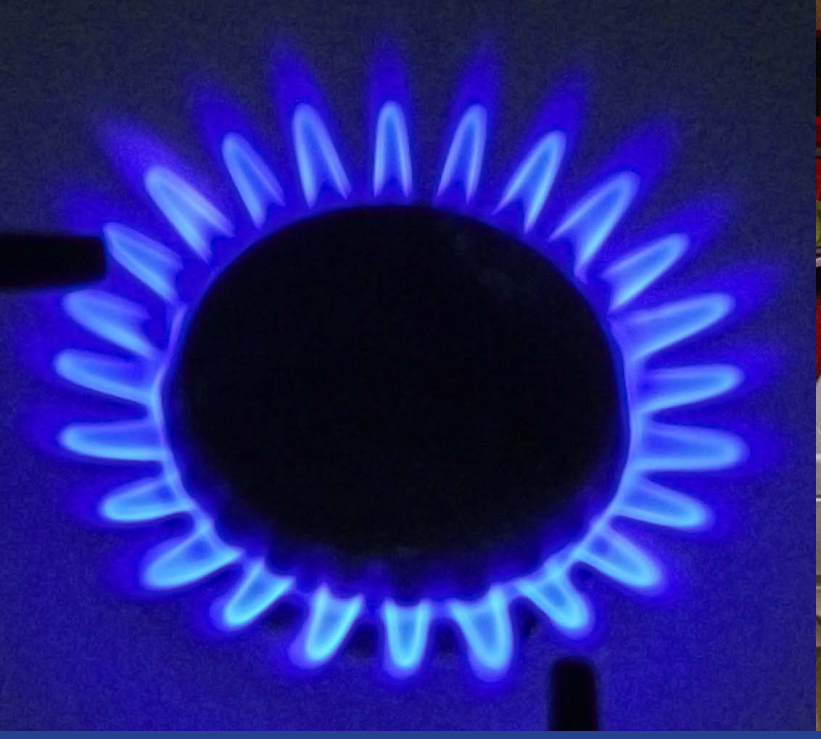

A Critique of Residential Gas and California Air Pollution Paper: POOR POLICY FOR CALIFORNIA

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Executive Summary

Natural gas is an essential low-cost, non-polluting fuel for heating, cooking, industrial use, and generation of electric power. More than 90 percent of California households use gas and almost 70 percent use gas stoves. Nevertheless, the authors of the UCLA study titled "Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California"[2] propose to take natural gas appliances away from California residents.

The April, 2020, study from UCLA did not develop any new data but instead used models and hypothetical cooking scenarios to claim that residential gas appliances cause harmful indoor and outdoor air pollution. In the case of indoor air pollution, a detailed read of the UCLA paper shows that:

- Stoves are the only appliances that might be a concern for indoor air. California law requires furnaces, water heaters, and other gas appliances to use outside vents.
- CO and NO_2 are the only pollutants from stoves that may be of concern.
- The models used in the study did not find that CO emissions exceed California or U.S. air quality standards.
- The models found that NO_2 levels exceeded California air quality standards, but at levels where the U.S. EPA found "no health impacts."
- The studies cited by the UCLA paper did not find evidence that NO_2 emissions from gas stoves are unhealthy.

Contrary to the paper conclusions, residents can have confidence that modern gas stoves do not pose an indoor air pollution health risk.

The second part of the UCLA paper claims that gas appliances generate harmful $PM_{2.5}$ particle pollution. It claims that if California residential gas appliances were transitioned to electric, the reduction in $PM_{2.5}$ emissions would reduce deaths and cases of bronchitis, and reduce health costs by approximately $3.5 billion each year.

Regarding outdoor air pollution from gas appliances:

- The paper projects a $PM_{2.5}$ increase of 0.11 $\mu g/m^3$ in outdoor air, less than 1 percent of California $PM_{2.5}$ pollution.
- The study relies on the assumption that low levels of particle pollution cause premature death, which is being challenged.
- The study provides no evidence that bronchitis is caused by $PM_{2.5}$, which is primarily caused by smoking.
- Other sources of particles, such as smoking, forest fires, and industry, emit orders of magnitude more particles than residential gas appliances.

Removing gas from California residences will not measurably improve either indoor or outdoor air quality. But residents will lose the advantages of the flexibility, efficiency, and low-cost operation of gas appliances.

