

How California Beat the Heat

By John Benson

October, 2022

1. Introduction

California has not been unique this summer in that we too have been suffering from extreme heat. However we have been unique in three ways:

1. Our extreme heat frequently comes in late summer to early fall, as it did recently.
2. Our recent extreme heat event broke many records.
3. In spite of “2” above, the electric utilities in California managed to mostly keep the grid operating.

I covered the major heat waves that the rest of the U.S. and World were experiencing in a post (described and linked below) in late August.

They Just Keep on Coming: *This summer it seems that every time I read a scientific or news publication or watch a program on television with a similar subject-matter, I am confronted by major effects of climate change. Going forward, these will increase in frequency and severity stressing our ability to adapt to them. They are also very complex and thus difficult to predict in advance. Most of these are secondary, tertiary or higher-order effects.*

These include the following, which we have known about for some time:

- *The sea-level is rising primarily due to a secondary effect and a tertiary effect of climate change. The secondary effect is the thermal expansion of sea water as it warms. The tertiary effect is the melting of glaciers and ice sheets (primarily the Antarctic and Greenland Ice Sheets) as they warm, providing run-off into the oceans thus further increasing the level of the oceans.*
- *Both heat and CO₂ enter the oceans and the latter acidifies them, causing major damage to coral, shellfish and possibly other aquatic life.*
- *The melting of the Greenland Ice Sheet has freshened the water in the North Atlantic, which has disrupted the Meridional Overturning Circulation (MOC, the Gulf Stream and other major ocean currents).*
- *Increasing atmospheric temperatures and the MOC disruption have caused major changes to weather patterns around the world.*

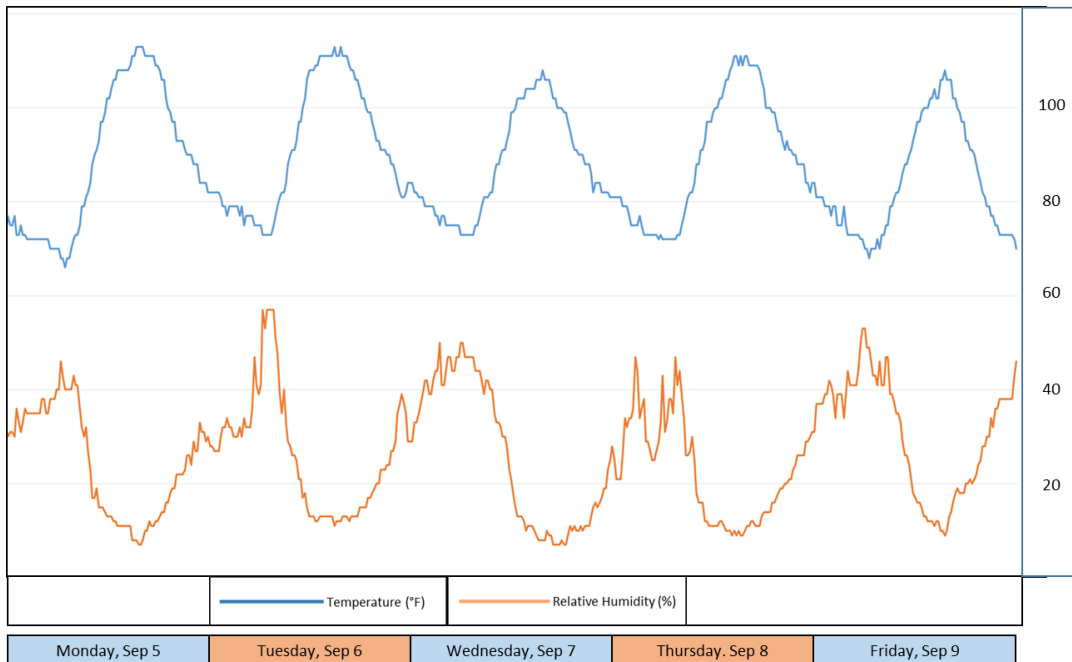
The latter has led to the slow-down or stalling of the Jet Stream in summer, leading to long-term heat waves throughout much of the World. Section 2 of this post will explore recent heat waves, and section 3 will describe higher-order effects of climate change.

