Cooking, Health and Kitchen Ventilation

Dr. Iain Walker
Both food and heat sources generate pollutants.

**Methane**
- Particles
- NO$_2$ (and NO), CO, Aldehydes
- CO$_2$ & H$_2$O

**Electric**
- Particles

**Food**
- Particles, Formaldehyde, Acetaldehyde, Acrolein, H$_2$O, Odors
Critical contaminants related to health are emitted by cooking.

DALY = Disability Adjusted Life Year
Background to kitchen ventilation studies

Well-established connection between children’s health and gas cooking (see bibliography)
- Primarily NO₂

Well-established connections between PM2.5 and health

WHO, EPA etc. give limits for these contaminants
- 100 ppb for NO₂ over 1 hour
- 25 microgrammes/m³ for PM2.5 over 24 hours

How well do kitchens need to be vented to keep these contaminants below health thresholds?
Measurements in homes
Cooking and range hood monitoring

Monitor cooktop and oven use with iButton temperature sensors

Monitor range hood (RH) use with anemometer
IAQ Monitoring

Time-resolved IAQ

- Formaldehyde
- PM\textsubscript{2.5}, CO\textsubscript{2}, T, RH*
- NO\textsubscript{2}
- UFP

Time-integrated

- PM\textsubscript{2.5}
- NO\textsubscript{x}

Concurrent Outdoor Monitoring

* Monitored at two locations: central area, bedroom
Scripted cooking with gas

NO₂ in kitchen exceeds ambient Air Quality threshold value

4 of 9 homes had kitchen NO₂ exceed 100 ppb over 1h

Singer et al., 2017, Building Environment
Does NO$_2$ just stay in the kitchen?

No it does not.....

In this example: bedrooms about 20% lower than central location
Apartments & smaller homes more critical

LIA = Low Income Apartments
SFD = Single Family Detached

Low Income:
About twice as much cooking
More cooking for longer in smaller homes = Bigger Health Risk
Apartments are more critical

Apartments more likely to be:
- Low Income
- Disadvantaged communities

Improvements in kitchen venting and switching to electric cooking are helping those that need it most
Background to kitchen venting proposal

• Assumes ASHRAE 62.2 ventilation
  • includes additional ventilation from range hood operation
  • Includes outdoor PM2.5 and NO2
• Same PM2.5 emissions for gas and electric cooking
• NO$_2$ emissions from gas only
• Both PM2.5 and NO2 emissions from LBNL lab testing of several meals
• Relationship between CE and air flow from lab studies
Kitchen Venting
Capture efficiency (CE): The fraction of pollutants emitted at the cooktop or in the oven that are removed before mixing into the air of the home.

Standardized test method for rating about to become international = ratings coming soon.
Lab Testing
Field Testing
Capture Efficiency

Two front burners

Current minimum in US stds = 100 cfm

Two back burners

Airflow (CFM)

Capture Efficiency

Range hood

OTR

OTR = Microwave with Exhaust
Laboratory Testing for Contaminants
Hood exhaust balanced with MERV13 filtered supply.
### Scripted Breakfast Meal

