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Brett Singer Responses to Workshop Questions and Other Comments

Additional submitted attachment is included below.

Comments about upcoming solicitation for research to quantify indoor air pollutants in multifamily homes that cook with gas stoves or alternatives.
Docket #19-ERDD-01

From: Dr. Brett C. Singer, Lawrence Berkeley National Lab
Date: 3/18/2022

The comments provided below reflect my individual assessment as a researcher with experience in this field of study and do not reflect any institutional positions or opinions of Lawrence Berkeley National Lab (LBNL). I note my affiliation only for identification purposes.

I commend the CEC for their consideration of the important topic of human exposures to health-damaging pollutants from residential cooking in multifamily homes that cook with gas as well as alternatives to gas (e.g., propane, electric resistance, induction).

The announcement and staff presentation compellingly rationalized interest in this topic, noting that (a) gas cooking appliances are not vented directly to the outdoors; (b) that smaller homes — including apartments which are more likely to be occupied by resource-limited households — tend to have higher pollutant concentrations; and (c) that in the absence of adequate mechanical ventilation, tightly sealed homes with gas cooking appliances can exceed thresholds set for ambient air quality for NO2 (1-hour basis) and PM2.5 (24-hour basis). The CEC also noted that NO2 and ultrafine particles (UFP) are generated by the combustion of fossil gas, while the majority of PM2.5 mass and also UFP and other contaminants are generated by the process of cooking (preparing food with high temperatures), regardless of cooking fuel (e.g., gas vs. electric). The presentation also noted that both NO2 and PM2.5 have been associated with substantial health impacts including asthma, cardiopulmonary disease, and premature birth (World Health Organization, 2021).

Provided below are responses to the specific questions asked by CEC during the meeting. To set the context for those responses, I first provide some thoughts on the overarching scope and framing of the research.

The purpose of the solicitation appears to be the quantification of exposure to pollutants from cooking appliances to (a) inform future research on related health impacts, and (b) inform future Title 24 Standards.

Comment: I encourage the CEC to consider other possible goals and an expanded purpose, which I think can be addressed with the basic type of research that is envisioned. As noted in the presentation, the CEC has funded several studies in recent years that informed Title 24 ventilation requirements to address air pollutants from varied sources, including cooking. And kitchen ventilation standards in particular were updated in the most recent version of Title 24 to address the need for higher ventilation rates in smaller apartments and when the main cooking fuel is natural gas. Except in cases of major renovation or reconstruction, existing buildings are generally not subject to Title 24, leaving occupants of those homes at potentially much higher

risk. Relevant to existing homes, the state's goals of reducing greenhouse gas emissions from the building sector requires that many if not most buildings will have to be retrofitted to reduce energy use and carbon emissions. Air sealing is typically among the most cost-effective retrofit measures; but can lead to increasing concentrations of pollutants from indoor sources if not mitigated by ventilation. Retrofit packages can include the installation of dwelling unit ventilation (using exhaust, supply or balanced ventilation equipment) and adding kitchen exhaust ventilation; but the latter can be difficult and costly in apartments that do not already have the exhaust ducting installed. And in some cases, it could be limited by codes that limit the placement of exhaust vents.

The focus of the study on considering differences between fossil fuel based and electric cooking appliances implicitly suggests the potential to mitigate exposure by shifting cooking from one fuel to another, which could happen in conjunction with a more comprehensive energy retrofit. But even with such a shift, the pollutants emitted by the cooking process itself (with any fuel) can lead to exposures that exceed health-based thresholds (as noted by the CEC).

Ideally the new research could inform the benefits of dwelling unit ventilation and other controls (e.g. filtration) at reducing the risk of high exposures to those pollutants that will continue to be emitted from the cooking process, even if the cooking fuel switches to electricity. Such data and analyses would inform the need for ventilation or alternative retrofits to existing homes during energy efficiency retrofits, and potentially also in homes that are already efficient; but lack adequate mechanical ventilation because they were built before Title 24 incorporated ventilation requirements.

Comment: The concept, as currently formulated, appears to have too wide of a scope for the anticipated funding level of "up to $2 million". Analyzing air or particle samples to determine chemical composition is expensive. For example, detailed organic chemical analysis of a single air of filter sample could cost hundreds of dollars. Monitoring for time resolution, especially for particle size distributions and ultrafine particles is also expensive (UFP monitors are >$10K/each). And given the study objectives of characterizing exposure, samples need to be collected to characterize the diversity of circumstances, comprising variations in emissions, which vary with cooking activity, and the use of controls (kitchen ventilation, dwelling unit ventilation, filtration, etc.) Even within a single household, cooking related emissions and ventilation practices each can vary on daily, weekly and seasonal patterns. The combination of spatial and temporal resolution translates to a more expensive configuration of equipment needed for each home. And longer sampling durations to capture temporal variability ties up that expensive equipment for extended periods. And characterization of the buildings, ventilation systems, and cooking equipment, and detailed monitoring of cooking activities with sufficient robustness is also costly. The projected funding is sufficient to do such "deep" research in a modest number of homes; but not sufficient to collect such rich data in a "large sample" of homes. For this funding level, I believe there will be a need to choose between those two stated objectives. (Note: A substantial budgeting exercise and some decisions about exactly how much resolution in each home would be required to provide a number for the "modest" sample. The

key point is that it would be too small to capture variability for any significant number of variables across the population.)

