WHY DO WE CARE ABOUT...

IAQ METRICS

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WHY DO WE CARE ABOUT…METRICS?

- Metrics allow us to quantify an effect of interest
  e.g. kWh is an energy metric

- Metrics allow us to combine similar effects into a single measure of performance
  e.g. kWh & m$^3$ natural gas -> kg of CO$_2$

- Metrics allow us to optimize performance relative to other criteria
  e.g. kg of CO$_2$ saved per $ invested

- Metrics can be used in codes & standards
  e.g. Max CO$_2$/m$^2$/yr
WHY DO WE CARE ABOUT...INDOOR AIR QUALITY?

IAQ is generally considered to be one of the top 5 health hazards in the developed world

but you can’t get the health service to pay for it

IAQ is one of the services we expect our buildings to provide

usually through ventilation (inc. infiltration)

IAQ is a potential barrier to effecting energy efficiency in buildings

Tightening reduces infiltration
WHICH IAQ EFFECTS DO WE CARE ABOUT?

1. **HEALTH**: The most fundamental IAQ criterion is harm to people from indoor air.

2. **ACCEPTABILITY**: Odor, irritancy can make IAQ unacceptable even if not unhealthy.

3. **MOISTURE**: Indirect effect but can promote biological growth or material degradation.

4. **OCCUPANTS**: The best laid plans of mice and men often go awry. Each could have its own sub-metric.
WE HAVE A HEALTH METRIC: DALY

Disability Adjusted Life Years (DALYs)  \[ \text{DALY} = \text{YLL} + \text{YLD} \]

\[ \text{YLL} = \text{Years lost to premature death} \]

\[ \text{YLD} = \text{Equivalent years lost to disability} \]

US DALY valued at roughly $50,000 - $200,000

Non-Fatal Stroke: \(~9.5–13\) DALYs
FULL IAQ METRICS IS THE GOAL

**IAQ Metrics needs more research investment**

- Need to know all contaminants of concern, emission rates, impacts, etc.
- Need to monetize acceptability & moisture like for DALYs. (e.g. via harm)

**IAQ Score is doable now**

- Substitutes expert judgement for quantitative metrics
- LBL has been developing...
SCORE VISION IS SIMILAR TO METRICS VISION

THE IAQ SCORE CAN BE USED TO ADDRESS IAQ CHALLENGES

<table>
<thead>
<tr>
<th>Rate</th>
<th>homes and inform buyers and sellers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guide</td>
<td>new home designs and retrofits to improve IAQ</td>
</tr>
<tr>
<td>Improve</td>
<td>codes, standards, programs and regulations</td>
</tr>
<tr>
<td>Serve</td>
<td>as an interim IAQ Metric</td>
</tr>
</tbody>
</table>
MODELED AFTER HERS

IAQ Index
- More severe hazards; Poor controls
- Fewer hazards; Robust controls

HERS® Index
- More Energy
- Less Energy
- This Home: 65

RESNET WER® Index
- More Water
- Less Water
- Reference Home: 100
- This Home: 68
IAQ Scoring Framework

Raters rate house as found
- Use typical occupant patterns

Identify hazards and potential harm
- Based on expert judgement

Evaluate hazards mitigation (control) impacts
- Based on expert judgement

No reference house
- Can be applied to new or existing
IMPORTANT FEATURES

No prescriptive requirements – this is a scoring tool

Measurements not required; but scores improve when device performance is verified

Many parameters have defaults; rater enters locally correct values
- Enables score when data not available
- Examples: Outdoor AQ, Radon, Fan flows....

Raters have to assess some hazards or controls
Contaminants identified by location and source

- Kitchen: Cooking emits PM$_{2.5}$, NO$_2$, VOCs, etc.
- Outdoors: NO$_2$, PM2.5, ozone, etc.
- Building materials: formaldehyde, VOCs, SVOC
- Foundation: Moisture from ground

Contaminants

- CO, NO$_2$ & NO;
- PM: PM2.5, PM10, UFP
- VOCs: Formaldehyde, general VOC, SVOC, and other chemical hazards;
- Ozone; Radon;
- Mold; Allergens; Other biological hazards

Risks assessed for general population

- Hazard score considers toxicity and typical amount of exposure
- Risk for general population including susceptible groups
SPECIAL HAZARDS THAT INCREASE SCORE

- Unvented combustion appliance(s)
- Traditional fireplace
- Bad outdoor air quality, nearby sources
- Indoor hot tub or sauna
- Chemical contamination, e.g. from tobacco
- Visual or odor evidence of dampness & mold
Current smoking

