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NOx Research Update For Commercial And Residential Kitchen Equipment



Frank Johnson, PhD

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Residential Foodservice R&D Program

Active Research at GTI:

- Evaluating residential ventilation systems for effectiveness at capturing and exhausting heat and airborne particles
- Review of publications and information associated with residential cooking IAQ
  - Gas vs. Electric
  - NOx and particulate emissions
- Testing of residential ranges
  - Determine the volumes of pollutants generated by cooking with natural gas and electric, including NOx, ultrafine particles and moisture/heat
  - Measure actual capture effectiveness of the best residential cook hood available and quantifying the improvements proper ventilation has on IAQ
  - Identify a new burner design to improve efficiency and emissions for a residential range





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Foodservice Laboratories (BDL/RVL)

- **Burner Development Lab (BDL)**
  - High-resolution gas meters, IAQ instrumentation, flue gas analysis (O2, CO, CO2, NOx, and ULNOx)
- **Residential Ventilation Lab (RVL)**
  - Flexible burner test area and residential kitchen test stand
  - Shadowgraph for flue gas flow visualization
  - Adjustable ventilation
  - Capture-efficiency equipment
  - Distributed IAQ sensors to measure emissions at key locations.





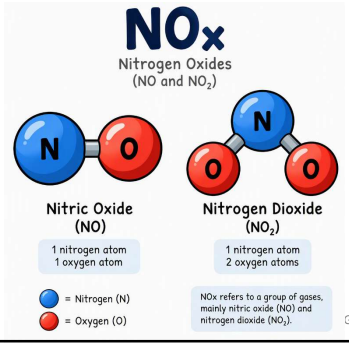


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What is NOx?

- NOx is collective term for nitrogen oxides
  - NO & NO_2
  - Product of combustion like carbon monoxide
- Why NOx matters, it contributes to:
  - Ground-level ozone (smog) formation
  - Fine particulate matter (PM2.5) formation
  - Respiratory problems such as asthma aggravation
  - Reduced visibility and environmental damage
  - Acid rain
- NOx emissions are commonly reported as:
  - ppm (parts per million)
  - ng/J (nanograms per joule)
  - lb/MMBtu (pounds per million Btu)
  - g/kWh (grams per kilowatt-hour)



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CFS Research: Emissions



- Carbon Monoxide – 800 ppm
- Until
- 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



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Issues with NOx 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
- Fewer combustion design experts







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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???



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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



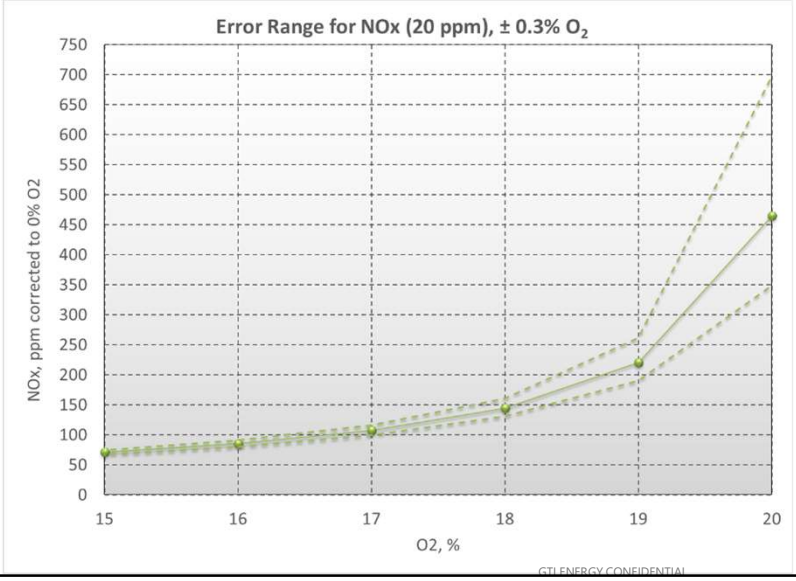


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NOx: Capture and Analyzing

- Sample dilution, > 18% O_2



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NOx: Measurement Keys



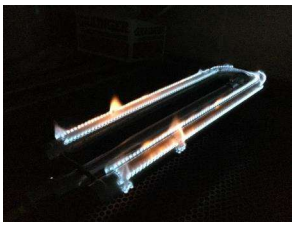
- Stable combustion/operation
  - CO emissions
  - Visual Inspection
- Minimal sample dilution
  - < 18% O_2, prefer < 15%
- No interfere with combustion from sampling
- Capture sample from entire flue stream
- All results are appliance specific
  - Minor design changes in burner and/or unit can have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