Workshop Questions that will Inform a Future Solicitation:

1) How should the study approach and sample design be structured to provide insights on the following?

a. Quantify actual human exposures to indoor air pollutants, including PM2.5 and NO2, in multifamily homes¨

Comment: Exposure is the product of airborne concentration and the time that a receptor individual is present in an environment. Even within a relatively small apartment, concentrations can vary in different rooms. Spatial differences can result when rooms are physically separated, e.g. by a closed bedroom door, or if there is an air cleaning device or directional ventilation (exhaust or supply) in only one of the spaces, or even just pressure driven directional airflow. It is therefore recommended that the CEC clarify if the intent is to try to characterize exposure for each occupant of any studied apartments, or only for those that are in the same space with the cooking appliance. It is also important to clarify if cooking refers to any food preparation involving heat, e.g. including toasting and microwave use, or primarily or exclusively focused on cooking that occurs on the main cooktop or oven appliance. And given the reference to the problem of acute NO2 exposures, it would be helpful to confirm if time resolution of NO2 levels is essential or just desirable.

It would also be helpful for CEC to clarify the extent to which they are seeking information about the mechanistic factors that impact cooking-related air pollutant concentrations in apartments. Among the subsequent questions, this seems to be most relevant to #3; and I will therefore address it there.

b. Improve characterization of chemical composition, size distribution, concentrations, and characteristics that relate to health impacts of combustion and cooking-generated PM in kitchens, including:
- *Inform a more accurate assessment of the health implications.*
- *Inform low-cost strategies for monitoring PM in home kitchens.*

Comment: The second bullet offers a potential path to moving toward the goal of a large sample; but available low-cost monitoring equipment does not provide information about chemical composition.

c. Assess indoor exposures to PM2.5 associated with cooking episodes.

Comment: As noted by the presenter, different types of cooking can lead to different PM2.5 emissions; so event characterization (specifics of what was cooked, on what equipment, how much, etc.) is critical. This will be a challenging and costly activity.

d. Understanding the differences in the potential health impacts of cooking generated PM2.5 in homes that burn gas relative to alternatives (i.e., fuel type, cooking style).

Comment: since the foods and how they are prepared with heat account for the vast majority of PM2.5 mass, and pollutant concentrations between apartments would vary based on the controls used, even if emissions were precisely the same, it seems possible if not likely that cross-sectional comparisons of apartment with gas versus other fuels will not provide a clear picture of the role of the cooking fuel. A study of the impact of the cooking fuel on emissions would be best done in a controlled manner, not by monitoring occupied homes.

2) What factors should be considered when determining which communities should be selected for sampling multifamily units?

Comment: PM emissions can vary widely for various foods and cooking processes, and cooking frequencies can also vary based on both household-specific factors and cultural practices. At a minimum, it is important to recruit and sample in homes with occupants with varied ethnic and cultural cooking practices. And for quantitative exposure assessment, it is recommended to focus the study on households that cook frequently.

3) What housing type(s) and/or factors should be considered in the study sample? a. Mobile homes, town homes, apartments, designated square footages, air exchange?

Comment: It would make sense to set a maximum residence size limit. Small (single section) manufactured homes would have many of the same challenges as apartments and also be occupied in higher percentages by lower-income households. In general, single detached provide better opportunities to add kitchen exhaust ventilation.

4) What chemical attributes of particles would be beneficial to measure?

Comment: there are assays for oxidative stress that could be considered.

5) Are there other research study areas or programs that could inform or be leveraged to fulfill the goals and requirements of this research effort?

Comment: Definitely worth reviewing what has been done in controlled studies to characterize chemical constituents of cooking various dishes and meals. Please contact me for a list of references if desired.

6) The proposed research will aim to measure ultrafine (less than 0.1 µm) particles from cooking food. Limited research has been done on particulates of that size. Are there other research efforts on ultrafine particles that we should be aware of?

Comment: Presuming this is asking about current efforts, I am not aware of any. But there are several studies that have been reported in the literature (e.g. a large study in Germany in recent years, the early Bhangar work in California, a study in Denmark; and researchers at Tufts have

looked at UFP in connection to near freeway exposures). I can help CEC staff find the papers. (Don't have citations at my fingertips and no time now to look.

7) What confounding variables/factors (such as contribution of outdoor air) should the study design consider or be aware of for measuring actual exposure to indoor pollutants?

Comment: The great benefit of a field study of the type described by CEC is in learning about what people do. For exposure, there is evidence of important confluences of source magnitude and controls. For example, a study done by my group (Zhao et al., 2020) found that people use their range hoods more frequently during meals with more cooktop burner use, and either when there were any substantial particle emissions (in houses) or when particle concentrations from cooking reached high levels (in apartments). Both of those studies were focusing on mechanical ventilation; so people were asked to not use windows for ventilation. Whether and how people actually use windows, ventilation and air cleaners when cooking is not well understood.

Citation

Zhao H, Chan WR, Delp WW, Tang H, Walker IS, Singer BC. 2020. Factors impacting range hood use in California houses and low-income apartments. *International Journal of Environmental Research in Public Health, 17*(23): 8870. *Online 28-Nov-2020.* [*Journal Link*]