TESTING OF COMMERCIAL FOODSERVICE EQUIPMENT FOR NEW NO_X EMISSIONS STANDARDS

PRESENTER: FRANK JOHNSON – GAS TECHNOLOGY INSTITUTE

ASGE: 2018 NATIONAL TECHNICAL CONFERENCE

JUNE 2018

COMMERCIAL FOODSERVICE IS DIFFERENT

- Did you eat out this week?
- Have you worked at McDonalds?
- Do you watch cooking shows?

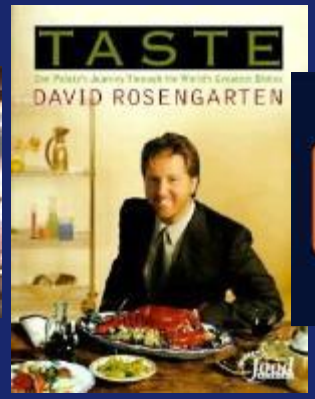
COMMERCIAL FOODSERVICE IS DIFFERENT

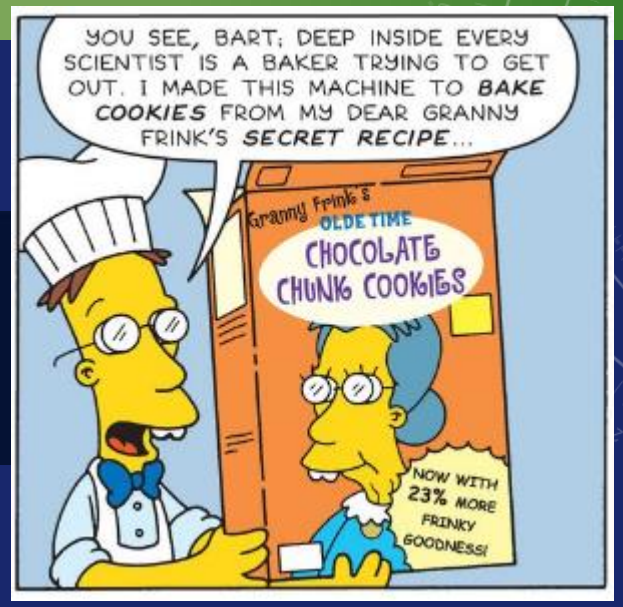
- ***Foodservice is Unique***
  - People understand it
    - Everyone eats out
    - 44% at least once/week
  - People worked in it
    - Currently 12 million employees
    - 1 in 8 worked at McDonald's alone*
  - People are fascinated by cooking
    - 8 in 10 watch cooking shows**

* Fast Food Nation by Eric Schlosser
** Harris Interactive

ICONIC FAST FOODS

MY FOOD OBSESSION





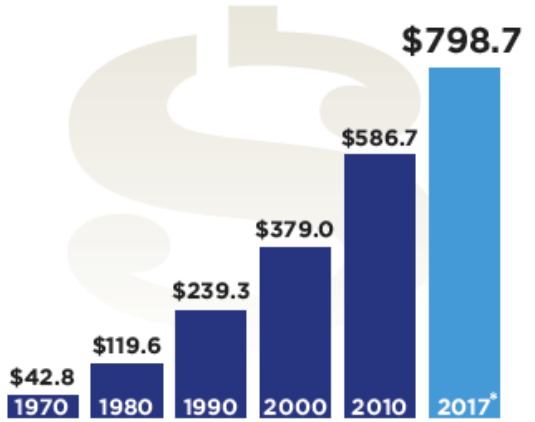
- Cooking for Profit Article, 2011
  - "I Want Some of That and Where Can I Get It?"

CFS INDUSTRY OVERVIEW

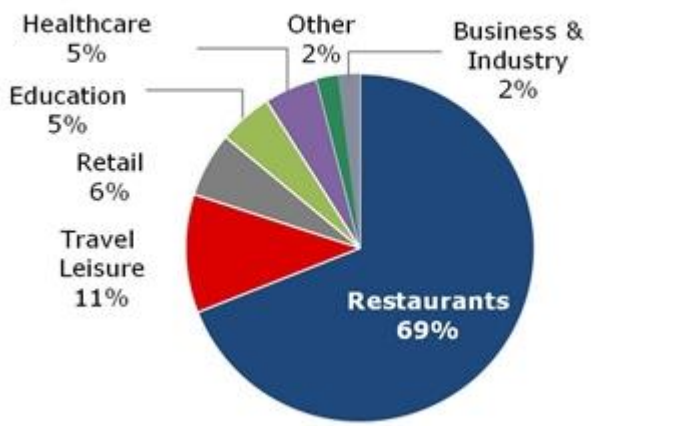
RESTAURANT INDUSTRY SALES ($B)

2017 Industry Sales Projection

Commercial Restaurant Services	**$736.3**
Eating Places	$551.7
Bars and Taverns	$19.8
Managed Services	$53.6
Lodging Places	$36.1
Retail, Vending, Recreation, Mobile	$75.2
Noncommercial Restaurant Services	**$59.7**
Military Restaurant Services	**$2.7**

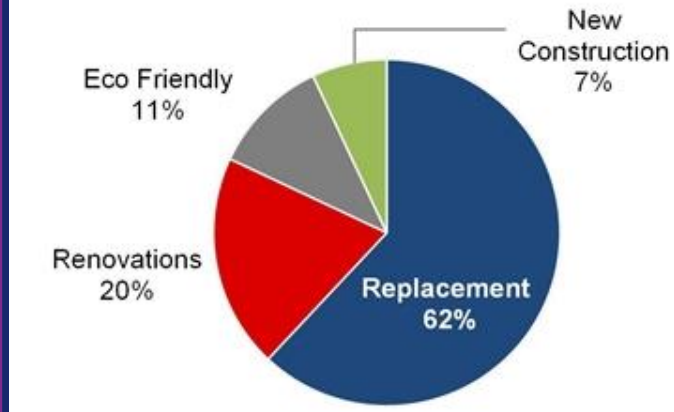


U.S. Industry End Market Overview²



Source: NRA, 2015 estimated CFS sales by end market

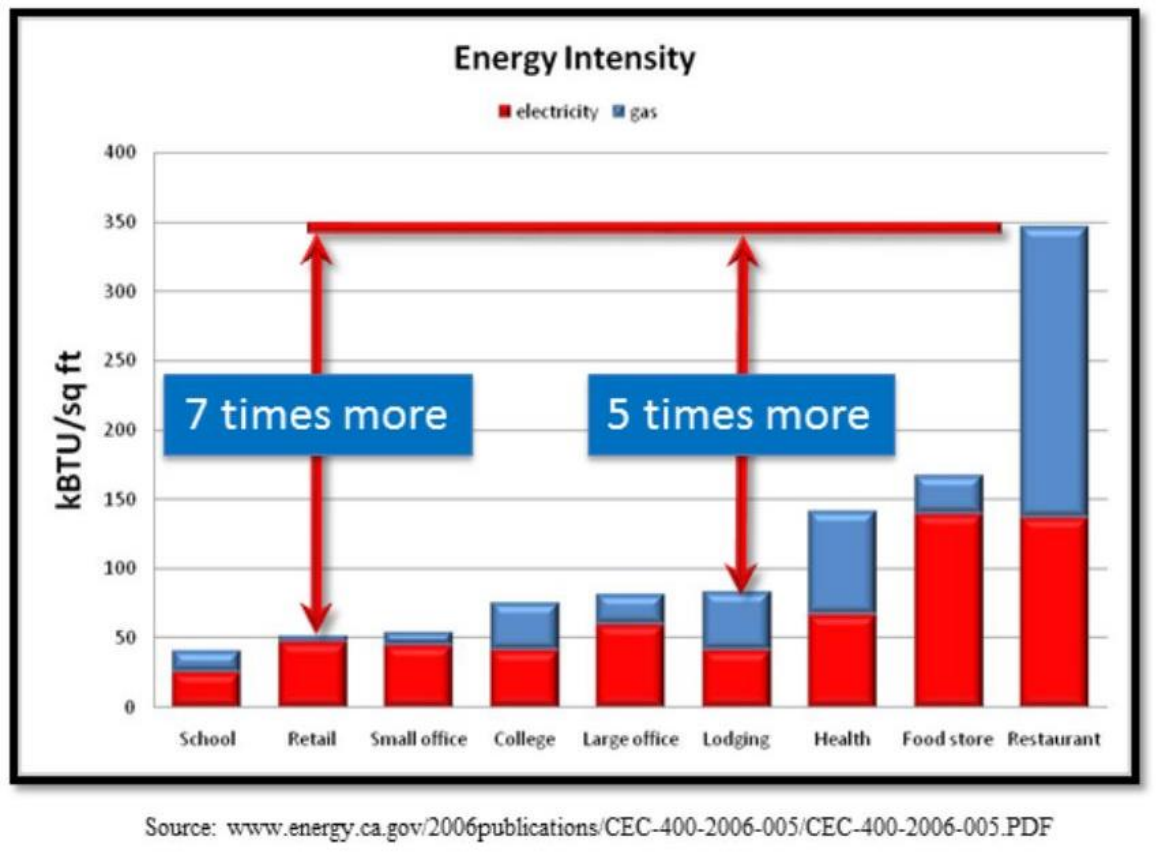
2016 U.S. Foodservice Equipment Needs¹



Source:https://www.sec.gov/Archives/edgar/data/61986/000119312516467650/d133002dex991.htm

Energy Sales in CFS

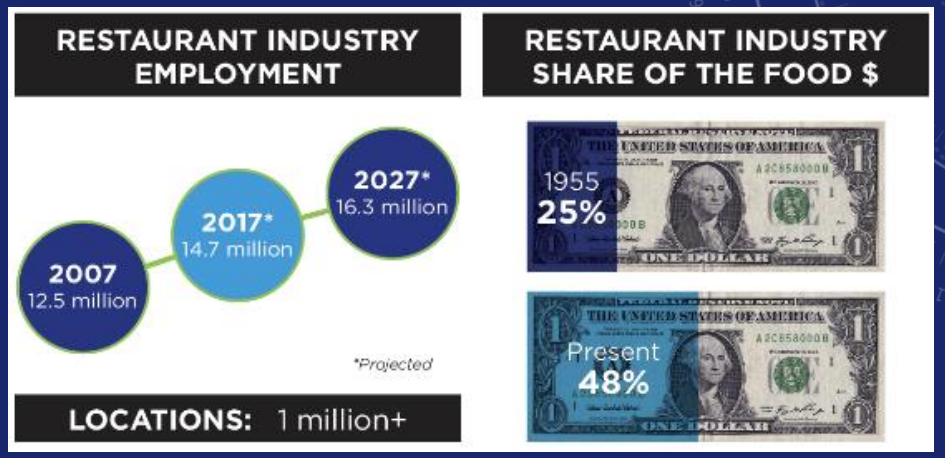
CFS INDUSTRY OVERVIEW



Source: www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF

CURRENT TRENDS/ISSUES IN CFS INDUSTRY

- Equipment Buying Decisions
  - Gas vs. Electric
  - New vs. Old
  - Purchase Price vs. Lifetime Savings
- Technology Issues
  - Energy Efficiency
  - NOx Emissions



60% Consumers who say availability of environmentally friendly food would make them choose one restaurant over another.

