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TO: California Energy Commission, 2022 Title 24 Pre-Rulemaking

FROM: Dr. Brett C. Singer, Lawrence Berkeley National Laboratory

DATE: October 16, 2020

SUBJECT: Air pollutant exposures from use of natural gas cooking burners, relevant to Docket No.19-BSTD-03

Thank you for the opportunity to present at the panel discussion and workshop on Indoor Cooking and Air Quality that was convened on September 30, 2020.

I greatly appreciate the Commission's interest in using the best available science to ensure that California's Building Energy Efficiency Standards do not adversely impact indoor air quality or result in hazardous air pollutant exposures in California homes and commercial buildings.

During the workshop, Professor Yifang Zhu presented summary results of a recent study conducted by her group at UCLA, entitled "Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California". Among the analyses conducted in that study was a mass-balance based simulation study of air pollutant concentrations that could occur in California homes when using gas cooking burners over varied durations, including 15-min, 1-h and 2-h of cooking per day with either cooktop only or cooktop and oven burners. The report focused on peak and average concentrations of NO2 and CO and compared these to threshold concentrations used in California and US ambient air quality standards. The study found that under the conditions and assumptions of their simulations - which included no use of venting range hoods or kitchen exhaust fans - average NO2 concentrations could exceed the concentration threshold used for the annual ambient NO2 standard in a substantial minority of California homes and peak concentrations in kitchens could exceed thresholds for the daily highest 1-h ambient standard in the vast majority of homes.

As noted during the workshop, my group at LBNL has also used mass-balanced simulations to estimate concentrations in California homes using gas burners for cooking, and also conducted several field studies in recent years in which NO2 and in some cases CO concentrations were measured in homes with gas cooking burners. The simulation study (reported most extensively in Logue et al., 2014) used measured data on pollutant emissions from used cooking appliances obtained in California, and self-reported cooking frequencies from thousands of homes in Southern California. The measurement studies included some in which time-averaged concentrations were measured as participants were asked to use burners as they normally do during a weeklong monitoring period. Mullen et al., 2016 focused a large portion of its sampling on existing homes with factors that could lead to higher concentrations of combustion pollutants. Singer et al. 2020 measured pollutants in 70 single-detached homes with natural gas cooking that were constructed after the state building code started to require mechanical ventilation in all new homes. Zhao et al. (accepted) measured time-integrated concentrations in 23 apartments with mechanical ventilation and time-resolved NO2 in a subset of the apartments. Singer et al. 2017 conducted time-resolved measurements of NO2 in kitchens and bedrooms or distant locations in 9 homes as gas burners were operated with standardized procedures to simulate common use. Additionally, Chan et al. 2020 reports another simulation-based study that sought to determine what level of capture efficiency is required to enable cooking to occur in new California homes, which are required to have dwelling unit (general) mechanical ventilation and also a venting range hood.

The analysis reported in Logue et al. 2014 found that without range hood use, 1-h average NO2 concentrations may exceed the threshold of 100 ppb during winter conditions in a majority of the households that we simulated in Southern California. The time-integrated measurements reported in Mullen et al. 2016 and the time-resolved measurements reported in Singer et al. 2017 demonstrated that the concentrations calculated by simulation and reported in Logue et al. 2014 were reasonable and within the bounds of what is observed in real homes when substantial cooking with gas burners occurs.

I am writing here to comment on the observation that the calculated peak NO2 concentrations reported in the recent UCLA study appear to be substantially higher than the highest 1 h results reported in the Logue et al. 2014 simulation study or the Singer et al. 2017 measurement study.

My understanding is that these differences result from differences in the assumptions used in the simulation models.

1. Cooking burner usage. As a simplification, both the recent UCLA study and Mullen et al. 2020 considered discrete amounts of daily burner usage. Each accounted for variations in emission rates, including variations in the emission factors (in units of mass of pollutant generated per quantity of fuel energy consumed, e.g. as ng/J) and in the case of the UCLA study also variations in burner size (commonly reported in units of Btu of fuel energy per h). The scenario of 2h of cooking burner use per day in the UCLA study is substantially higher than that considered in Chan et al. 2020. And the Logue 2014 study estimated daily cooking burner use by day for each simulated household based on the weekly cooking patterns that each reported in the 2003 Residential Appliance Saturation Survey. The average burner use in that study was much less than the 2 h use scenario of the UCLA study, leading to lower time-averaged concentrations and chronic exposures.
2. Method used to estimate the higher concentrations in kitchens compared to average concentrations in the air throughout the home. In Logue et al. 2014 we first calculated the concentrations that would result as the combustion pollutants emitted in the kitchen mixed throughout the home. Then to estimate the higher exposures that result from being in the kitchen during burner use, we applied a proximity factor of 2.0 for the highest 1h concentration encountered by the person who is assumed to be in the kitchen during cooking. This factor was based on very limited data available at the time. The subsequent measurement study reported in Singer et al. 2017 validated that proximity factor as reasonable for the 1h highest concentration in kitchens vs. other parts of the house. The Chan et al. 2020 report did not address higher exposures in the kitchen. And

the UCLA study estimated peak kitchen concentrations in the volume of air associated with the kitchen as a virtual zone within the larger house.