<https://energycentral.com/c/ec/they-just-keep-coming>

2. Up Close and Personal

First of all, the heat wave Sep 5 through 8 in California broke many records, but none so thoroughly as in my town, Livermore and our state capital (Sacramento). See below.

2.1. Livermore



Peak temperature on Monday (Labor Day): *“Livermore recorded an all-time high temperature Monday, and eight other Bay Area sites had records for the date, the National Weather Service said.”*¹

Livermore, 116. Previous all-time record 115 (1950). Previous Sept. 5 record 108 (1950).

Also, the next day (Tuesday) tied the new all-time record.

One clarification: the above chart is based on a 5-minute interval data-set from the National Weather Service (NWS). Also note the relative humidity is around 10% at the peak temperature. The highest temperature in the data-set was 113°, but with this low humidity, the temperature is very dynamic, and it would be reasonable for it to spike to 116° within a given 5-minute interval. Also, the above quote is from a highly respected source (see reference), indicated that their data was from the NWS, and all other major media outlets in the Bay Area reported the same record temperatures.

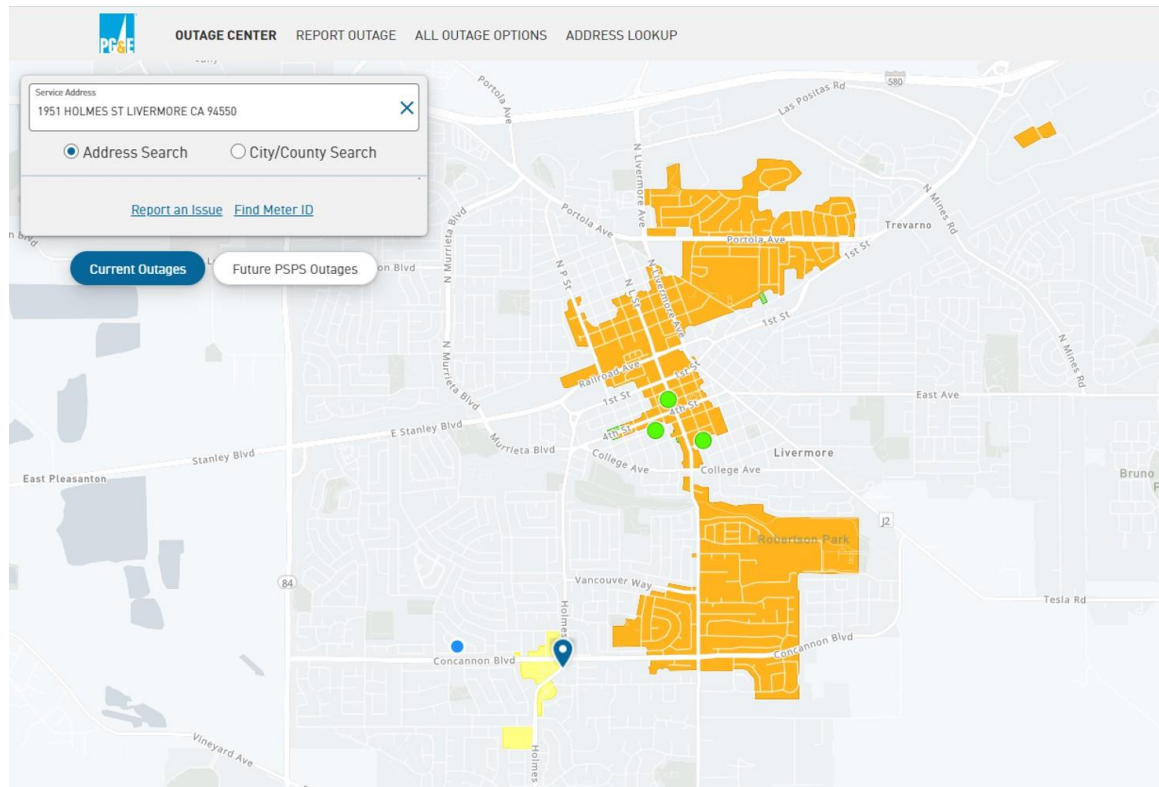
My lights stayed on throughout the above period, but others in Livermore were not so lucky. I screen-captured PG&E’s outage map for Livermore on 9/6. I pasted this on the next page. As you can see much of Livermore had outages (orange or yellow areas), and the media reported that many of these lasted for many hours.²