Pollutants from unusual hobbies, extreme activities

Chemicals presently in home

Number of current residents

Current pets

Clutter, dirt, grime, dirty laundry, etc.
CONTROLS ARE BUILDING ASSETS THAT MITIGATE HARM

Effectiveness of some controls will vary with home characteristics

Default values may be needed for some controls

<table>
<thead>
<tr>
<th>Range hood capture efficiency</th>
<th>Range hood air flow rate</th>
<th>Bathroom fan air flow rate</th>
<th>Whole house ventilation</th>
</tr>
</thead>
</table>

2018
SCORING
APPROACH
EXAMPLE: CO FROM COOKTOP BURNER
EXAMPLE: CALCULATING A PIECE OF AN IAQ SCORE

Source of Hazard:
- Gas Range (oven under cooktop)
  - Two pilot burners

Existing Controls:
- Range hood
  - 150 cfm measured
  - 2 sones HVI-rated (or ~40 dB)
  - Unknown capture efficiency (CE)
  - Max flow of 300 cfm
- General kitchen exhaust pulling 20 cfm from kitchen
# Health Hazards:
**Gas Cooktop, two pilot burners**

<table>
<thead>
<tr>
<th>IAQ Score Type</th>
<th>Pollutant</th>
<th>Source Category</th>
<th>Source</th>
<th>Contaminant Score</th>
<th>Hazard Quantity</th>
<th>Health Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PM2.5</td>
<td>Kitchen</td>
<td>Gas cooktop</td>
<td>10</td>
<td>1</td>
<td>10</td>
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<tr>
<td></td>
<td>PM2.5</td>
<td>Kitchen</td>
<td>Gas oven under cooktop</td>
<td>7</td>
<td>1</td>
<td>7</td>
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<tr>
<td></td>
<td>PM2.5</td>
<td>Kitchen</td>
<td>Gas oven not under cooktop</td>
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<td>2</td>
<td>7</td>
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<tr>
<td></td>
<td>PM2.5</td>
<td>Kitchen</td>
<td>Pilot burner(s)</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td></td>
<td>NO2</td>
<td>Kitchen</td>
<td>Gas cooktop</td>
<td>7</td>
<td>1</td>
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<td>Kitchen</td>
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<td>7</td>
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<tr>
<td></td>
<td>NO2</td>
<td>Kitchen</td>
<td>Pilot burner(s)</td>
<td>5</td>
<td>0</td>
<td>5</td>
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<tr>
<td></td>
<td>VOC</td>
<td>Kitchen</td>
<td>Cooking under range hood</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td></td>
<td>VOC</td>
<td>Kitchen</td>
<td>Cooking not under hood</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>VOC</td>
<td>Indoor sources</td>
<td>Furnishings, Hobbies, Personal care prods</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
### IAQ Score Calculation

**IAQ Score** = Sum of Reduced Hazard Scores

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**General Kitchen Exhaust**

- **20 cfm**
  - Any continuous kitchen exhaust: 10%
  - Measured air flow rate: 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1
  - Rated air flow rate: 0.1
  - Location, below or directly above cooking device, scored separately for cooking and oven/sum for separate appliances: 5%

- **150 cfm**
  - Measured air flow rate: 0.05, 0.05, 0.05, 0.05, 0.05, 0.05
  - Rated air flow rate: 0.1

- **300 cfm**
  - Measured sound @ CE or flow rate: 0.7, 0.7, 0.7, 0.7, 0.7, 0.7
  - Airflow at highest setting (to deal with emergencies): 10% above 50 cfm, 20% above 100 cfm, 30% above 200 cfm, 40% above 300 cfm

**Reduced Hazard Score**

<table>
<thead>
<tr>
<th>Source</th>
<th>IAQ Score (Summed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAQ Score</td>
<td>22.14</td>
</tr>
</tbody>
</table>

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**Control Table**

<table>
<thead>
<tr>
<th>Control Scoring Criteria</th>
<th>Control Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Quantity</td>
<td>1 1 0 2 1 1 0 1 1 1</td>
</tr>
<tr>
<td>Health Hazard</td>
<td>10 7 0 4 7 7 0 2 1 3</td>
</tr>
</tbody>
</table>
NEXT STEPS

For IAQ Score

- LBL hopes to have beta test this year
- Browser based
- Create version for general use next year

For IAQ Metrics

- Needs more research on key aspects
- Health researchers, economists, etc
- LBL efforts on hold
CONCLUSION

IAQ Metrics enable use of powerful optimization and economic tools to improve buildings
• Years away from full achievement
• Ventilation metrics help pave the way

IAQ Score gives similar functionality in the interim
• Hopefully available for use within a year
THANK YOU

QUESTIONS?