers do not condense all the time



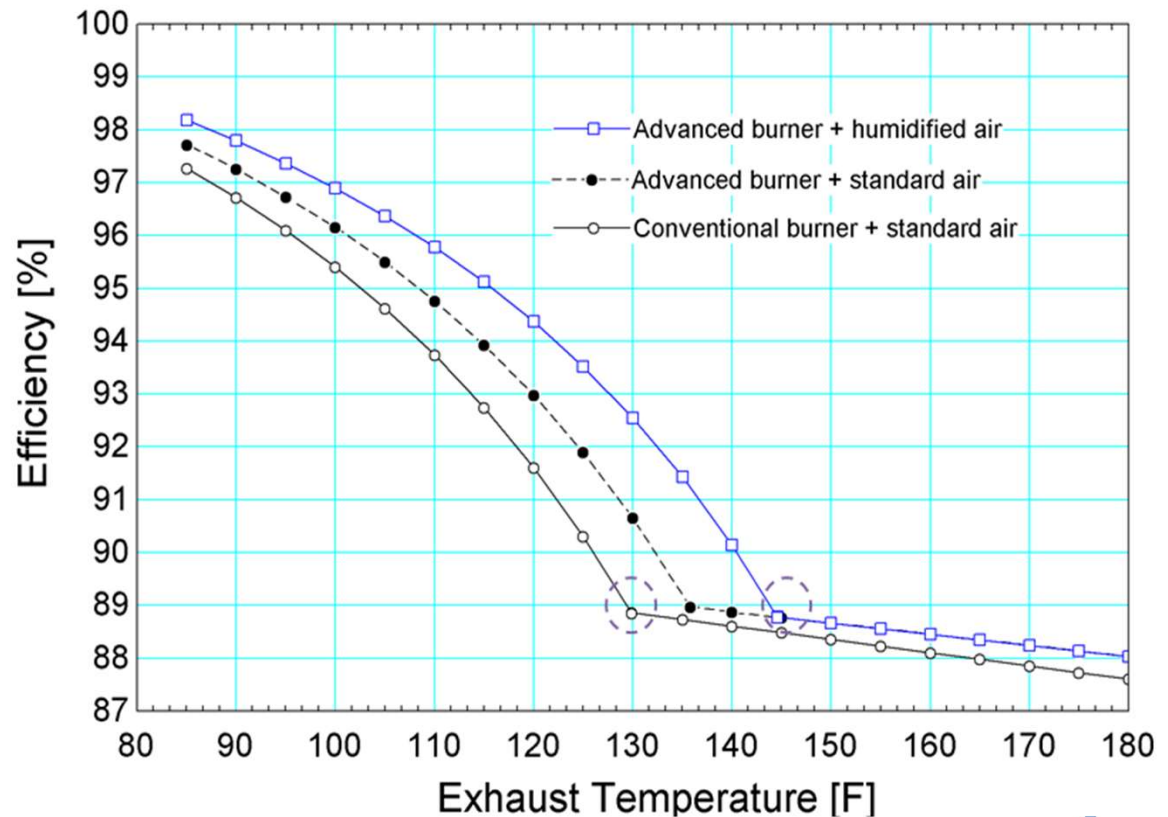
Condensing

- Most condensing occurs at or below 130°F
- Limiting factor for a boiler is the setpoint temp:
 - Water heater: 125 - 160°F \pm 10)
 - Boiler: 150 - 180°F \pm 10)