When I initially saw how many outages there were, I guessed that these were transformer failures. Later, the media reported: *“Throughout the Bay Area, the main cause of outages that we’re seeing is transformer failure because these components are not able to cool down overnight,”* said Mayra Tostado, a PG&E spokeswoman, *“We have*

¹ The Mercury News, “The 9 places in the Bay Area where heat records were broken,” Sep 6, 2022, <https://www.mercurynews.com/2022/09/06/9-bay-area-heat-records-broken-labor-day/>

² Max Darrow, CBS SF Bay Area via MSN, “Livermore residents go to bed and wake up in the dark as PG&E outages sweep the Bay Area,” Sep 7, 2022, <https://www.msn.com/en-us/news/us/livermore-residents-go-to-bed-and-wake-up-in-the-dark-as-pg-26e-outages-sweep-the-bay-area/ar-AA11xzbc>

brought in crews from outside the area to support with restoration efforts. Today, we have more than 240 trouble-men and repair crews..."



2.2. Sacramento

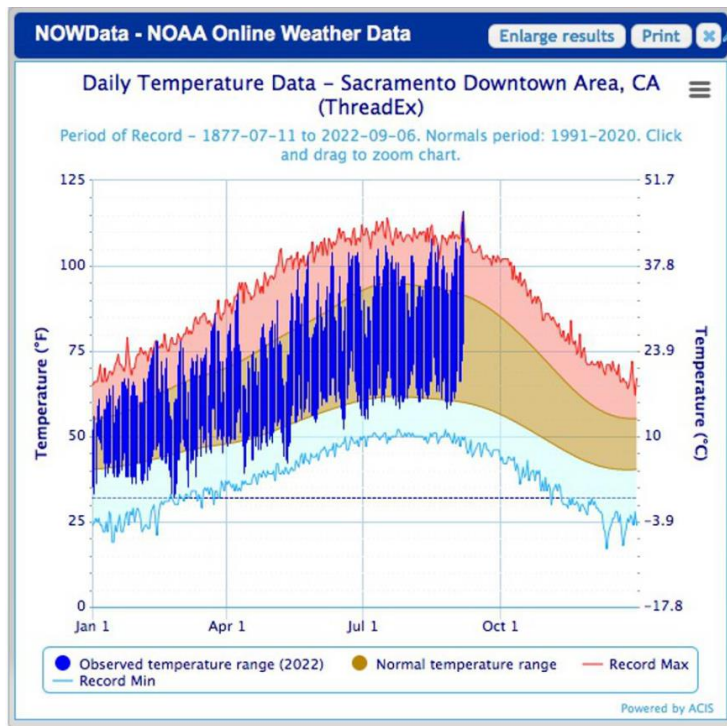
My fingers shouldn't be typing this: It was 116 degrees Fahrenheit in Sacramento, California this week. In case that is not bizarre enough on its own, consider this tweet from the National Weather Service in Sacramento.³



Here are four startling weather-climate aspects of the ongoing heatwave in the American West.