Should homeowners be forced to switch to electric appliances, they will be exposed to the full measure of rising California electricity rates. Today, California rates are among the highest in the nation and are rapidly increasing. In addition, mandates for 100 percent renewable energy will cause California electricity prices to double or triple in the next decades. Rising electricity prices will cause a painful loss of standard of living, particularly in low-income households. At the same time, elimination of gas appliances will have a negligible effect on air quality and climate change.

1. Introduction

Accuracy and perspective seem to be missing from some of today's published scientific papers. An example is a paper that was published in April, 2020, by the University of Southern California, titled "Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California."[3]

The paper by UCLA describes a study that provides no new measured data but instead uses models and data from other scientific papers to estimate levels of air pollution. The study concludes that residential gas appliances cause dangerous indoor air pollution and exhaust emissions that add to outdoor air pollution. It further concludes that hundreds of lives and billions of dollars could be saved each year if California residences switched to the use of electric appliances.

The UCLA paper calls for electrification of California homes and elimination of gas appliances. Today, gas appliances are overwhelmingly preferred by California residents.

This paper is a critique of the UCLA study, finding fault with the study for shaky assumptions and conclusions, and adding some much-needed perspective. This paper challenges the notion that gas appliances cause dangerous indoor air pollution. It cites research to show that small particle outdoor pollution does not cause premature death. Further, this paper provides evidence that efforts to electrify California homes and to "decarbonize" California's power grid will raise energy prices and reduce the standard of living for California residents, without any measurable air quality or environmental benefits.

2. Claims Regarding Hazardous Indoor Air Pollution

The April, 2020, study from UCLA makes a number of unfounded claims. The paper concludes that "Exposure to the pollutants produced from gas appliances can be detrimental to human health…"[4]

The UCLA paper makes the broad statement that:

> Combustion pollutants are produced from the use of gas appliances, including water heaters, stoves, ovens, furnaces, and other indoor heating devices, such as gas fireplaces. Notable pollutants include CO, NO_2, NO_X, formaldehyde, and PM…"[5]

While this claim raises concerns for indoor air quality, the paper itself goes on to reduce the scope of this assertion in two ways.

First, it points out that California state law requires that water heaters, furnaces, space heaters, and fireplaces be vented to outside air. Therefore, in a residence that complies with state law, stoves are the only gas appliance that might be a concern for indoor air.

Second, the paper eliminates formaldehyde and particulates (PM) from the indoor model. It states that "concentrations of CO and NO_2 during cooking events can exceed levels set by national and California-based ambient air quality standards"[6] but provides no evidence or projections on formaldehyde and indoor particulates. It is true that CO and NO_2, if breathed in high concentrations, can be hazardous to human health.

Carbon Monoxide (CO)

Inhaled CO binds with hemoglobin, reducing the amount of oxygen that can be transported by the blood. At high levels of CO

inhalation, CO poisoning results in dizziness, unconsciousness, and death.[7]

Inhalation of smoke from fires causes most cases of carbon monoxide poisoning. Excepting fire causes, CO poisoning is responsible for about 50,000 hospital visits and 1,200 deaths per year in the U.S. About 400 CO poisoning deaths per year are inadvertent, with 800 deaths per year from intentional causes.[8]

Carbon monoxide poisonings in the U.S. have been declining since at least 1980.[9] Non-fire related poisonings, both accidental and intentional, declined by about 34 percent from 1999 to 2014.[10] Declines in unintentional deaths from CO have been attributed to improved safety of cooking and heating appliances and improved automobile pollution control systems, as well as the use of CO detectors.[11]

Despite the statement by the UCLA paper that "concentrations of CO…can exceed… ambient air quality standards," its own model results don't show this. The model results summarized in Table 2-2 of the UCLA paper *did not find* that CO emissions exceed either California or U.S. Environmental Protection Agency (EPA) standards.[12]

Modern gas stoves, when properly maintained, do not pose a carbon monoxide risk for today's homes. CO detectors are essential to detect faulty operation, but residents of California can have confidence that their gas stoves are not emitting hazardous levels of carbon monoxide.

Nitrogen Dioxide (NO_2)

According the EPA, most NO_2 emissions are generated by vehicles, power plants, and off-road equipment. In the environment, NO_2 emissions can add haze to our air and reduce visibility. NO_2 can also react with chemicals in the air to form particulates and ozone.[13]

Inhalation of nitrogen dioxide, in high concentrations, can irritate airways in humans. Exposures over short periods can result in coughing and difficulty breathing. NO_2 can aggravate respiratory diseases, particularly asthma.[14]

The UCLA paper concluded that "under a hypothetical cooking scenario" indoor air pollution from gas stoves exceeded the California and EPA national air quality standards for NO_2 in some limited cases.[15] Let's examine this claim.