GAS TECHNOLOGY INSTITUTE

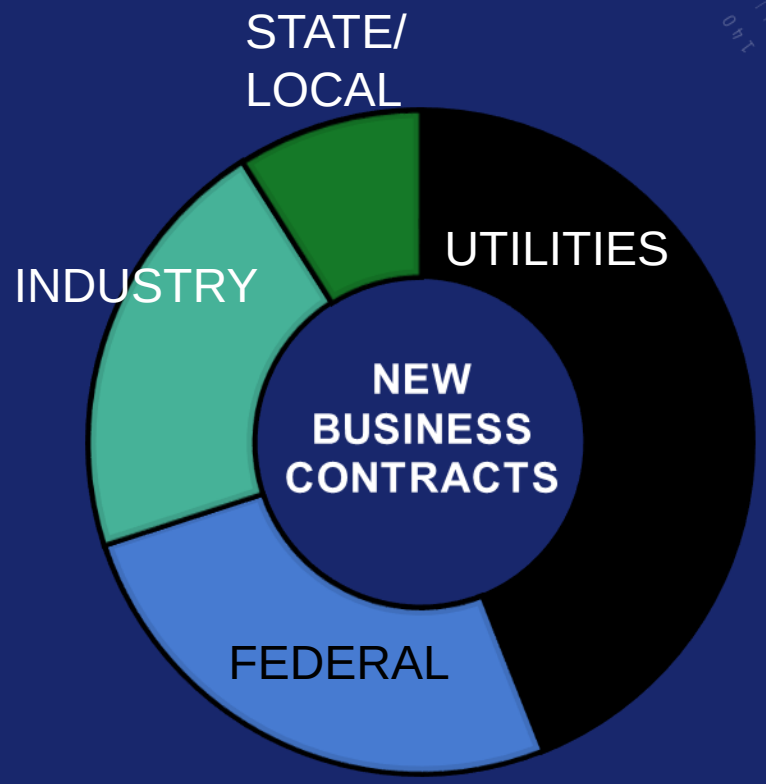
- Independent, not-for-profit established by the natural gas industry
- GTI tackles tough energy challenges turning raw technology into practical solutions
  - > From the well to the burner tip including energy conversion technologies

GTI HIGHLIGHTS

DIVERSE CUSTOMER BASE

GTI provides solutions to clients in the private sector, federal government, and state government agencies

- 300+ active projects
- 20 patents issued
- 10 patent applications



2016 Results

U.S. OFFICE LOCATIONS

California
- Oakland, West Sacramento, Davis, San Ramon, Los Angeles (Frontier Energy)
- Woodland Hills

Illinois
- Chicago (LocusView)
- Des Plaines (*Headquarters)

New York
- Cazenovia (CDH Energy)

Texas
- Houston
- Austin (Frontier Assoc)

Washington, DC
- Capitol Hill

COMMERCIAL FOODSERVICE AT GTI

- Experienced staff
  - Over 19 years of CFS work
- State of the art laboratory

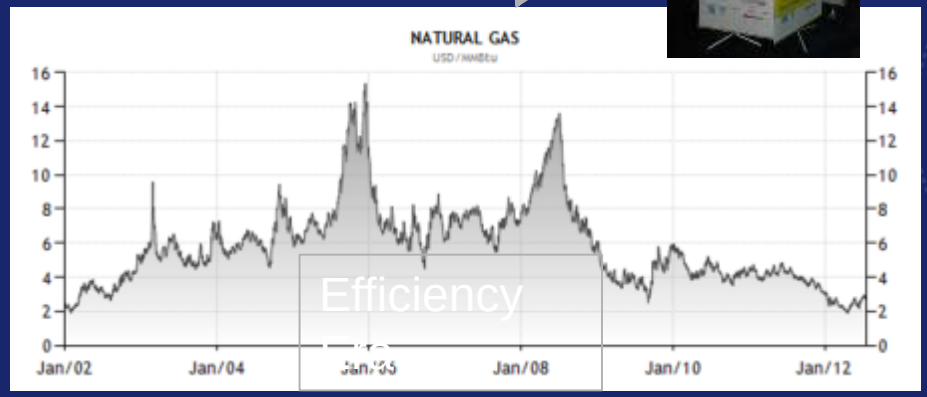
CFS RESEARCH EMPHASIS TIMELINE

0 BMc | 1975 | 1985 | 2005 | 2012

New Appliances:
How it cooks
First cost

Energy Crisis:
Efficiency

How it cooks
First cost



CFS RESEARCH: TECHNOLOGY

> CFS lags behind other industries in terms of burner technology

- Cost
- Cooking characteristics
  - > “Not broke, don’t fix it”
- Burner expertise







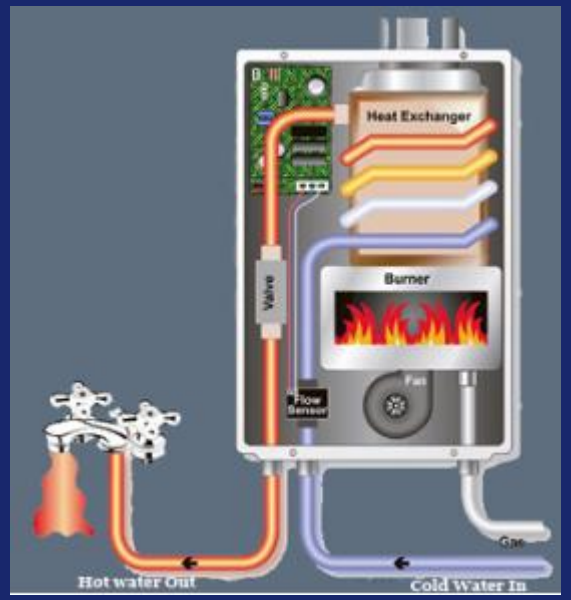






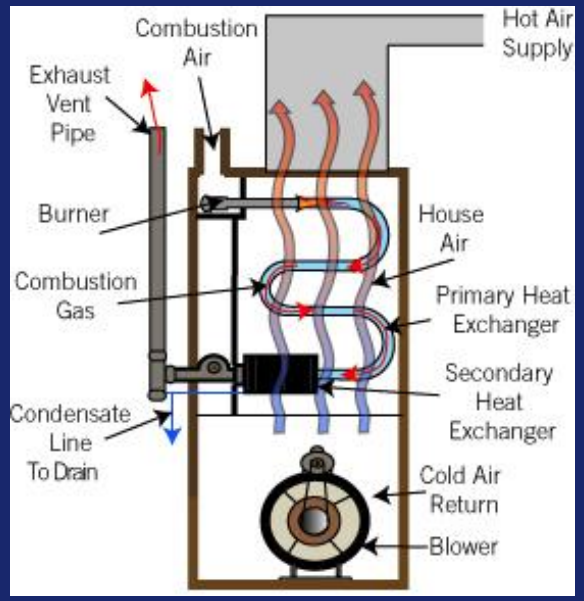

CFS RESEARCH: TECHNOLOGY

> Temperature vs. Taste

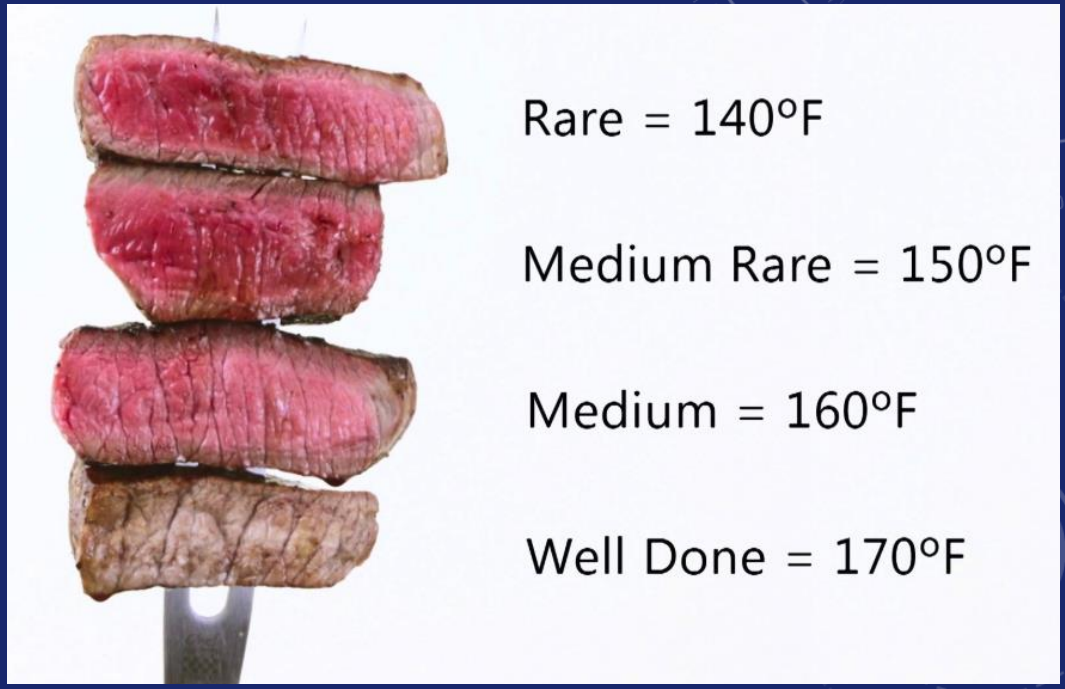


Water:
100 ºF
1 gal/min

Air:
140 ºF
1600 cfm



When is a steak cooked?