³ Marshall Shepherd, Forbes, "How A Western Heatwave Is Setting Disturbing Records," Sep 7, 2022, https://www.forbes.com/sites/marshallshepherd/2022/09/07/4-startling-aspects-of-the-heatwave-in-the-western-us/?sh=18e650f15169&utm_source=newsletter&utm_medium=email&utm_campaign=currentclimate&cdclid=628673ca6e1a1d1211f1d747

September itself is the first thing that catches my eye. The U.S. National Weather Service predicted temperatures for September 6 and 7 that could break records by as much as 3 to 5 degrees. Typically, temperature records are broken by smaller increments. This heatwave is shattering records during September, which is traditionally not the warmest month at these locations. Salt Lake City, for example, experienced its hottest five September days on record this week according to numerous reports. Referring back to Sacramento, its maximum temperature typically peaks much earlier in the summer (see graphic below), and that value is nowhere near 116 degrees F. The spike that you see in the graphic below is well beyond the record maximum (red line).



Average daily temperature range for Sacramento, California: nws

Another fascinating aspect of the heatwave is the meteorology itself. Heatwaves are typically associated with strong areas of high pressure or anti-cyclonic flow, and this one is no different. Heat is trapped in domes of high pressure and as the NOAA SciJinks website reminds us, "High-pressure systems force air downward." The sinking air warms by something called 'adiabatic compression', and rain-producing clouds are suppressed. Studies suggest that blocking associated with high pressure and mid-latitude heatwaves will continue to be problem in our ongoing and future climate system (more on this later). The NOAA Weather

Prediction Center forecast discussion said, "The dominant and anomalous upper-level ridge parked over the central Great Basin responsible for the ongoing western U.S. heat wave is anticipated to finally begin dissolving on Thursday (9/8) and offer a cooling trend for areas experiencing record shattering September heat." Unfortunately, the run of upper 90s to values in excess of 110 degrees F will continue until the high weakens.

A third jaw-dropping aspect of the heatwave is that it is consistent with long-term expectations about changing climate. Attribution studies are maturing to the point that they can detect the "DNA" of climate change in current extreme weather events. Yes, we know. Weather events are naturally-occurring, but they are now modified by human-activities. Grass is naturally-occurring too, but it grows differently when soil is fertilized. It is not "either/or." It is "and."

Scholarly studies continue to warn that climate change has increased the frequency and intensity of mega-heatwaves like the September 2022 event or the one in Europe weeks ago. By the way, 104 degrees F is not normal in London and explains why such places are devastated by extreme heat. The Pacific Northwest (U.S.) and Canadian heatwave of 2021 is another example. Like the United Kingdom, many of homes in that region do

not have air conditioning. A 2021 study concluded the magnitude of that heatwave was basically “impossible” without climate change...

3. How Did California Utilities Keep the Power On?

There is no single resource that the utilities use to keep the power on. In this section we will examine several reasons that we are able to keep power on with unprecedented challenges.

3.1. The New Normal

All major stake-holders in our utility infrastructure understand that climate change is our new normal, and the effects of climate change will continue to worsen until we (the world) fix our climate’s imbalances. This understanding extends to our governmental leaders, our electric utility executives, the utility pros on the front-line, and California’s electric consumers. In order to keep pace with the rate of change of this human-caused force of nature, we must move aggressively to adapt the grid and adjust our usage in order to avoid major disasters.

3.2. Government

In late August we experienced an earlier heat wave. Although this was not as severe as the more recent heat wave, Governor Newsom issued a Proclamation of a State of Emergency, and took the following actions:

*Thanks to the Governor’s Emergency Proclamation and efforts made by large energy users, energy producers and California residents, the state avoided power outages. These savings were critical to yesterday’s success, but extreme heat continues to grip the state. With triple-digit temperatures in much of California and the West, the power grid operator is again expecting high electricity demand, primarily from air conditioning use, and needs voluntary conservation steps to help balance supply and demand.*⁴

Additional details on state actions to maintain grid reliability and keep the lights on:

Department of Water Resources:

DWR’s State Water Project (SWP) is maximizing electrical generation from our hydropower plants during this extreme heat wave. Yesterday, DWR provided approximately 500 MW of clean hydropower to the grid.