Natural gas is a clean-burning fuel that produces primarily carbon dioxide and water vapor when burned. For all practical purposes, there are no nitrogen compounds in natural gas fuel. The overwhelming majority of NO_2 emissions from modern society come from burning coal and petroleum, which contain small amounts of nitrogen. But at high stove flame temperatures, NO_2 can be produced.

Nitrous oxide (NO) is produced at combustion temperatures above 1600°C by breaking down nitrogen molecules in air.[16] Modern stove burner flames reach temperatures above 1600°C, producing NO. NO then combines with oxygen to form NO_2. But the good news is that the amount of NO_2 generated by stoves is very small, only parts per billion (ppb) levels.

The UCLA study models projected that if a stove and oven were used simultaneously for two hours of cooking, residential levels of NO_2 could reach 34 ppb. This would exceed the California Ambient Air Quality Standard (CAAQS) of 30 ppb. Residential concentrations of NO_2 were projected to be less for cooking times of one hour or less.[17]

Note that we are talking about very tiny amounts of NO_2. Thirty-four parts per billion is equal to only about 34 kernels of corn in

a 45-foot-high, 16-foot-diameter silo filled with corn.[18]

It's not even clear that NO_2 concentrations of 34 ppb are hazardous to health. The California CAAQA standard of 34 ppb is the tightest in the world. The EPA National Ambient Air Quality Standard (NAAQS) for NO_2 is 53 ppb. EPA states that, for NO_2 levels below 50 ppb, "No health impacts are expected for air quality in this range."[19]

In addition, most of the studies cited by the UCLA paper *did not find evidence* that NO_2 emissions from gas stoves are unhealthy. The UCLA study cites Dales (2008), which states:

> Whether chronic exposure to low concentrations of nitrogen dioxide from indoor sources increases the risk of respiratory illnesses is unclear."[20]

The study cites Basu (2001), which concludes:

> We conclude that the evidence does not support a causal relationship between exposure to NO_2 or use of a gas stove and increased risk of respiratory morbidity at the levels of NO_2 typically associated with gas stoves.[21]

The study cites Bernstein (2008), which states:

> Because more than half of all households in the United States use gas, the primary source of indoor NO_2 is gas-fueled cooking and heating appliances. An extensive literature has examined the link between NO_2 exposure and duration causing adverse respiratory effects in susceptible populations, but results are inconclusive.[22]

Note that the UCLA paper provides no measured data. It uses data from other scientific papers to model indoor levels of NO_2 arising from emissions from gas stoves. The authors also relied primarily on data from a 2009 report to develop appliance emissions factors for the study, so the emissions estimates were from stove models that were more than 10 years old.[23] The authors made many assumptions, including stove venting, daily cooking time, and kitchen room size to drive model outputs. So even the projection of 34 ppb is questionable.

Based on only questionable model projections on nitrogen dioxide, with no evidence on carbon monoxide or other indoor pollutants, and with only inconclusive support from the scientific literature, the UCLA paper urges the elimination of all California gas appliances, including stoves, furnaces, water heaters, clothes dryers, and fireplaces.

3. Claims Regarding Outdoor Air Pollution and Health Benefits

The UCLA paper claims that, under a scenario "where all California residential gas appliances were transitioned to electric," the reduction in $PM_{2.5}$ emissions would result in 354 fewer deaths, and 596 and 304 fewer cases of acute and chronic bronchitis annually in California. The paper goes on to say that "the reduction in associated negative health effects is equivalent to approximately $3.5 billion in monetized health benefits" each year.[24]

The UCLA study estimates that emissions from residential gas appliances account for about three percent of total NO_X emissions in California.[25] NO_X emissions produce nitrate particulates. The study further estimates that direct emissions of $PM_{2.5}$ particles and secondary production of particles from NO_X emissions from gas appliances increase $PM_{2.5}$ levels by 0.11 micrograms per cubic meter (μg/m^3) in California air,[26] or less than one percent of the state's $PM_{2.5}$ pollution. Particulates will

be discussed below.