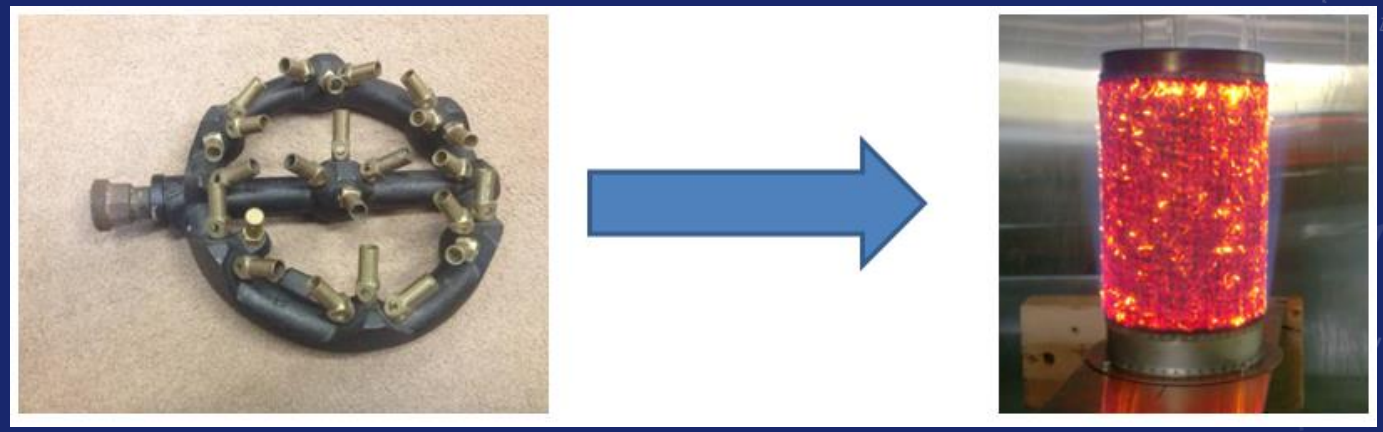


CFS RESEARCH: TECHNOLOGY

> Show value of bringing cutting edge burner designs to commercial foodservice

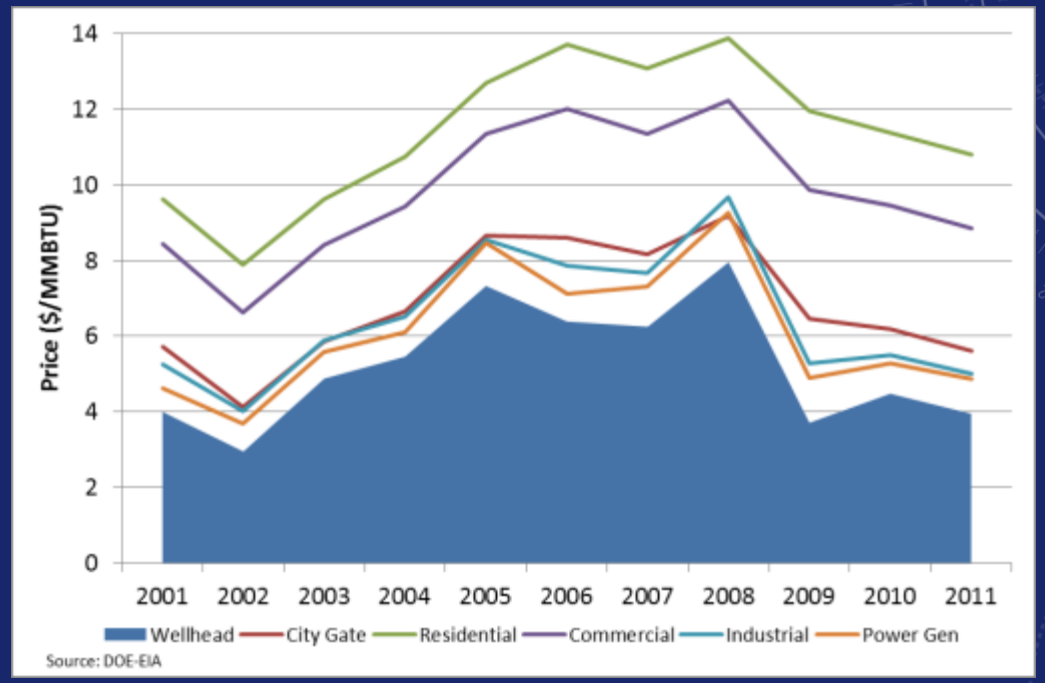
> Improve

- Efficiency
- Emissions
- Cooking Performance



EFFICIENCY IN A RESTAURANT

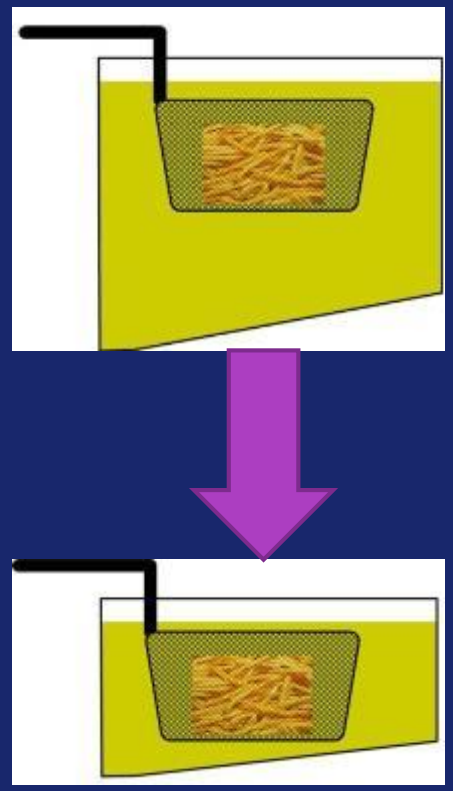
- Major Hurdles
  - Higher cost of equipment
  - Limited availability
  - Decreased cost of energy
  - Energy intensity
  - Uncertainty about cooking performance



- Cooking for Profit Article, 2014
  - Why Efficiency Still Matters

THE VALUE OF NEW TECHNOLOGY: REAL WORLD EXAMPLE

- Demonstration of Energy Efficient Fryer
  - 6 locations in North America
- Testing
  - Baseline
    - Energy Usage, Food Quantity
  - Usage Survey
    - Old vs. New Fryer
  - Oil Life Tests
    - Old vs. New Fryer
  - Advanced Fryer
    - Energy Usage, Food Quantity



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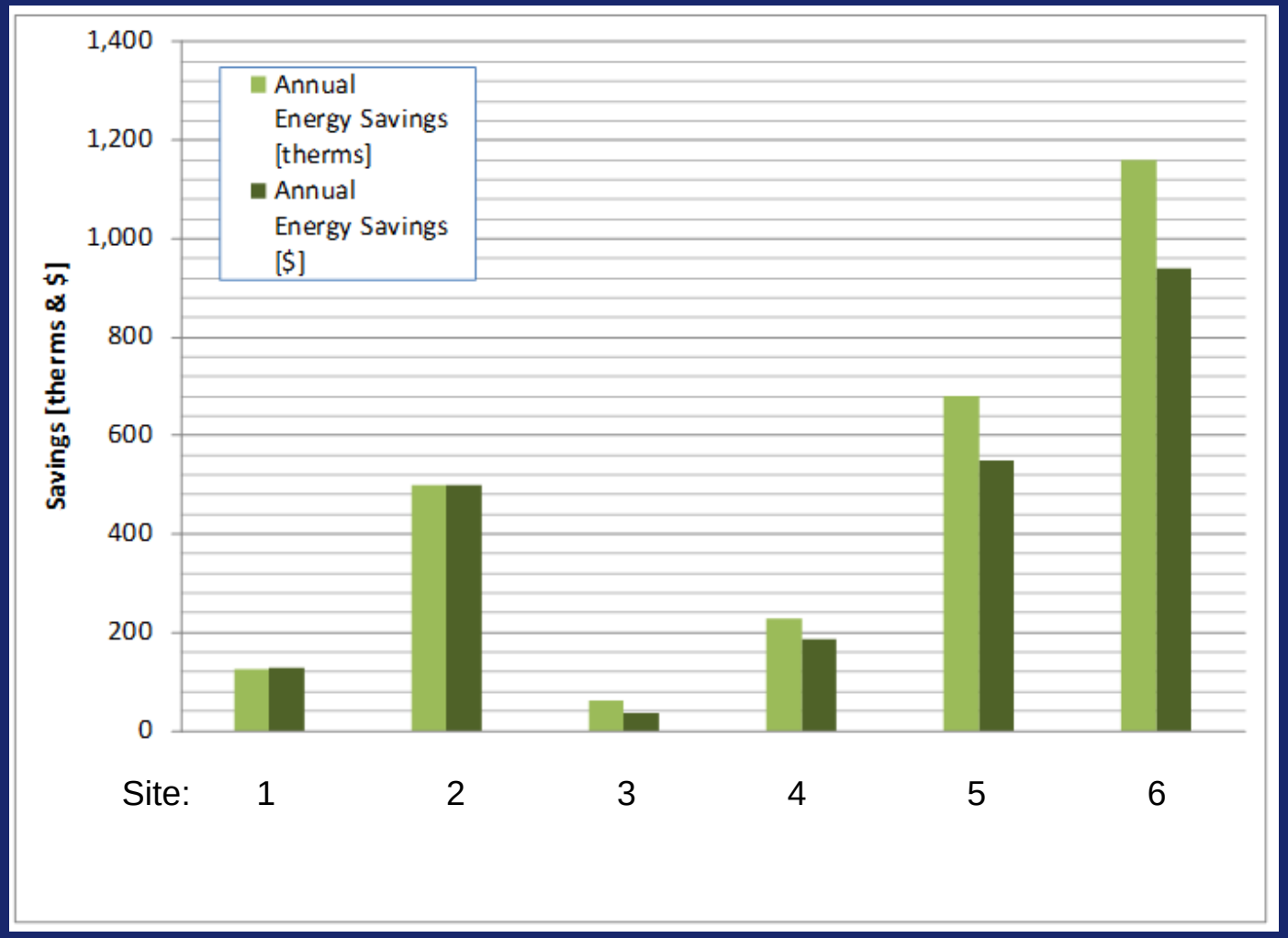