Regarding point #1 above, we note that caution should be exercised when considering how pollutant concentrations that result from an assumed cooking rate are compared to standards developed to protect against chronic exposure, as the annual ambient air quality standards are designed to do. In Chan 2020 we calculated highest 1 h NO2 concentrations based on the burner use required to cook a dinner for 3-5 people in consideration that such an event could occur on any given day in any dwelling. The analysis is framed around finding a range hood performance level that would be protective and lead to NO2 concentration exceeding the 100 ppb threshold in less than 1% of homes if the range hood is used. It is reasonable to also consider the ramifications to chronic exposure if all households used their cooking burners on average at some fixed amounts through every day of the year; but it is important to identify this as a hypothetical exercise that is likely not consistent with actual cooking behaviors across the population, based on the data from the RASS.

Regarding point #2 above, we note that caution should be exercised when considering the estimated enhanced concentrations in the kitchen either by the method used in Logue et al. 2014 or the recent UCLA study. The Singer et al. 2017 study looked at only 9 homes under a limited set of simulated conditions. It showed that a kitchen proximity factor of 2.0 for NO2 emitted from gas cooking is reasonable and may even be low in many cases; but the factor also varies between homes and almost certainly varies with the conditions of airflow in the home. The method used in the UCLA study, in which pollutant concentrations are tracked separately for a virtual zone of well-mixed air in the kitchen is a valid conceptual approach. However, the specification of air exchange rate between the virtual kitchen volume and the surroundings, and the concentration of NO2 in the air entering the kitchen from its surroundings are highly variable quantities. My understanding is that the UCLA study assumed this rate to be the same as the overall air exchange rate of the house, in units of air changes per hour. This rate could substantially understate mixing from the kitchen with air from other parts of the house, and thus overstate concentrations in the kitchen, in many cases. It is also important to include the increase in combustion pollutant concentrations that originated in the kitchen and transferred to other parts of the house, as this phenomenon will tend to increase concentrations in the kitchen relative to assuming that the kitchen exchanges air directly with the outdoors. The quantitative impact of these factors on the estimated peak kitchen concentration is not explicitly discussed in the UCLA study; but I assess that the net effect is likely to be to overestimate peak kitchen concentrations, potentially substantially. That said, the measurements in Singer et al. 2017 demonstrate that 1 h NO2 concentrations can readily exceed 100 ppb and reach levels above 200 ppb in enclosed or semi-enclosed kitchens and approach or exceed 100 ppb even in open kitchens when substantial cooking occurs.

Through research supported by CEC, CARB, the US Department of Energy’s Building America Program, the US EPA Indoor Environments Division, and the US Department of Housing and Urban Development, our group and other groups have been able to learn a great deal about elevated pollutant concentrations in homes resulting from the use of gas cooking burners. Much of the commentary above has been focused on concentrations that *can* result when burners are used without venting. It is important to note that substantial data exists showing that use of venting range hoods can substantially reduce pollutant concentrations and occupant exposures. And while hoods are not used nearly enough and in only a minority of homes, there are some that appear to use them either routinely or as they are perceived to be needed. As part of LBNL's recent CEC-supported project Effective Kitchen for Healthy ZNE Homes with Natural Gas, we analyzed data collected from the detached houses reported in Singer et al. 2020 and the apartments reported in Zhao et al. (accepted) to assess the frequency of range hood use. The abstract of the submitted manuscript notes the following:

"We analyzed data from 54 single family houses and 17 low-income apartments in California in which cooking activities, range hood use, and $PM_{2.5}$ were monitored for one week per home. Range hoods were used for 36% of cooking events in houses and 28% in apartments. The frequency of hood use increased with cooking frequency across homes. In both houses and apartments, the likelihood of hood use during a cooking event increased with the duration of cooktop burner use, but not with the duration of oven use. Actual hood use rates were higher in the homes of participants who self-reported more frequent use in a pre-study survey, but actual use was far lower than self-reported frequency. Residents in single family houses used range hoods more often when cooking caused a discernible increase in $PM_{2.5}$. In apartments, residents used their range hood more often only when high concentrations of $PM_{2.5}$ were generated during cooking."

If this paper is accepted for publication, we will provide that reference to the CEC. And whether it is or not, the results will be reported in the final project report to CEC.

Citations

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