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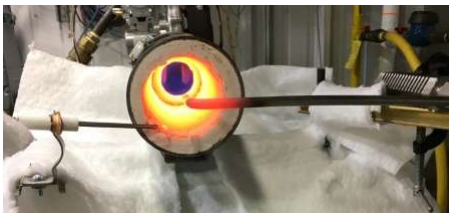
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CFS Industry Response

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







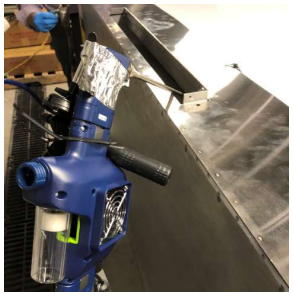
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GTI Energy Testing at CFS Manufacturers

- Testing at the factory
- Portable combustion emissions analyzer
- Measured: O2, NOx and CO (from cold start up to steady state)





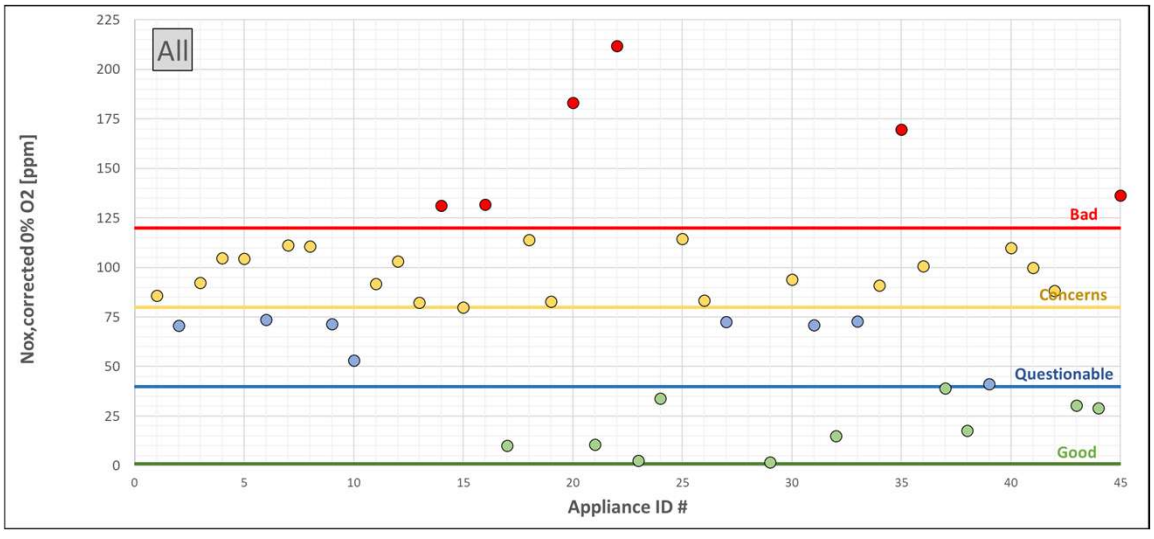


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GTI Energy Testing



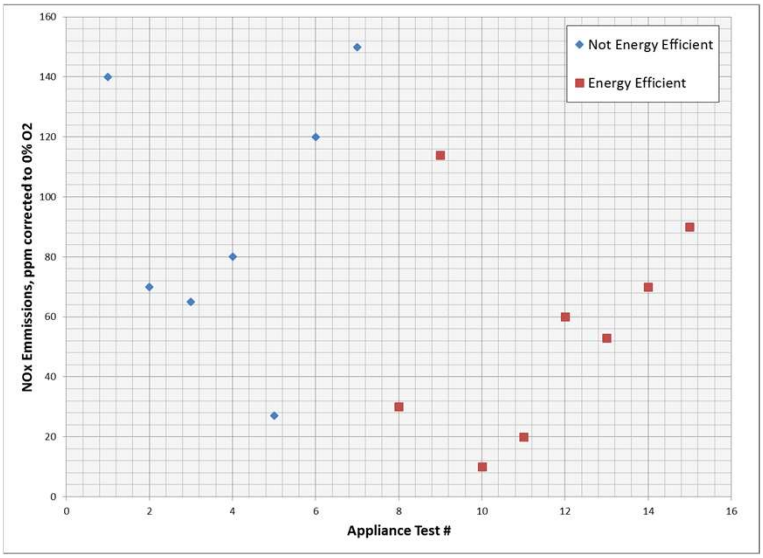
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Results