The UCLA study makes many assumptions to arrive at the estimate of lives saved and monetized health benefits. It assumes that all California appliances are transitioned from electric to gas, which would require retrofit of more than 13 million California buildings. The study also assumes that, per the adopted Renewable Portfolio Standard of 2018, 100 percent of California electricity is generated from renewable sources.[27] The study does not include emissions from electric appliances, which are lower than emissions from gas appliances, but which are not zero. The study assumes appliance usage levels but did not do any measurements or surveys to determine actual appliance usage.[28]

But the biggest assumption in the UCLA study is the false idea that inhalation of small particles causes premature death.

$PM_{2.5}$ and Premature Death

In 2011, EPA Administrator Lisa Jackson told Congress, "Particulate matter causes premature deaths. It doesn't make you sick. It's directly causal to dying sooner than you should."[29]

The particulate matter we are concerned about is $PM_{2.5}$, which is classified by the EPA as particles smaller than 2.5 microns in diameter, smaller than the eye can see. Particle pollution is a mixture of dust, metals, pollen, organic chemicals, and nitrates and sulfates.

EPA claims any level of small particles can cause premature death. The agency warns that death may occur within a few hours of inhalation of $PM_{2.5}$, or may be caused by long-term inhalation over decades.[30] In 2013, EPA Policy Advisor Amanda Brown stated that between 130,000 and 320,000 Americans died prematurely in 2005 due to particle pollution, an incredible 6 to 15 percent of total US deaths.[31]

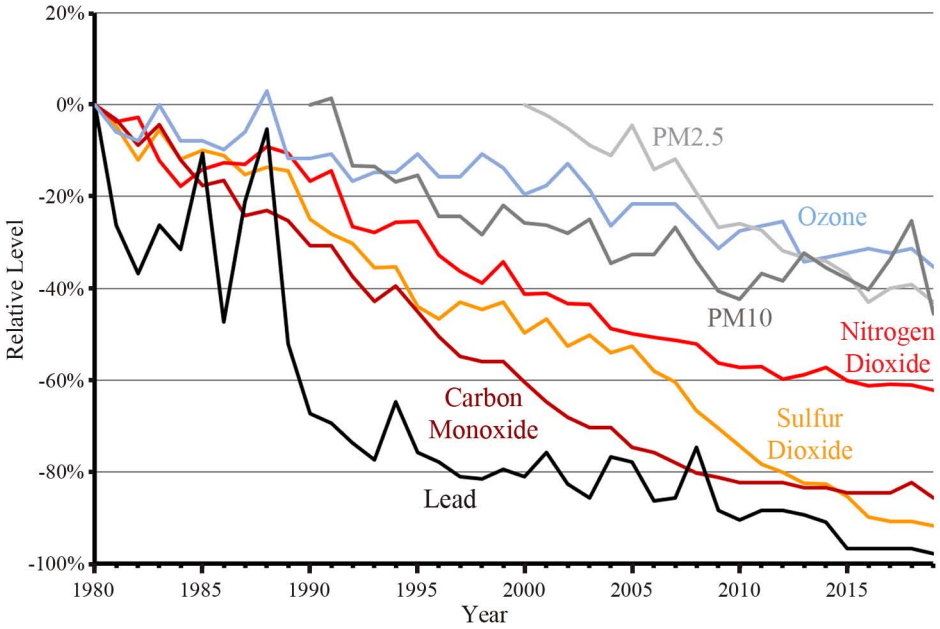
The EPA claims that particle pollution triggers heart failure, respiratory failure, and other causes of mortality. If a senior citizen dies on his 70th birthday, and a coroner determines heart failure to be the cause of death, the EPA may regard this death as "premature" and caused by small particle pollution.

Today, our nation's air is remarkably clean. Health incidents from serious air pollution are rare. The six criteria air pollutants of the EPA, lead, nitrogen dioxide, sulfur dioxide, ozone, and particulates, are down a combined 77 percent in 2019 compared to 1980 (see graph next page).[32] These improvements in air quality have been achieved with U.S. residents using over 50 percent more natural gas today than in 1980.[33] $PM_{2.5}$ particle pollution is typically below the EPA national standard of 12 $\mu g/m^3$, down 43 percent since 2000.[34]

Twelve micrograms per cubic meter is not very much. Dr. James Enstrom, a retired researcher from the UCLA School of Public Health, points out that a person breathing in 12 micrograms of small particles per cubic meter would inhale less than 5 grams, or less than one teaspoon full, of these microscopic particles over an 80-year lifespan.[35] The EPA's assertion that this tiny dose of small particles causes premature death is not credible.

