From: Tom Phillips, Healthy Building Research, Davis, CA

To: CARB AB 32 Scoping Plan Update

Date: January 21, 2022

Re: Comments on Dec. 13, 2021 Buildings Workshop, 2022 Scoping Plan Update

Thank you for outlining your approach to Building Decarbonization for the Scoping Plan at the [December 13, 2021](https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/scoping-plan-meetings-workshops) workshop. As mentioned in my oral comments at the workshop, I strongly support the need to not only reduce carbon emissions and energy use by our buildings, especially in existing buildings, but also the need to:

* Assess and factor in the nonenergy benefits such as indoor environmental health, productivity, liability, and grid benefits that can be obtained by designing buildings for future climates and power outages.
* Give passive energy efficiency a high priority in order to avoid locking in inefficient buildings, to reduce embedded carbon from PV and battery systems, and to improve passive survivability.
* Provide both quality control of the building process and the training of building and maintenance professions and trades. These steps are all critical to achieving our building performance goals over the long term and minimizing false steps and push back.

CARB and other state agencies have a legal mandate to address health and equity impacts related to climate change. They should meet this mandate using the best available science. They should also build on the examples of programs around the world that are already addressing future climate adaptation, reduced overheating risks, and improved passive cooling efficiency. California can and should become a world leader in this area of healthy, low carbon buildings by learning from other programs and investing in people, and not locking in inefficient, maladapted, unhealthy buildings.

Discussed below are key points, supporting information, and examples that I mentioned at the Buildings workshop. Additional comments and supporting information are provided in my comments on the September 30, 2021 Scenarios Input workshop.[[1]](#endnote-1)

1. **Develop the Health and Equity Analysis for the update up front in order to provide meaningful guidance in developing our climate adaptation mitigation strategies for California.** Under the current project plan, the health analyses will not be drafted until early 2022, so is not clear that health and equity will be important factors in evaluating carbon reduction options.
2. **Include nonenergy benefits from improved indoor thermal health, indoor air quality, and productivity in development of the Scoping Plan.** Based on current science and best practices, substantial nonenergy benefits can be estimated. For example:

Indoor PM and NO2 Health Risk Reduction

The E3 economic model used for the Scoping Plan health analysis only considers outdoor concentrations of PM2.5, but reduced exposure to indoor PM and NO2 also have substantial health and cost benefits, especially for vulnerable populations. Weatherization programs can greatly reduce the infiltration of outdoor PM, including wildfire smoke, by reducing air leakage of building shells and ductwork, and reducing the need to operate heating and cooling systems. Modeling of indoor air quality in weatherized homes with improved ventilation has shown that significant health benefits can be achieved, especially in vulnerable populations.[[2]](#endnote-2) [[3]](#endnote-3) [[4]](#endnote-4) [[5]](#endnote-5) [[6]](#endnote-6) [[7]](#endnote-7) [[8]](#endnote-8) Similar benefits can be expected in other building types such as schools and care facilities. For indoor NO2, LBNL and others have already measured and modeled reduced indoor exposures from electric gas stoves and improving kitchen ventilation in homes. EPA and others have developed guidelines and protocols to protect and enhance indoor air quality in weatherization programs.[[9]](#endnote-9) These health benefits of these reductions in indoor PM and NO2 can be assessed using available health risk cost estimates.

Indoor Heat Stress Reduction

Indoor exposures dominate the heat risks for most vulnerable populations such as older persons, children, and chronic disease patients. Two thirds of heat wave deaths from the 2006 California heat wave occurred indoors, especially in coastal areas.[[10]](#endnote-10) A similar pattern has been observed for other heat waves in other regions, including the 2021 Pacific Northwest heat dome catastrophe. Over a third of heat related deaths occurred indoors in Maricopa County, Arizona, witch has a high fraction of air-conditioned homes and a climate similar to future Central Valley climate.[[11]](#endnote-11) When indoor heat exposure is included in mortality estimates of older persons, a much better correlation is achieved and a nonlinear increase is observed, indicating the importance of indoor exposures at higher temperatures.[[12]](#endnote-12) In addition, outdoor workers rely on cool homes for sleeping and enabling their bodies to recover from frequent heat stress. Cooling shelters and heat warning systems can only meet a small part of the cooling needs for public and worker health protection.