Author’s comment: There is a storage element to most hydropower. If a major heat wave is forecast several days in the future, hydroelectric generators with reservoirs can reduce their production (read: generators’ water-flow) for the days before the peak demand, store this water and maximize their generation on the days of the event.

As the largest energy user in the state, the SWP is also reducing energy consumption by minimizing pumping operation during peak hours, instead moving water across the state at night when energy demand is lower.

The Route Fire near Castaic briefly shut down transmission lines for the William Warne Hydroelectric Powerplant; however, the lines were reenergized this morning (9/1) and the plant is back online and delivering power to the grid.

⁴ Office of Governor Gavin Newsom, “Governor Newsom’s Update on Extreme Heat and Grid Reliability,” Sep 01, 2022, <https://www.gov.ca.gov/2022/09/01/governor-newsoms-update-on-extreme-heat-and-grid-reliability/>

The four emergency generators that can contribute 120 MW to the state's Strategic Power Reserve are online and ready to be utilized if demand exceeds supply...

Public Utilities Commission:

Demand Response allows customers to lessen demand on the grid by reducing their electricity use during key times of the day and get compensated for it.

Demand Response programs are available for residential, commercial, and industrial customers, and include the Emergency Load Reduction Program for non-residential customers and the Power Saver Rewards Program and Smart Energy Program for residential customers.

Author's comment: I joined the **Power Saver Rewards Program** several months ago. I describe steps I take to reduce demand in a later section.

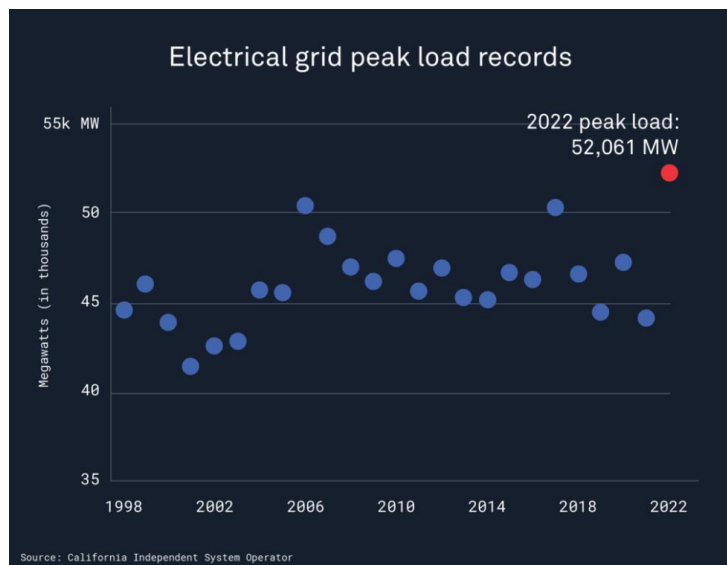
Government Operations:

DGS (Department of General Services) is ensuring state buildings reduce electricity usage including increasing thermostat temperatures and closing blinds.

DGS is promoting enrollment in energy conservation programs that enable more strategic management of the state's electrical grid and has reminded all employees to conserve...

California Independent System Operator (CAISO)

Tuesday's (9/6) peak demand set an all-time record, according to historical data from CAISO, reaching over 6,000 kilowatts more than the average peak over the last 20 years. See the figure below.⁵



The California power grid withstood its biggest test ever on Tuesday and passed—barely. The only rolling blackouts that occurred during the Stage Three Energy Emergency alert were results of miscommunication.⁶

For nearly three hours Tuesday night, California officials warned of imminent rolling blackouts as the state's electrical grid struggled to keep up with surging demand during a punishing heat wave," wrote Grace Toohey, Harriet

⁵ Jenna Cohen, PBS, "California's electricity demand breaks all-time record during severe heat wave," Sep 9, 2022, <https://www.pbs.org/newshour/nation/californias-electricity-demand-breaks-all-time-record-during-severe-heat-wave>

⁶ Irvin Dawid, Planetizen, "Disaster Averted!," Sep 11, 2022, <https://www.planetizen.com/news/2022/09/118681-disaster-averted>

Ryan, Alexandra E. Petri, and Gregory Yee for the Los Angeles Times at 10:25 PM (PST) on September 6.