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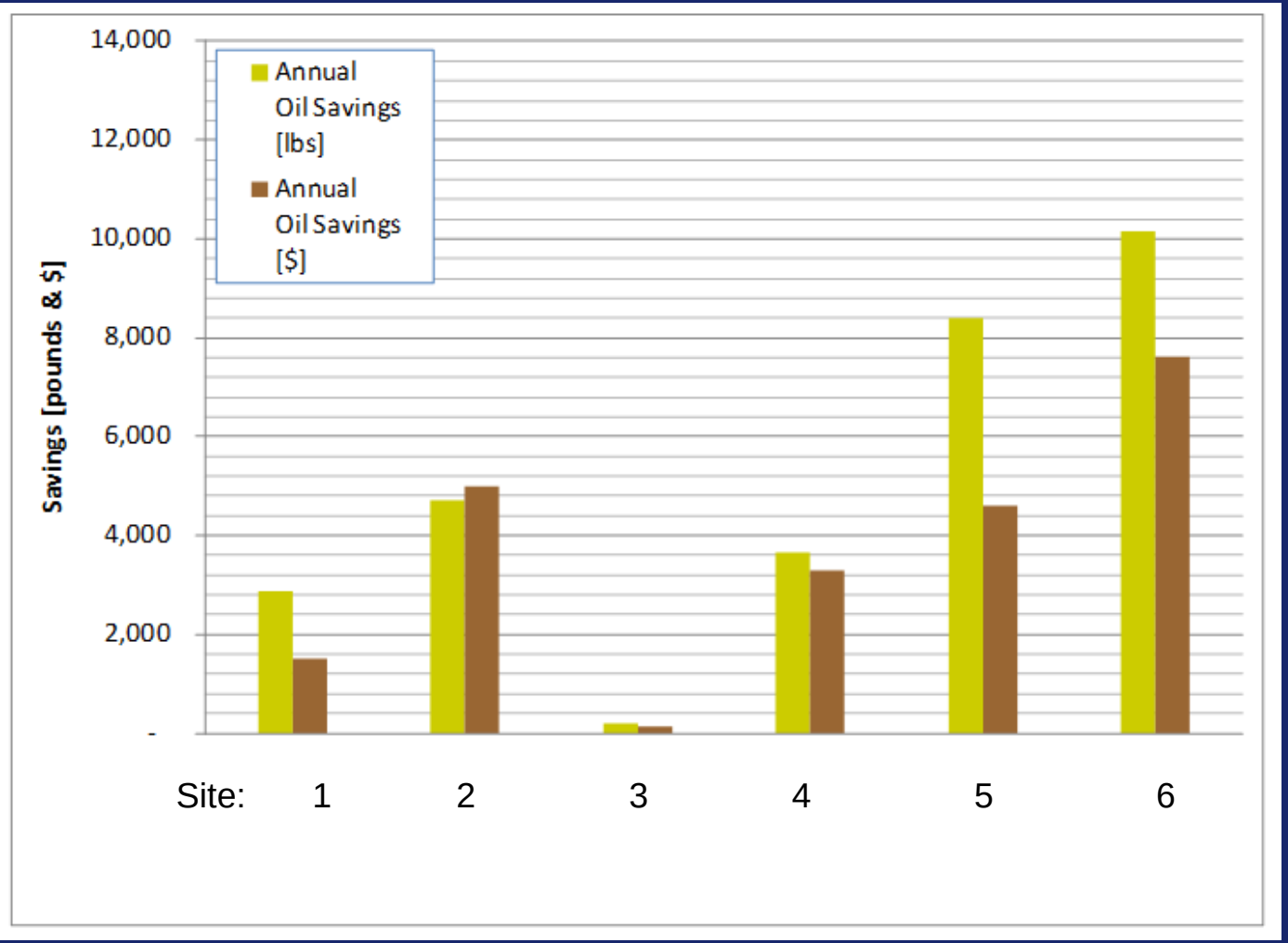


THE VALUE OF NEW TECHNOLOGY: REAL WORLD EXAMPLE

- Average Savings of $4,800/yr
- The End Users:
  - Manager of Site 2, “much easier to clean”, oil changes “Drastic change, we changed the other fryer twice as much”
  - Manager Site 3, “Food looks much better, longer and the fries are nice and golden”, “Awesome”
  - Chef of Site 4, “A million times better” than the old fryer
    - When asked if wants to return old fryer
      - “not in a million year” “over my dead body” “its part of the family”

A NEW ISSUE: NO_X

- The South Coast Air Quality Management District (SCAQMD)
  - Responsible for clean air planning in the South Coast Air Basin (Basin), an area that includes Orange County and the non-desert portions of Los Angeles, Riverside and San Bernardino counties.
  - 2016 Air Quality Management Plan
    - Establish new NOx emissions limits
    - Limits already exist for furnace, water heaters boilers
    - No existing limits on commercial foodservice

http://www.aqmd.gov/home/library/clean-air-plans/air-quality-mgt-plan/reviseddraft2016AQMP

ISSUES WITH NO_X REGULATIONS

- Emissions in CFS are not regulated
  - Except Carbon Monoxide for safety
- Burner diversity in CFS
- Equipment design diversity
- No established protocols
- NOx is difficult to measure accurately

COMMERCIAL COOKING EQUIPMENT NOX CHARACTERIZATION STUDY

Goals

1. Develop emission test procedures for several types of commercial cooking equipment
2. Collect NO_x emissions data for selected units
    - Can be used as baseline values when SCAQMD develops future NO_x incentives, regulations

Participants

- SCAQMD, Frontier Energy, SoCalGas, NAFEM, CSA, CRA, GTI, others

NO_X CHARACTERIZATION STUDY

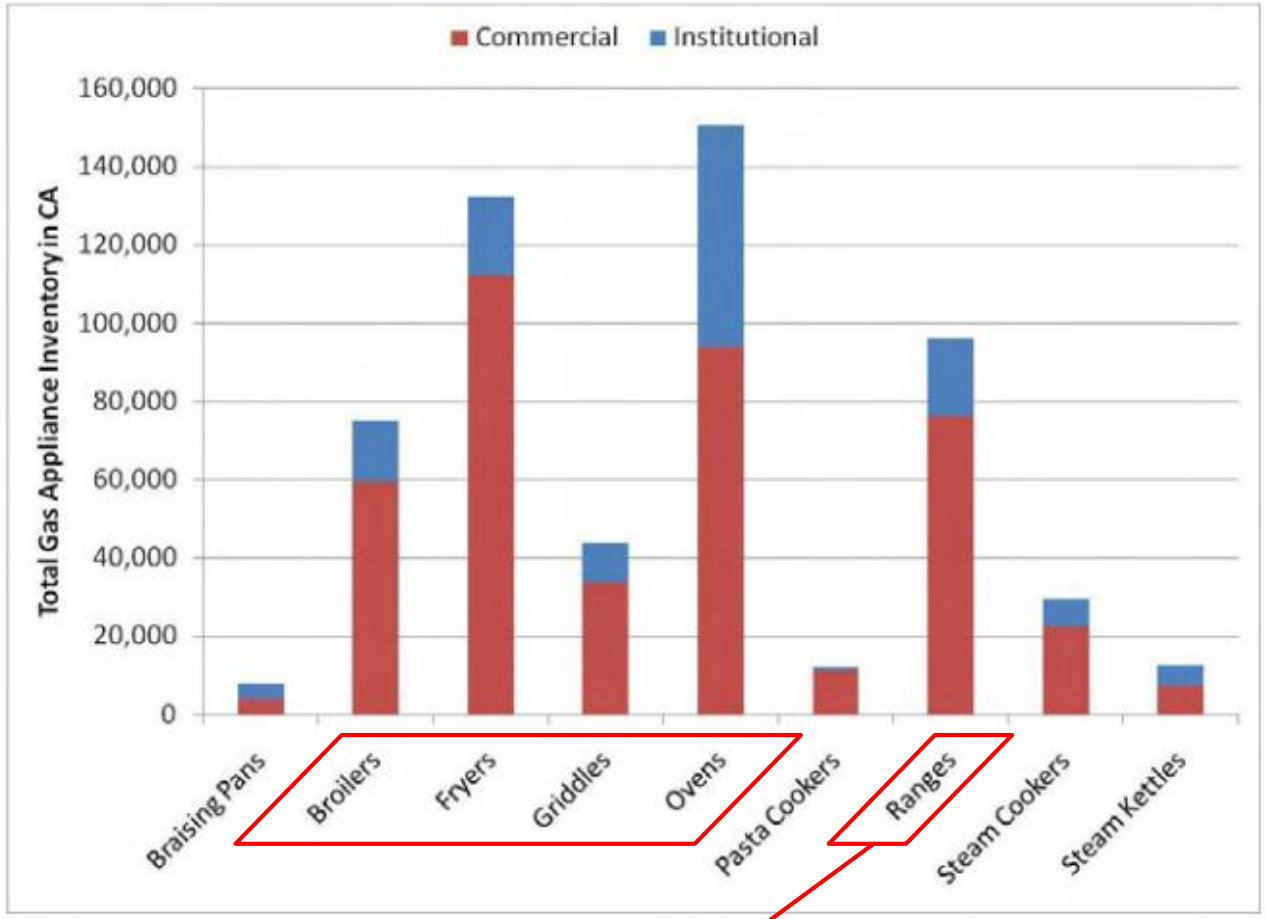
Units Tested

» Total of 47 units across 9 equipment types:

1. Broiler
2. Fryer
3. Griddle
4. Oven – Standard
5. Oven – Convection
6. Oven – Combination
7. Oven – Conveyor
8. Oven – Deck
9. Oven – Rack

» Tested a mix of standard and efficient models
  - Broiler, Oven – Standard, and Oven – Deck do not have an efficiency classification or rebate offered

Figure ES-1: Gas-fired appliance inventory estimates in commercial and institutional foodservice facilities in California



The selected Oven – Standard units all had ranges on top

Fisher-Nickel, Inc.: Report to CEC: Characterizing the Energy Efficiency Potential of Commercial Foodservice Equipment

NOX TESTING PROTOCOLS

- ANSI Z83.11 based
  - Not NOx specific
  - $CO_{corrected,}$ $0\%O_2$ < 800 ppm
  - Data taken from cold start until burner cycles or 15 minutes
- SCAQMD – Rule 1111 and Method 100.1
  - NOx measured using chemiluminescent analyzer
  - Measured in ppm, calculated to ng/J
  - Heated sample line with dryer filter
  - Stainless steel and teflon sample line
- Portable Analyzers???

