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Assessing and mitigating overheating in buildings

Please consider the attached proposal to assess and mitigate overheating of buildings. This best practice approach will help implement the recommendations of the 2013 and 2022 Extreme Heat Plans for California, and help meet the CEC's regulatory mandate to address IEQ and to consider climate change, non-energy benefits, and environmental equity.

This draft proposal was also submitted to the CASE Stakeholder team.

Thank you for your efforts to protect our indoor environment and our planet.
Tom

Additional submitted attachment is included below.

Title 24 2025 Update Proposal

Outline for Climate Ready Buildings:
Assess and Mitigate Overheating Risks For Future Climates and Outages

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PROBLEM

New and existing buildings in California are already overheating, especially during heat waves, power outages, and wildfire episodes. This has resulted in numerous deaths, hospitalizations, ER visits, lost school days, and untold losses in worker productivity. Climate change will exacerbate this problem more and more over the 100-year life of most buildings.

There is an urgent need to address the climate and equity crises by making our buildings climate ready, i.e., adapted to ongoing climate change and making buildings survivable or thermally safe during power outages. Consequently, California's 2022 Extreme Heat Action Plan calls for updating the building standards to address climate change impacts. In addition, proposed legislation is now calling for a limit to maximum temperatures in rental housing. Legal actions to address overheating problems in new California multifamily buildings have resulted in major settlement or award costs, and building professional organizations have recently confirmed their responsibility to address climate change impacts.[1] [2]

Overheating is also a climate justice problem. All buildings are at risk of overheating if solar and internal heat gains are not well controlled or adapted to future climates, even during the winter. But the health impacts of overheating are greatest where vulnerable populations live and study: multifamily buildings care facilities, schools, manufactured homes, and low-income households. Overcrowding has also been increasing in Californian housing for years, and this can exacerbate overheating.

SOLUTION

The solution is to prevent overheating by designing for future climate rather than past climates, to adapt to urban heat buildup, and to prepare for the increased frequency and severity of extreme weather events, power outages, and cascading impacts. Adaptation of existing and future climates can be done cost effectively, as shown in a modeling study of multifamily buildings in British Columbia, and by various projects in the UK and Canada.[3]

In addition to energy and operating cost savings, designing buildings to prevent overheating and additional peak energy use can capture substantial benefits. These benefits include:

- Reduced stress on grid reliability and efficiency.
- Reduced lock-in of lower efficiency buildings, dependence on mechanical cooling, and emissions of GHGs and waste heat.
- Downsizing of HVAC and PV systems, and their resultant production of GHG emissions and waste heat.
- Improvements in public and worker health, student performance, worker productivity, and property value.
- Reductions in outdoor air pollutant intrusion, health care system stress, liability risk, urban heat, and air pollutant and GHG emissions.

The value of the non-energy benefits above can be enormous. Based on the studies of new and existing homes in the UK and Canada and the larger population size of California, we can expect California benefits for reduced mortality alone to be on the order of $10 billion per year or more over time.[4] [5] [6] Regarding increased liability risks, several jurisdictions and professional organizations have adopted building standards or guidelines to prevent overheating under current or future climates.[7]

Several groups have indicated they support the need for this type of building code change, and sooner rather than later. These groups include architects, health professionals, energy agencies, and health, environmental, energy, and climate equity NGOs. I am contacting some of them to confirm their support.

This design strategy is widely accepted among high performance and health conscious builders in North America and Europe. It is required by the new building standard in the UK, and has been demonstrated in several UK projects for various building types. In addition, this design approach is widely used in building energy and comfort studies in the U.S. and elsewhere around the world, and its research and demonstration application has been growing rapidly.

Regarding technical limitations or market barriers: there are no major ones that I know of. Builders that use this approach have a market advantage, and owners can benefit from much lower Total Operating Costs and reduced liability. For some small builders and affordable housing programs, they may need financial and technical assistance initially.

PROPOSED CODE UPDATE

A) Overheating From Climate Change and Urban Heat Island Impacts: Assessment and Mitigation

1. Using integrated, whole house design (performance based), first optimize cooling efficiency of the building shell through passive efficiency measures, including external shading, window solar heat gain, insulation, air sealing, cool walls and roofs, window orientation and sizes, cross ventilation, and thermal mass, among others.
    a. Model dynamic hourly energy and thermal performance, using hourly 20 year weather files for RCP 8.5 mid century (2045-64) and late century 2080-99) climates.
    b. Use downscaled future weather files that include urban heat island (UHI) projections, such as those from Altostratus. If those are not available, use future weather files that are morphed for climate change. For morphing, use local Tmax projections from Cal-Adapt Extreme Heat Tool for the building location.
    c. For morphing adjustments for UHI, use peak summer UHI data for the location; if they are not available, use annual average UHI data from the CalEPA urban heat island mapping study.
    d. NOTE: WBGT and SET metrics need to be considered too.
    It is preferable to using WBGT, given the wide variety of humidity levels in California, and the projected increases in hot, humid weather systems due to climate change. WBGT can be easily calculated using the calculator in the UC Center for Built Environment Comfort Tool, https://comfort.cbe.berkeley.edu/upload. However, WBGT is not easy to measure in the field.
    SET includes T and RH, but not radiant T or wind speed.