Indoor heat exposures are expected to increase substantially due to climate change, increased power outages, and a growing population in California and many other regions. For California’s metropolitan regions, Sheridan et al. estimated that heat waves of 2 weeks or more would occur much more frequently in coastal areas and premature deaths of persons over 65 could increase up to 10 fold by the 2090s in major urban centers. Most of estimated heat related mortality would probably occur indoors, and adaptation could reduce that impact substantially.[[13]](#endnote-13)

Valuation of Nonenergy Benefits

Several studies in the U.S. and other countries have modeled the impacts of overheating and climate change, and the health, productivity, and energy benefits of interventions in existing and new buildings. These studies general find that the both the nonenergy and energy benefits are sizeable and feasible. Below are a few examples:

* A Canadian Institute for Climate Choices study estimated the social costs of future heat related impacts on mortality and morbidity impacts to $4.9 billion per year (2050s) and $10.8 billion per year (2080s).[[14]](#endnote-14) The results indicated that installing external and internal shades on 25 private homes could save 21 deaths by the 2050s and 90 deaths by 2085, with a net social value of about $180 million. Installing the shades in 55% of private homes by 2085 was valued at $1.3 million net. The mortality benefits of green roofs on other building types and the productivity benefits of shading on manufacturing facilities were also estimated.
* Porter and Scawthorn used an overheating assessment tool for new buildings, in a report to Canada’s Institute for Catastrophic Loss Reduction.[[15]](#endnote-15) They estimated that pro-active climate adaption of new buildings would prevent on about 100 heat-related deaths per year by mid-century, valued at $1 billion CAD per year.
* The ClimaCare project studied interventions to reduce overheating in UK care homes.[[16]](#endnote-16) [[17]](#endnote-17) [[18]](#endnote-18) The pilot study identified active and passive cooling measures and packages that would be the most effective in older and newer care homes under the current climate. Reduced mortality risks from the interventions were monetized using three different methods: custom external shading for a 50-person facility yielded benefit estimates of £90,000, £230,000 and £44,000 ($122,000, $313,000, and $54,000) over 20 years. Future climate scenarios will also be examined.

Productivity Improvements

Many schools and workplaces in California and the rest of the U.S. already suffer from overheating.[[19]](#endnote-19) Poor “thermal health” in buildings can adversely affect the test performance of grade school, high school, and college students.[[20]](#endnote-20) [[21]](#endnote-21) This can have substantial economic impacts over the long term. For example, based on reduced test scores and future earnings, the value of providing an air-conditioned classroom in Houston was estimated to be roughly $1 million per year in a high school of 1,000 students.[[22]](#endnote-22) Poor thermal health at home can also affect student and worker performance.

Liability Risk Reduction

Liability for overheating problems is a growing problem for the building sector.[[23]](#endnote-23) Lawsuits over overheating in high-rise condominiums have resulted in major

court settlements and awards in California. Nursing home deaths in other states have resulted in civil lawsuits and criminal charges. Given that we have known for several years about overheating problems in buildings under current and future climates, the potential health and productivity impacts, and how to prevent these problems, no building professional, health professional, or planning professional can claim ignorance. Rather they must carry out due diligence.

The Conservation Foundation has published a review of the legal theories and cases on climate adaptation and liability of designers, contractors, developers, builders, real estate agents, insurers, and government officials.[[24]](#endnote-24) The report als o contains a summary of a series of workshops on this issue, including recommendations from various stakeholder groups.

1. **Learn from and build on the examples of other jurisdictions and programs that assess and mitigate overheating risks in buildings.**Several guidelines and standards have been used to assess current and future overheating risks in buildings.[[25]](#endnote-25) The Collaborative for High Performance Schools has adopted climate vulnerability assessment, energy resilience, and passive survivability credits for the national and California criteria. Programs in Canada, the United Kingdom, and Australia are using future weather files in building energy models. California has localized weather files for future climate and urban heat in California, and morphed weather files are also available. Cal Adapt staff recently said it was going to produce future weather files in 2022. Why isn’t California moving rapidly to develop and implement overheating guidelines and standards?