EMISSION SAMPLING - ANALYZER

Measures CO, NO, NO_2, O_2, CO_2

Analyzer box and probe

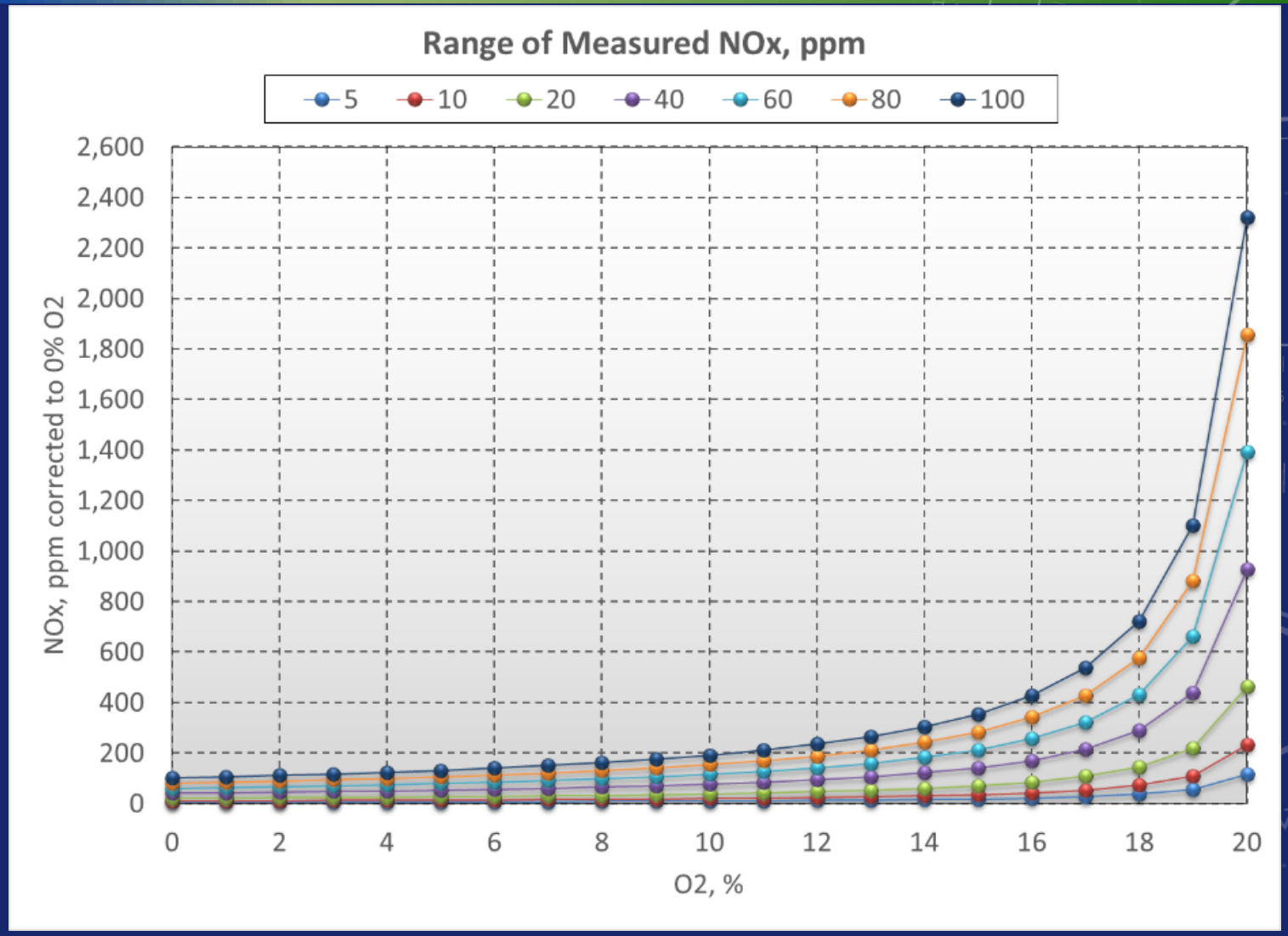
Single point probe with elbow, for a small flue on a combi oven

NOX: CAPTURE AND ANALYZING

- Sample dilution
  - Concentrating flue capture
    - Burner interference
    - Flow through
  - Correction to 0% O_2
    - Greater than 18% O_2 problematic
    - Less than 15% O_2 preferred

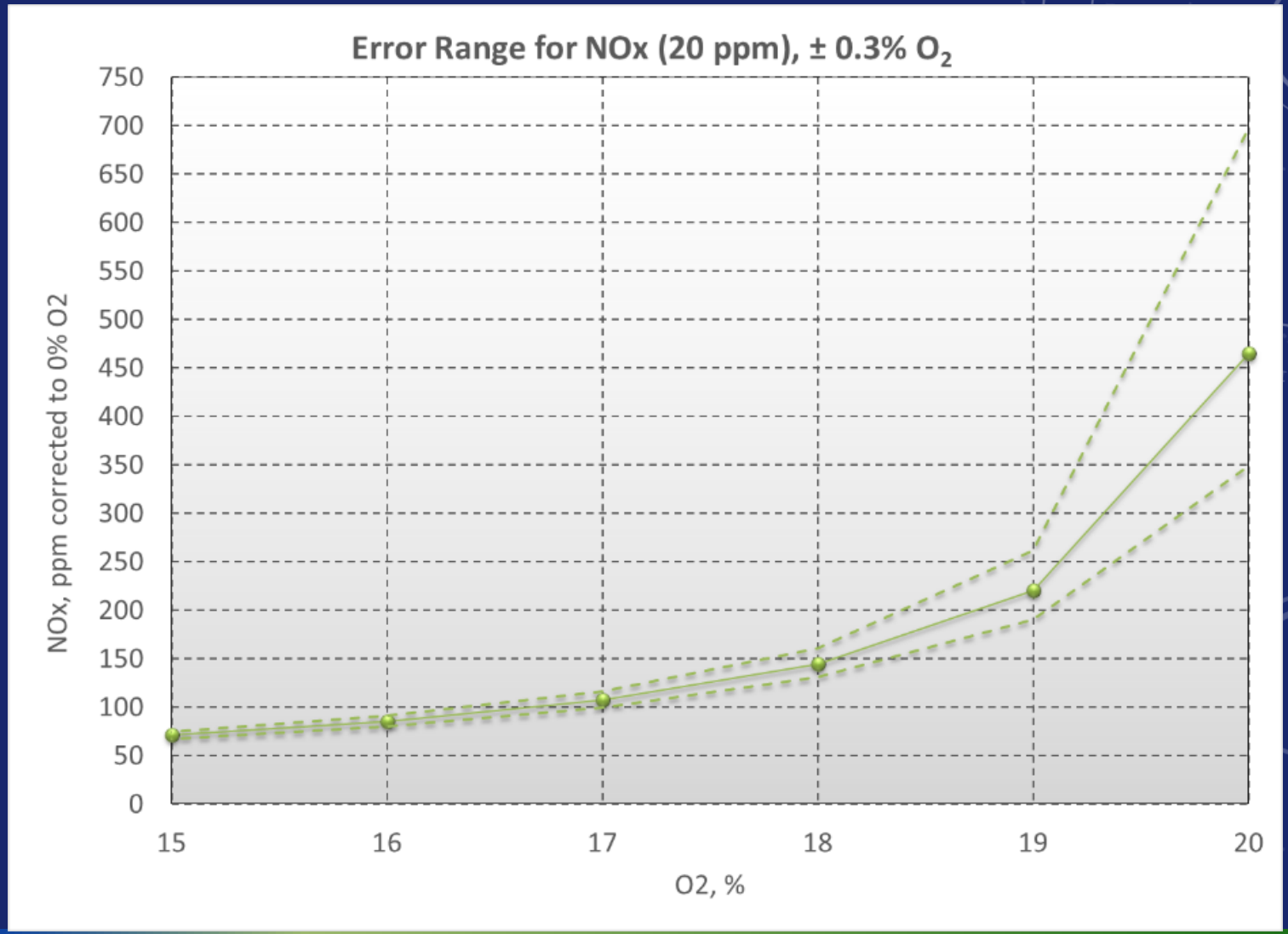
NOX: CAPTURE AND ANALYZING

- Sample dilution, > 18% O_2



NOX: CAPTURE AND ANALYZING

- Sample dilution, > 18% O_2



NOX: MEASUREMENT KEYS

- Stable combustion/operation
  - CO emissions
  - Visual Inspection
- Minimal sample dilution
  - < 18% O_2, prefer < 15%
- No interfere with combustion from sampling
- Capture sample from entire flue stream
- All results are unit specific
  - Minor design changes in burner and/or unit can have major effects on NOx emissions

TEST PROCEDURE

Equipment with thermostat control (most units)

1. Start preheat to the specified setpoint
2. Start monitoring emissions
3. After burners shut off, test is complete
4. Average the emissions for a specified time period (e.g. 15 sec) before burner shutoff

Equipment without thermostat control (broilers, some griddles)

1. Warm up the unit for a specified duration (e.g. 30 min)
2. Monitor emissions for a specified duration (e.g. 15 min)
3. Average the emissions