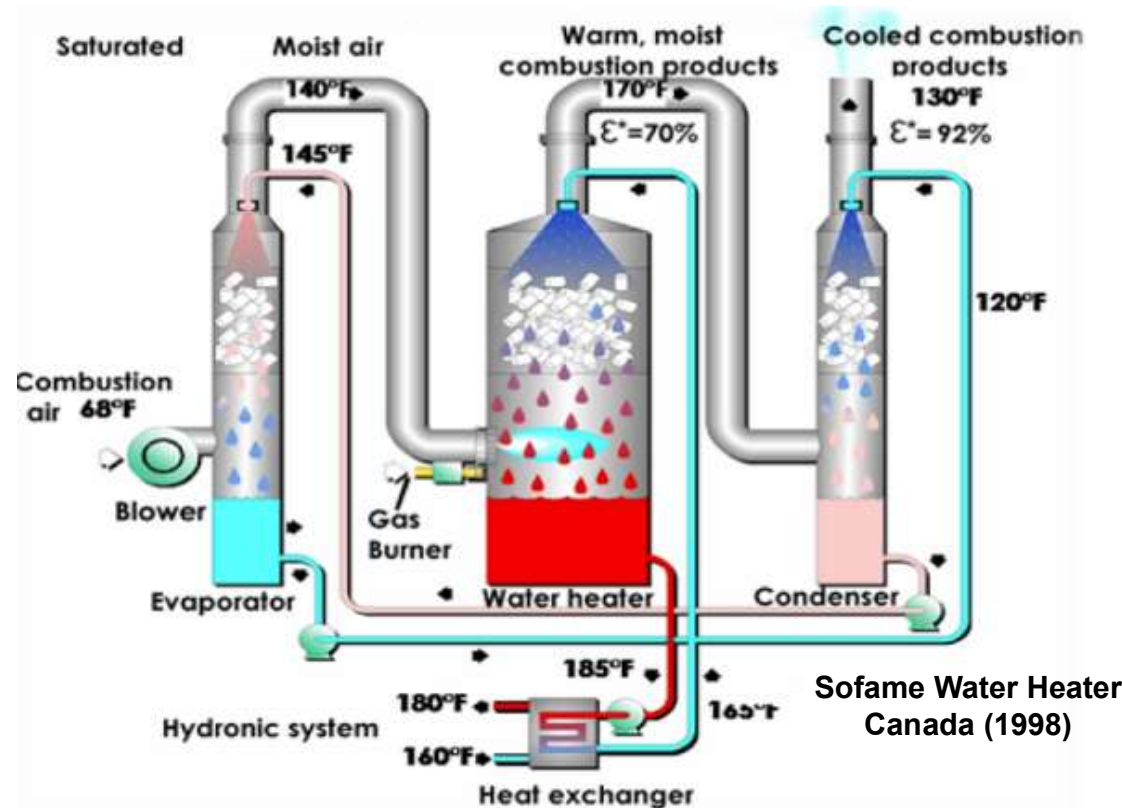
Technical Approach

- Reduce excess air
- Use latent heat and condensate from the flue gas to preheat and humidify combustion air
- The Effect:
 - Increased efficiency
 - Reduced emissions
- Flue gas heat recovery is increased 2.5 -10 times



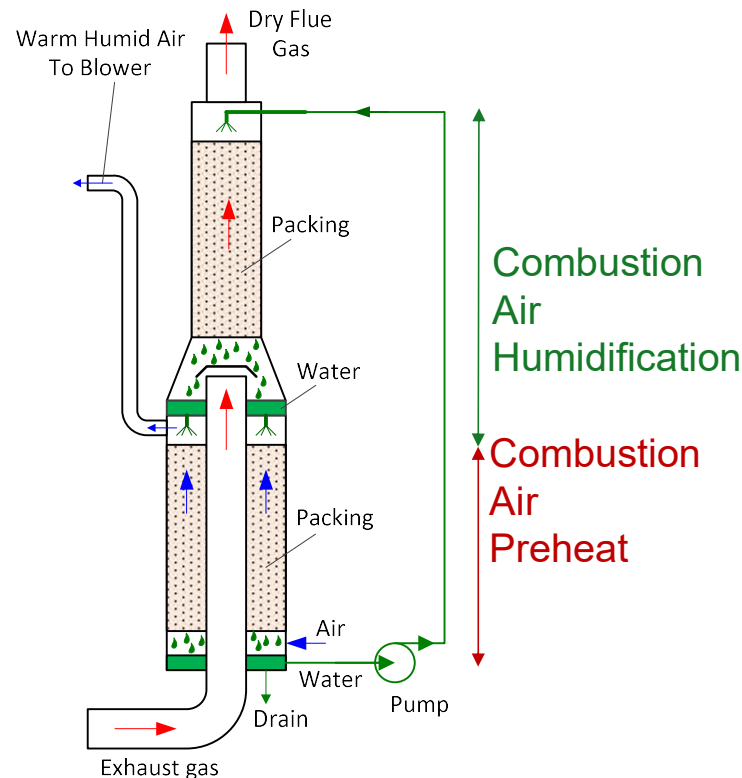
Wet Way Combustion

- “Wet Way Combustion” is the controlled recycling of water vapor and heat from combustion products
- A secondary HX preheats and humidifies combustion air
- Results
 - Efficiency gains
 - Reduced NO_x emissions