How do the EPA, the California Air Resources Board (CARB), and other regulatory agencies conclude that thousands of Americans die prematurely each year from particle pollution? No coroner ever attributes the cause of death to small particles. Instead, the EPA relies on epidemiological observational studies that associate particle pollution with death.

Epidemiological studies analyze statistical associations between exposure to an agent



Air Pollution in the United States 1980—2019. Declining ambient concentration levels of lead (Pb), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and particulates ($PM_{2.5}$ and PM_{10}) are shown. (EPA, 2020)[36]

and appearance of disease in a population. An example is the Doll and Hill study in the 1950s that found that cigarette smoking caused lung cancer in a population of 41,000 British medical doctors.[37] The EPA has concluded that associations found in epidemiological studies show that inhalation of small particles causes premature death.

The Harvard Six Cities study of 1993[38] and the American Cancer Society study of 1995[39] are two of the studies that form the basis of EPA small particle science. These studies found an increase in relative risk of less than 20 percent (RR=1.2). An increase in death rates of less than 20 percent (RR=1.2) is almost statistically indistinguishable from zero. In comparison, the Doll and Hill study on cigarettes and lung cancer found smokers had 10 times the rate of lung cancer of non-smokers, a relative risk of RR=10.[40] The weak association (small relative risk) between death and particle pollution that the EPA judges to be causal could be due to other factors in measured populations, or even random chance.

A number of other studies have found no causal association between small particle pollution and death. For example, a 2017 study by Anthony Cox analyzed small particles and death of persons 75 years or older in Boston and Los Angeles during periods from 2007 to 2013. The study found that average ambient $PM_{2.5}$ concentrations did not predict average elderly mortality rates in either Boston or Los Angeles.[41]

The underlying data from the Harvard Six Cities study and the American Cancer Society study have never been released. As a result, other scientists are not able to replicate and verify the results of these studies.

The EPA recently issued a Supplemental Notice of Proposed Rulemaking, titled "Strengthening Transparency in Regulatory Science." This proposed rule is a follow-on effort from a 2018 NPRM intended to base regulatory policy on scientific studies which release their underlying data for reanalysis and

critique.[42] This is certainly needed in the case of epidemiological studies claiming premature death from small particle pollution.

PM2.5 and Bronchitis

The UCLA study claims a reduction in annual cases of acute and chronic bronchitis if California residents move from gas to electric appliances but provides no evidence to support this claim. The study cites five references—Chaung (2011),[43] Kaufman (2016),[44] Karottki (2014),[45] Buteau (2018),[46] and Lee (2017)[47]—as evidence that small particle pollution causes bronchitis. But *none of these studies mention bronchitis* in their text.

The science is mixed on whether low levels of small particle pollution cause bronchitis. Bronchitis appears to primarily be a disease that is primarily caused by high levels of chemicals inhaled from smoking.[48]

Some Perspective on Particle Pollution

On January 1, 2018, California legalized the recreational use of marijuana.[49] Marijuana smokers and tobacco smokers inhale thousands of times more particles than residents breathing ambient air. A 2011 study by Alderman and Ingrebrethsen determined that smokers inhale more than a billion small particles per cubic centimeter of air while smoking.[50] A single tobacco cigarette or a single marijuana joint delivers more than 100 billion small particles to the user, which is more than a year of breathing California ambient air.

In 2017, California experienced some of the worst forest fires in history. During only two days in October, fires in Napa Valley produced an estimated 10,000 tons of $PM_{2.5}$. This is roughly the amount that 35 million California vehicles produce in a year.[51]

It is unlikely that elimination of gas appliances from California residences will measurably improve air quality. Nor is there evidence that a switch to electric appliances will "prevent premature deaths." Other natural and human sources of pollution have orders of magnitude greater impact on air quality than gas appliances. The authors of the UCLA paper need some perspective.

4. Climate Concerns and Rising Costs for California Homes

Natural gas is an essential low-cost, non-polluting fuel for heating, cooking, industrial use, and generation of electric power. More than 90 percent of California households use gas, and almost 70 percent of households use gas stoves.[52] Nevertheless, the authors of the UCLA paper propose to take natural gas appliances away from California residents.

As discussed above, the evidence shows that removing natural gas appliances from California residents will not measurably improve either indoor or outdoor air quality. In the case of indoor air, the UCLA study provides only weak arguments based on model projections, without any new measured data. For outdoor air, the study relies on the shaky assertion that particulate pollution causes premature death. But other pollution sources, such as smoking, forest fires, and emissions from industry, overwhelmingly dominate air quality issues.