- Shortly after 7 p.m., the California Independent System Operator (Cal ISO) noted that peak grid demand had hit 52,061 megawatts, “a new all-time record.”
- At 8 p.m., Cal ISO downgraded its level 3 alert, (a level 3 alert is the final step before calling for rolling blackouts), saying that “consumer conservation played a big part in protecting electric grid reliability...”

California had last used rolling blackouts in August 2001. This time, the state's grid operator was more prepared, having more battery storage and, to the chagrin of many in the environmental community, four new “temporary emergency power generators,” as described by the California Department of Water Resources, that were activated for the first time on Tuesday.

The temporary emergency power generators are powered by natural gas and are equipped with Selective Catalytic Reduction (SCR) systems to reduce emissions and limit air quality impacts. The program is designed to support a transition to a clean energy future and is temporary in nature.

Commercial and Industrial Consumers, PV + Storage Generators

“The state also has provided incentives to dramatically boost industrial battery storage — which captures electricity from large solar farms during the day and releases it early in the evening when solar power drops because the sun has gone down, but hot temperatures keep air conditioning demand high,” reported Paul Rogers for The Mercury News on September 7.

Such battery storage provided about 3,500 megawatts Tuesday and Wednesday, 10 times as much as two years ago.

Residential Consumers

But Rogers indicated that what may have been the most critical technology to avoid power outages was not energy-related but one of communication.

At 5:45 p.m. the California Office of Emergency Service sent an emergency bulletin that popped onto the cell phones of 27 million people in 25 counties with the largest populations and highest temperatures.

“Conserve energy now to protect public health and safety,” read the alert in English and Spanish. “Extreme heat is straining the state energy grid. Power interruptions may occur unless you take action. Turn off or reduce nonessential power if health allows, now until 9 p.m.”

Over the next 45 minutes, as homeowners turned off lights and eased off air conditioning, electricity demand fell by 2,600 megawatts, more power than the Diablo Canyon nuclear power plant was generating at full capacity, and enough electricity to power 2 million homes.

“Within moments we saw a significant amount of load reduction,” said Elliot Mainzer, CEO of the California Independent System Operator [on Wednesday, 9/7]. “That significant response allowed us to restore our operating reserves and took us back from the edge...”

3.3. My Strategy

In the above text, you read that the California consumers are one of the most effective methods for reducing load. I have known this for some time, as I worked on demand response systems throughout my career. I also know how to reduce my load:

First of all, we call these events “heat storms”, and as you go further inland they are even more common and hotter than here in Livermore. Our response to the peak demand response included.

- We are already on a PG&E Time of Use Rate (E-TOU-D) with peak demand rates from 5:00 to 8:00 PM on weekdays.
- PG&E has sends out special notice for each Power Saver Rewards Program event requesting us to extend our behavior during peak demand from 4:00 to 9:00 PM (until 10:00 PM during the worst days) during the heat storm, and we have complied with this request (as have most Californians per the above subsection).
- We have a high-efficiency full-house HVAC Unit, double-pane windows and we turn up the AC setpoint to 79° during the above-described period.
- We have a big full-house attic-fan (blows from the house into the attic and out the attic-vents). When I get up in the morning during a heat storm, the outside temperature is between 65° and 75° because of our low humidity. I open windows and doors and turn this fan on for 30 to 60 minutes. This both pre-cools the house and attic. One of the effects of a multi-day heat storm is that most attics steadily heat up over this period, which results in steadily increasing demand over the heat storm (from the air conditioning).
- We do not use any high-demand appliances during the above described periods.

3.4. Needed Action

This is a no-brainer, so I expect the state energy agencies (mainly the California Energy Commission) and major electric utilities are already working on it. We need to upgrade all transformers to beat the heat. This will be very expensive, but is also necessary.