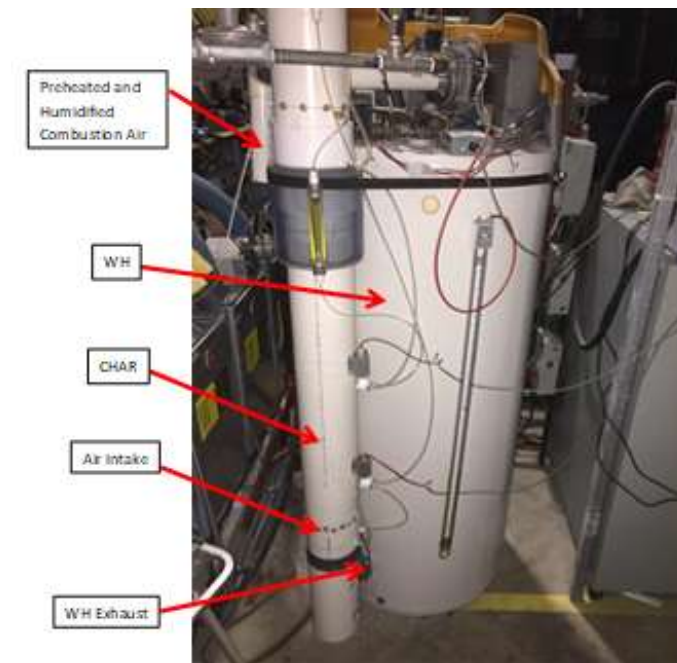


Condensing Humidified Air Recuperator (CHAR)

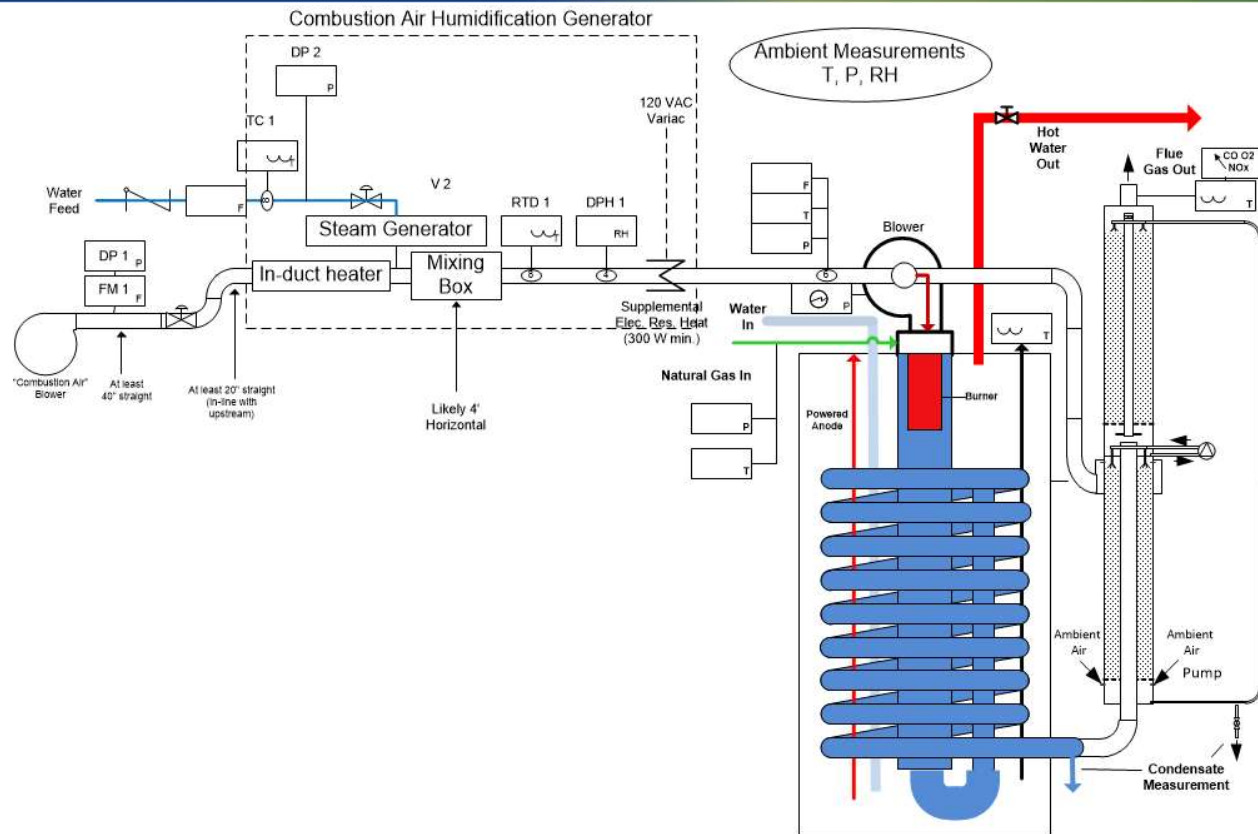
- Condenses and dehumidifies flue gas using ambient air
- Preheats combustion air
- Humidifies combustion air using flue gas condensate