EMISSION SAMPLING - PROBES

Fabricate various attachments to suit the flue geometry

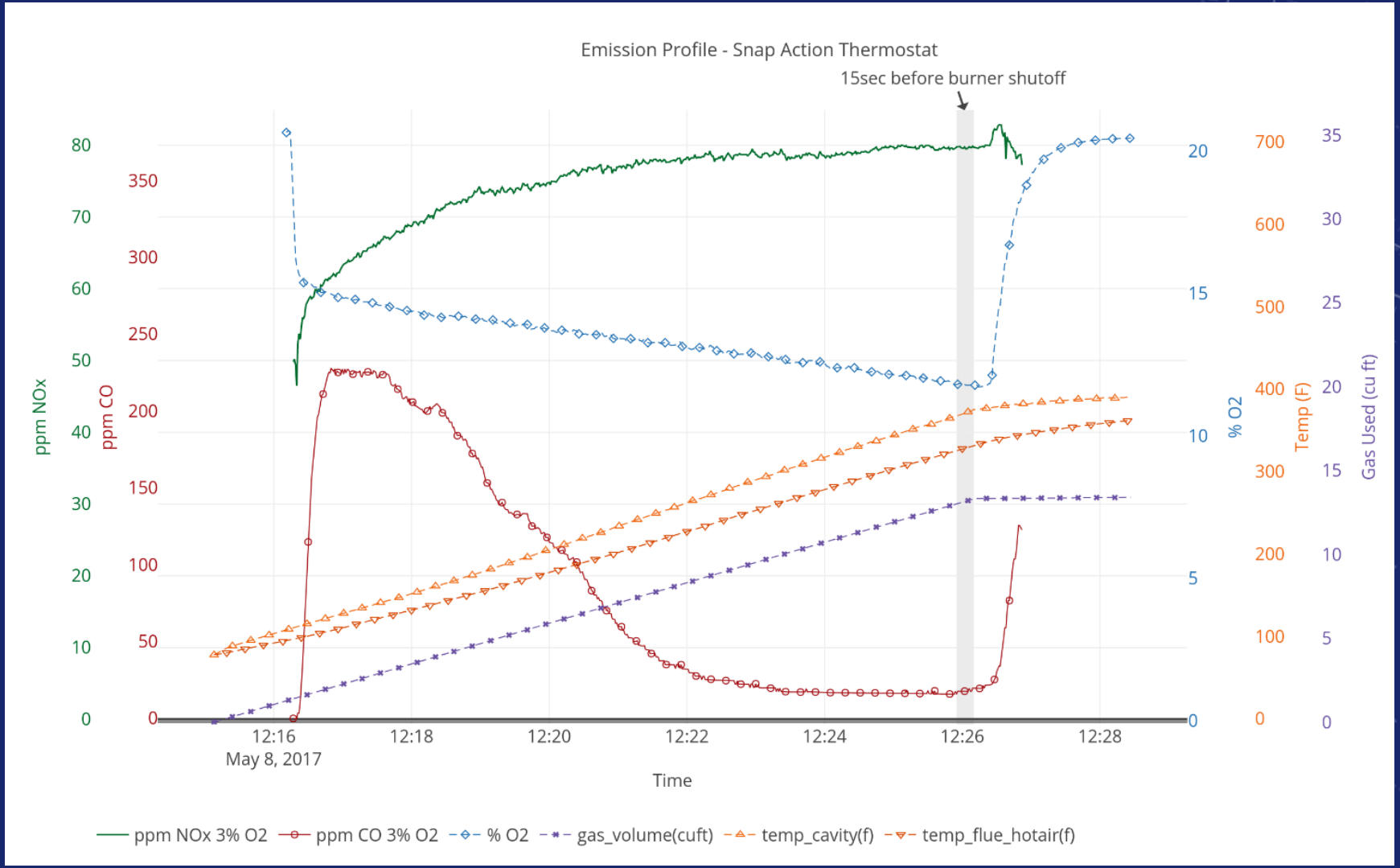
T-shape manifold probe with multiple holes, to cover a wider flue on a convection oven