- Correlations
  - Burner Type
  - Appliance Type
  - Efficiency



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Conclusions: NOx in CFS

- No single burner design is the solution
  - Emissions is strongly dependent on appliance design
- No definitive trends in terms of burner or appliance type
  - Efficient vs. Standard
    - Infrared performed the best
  - Powered vs. Non powered
- Efficiency Matters
  - NOx emissions
  - Decarbonization
- Current State
  - Fairly quiet for 5 years
  - Only FS standard: SCAQMD standards for large bakery ovens







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Growing Concerns of the Safety of Cooking with Natural Gas - Residential



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Claims against Cooking with Natural Gas



- Causes asthma in children
- Causes asthma in women
- Causes allergies in children
- Lowers IQ or causes learning disabilities in children
- Makes COVID symptoms worse
- Releases harmful greenhouse gases
- Larger carbon footprint than electric
- Causes cancer because of Benzene, etc.
- Wastes more energy than electric
- Releases harmful PM (particulate matter) that kills 354 persons/year in California
- Cooking a grilled cheese is more toxic than car exhaust

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Research: NOx Emissions

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IAQ Resources: Example

Article Claiming 12.7% of Childhood Asthma Cases Caused by Cooking with Natural Gas

Article published in the International Journal of Environmental Research and Public Health (Link) that found that 12.7% of current childhood asthma in the US is attributable to gas stove use.

AGA released the following concerning this article.

Population Attributable Fraction of Gas Stoves and Childhood Asthma in the United States

by Talor Gruenwald [1,†], Brady A. Seals [1,*], Luke D. Knibbs [2,3] and H. Dean Hosgood III [4]

[1] RMI, Carbon-Free Buildings, Boulder, CO 80301, USA
[2] Faculty of Medicine and Health, Sydney School of Public Health, The University of Sydney, Sydney, NSW 2006, Australia
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Int. J. Environ. Res. Public Health **2023**, *20*(1), 75; https://doi.org/10.3390/ijerph20010075

January 10, 2023

AGA Statement on the International Journal of Environmental Research and Public Health Report

Washington, D.C. – A December 2022 report in the International Journal of Environmental Research and Public Health linking natural gas cooking with asthma is not substantiated by sound science. Any discussion or perpetuation of the allegations in this report which is funded by non-governmental organizations to advance their agenda to remove consumer energy choice and the option of natural gas is reckless. The authors conducted no measurements or tests based on real-life appliance usage, and ignored literature, including one study of data collected from more than 500,000 children in 47 countries that "detected no evidence of an association between the use of gas as a cooking fuel and either asthma symptoms or asthma diagnosis. Any allegation that gas stoves exceed standards set by the Environmental Protection Agency and the World Health Organization is patently false. Regulators, like the Consumer Products Safety Commission, should rely on real data and science not unsubstantiated claims of advocates. Attempts to generate consumer fears with baseless allegations to justify the banning of natural gas is a misguided agenda that will not improve the environment or the health of consumers and would saddle vulnerable populations with significant costs.

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Research: NOx Emissions

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- Recent news stories have reported that gas stove emissions cause about 13% of childhood asthma in the United States.
- Previous literature identifies questionable research practices (QRPs) to avoid in drawing sound causal conclusions.
- Key QRPs include claiming causality without doing causal analysis or collecting data that supports valid causal inferences.
- The claims about gas stoves causing childhood asthma exemplify previously identified QRPs.
- These claims are not supported by the data collected or the analyses performed. Checking QRPs can improve risk analyses.



Global Epidemiology
Volume 5, December 2023, 100104

Commentary

The gas stove-childhood asthma kerfuffle: A teaching opportunity

Louis Anthony Cox Jr.