RMI, Canada, England, the EU, and the International Energy Agency have all published climate action plans that stress building energy efficiency and grid benefits. The IPCC is including a section on building adaptation for the first time. The EU is funding a major renovation project to address energy poverty, decarbonization, and public buildings and the social sector.[[26]](#endnote-26) It has also funded several demonstration projects for deep energy retrofits of multifamily buildings that provide good indoor environmental quality and avoid energy efficiency lock in. For example, low carbon, near passive house performance was achieved by reducing energy use by 90% in a cost effective manner without requiring occupants to move out.[[27]](#endnote-27) Why isn’t California moving this aggressively in the building sector?

California should implement demonstration studies of climate adapted, resilient buildings to prevent overheating and minimize carbon emissions over their life cycle. State buildings, universities, community colleges, schools, housing, and other public buildings are all good candidates for this approach. Training programs and quality control programs also need to be expanded to ensure that new design and construction practices are successful.

1. **Develop guidance, tools, training, and incentives to accelerate the climate adaptation of new existing and new buildings, especially for heat-vulnerable populations**.

We cannot assume that current building standards will adequately protect our indoor environmental quality (IEQ). The building energy standards do not assess indoor thermal performance for historical climate conditions, let alone for the next 60-100 years, for several reasons:

	1. Our building standards do not address thermal comfort or health at the design stage or at the operation and maintenance stage, other than to guide the sizing of HVAC equipment.
	2. Our housing standards include lower temperature limits but do not include upper heat stress limits or requirements for air conditioning. Schools and other workplaces have to meet occupational health standards, but the students or other-heat sensitive populations are not covered by those standards. Some nursing homes have to meet federal regulations for upper and lower temperature limits, but those regulations are not well enforced.
	3. Enforcement of our building standards and quality control in our building construction are notoriously poor.
	4. Neither future climate conditions, more extreme heat, nor urban heat islands are currently considered in developing our building standards. However, Cal-Adapt projects that future cooling loads are expected to increase by about 60% (mid-century) and 100% (late-century) in the Central Valley, while heating loads will decrease drastically.[[28]](#endnote-28) Extreme heat days are expected to increase by 14 and 20 days per year, respectively, and extreme heat nights are projected to increase even more. On top of that, urban heat islands already experience temperature increases of several degrees Fahrenheit over that at airport weather stations used in the building standards. Urban heat effects are also expected to increase due to climate change and, indirectly, increased waste heat from the increased use of air conditioning.
	5. Several studies have shown that unless a building is designed to address peak summer cooling loads and outages, it can still experience overheating, especially under future climate conditions. Therefore, additional analysis is required to assess overheating risks and the cooling measures that will mitigate the risks.

In order to address this issue now, California must quickly get up to speed on current building science and establish an expert task force to develop a strategy to make our buildings ready for climate change and power outages. Several examples of climate adaptation and resilience programs for buildings are available to build on: the Collaborative for High Performance Schools (CHPS), the UK Future Homes Standard, the London Plan, and the British Columbia Step Code.[[29]](#endnote-29) These programs all include a climate change vulnerability assessment for overheating; the CHPS climate adaptation and resilience criteria also contain measures for energy resilience and passive survivability. Future weather files, urban heat weather files, and summer design files can be used in energy models and overheating risk assessments for the common building typologies in California. The CEC-funded research by Altostratus can be used to provide future weather files that include the urban heat effect. Cal-Adapt can produce future weather files in 2022. Building stock data bases and typologies can be used to help identify which building types and locations and socioeconomic groups are most at risk for overheating and energy equity problems. Multi-objective optimization models can be used to integrate overheating, carbon, energy, and cost in building design.

In summary, our new and existing buildings are maladapted for current and future increases in extreme heat and urban heat. We cannot wait several years for building standards to address this problem. Merely increasing the energy efficiency of homes and adding PV systems will often reduce but not prevent overheating of buildings, and it can result in locking in suboptimal energy efficiency and indoor environmental quality.

Thank you for the opportunity to provide input on the Scoping Plan. I hope and expect that California will once again become a world leader in addressing climate change and reducing its health impacts, using the best available science. For further information, please contact me at tjp835@gmail.com.