GTI CHAR (US patent, 2014)

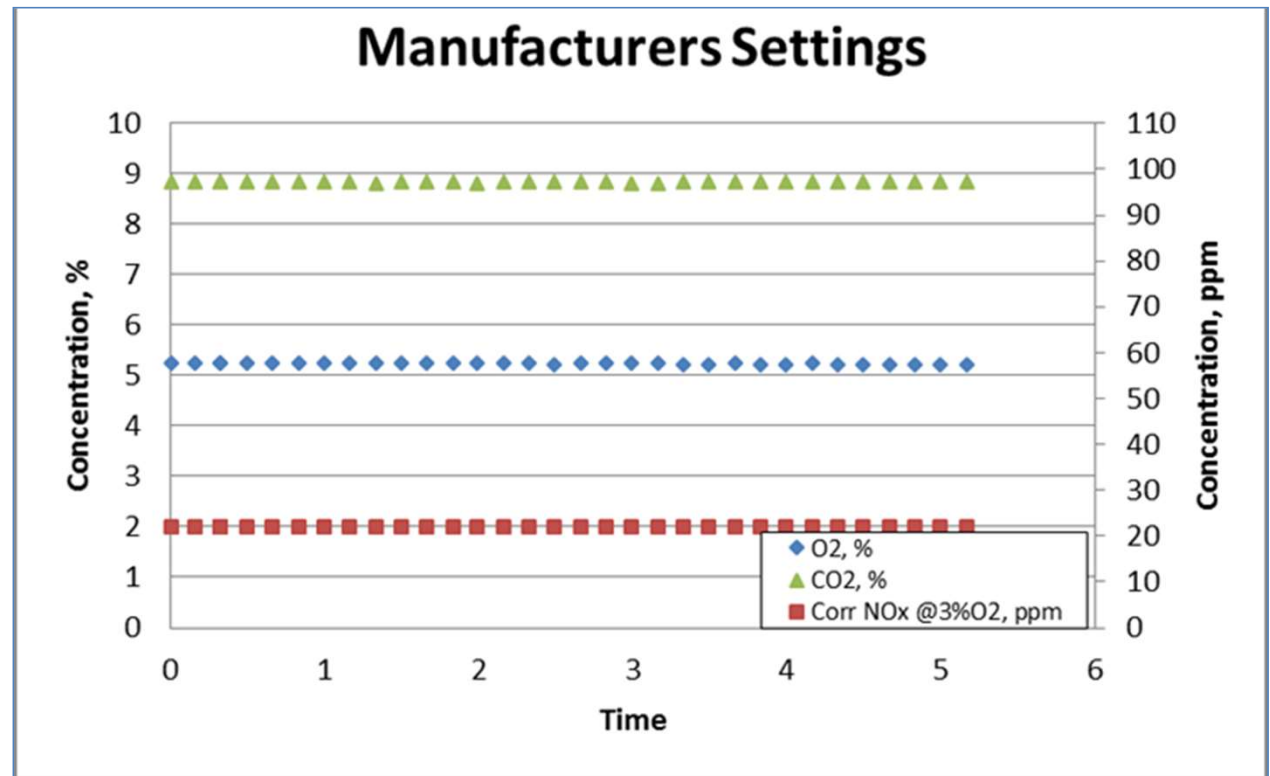


Test – Set Up



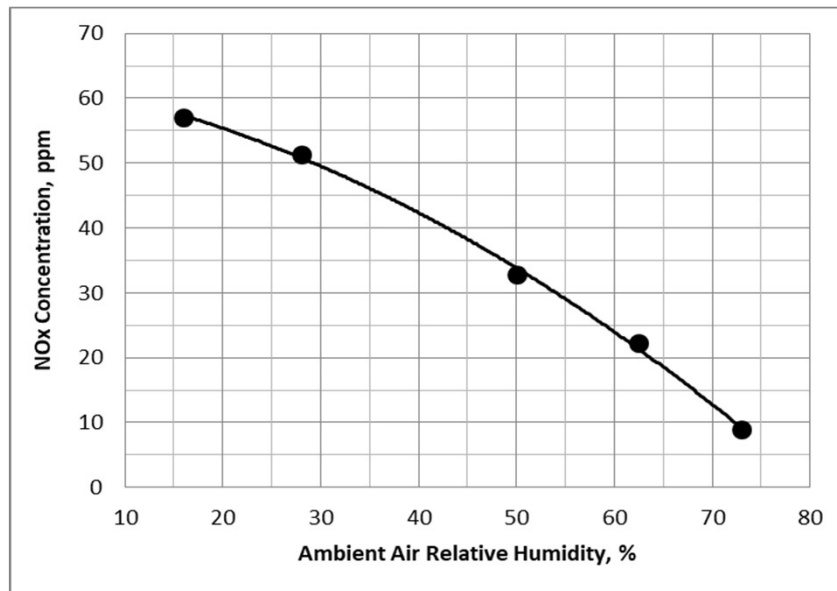
Test Results – Baseline Operation

- California AQMD Rule 1146.2 requires 