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CLIMATE UGLINESS ECONOMY-HEALTH GOVERNMENT IDIOCY

Gas Stove Ban and The Nitrogen Dioxide–Childhood Asthma Causal Claim, Part II

15 hours ago Guest Blogger 30 Comments

Guest post by Warren Kindzierski, Stan Young and John Dunn

"P-Hacking"

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NOx in Residential Cooking

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INTERIM UPDATE UTD PROJECT

New York Gas Stove Labeling

- The proposed bill A00073B also known as the "Healthy Homes Right to Know Act"
  - Require warning labels and notices on gas stoves sold, displayed for sale or offered for sale to consumers in the state of New York
  - Goal of the bill is to "provide consumers with information about potential indoor air pollutants associated with gas stove use."
- Generated "Talking Point" document for NAFEM (North American Foodservice Equipment Manufacturers) and NYSRA (New York State Restaurant Association)

"WARNING: Gas stoves can emit gases (such as NITROGEN DIOXIDE, CARBON MONOXIDE, BENZENE, and FORMALDEHYDE) inside homes at levels exceeding the EPA's standards for outdoor air quality. The presence of these pollutants can affect your health and may exacerbate or contribute to the development of respiratory illnesses. Properly installed and operating ventilation to the outdoors can reduce but not eliminate emissions."

NOx in Residential Cooking

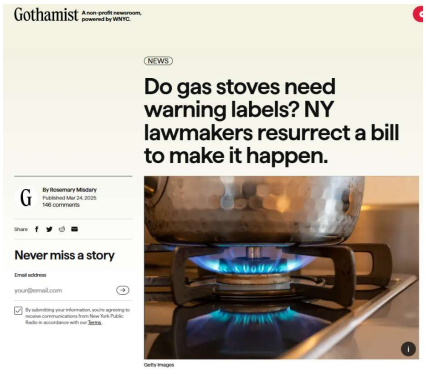
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INTERIM UPDATE UTD PROJECT

Project Results: New York Gas Stove Labeling

- Talking Point 1: Application of the Bill to Commercial Foodservice
- Talking Point 2: Addressing Cooking Emissions
- Talking Point 3: Health Claims
- Talking Point 4: Comparison of Cooking to Space Heating
- Talking Point 5: Claims of "Robust and Growing" Health Data
- Talking Point 6: Claims from Meta-Analysis
- Talking Point 7: Ventilation
- Talking Point 8: Appliance Manufacturer Concerns

Full document available by request



NOx in Residential Cooking

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INTERIM UPDATE UTD PROJECT

Project Results: New York Gas Stove Labeling

- Talking Point 1: Application of the Bill to Commercial Foodservice
  - The title of the bill includes the term "Homes," which suggests the bill was initially developed for residential applications only.
  - Commercial applications are included in the language of the proposed bill.
    - Commercial kitchens require mechanical ventilation and at much higher rates than recommended residential rates.
    - Commercial kitchens are regulated by different buildings, fire, mechanical and health codes than residential.
    - Commercial kitchens operate fundamentally differently from residential kitchens in terms of size, usage time, number of occupants and volume of food prepared.

Text from New York Assembly Bill No. A00073

28 § 322-d. Labeling requirements for gas stoves. 1. For
29 this section, "gas stove" means a stove or range that ut
30 gas or propane and is used for indoor food preparatic
31 commercial or residential setting, and provides at leas
32 following functions:
33 (a) surface cooking;
34 (b) oven cooking; or
35 (c) broiling.



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INTERIM UPDATE UTD PROJECT

Project Results: New York Gas Stove Labeling

- Talking Point 2: Addressing Cooking Emissions
  - The bill focuses on combustion emissions as justification for labels on gas stoves,
  - The bill does not include pollutants such as:
    - particulate matter (PM)
    - volatile organic compounds (VOCs)
    - water vapor
    - heat
  - These pollutants are generated from food products cooked using both natural gas and electricity.
  - These pollutants also have health and human comfort concerns associated with them.



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Current State of NOx Research

Commercial Foodservice

- Pre 2021
  - Measuring existing equipment
  - Data correlation
  - Alternate burner testing
  - New burner designs development
- Post 2021
  - Less discussions of NOx regulations
  - Still measured as part of standard testing
  - New burner development but focused on larger commercial or industrial processes

Residential Foodservice

- Since 2016
  - Reviewing article and publication on residential cooking emissions
  - Testing of existing range top and oven burners
  - Testing of prototypes
  - Development of new range top burner designs
  - Some attempts to regulate or ban gas cooking

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NOx Research Update For Commercial And Residential Kitchen Equipment

- Need More Information*: Contact me at fjohnson@gti.energy
  - **Project Team:**
    - Frank Johnson, PhD
    - Shawn Scott
    - Yan Zhao
    - Jacob Pixler
    - William Asher
    - Navroop Singh
    - Mason Bushell











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