CC: Architects Institute of California

CDPH Office of Climate Equity and Indoor Air Quality Section

Collaborative for High Performance Schools

 Energy Efficiency For All

Environmental Justice Advisory Committee

 LBNL Indoor Environment Program

Physicians for Social Responsibility

RMI

 Mothers Out Front

 NRDC

 Passive House California

 3C REN, BayREN

Attachment:

Phillips and Higbee, January 2022. [The New ABNORMALS: How to Adapt Buildings to Extreme Heat and Power Outages](https://drive.google.com/file/d/1XEYwxM4E5zXJMXCEpsfsO-Tfsnq5qsFQ/view?usp=sharing). Lead and Healthy Housing Winter Conference.

ENDNOTES

1. Phillips, October 22, 2021. Health, Equity, and Energy Efficiency comments. September 30, 2021. Scoping Plan Scenarios workshop. [Attachment](https://www.arb.ca.gov/lists/com-attach/89-sp22-inputs-ws-AWBSNgFfUTFXYwJd.pdf). [↑](#endnote-ref-1)
2. Porritt et al., 2014. [Ranking of interventions to reduce dwelling overheating during heat waves.](https://www.sciencedirect.com/science/article/abs/pii/S0378778812000898) [↑](#endnote-ref-2)
3. Underhill et al. 2018. [Modeling the resiliency of energy-efficient retrofits in low-income multifamily housing](https://pubmed.ncbi.nlm.nih.gov/29280511/). [↑](#endnote-ref-3)
4. Tieskens et al., 2021. [The impact of energy retrofits on pediatric asthma exacerbation in a Boston multi-family housing complex: a systems science approach](https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00699-x) [↑](#endnote-ref-4)
5. Ferguson et al., 2020. [Exposure to indoor air pollution across socio-economic groups in high-income countries: A scoping review of the literature and a modelling methodology](https://www.sciencedirect.com/science/article/pii/S0160412019340917). [↑](#endnote-ref-5)
6. Shrubsole et al., 2014[. Impacts of energy efficiency retrofitting measures on indoor PM2.5 concentrations across different income groups in England: a modelling study](https://www.tandfonline.com/doi/abs/10.1080/17512549.2015.1014844?journalCode=taer20). [↑](#endnote-ref-6)
7. Taylor et al., 2015. [Understanding and mitigating overheating and indoor PM2.5 risks using coupled temperature and indoor air quality models](https://journals.sagepub.com/doi/10.1177/0143624414566474). [↑](#endnote-ref-7)
8. Taylor et al. 2018. [Comparison of built environment adaptations to heat exposure and mortality during hot weather, West Midlands region, UK](https://www.sciencedirect.com/science/article/pii/S0160412017315477?via%3Dihub). [↑](#endnote-ref-8)
9. EPA, 2021. [Energy, Weatherization and Indoor Air Quality](https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality). See also: DOE, 2017, [Standard Work Specifications for Multifamily Home Energy Upgrades](https://www.energy.gov/eere/wipo/guidelines-home-energy-professionals-standard-work-specifications). 2022 [update in progress](https://sws.nrel.gov/maintenance). [↑](#endnote-ref-9)
10. Joe et al., 2016. [Mortality During a large-scale heat wave by place, demographic group, internal and external causes of death, and building standards climate zone](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4808962/). [↑](#endnote-ref-10)
11. Maricopa Co. Department of Health, 2016. [Heat Mortality in Maricopa County
2006 – 2015](https://www.maricopa.gov/ArchiveCenter/ViewFile/Item/3392). [↑](#endnote-ref-11)
12. Buchin et al., 2016. [The role of building models in the evaluation of heat-related risks](http://dx.doi.org/10.5194/nhess-16-963-2016)**.** [↑](#endnote-ref-12)
13. Sheridan et al. 2011. [A spatial synoptic classification approach to projected heat vulnerability in California under future climate change scenarios](https://ww3.arb.ca.gov/research/single-project_ajax.php?row_id=64809). Final report, seminar, and journal articles. [↑](#endnote-ref-13)
14. Canadian Inst. for Climate Choices, 2021. [The Health Costs of Climate Change](https://climatechoices.ca/reports/the-health-costs-of-climate-change/%27).