20 ppm of NOx emissions (at 3% O₂, dry) on commercial water heaters.

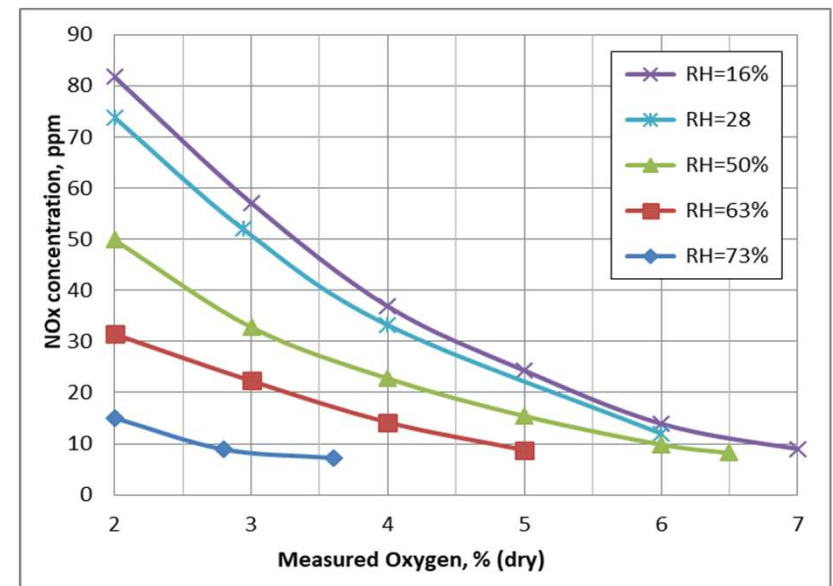


Test Results – Baseline the Affect of Relative Humidity and Excess Air and on NOx