Instead, it appears that the real goal of the UCLA paper is to support climate change policies with arguments about projected improvements in air quality and illusory health benefits. The paper states that natural gas is primarily methane, "a potent greenhouse gas," that "buildings are responsible for an estimated 25 percent of GHG [greenhouse gas] emissions in California," and that California is

pursuing "programs to promote electrification (i.e., the transition from fossil-fuel-powered appliances to electric technologies) as a climate mitigation strategy."[53]

California gas appliances are an insignificant part of world energy usage, only 0.33 percent of world natural gas consumption.[54] In addition, global use of natural gas continues to grow rapidly. From 1965–2019, global gas consumption increased by more than six times. Gas usage doubled in the U.S. and rose by a factor of more than 10 in Europe. Today, Asians use more than 150 times the gas they consumed in 1965.[55]

If all 13 million California buildings converted appliances from gas to electric, the effect on global gas usage would be negligible. But the costs and inconveniences to Californians would be significant.

While gas and electric appliances both have advantages, usage shows that California residents overwhelmingly prefer gas appliances to electric appliances. Gas stoves offer better temperature control than electric stoves.[56] Consumer Affairs Research points out that gas dryers use 30 percent less energy than electric dryers.[57] Gas water heaters heat water twice as fast as electric water heaters.[58]

But the biggest advantage of gas appliances is lower cost of operation. Think Energy reports that homeowners can save $1,000 to $2,000 annually with a gas furnace compared to an electric furnace. Water heater savings can be $200 annually, and dryer and stove savings can each be $100 annually, when using gas instead of electric.[59]

On September 10, 2018, then California Governor Jerry Brown signed Senate Bill 100, mandating that the state obtain 100 percent of its electricity from "clean energy sources" by 2045. Brown stated:

> It's not going to be easy. It will not be immediate. But it must be done…California is committed to doing whatever is necessary to meet the existential threat of climate change.[60]

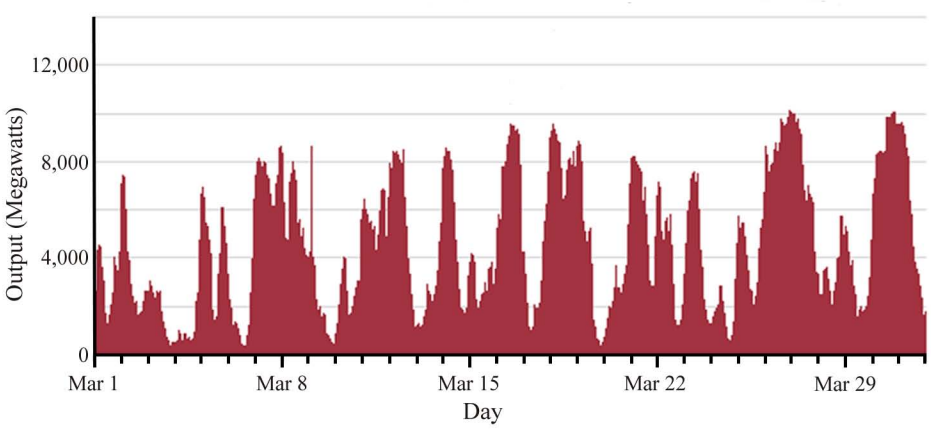
But Californians will experience the shock of rapidly rising electricity prices as more renewable energy is added to the power system.

Wind and solar cannot replace traditional coal, natural gas, and nuclear power plants if continuity of the supply of electricity is to be maintained. Wind and solar are intermittent generators. Wind output varies greatly from high output to zero, depending upon weather conditions. Solar output is only available about six hours each day when the sun is overhead and disappears completely on cloudy days or after a snowfall. Hydro power can replace traditional power plant output, but even this source is insufficient in years of low snow runoff or drought.

Because of intermittency, utilities can only count on about 10 percent of the nameplate capacity of a wind or solar facility as an addition to power system capacity. For example, wind output in March, 2014, for the state of Texas varied from over 8,000 megawatts to under 500 megawatts in a few hours (figure next page).[61]

To try to achieve "deep decarbonization," California will need to keep 90 percent of traditional power plants as backup while adding increasing amounts of wind and solar to existing systems. Traditional power plants will be run inefficiently at low utilization with priority given to renewables. Total system capacity must double and triple as 100 percent renewable output is approached.