2. Assess overheating risks of increasing severity at mid and late century, during the typical cooling season:
    a. Hours in May-September at 26 C (78.8 F) or more
    b. Hours in May-September at 28 C (82.4 F) or more
    c. Hours in May-September at 31 C (87.8 F) or more

3. Develop passive cooling measures, and then mechanical cooling measures, to limit overheating to the following (NOTE: these are targets based on existing guidelines from other jurisdictions and proposed legislation in California)
    a. < 5% of hours in May-September at 26 C (78.8 F) or more
    b. < 5% of hours in May-September at 28 C (82.4 F) or more
    c. < 5% of hours in May-September at 31 C (87.8 F) or more

4. Provide the modeling assumptions and results of the overheating analysis and mitigation recommendations to the owner, building department, and health department.

5. Obtain the owner's written signature to acknowledge their understanding of the results and recommended actions, and indicate which recommendations they will implement.

B) Passive Survivability: Thermal Safety During Power Outages

1. Using the optimized design and mitigation measures developed by the procedure for future climates, model the same overheating hour metrics for power outage conditions.
    a. Instead of future weather files, use the historical weather file for the maximum heat index over 4 or more consecutive days. If heat index data are not available, use maximum temperature data to select a weather file. Document the source of the weather data and rationale for selecting that data.
    b. Calculate the hourly SET metric for 7 days, starting at the beginning of the heat wave, by using the calculator in the UC Center for Built Environment Comfort Tool, https://comfort.cbe.berkeley.edu/upload.

2. Show compliance over the 7 days with the Path 2, Standard Effective Temperature (SET) method in the LEED Pilot Credit IPpc100, Passive Survivability (Thermal Safety), https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-48.
    a. Use passive efficiency measures first, and back up power if necessary, to meet the SET degree hour limits.
    b. (***add more specifics here***)

GUIDANCE FOR ENERGY RESILIENCE (Modified from CHPS 2019 National Core Criteria)

1. Provide at least 75% of the floor area to be within a daylit zone, as defined by the IECC-2015, ASHRAE 90.1-2016 or the Spatial Daylight Autonomy methodology.

2. Provide no less than 75% of the floor area is located in a space provided with an operable fenestration area to the exterior of at least 5% of the floor area of the space. Operable fenestration area shall be capable of manual operation.

3. Divide all power systems into primary/critical and secondary/non-critical sub-systems so that no more than 50% of the building loads are on the primary subsystem and the secondary sub-system can be disconnected from energy sources.

4. Provide on-site energy storage system sized to serve the loads on the primary subsystem for no less than 7 days without any interaction with energy supply infrastructures such as the electricity grid or is connected to renewable backup power with the same capacity.
A microgrid or renewable district energy system is acceptable for this criterion.
Critical energy systems such as HVAC equipment, energy distribution systems for the primary energy sub-system, onsite renewable energy systems and energy storage systems should be built and located to protect them from the most likely disturbances or natural disasters. For example, in high wind areas, these systems should be built in accordance with, or located in portions of the building built in accordance with, wind-resistant standards. Or in flood-prone areas, these systems should be located above the flood level. In areas prone to high wind, especially tornadoes and hurricanes, it is especially important that onsite renewable systems be built to withstand high wind loads.

5. See LEED Pilot Credit for Passive Survivability and other resources for additional measures, including those for food safety, water supply, and sanitation.

OPTIONAL FOR RETROFITS

1. Develop a plan to phase in mitigation measures in over time. Plan for any necessary infrastructure or preparations in the initial construction phase, e.g., brackets for external shades, substructure for green roofs, and electrical transformer/panel/wiring for more electrification, PV panels, internet of things, EV charging, and microgrids

2. Use EnerPHit (free) or a similar tool to develop the plan for scheduling and financing retrofit measures.

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[3] RDH, 2020. Designing Climate Resilient Multifamily Buildings. Report to University of British Columbia, Final Report | Project 21007.000m. Vancouver, BC.
[4] Kovats and Brisley, 2021. Technical Report, Chapter 5: Health, Communities and the Built Environment. UK Climate Risk Independent Assessment (CCRA3).
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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. (Cost conversion assumes $1.36 per Pound Sterling).
Tsoulou et al., 2022. Assessing the Current and Future Risk of Overheating in London's Care Homes: The Effect of Passive Ventilation. In: Proceedings of the International Building Performance Simulation Association (IBPSA, 2020).
[7] Examples are available from the UK, British Columbia, Germany, New Zealand, Australia (pending), Toronto, CIBSE, Passive House, et al. See me for details.