RH Impact on NOx



RH and Excess Air Impact on NOx

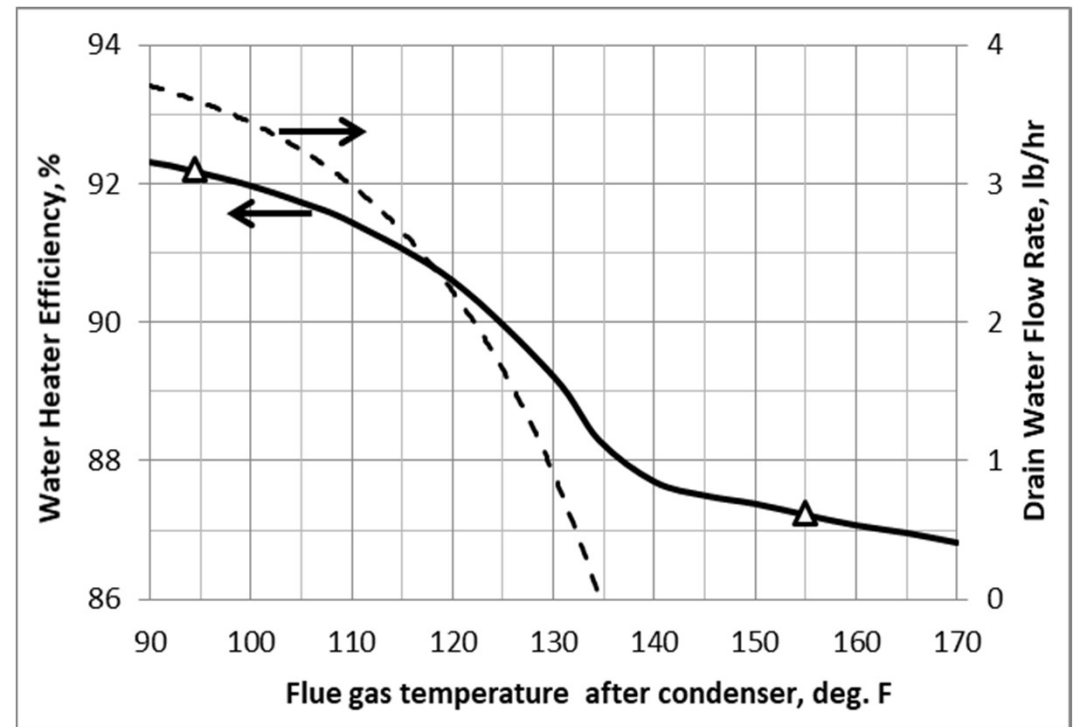


Both ambient air relative humidity and excess air impact NOx emissions

Test Results – CHAR Efficiency

Findings:

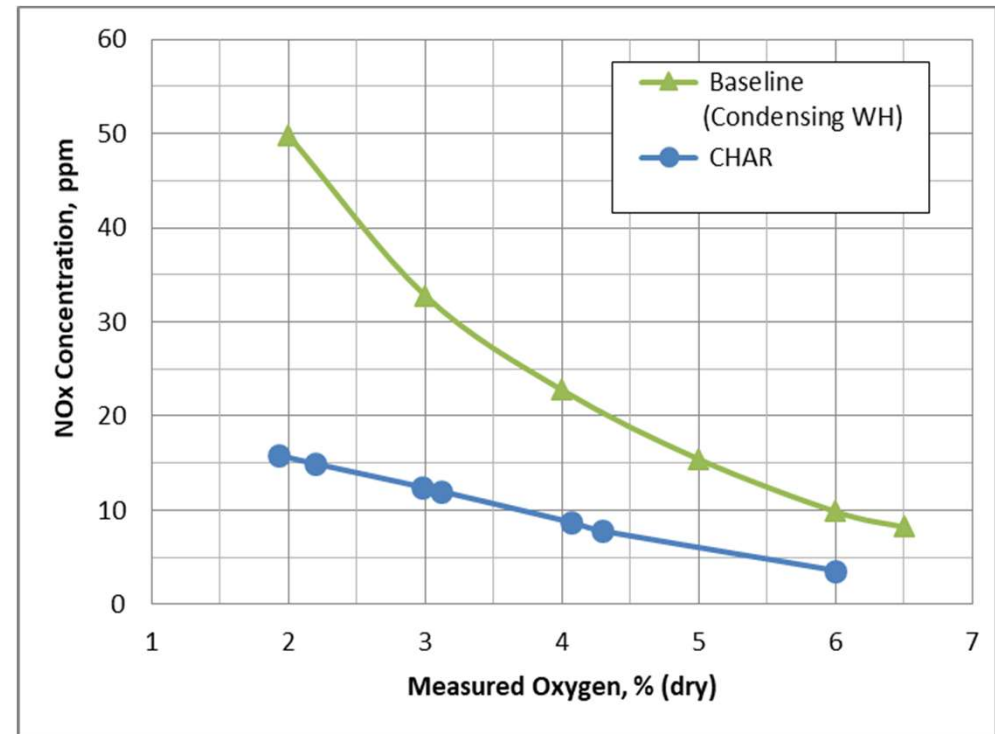
- Water heater efficiency went from our efficiency went from 87% to 92%
- Condensate production increased from .5 lb/Hr to 3.5 lb/Hr