A 2016 study by Brick and Thernstrom projected that California's power capacity



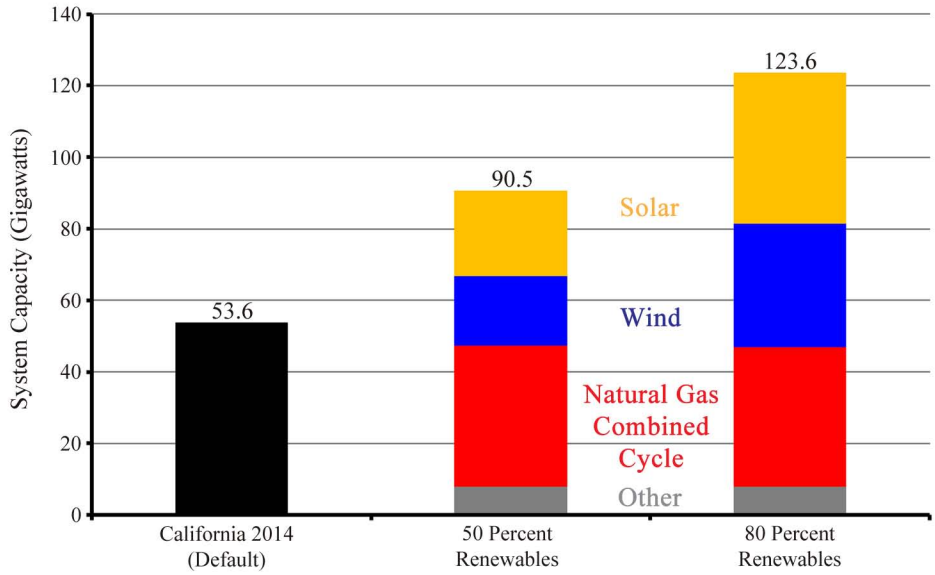
Texas Hourly Wind Generation, March 2014. Intermittent wind energy output for the state of Texas in March, 2014. ERCOT, EIA (2014)[62]

would need to rise from 53.6 gigawatts to 90.5 gigawatts at 50 percent renewable output and to 123.6 gigawatts to achieve 80 percent renewable output.[63]

As a result of rising system capacity, Brick and Thernstrom concluded that, to achieve 50 percent renewable penetration, wholesale electricity prices in California would need to rise from 5.2 cents per kilowatt-hour (¢/kW-hr) to 9.6¢/kW-hr. For 80 percent renewable penetration, prices would rise to 14¢/kW-hr, approaching a tripling of electricity prices.[64]

Green energy advocates recognize the shortfall of renewable intermittency and propose grid-scale batteries to solve the problem. They claim that large-scale commercial batteries will be able to store power during high levels of renewable output and then deliver power to the grid when wind and solar output is low.

But batteries are not a sufficient answer because of the large seasonal variation in renewable output. Wind and solar output in



Rising California Power System Size with Renewables Penetration. System capacity estimated at 50 percent and 80 percent renewable penetration. Most traditional plant capacity will still be required. Brick and Thernstrom, 2016[65]

California in December and January is less than half of the output in summer months.[66] Today's commercial batteries are rated to deliver stored electricity for only two hours or ten hours. No batteries exist that can store electricity in the summer and then deliver in the winter when renewable output is very low.

The UCLA paper authors and the electrification movement propose to force residents to use electric appliances. But California electricity prices are already high and rapidly rising.

In 2019, California residential electricity prices were 19¢/kW-hr, 47 percent higher than the national average. California electricity rates increased 30.4 percent over the last decade, compared to a U.S. residential price increase of 13.3 percent.[67]