L-shape manifold probe with multiple holes

Broiler emission hood with manifold probe

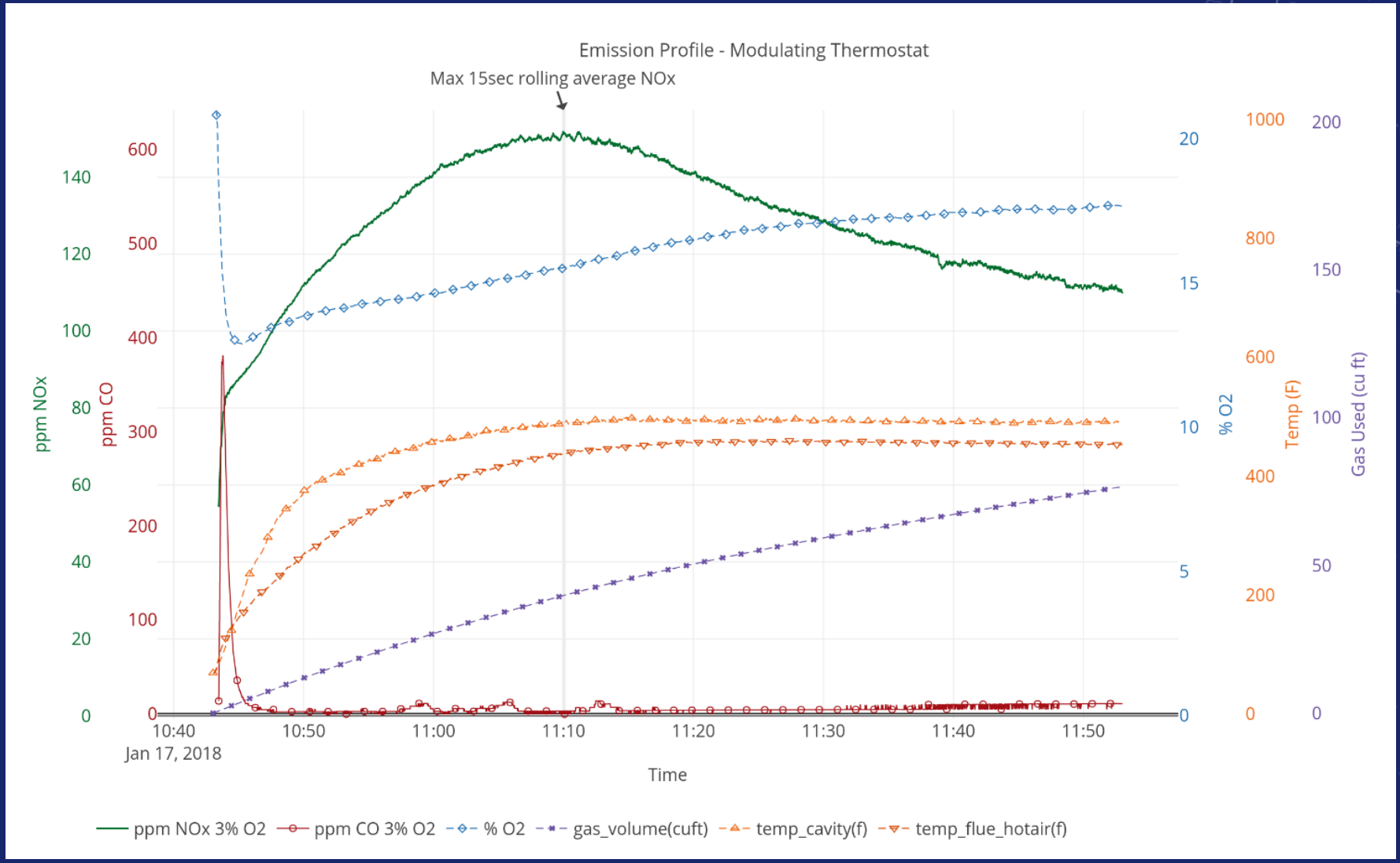
EMISSION PROFILE: ON/OFF BURNER CONTROL

SNAP ACTION THERMOSTAT, SOLID STATE THERMOSTAT



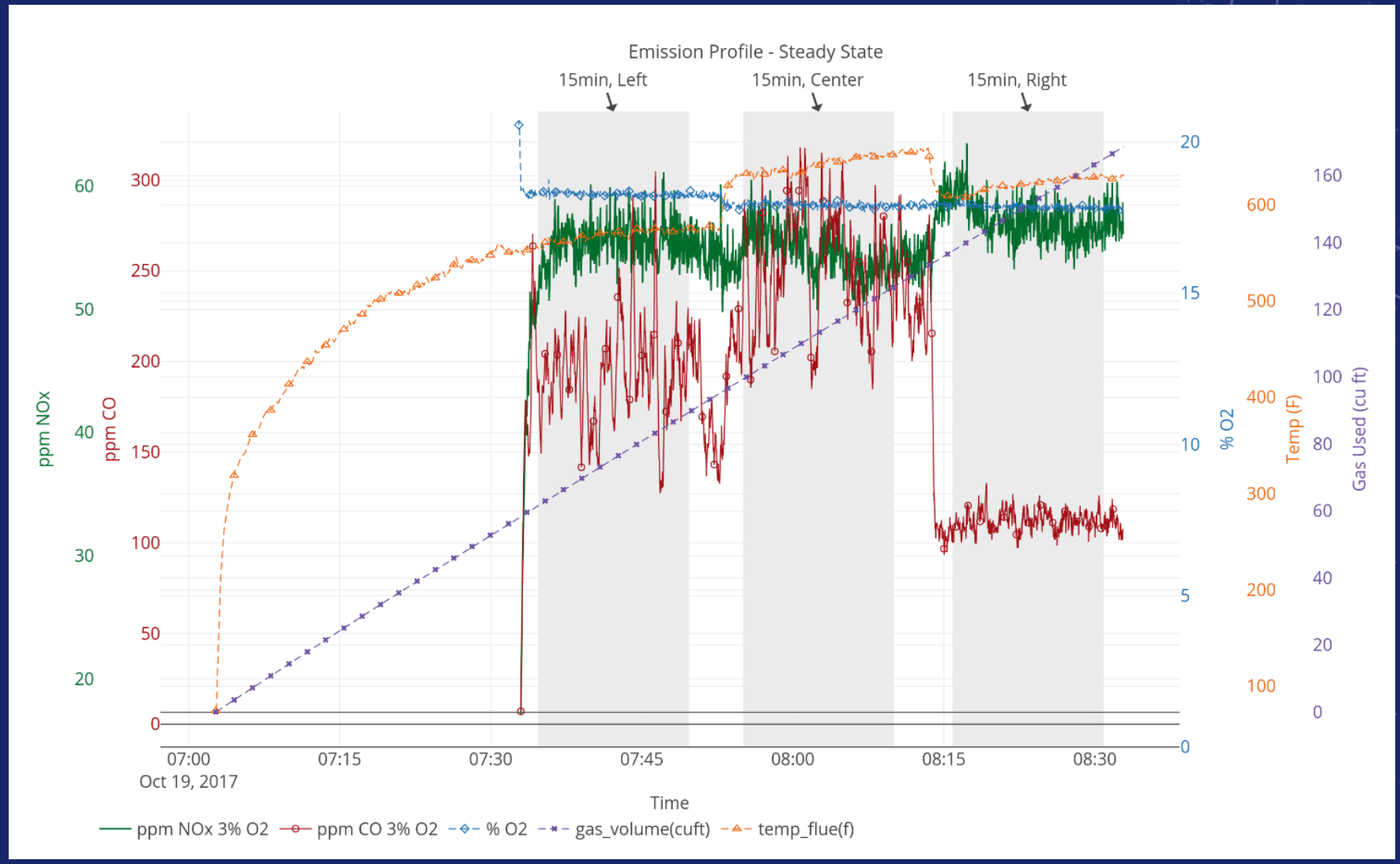
EMISSION PROFILE: MODULATING CONTROL

ELECTRONIC CONTROL, BULB-TYPE THERMOSTAT



EMISSION PROFILE: STEADY STATE

BROILER



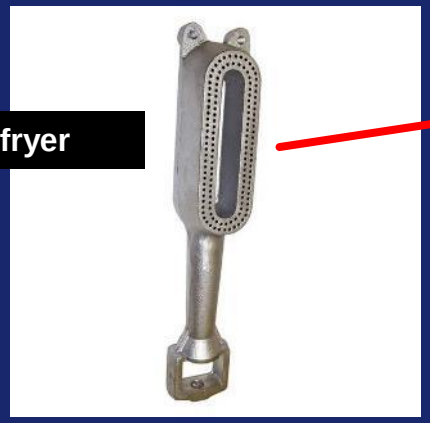
ATMOSPHERIC BURNER

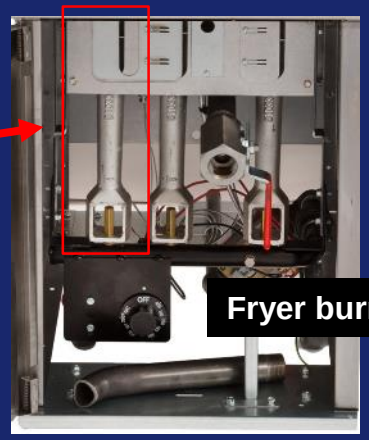
- Most common burner, found in all equipment types

Inshot burner for convection oven

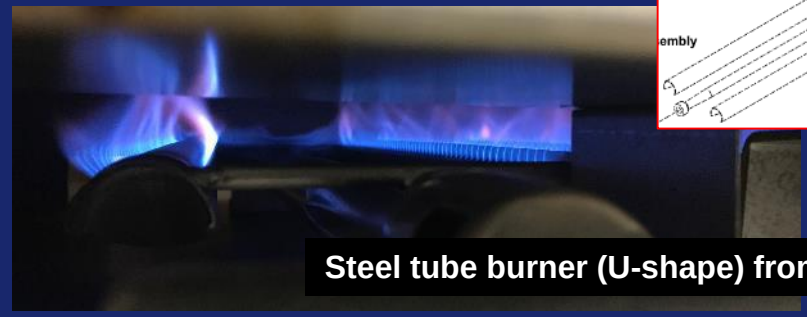
Inshot burner in furnace

Cast iron burner for fryer



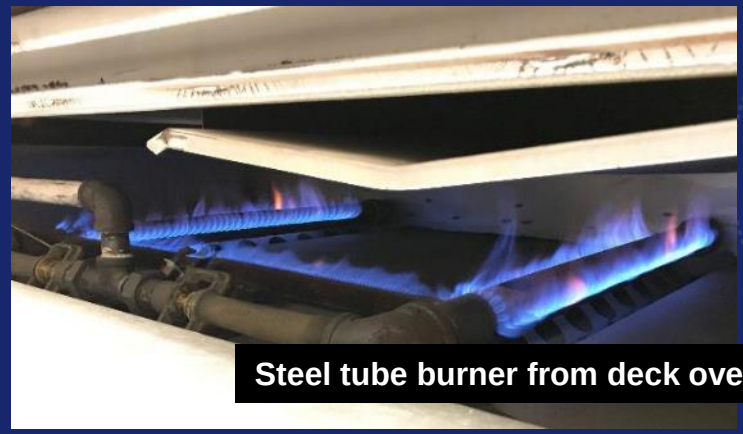


Fryer burners



Steel tube burner (U-shape) from convection oven

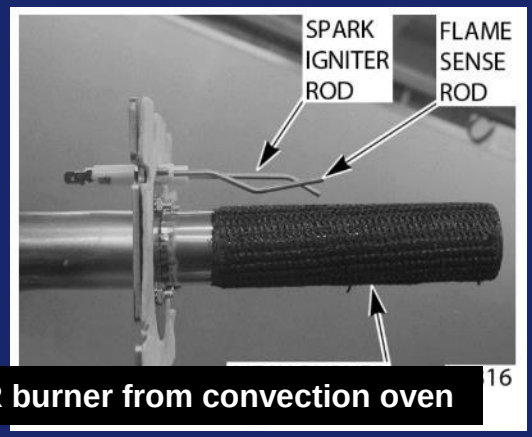
Cast iron tube burner from broiler



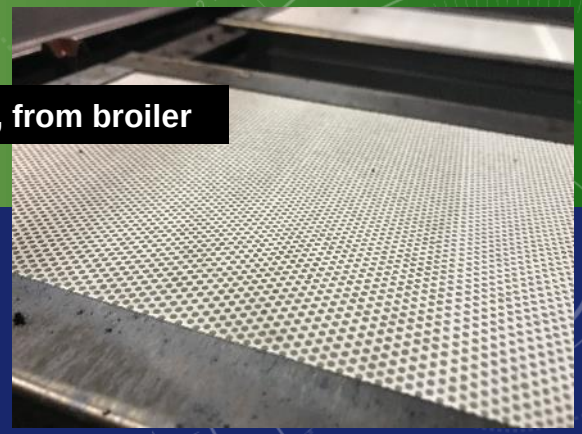
Steel tube burner from deck oven

INFRARED BURNER

- Heat transfer through radiation, as opposed to convection
- Combustion occurs right on the surface, and heat is quickly distributed to the ceramic or steel material. This cools the combustion reaction, lowering NO_x.
- Seen in broilers, fryers, griddles, convection ovens:
  1. Steel tube IR burner
  2. Perforated ceramic IR burner



Tube IR burner from convection oven

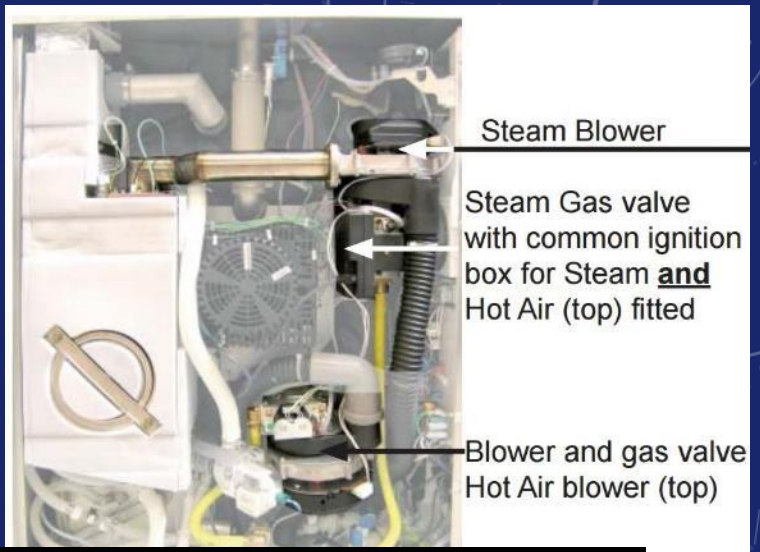

Ceramic IR burner, from broiler


Tube IR burner from fryer


Ceramic IR burner, glowing orange

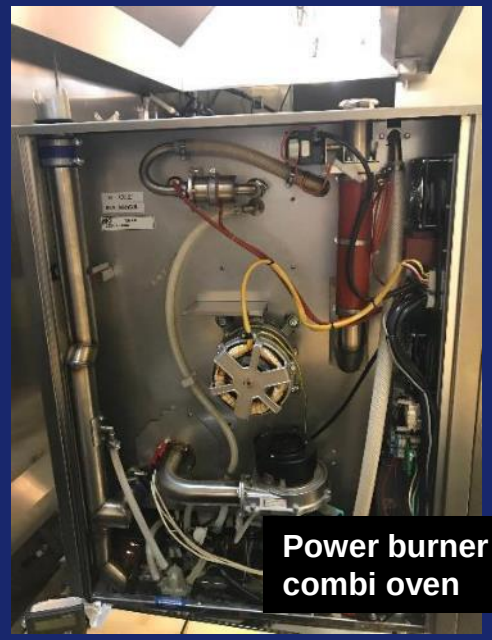
POWER BURNER

- Uses blower to bring in air at a pressure higher than atmospheric; can achieve higher input rates
- Comes with electronic controls and can modulate
- Less excess air used → More efficient, lower NO_x
- Found in combi ovens, rack ovens, fryers