Test Results – CHAR Emissions

Findings:

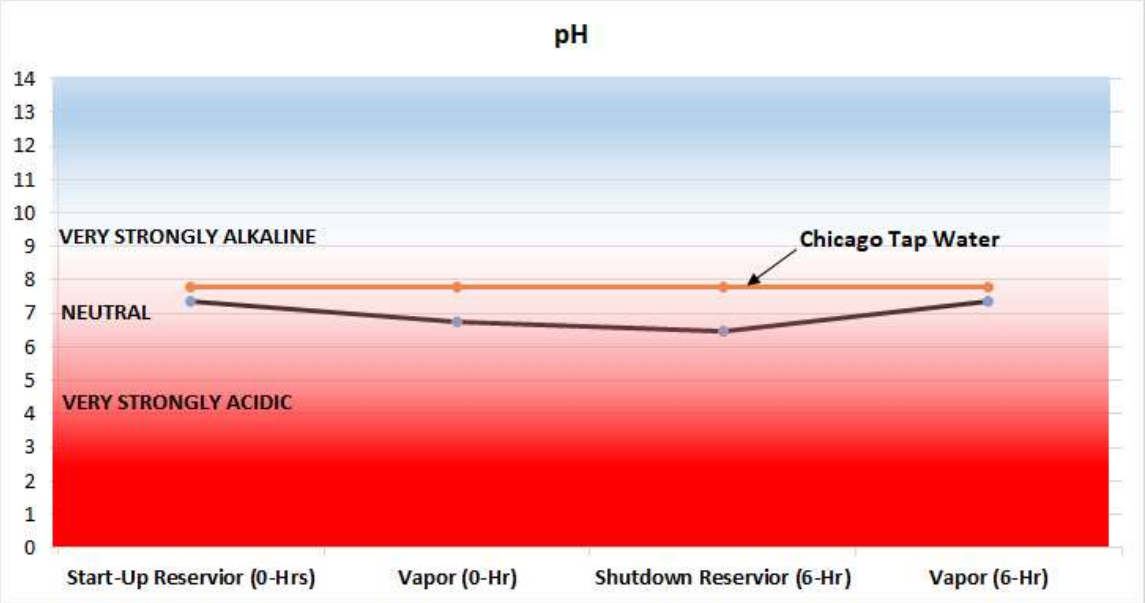
- Humidification decreases NOx concentration in combustion products by more than 60%
- Humidification on CO emissions was not same evident as for NOx due to very low CO values (2-5 ppm)