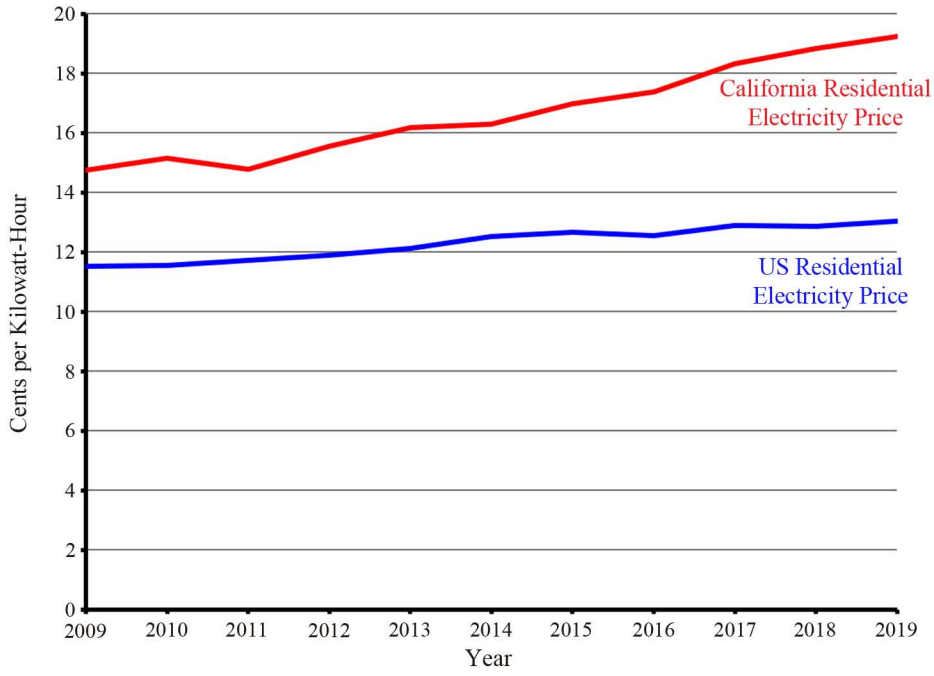
California's 100 percent renewable mandate, if aggressively pursued, will force already high electricity rates to double and triple by 2045. This price rise will add to already high electricity prices.

As of June, 2020, more than 30 California cities have enacted bans or restrictions on natural gas appliances in new construction, including the major cities of San Francisco and San Jose. Almost 10 percent of the population of California now lives in an area covered by gas building code restrictions.[68]

The UCLA paper is concerned about air quality impacts on low-income residents but is silent about the impact of skyrocketing energy prices. Banning gas appliances will force low-income Californians to spend much more of their limited budget for heating and cooking.

In 2018, the National Energy Assistance Directors' Association surveyed low-income households faced with high energy costs. Survey findings showed that, when faced with unaffordable energy bills, low-income households were forced to make choices:

- 41 percent went without medical or



California and U.S. Residential Electricity Prices (2009–2019). California residential electricity prices are up 30.4 percent since 2009, compared to a U.S. residential price rise of 13.3 percent. California prices are now 47 percent above the U.S. average. (Energy Information Agency, 2020)[69]

dental care;
- 36 percent went without food for at least one day;
- 31 percent did not fill a prescription or took less than a full dose;
- 25 percent kept their home at a temperature that was unsafe or unhealthy;
- 17 percent moved in with friends or family.[70]

Banning of residential gas appliances will subject Californians, and especially low-income households, to the full brunt of rising electricity costs. If enacted, gas appliance bans will have a real standard of living impact, while gains in air quality and health will be negligible.

5. Conclusions

This paper takes a critical look at the April, 2020, UCLA study titled, "Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California."

Regarding indoor air pollution, this paper finds that the UCLA study:

- Used model projections and questionable assumptions about indoor air pollution but provided no new data.
- Limited indoor pollution concerns to CO and NO_2 emissions from gas stoves.
- Did not find that CO indoor air quality levels from stove emissions exceed California and national standards.
- Projected that NO_2 indoor air quality levels from stoves exceeded tight California standards, but that neither the EPA nor the scientific literature shows that these levels are harmful to human health.

Regarding outdoor air pollution and the proposed elimination of gas appliances in California by the UCLA study, this paper finds that:

- Under a best-case scenario, the ban of gas appliances would eliminate less than one percent of California ambient $PM_{2.5}$, an air quality change that could not be measured.
- The assertion that $PM_{2.5}$ pollution causes premature death is being challenged, so projected health savings are illusory.
- No evidence was provided to establish that $PM_{2.5}$ causes bronchitis.
- Other sources of particles, such as smoking, forest fires, and industry, emit orders of magnitude more particles than residential gas appliances.

Regarding the policy proposal that California should ban residential gas appliances, this paper warns:

- Residents will lose the advantages of the flexibility, efficiency, and low-cost operation of gas appliances.
- California residential electricity rates are among the most expensive in the U.S. and rising faster than the national average.
- Mandates for 100 percent of electrical power from renewable sources by 2045 will double or triple electricity prices.
- California households, without natural gas appliances, will be subjected to the full brunt of rising electricity prices.
- Unaffordable electricity will cause significant reduction in resident standards of living, particularly for low-income households.

The UCLA paper authors and California state and local governments should reconsider their plans for bans on residential gas appliances.

NOTES

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