#### Breakfast Cooking Details - PARALLEL

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Activity</th>
<th>Gas (lpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Start front left burner on medium</strong> (2 lpm) for hash browns</td>
<td>-&gt;</td>
</tr>
<tr>
<td>0:15</td>
<td><strong>Start front right burner on medium</strong> (+2 lpm; <strong>Total 4 lpm</strong>) - bacon in pan (cook 12 min); remain to watch oil</td>
<td>-&gt;4.04</td>
</tr>
<tr>
<td>1.5</td>
<td><strong>Add 2 hash browns to small skillet</strong> (cook 9 min); remain</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flip bacon and adjust in pan; remain</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>Press hash browns 5s each; remain</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Flip bacon and adjust in pan; remain</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>Flip hash browns; press 5s each; remain</td>
<td>3.99</td>
</tr>
<tr>
<td>6</td>
<td>Flip bacon and adjust in pan; remain</td>
<td>3.97</td>
</tr>
<tr>
<td>8-12</td>
<td>Flip bacon every 30s</td>
<td>3.96</td>
</tr>
<tr>
<td>10</td>
<td>Return; flip hash browns; press</td>
<td>3.94</td>
</tr>
<tr>
<td>10:30</td>
<td><strong>Stop front left burner</strong>; remove hash browns to plate with paper towel; place skillet on back left burner.</td>
<td>-&gt;2.02</td>
</tr>
<tr>
<td>12</td>
<td><strong>Stop front right burner</strong>; remove bacon to plate; move pan to rear burner; leave uncovered</td>
<td>0</td>
</tr>
<tr>
<td>12.5</td>
<td>Place non-stick pan with butter on <strong>front left burner, start and adjust to medium</strong> (2 lpm)</td>
<td>-&gt;2.04</td>
</tr>
<tr>
<td>14</td>
<td><strong>Add eggs to non-stick pan</strong> (cook 4 min); remain</td>
<td>2.05</td>
</tr>
<tr>
<td>17</td>
<td>Flip eggs</td>
<td>2.05</td>
</tr>
<tr>
<td>18</td>
<td><strong>Stop front left burner</strong>; remove eggs to plate; place pan on front right burner</td>
<td>-&gt;0</td>
</tr>
<tr>
<td>48</td>
<td>Remove skillets and fry pan from cooktop</td>
<td></td>
</tr>
</tbody>
</table>
Off
Auto
PM2.5 (μg·m⁻³)
0 200 400 600
PN (#·cm⁻³)
0 1 \times 10^5 2 \times 10^5 3 \times 10^5
NOx (ppb)
0 50 100
0:00 0:15 0:30 0:45 1:00 1:15 1:30
Breakfast
NO₂ 1 hour
100 ppb threshold
PM2.5 24 hour
25 ug/m³ threshold
Breakfast - Induction

Induction = no Nox
Less Particles

NO\textsubscript{2} 1 hour
100 ppb threshold
(CARB)

PM\textsubscript{2.5} 24 hour
25 ug/m\textsuperscript{3} threshold
(WHO)
Proposed CA T24

- Key health contaminants are PM2.5 (gas and electric cooking) and NO₂ (only from gas)
- To meet health guidelines more/better kitchen ventilation is required for NO₂, i.e., gas cooking

<table>
<thead>
<tr>
<th>Cooking Fuel</th>
<th>Floor Area (ft²)</th>
<th>Capture Efficiency</th>
<th>Airflow as installed (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>&gt;1500 ft²</td>
<td>0.50</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>1000 - 1500 ft²</td>
<td>0.50</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>750 - 1000 ft²</td>
<td>0.55</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>&lt;750 ft²</td>
<td>0.65</td>
<td>160</td>
</tr>
<tr>
<td>Gas</td>
<td>&gt;1500 ft²</td>
<td>0.70</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>1000 - 1500 ft²</td>
<td>0.80</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>750 - 1000 ft²</td>
<td>0.85</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>&lt;750 ft²</td>
<td>0.85</td>
<td>280</td>
</tr>
</tbody>
</table>
Other ideas

• Do not allow gas cooking in apartments
  • Without automated hoods 70 to 90% of apartments will exceed 1 hr NO\(_2\) limit
  • No automation = no safe use of gas cookers
• Require usage sensors
  • Readily available in other countries (e.g., Japan)
  • Provide improved kitchen safety
  • No technical reason to not require these controls in US homes
References


Gas cooking and children's health bibliography


Garrett, Maria, Hooper, Martin, Hooper, Beverely, Abramson, Michael, Respiratory Symptoms in Children and Indoor Exposure to Nitrogen Dioxide and Gas Stoves, American Journal of Respiratory and Critical Care Medicine, Vol. 158, No. 3, Sep 01, 1998 https://doi.org/10.1164/ajrccm.158.3.9701084

PubMed: 9731022


Physicians for Social Responsibility, December 7, 2019
https://gbpsr.org/2020/01/06/massachusetts-medical-society-resolution-recognizes-health-link-between-g as-cooking-and-asthma/