Power burners (1 hot air, 1 boiler) from combi oven

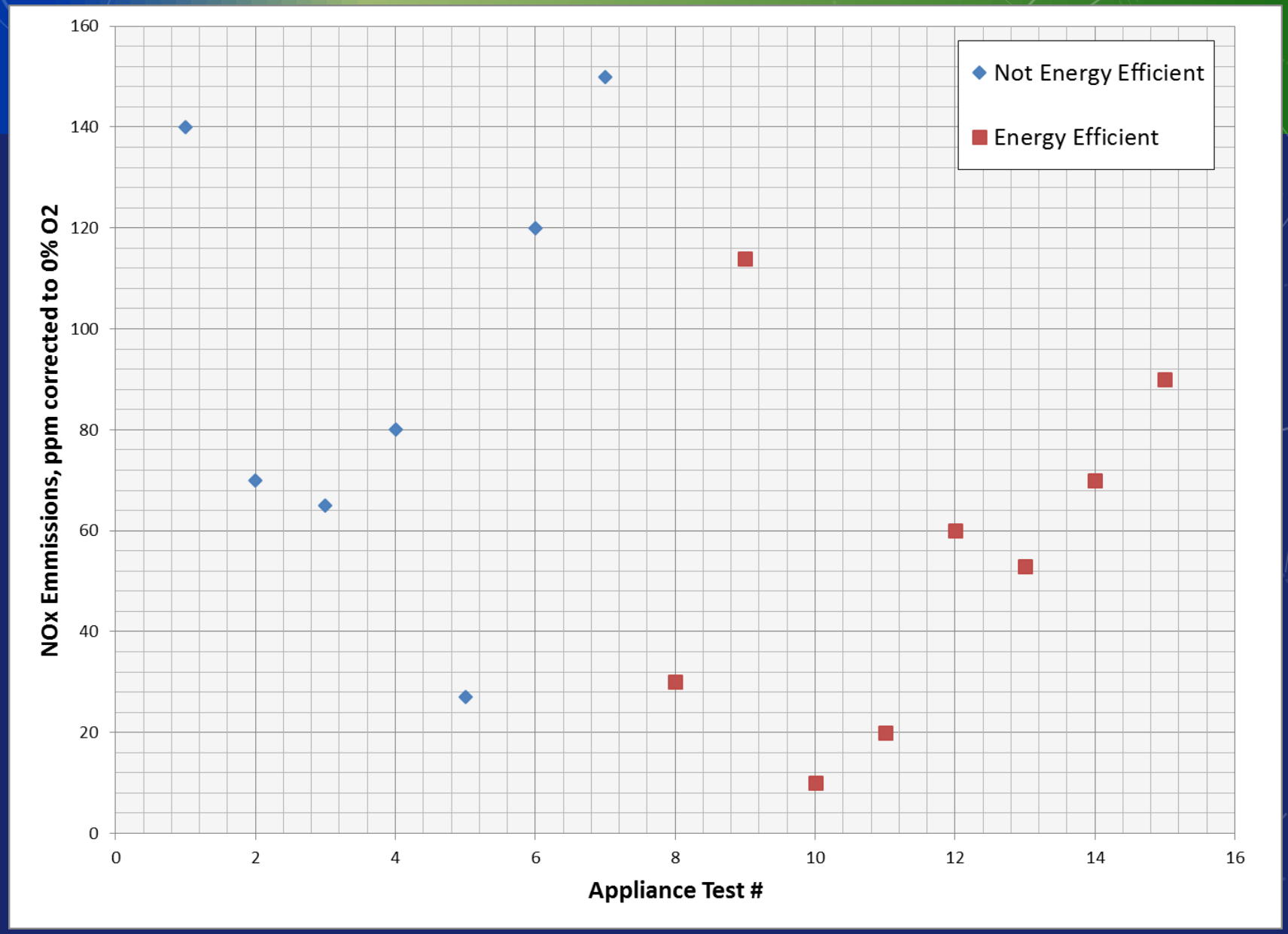
Power burner from rack oven



Power burner from boilerless combi oven

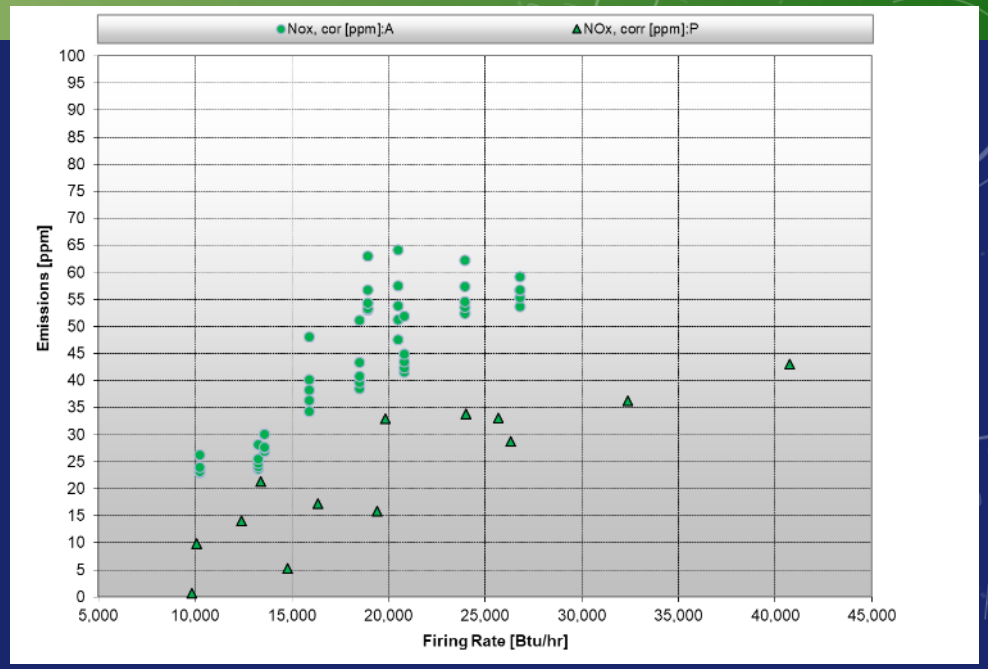
RESULTS

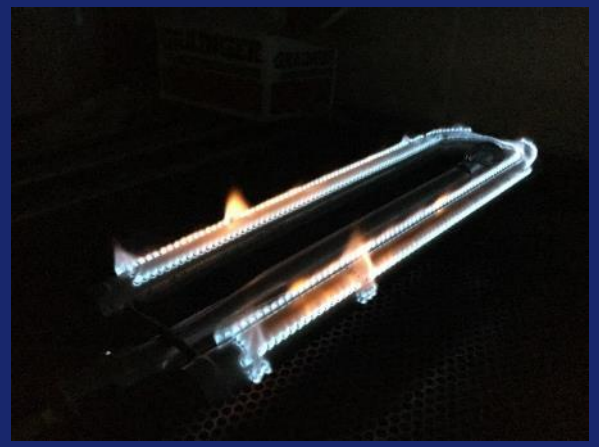
- Correlations
  - Burner Type
  - Appliance Type
  - Efficiency

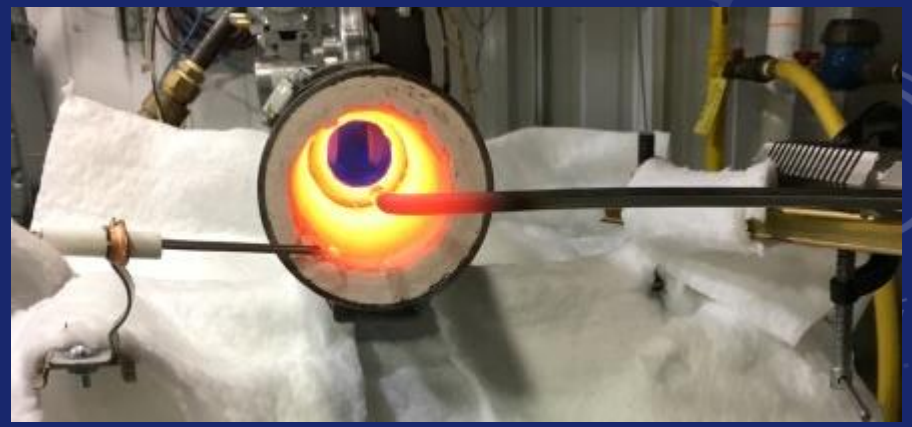


CFS INDUSTRY RESPONSE

- Measure existing NOx emissions
- Quantify NOx emissions of existing burner technology
- Develop new burner technology

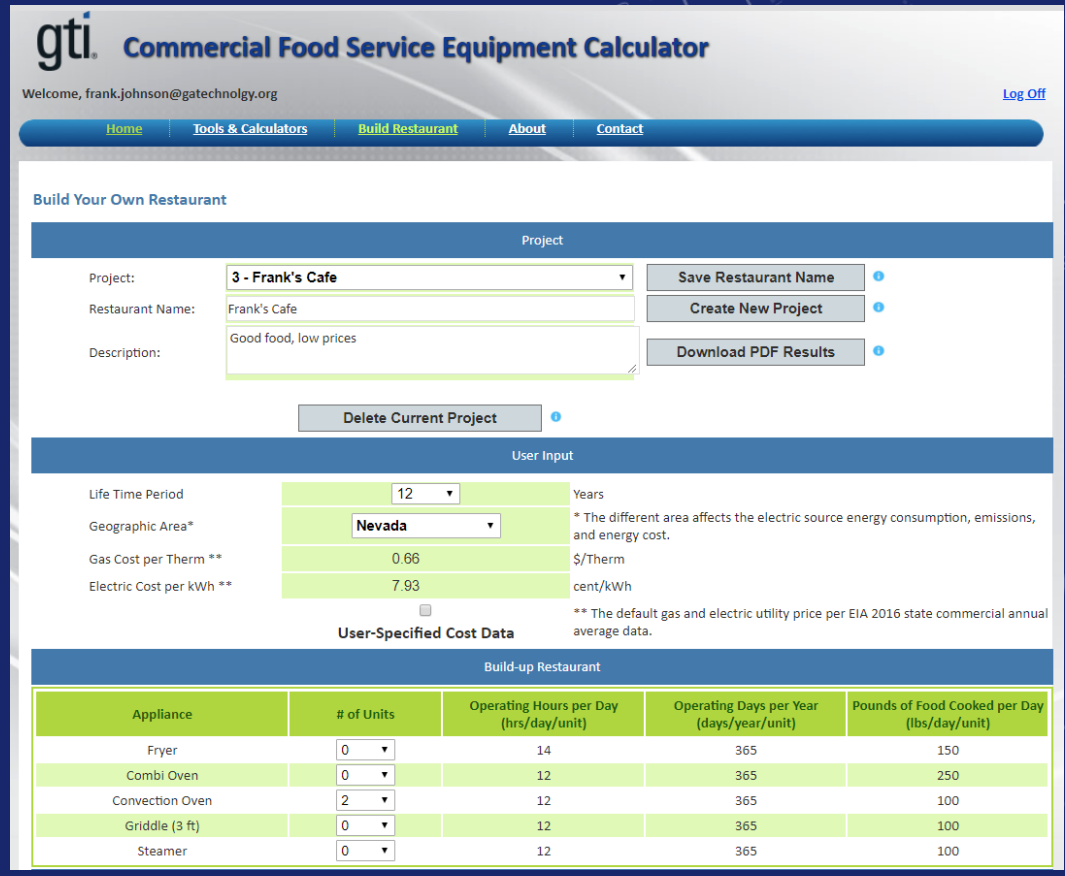






WHERE TO GET MORE INFORMATION

- GTI's CFS Tools & Calculators Website
  - http://cfscalc.gastechnology.org/
- California NOx Study
  - http://www.cookingequipmentemissions.com/
- Frontier Energy - FSTC
  - http://www.fishnick.com/
- Gas Foodservice Equipment Network
  - http://www.gfen.com/
- National Restaurant Association
  - http://www.restaurant.org/Home



HUNGRY FOR MORE?

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