pH Analysis of Condensate and Vapor

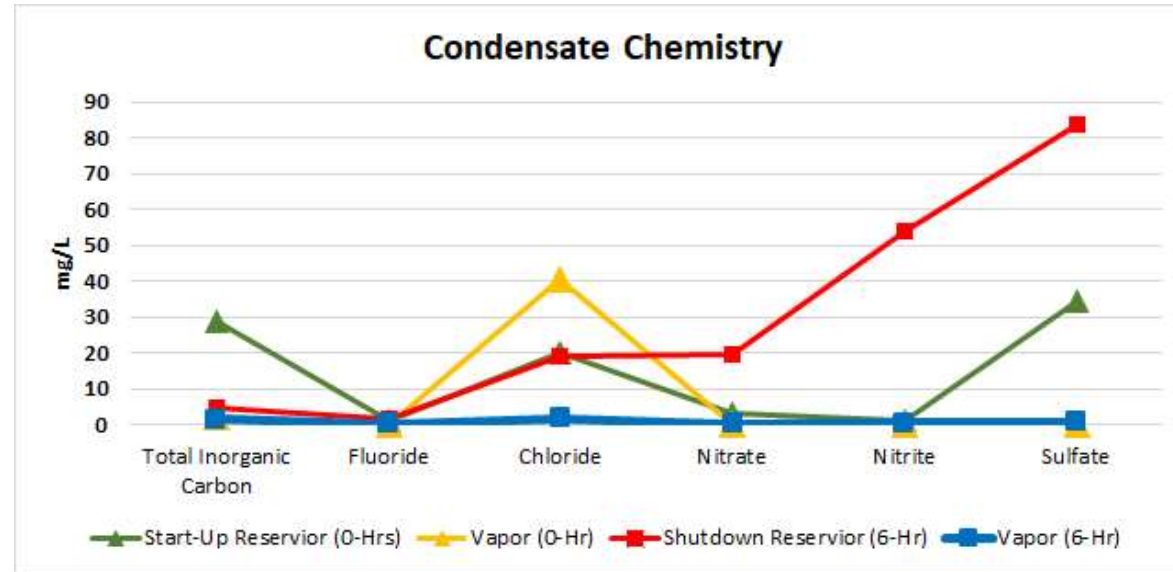
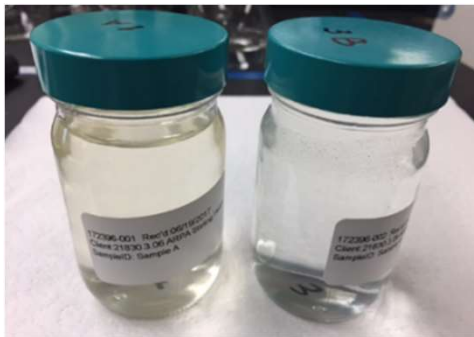
Findings:

- pH analysis showed that throughout operation the condensate and water vapor remained neutral



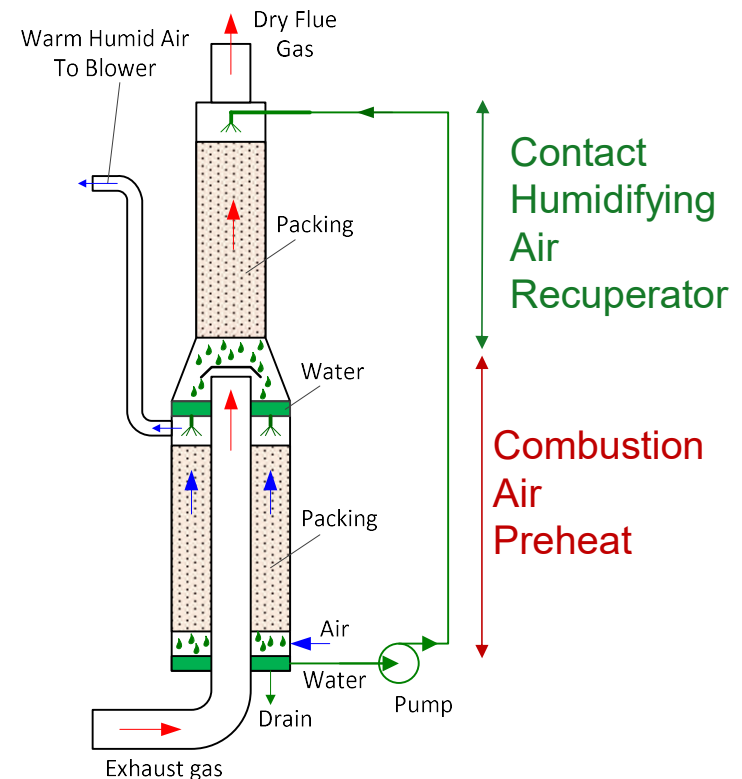
Chemical Analysis of Condensate and Vapor

- Chemical constituents in the condensate tend to fall out of the water vapor that has been reheated and added to the combustion air



Conclusion & Next Steps

- Conclusion
 - The Condensing Humidified Air Recuperator increased efficiency and reduced emissions.
 - Potential for both retrofit and new product design
- Next Step
 - Secure manufacturing partner to fabricate and field evaluate an optimized system



Thank You!