The alternative is that many consumers will take action on their own. I already have a plan to install PV plus storage early next year, and many that already have PV may start adding storage to it. But my big concern is that the least expensive black-out fixes for residents without PV are natural gas fueled back-up generators. At least in the short-term, this will set-back our greenhouse gas mitigation efforts.

4. Non-Grid Effects of Heat Storms

These mostly impact disadvantaged groups, and they can be deadly. The California state government has been attacking these for some time, and Governor Newsom just signed four bills that relate to these:

4.1. Recent Legislation

As the record-setting heat wave across the western U.S. continues, Governor Gavin Newsom today announced that he has signed legislation to help protect Californians from more frequent and severe heat waves driven by climate change. The legislation builds on California’s Extreme Heat Action Plan released earlier this year, an all-of-government strategy to strengthen the state’s resilience and mitigate the health,

economic and ecological impacts of extreme heat, which fall disproportionately on the most vulnerable Californians.⁷

“This week’s unprecedented heat wave is a painful reminder of the costs and impacts of climate change – and it won’t be the last,” said Governor Newsom. “California is taking aggressive action to combat the climate crisis and build resilience in our most vulnerable communities, including a comprehensive strategy to protect Californians from extreme heat. With lives and livelihoods on the line, we cannot afford to delay.”

Extreme heat ranks amongst the deadliest of all climate change hazards, with structural inequities playing a significant role in the capacity of individuals, workers, and communities to protect and adapt to its effects.

AB 1643 by Assemblymember Robert Rivas (D-Salinas) will create an advisory committee to inform a study on the effects of extreme heat on California’s workers, businesses and economy.

https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB1643

AB 2238 by Assemblymember Luz Rivas (D-Arleta) will create the nation’s first extreme heat advance warning and ranking system to better prepare communities ahead of heat waves.

https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB2238

AB 2420 by Assemblymember Dr. Joaquin Arambula (D-Fresno) is a first-in-the-nation measure that directs the California Department of Public Health to review research on the impacts of extreme heat on perinatal health and develop guidance for safe outdoor conditions to protect pregnant workers.

https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB2420

SB 852 by Senator Bill Dodd (D-Napa) will allow cities and counties to create climate resilience districts with financing power to invest in programs that tackle extreme heat, drought, wildfire and other climate impacts.

https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB852

To look at any of the above bills, go through the above link(s), scroll down to the “LEGISLATIVE COUNSEL’S DIGEST” and this is a (slightly) condensed summary.

4.2. State Action Plan

The following text is from the Executive Summary of the reference 8 document.⁸

California’s best climate science projects that every corner of our state will be impacted in years and decades to come by higher average temperatures and more frequent and severe heat waves. Extreme heat threatens public health and safety; economic prosperity; and communities and natural systems. It also poses profoundly disproportionate consequences for the most vulnerable among us. This plan outlines a strategic and comprehensive set of state actions to address extreme heat, and serves as

⁷ Office of Governor Gavin Newsom, “As Record Heat Wave Continues, Governor Newsom Signs Legislation to Protect Californians from Extreme Heat,” Sep 9, 2022, <https://www.gov.ca.gov/2022/09/09/as-record-heat-wave-continues-governor-newsom-signs-legislation-to-protect-californians-from-extreme-heat/>

⁸ California Natural Resources Agency, “Protecting Californians From Extreme Heat: A State Action Plan to Build Community Resilience,” April 2022, <https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Climate-Resilience/2022-Final-Extreme-Heat-Action-Plan.pdf>

an update to the [“Preparing California for Extreme Heat Guidance and Recommendations”](#) report released in 2013.

The substance and organization of this plan was guided by extensive public input, collected over the course of 2021 and 2022, including through five public listening sessions, ten regional workshops, and numerous consultations with California Native American tribes.

Actions in the plan are organized into four tracks – (A) Build Public Awareness and Notification; (B) Strengthen Community Services and Response; (C) Increase Resilience of Our Built Environment; and (D) Utilize Nature-Based Solutions.