Full Report: Boyd et al., Dec. 2020. Costing Climate Change Impacts on Human Health across Canada. [↑](#endnote-ref-14)
15. Porter and Scawthorn, 2020. Estimating the benefits of Climate Resilient Buildings and Core Public Infrastructure (CRBCPI). Prepared for the National Research Council Canada and the Institute for Catastrophic Loss Reduction. [↑](#endnote-ref-15)
16. Davies, 2021. ClimaCare: Overheating in Care Homes. [March Webinar](https://www.ukclimateresilience.org/news-events/overheating-in-care-homes/). [Project Website](https://www.climacare.org/). UK Climate Resilience Programme. [↑](#endnote-ref-16)
17. Tsoulou et al., 2022. [Assessing the Current and Future Risk of Overheating in London’s Care Homes: The Effect of Passive Ventilation](http://www.ibpsa.org/proceedings/BSO2020/BSOV2020_Oikonomou.pdf). In: Proceedings of the International Building Performance Simulation Association (IBPSA, 2020). [↑](#endnote-ref-17)
18. Ibbetson et al., 2021. [Mortality benefit of building adaptations to protect care home residents against heat risks in the context of uncertainty over loss of life expectancy from heat](https://www.sciencedirect.com/science/article/pii/S221209632100036X). (Cost conversion assumes $1.36 per Pound Sterling). [↑](#endnote-ref-18)
19. Leroy et al., 2021. [Hotter Days, Higher Costs: The Cooling Crisis in America’s Classrooms](https://coolingcrisis.org/) [↑](#endnote-ref-19)
20. Allen et al., 2017. [The 9 Foundations of Healthy Buildings](https://9foundations.forhealth.org/). Harvard T.H. Chan School of Public Health. [↑](#endnote-ref-20)
21. Park et al. 2021. [Learning is inhibited by heat exposure, both internationally and within the United States](https://www.nature.com/articles/s41562-020-00959-9). [↑](#endnote-ref-21)
22. Goodman et al., 2018. [Heat and Learning](https://www.nber.org/system/files/working_papers/w24639/w24639.pdf). NBER Working Paper Series.

See also: Park et al., 2020. [Heat and Learning](https://www.aeaweb.org/articles?id=10.1257%2Fpol.20180612). [↑](#endnote-ref-22)
23. Phillips and Higbee, January 2022. The New ABNORMALS: How to Adapt Buildings to Extreme Heat and Power Outages. Lead and Healthy Housing Winter Conference. See Liability slides. [↑](#endnote-ref-23)
24. Conservation Foundation, 2018. [Climate Adaptation and Liability: A Legal Primer and Workshop Summary Report](https://www.clf.org/wp-content/uploads/2018/01/GRC_CLF_Report_R8.pdf). [↑](#endnote-ref-24)
25. Phillips and Higbee, 2022, op cit. See Guidelines and Standards slides. [↑](#endnote-ref-25)
26. EU, 2020. [Renovation Wave](https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en). [↑](#endnote-ref-26)
27. Urge-Vorsatz et al., 2020. Vice-chair of IPCC WG-III & Professor at CEU)

Annual Reviews paper: [Advances Toward a Net-Zero Global Building Sector, Sep. 2020](https://doi.org/10.1146/annurev-environ-012420-045843).

[The Future of Cooling COP26](https://coolcoalition.org/future-of-cooling-cop26-webinar-series/)webinars, and the [Clean Cooling Coalition](https://www.cleancoolingcollaborative.org/). Interview 2020: <https://passivehouseaccelerator.com/articles/passive-house-podcast-ep-12-dr-diana-%C3%BCrge-vorsatz-of-international-panel-on-climate-change-ipcc?mc_cid=6e5df005bd&mc_eid=f9c935d41f>.

News and report: <https://www.passivehousecanada.com/international-study-detailing-the-advances-in-the-global-building-sector/>. [↑](#endnote-ref-27)
28. Cal-Adapt, 2021. [Climate Tools](https://cal-adapt.org/tools), Temperature: Cooling and Heating Degree Days, Extreme Heat Days and Nights. Fresno RCP 8.5 example. Heat Waves durations were shown in a previous version. [↑](#endnote-ref-28)
29. Phillips and Higbee, 2022, op cit. See slides on Overheating Guidelines and Standards. [↑](#endnote-ref-29)