

How Climate Change Impacts RENEWABLE ENERGY PRODUCTION



Record low water levels during the 2021 drought forced a shutdown of a hydroelectric power plant at Lake Oroville | Photo by CA DWR

SUMMARY

- The supply of electricity from many carbon-neutral resources is influenced by the very climate change impacts they are designed to mitigate.
- Increasing wildfire smoke is reducing solar production and increasing drought is reducing hydroelectric production.
- More research is needed to understand how changes in wind or cloud cover patterns will affect wind and solar generation.
- Understanding how solar, wind, and hydroelectric resources will be impacted in a changing climate can help California plan its clean energy future.

ENVIRONMENTAL CONDITIONS IMPACT RENEWABLE ENERGY

To combat the threat of climate change, California has enacted a number of policies to transition to a clean energy future. SB 100 (De León, Ch 312, 2018) requires 100 percent of electricity retail sales and state loads be from renewable and zero-carbon resources in California by 2045 .

Some carbon-neutral electricity sources, including geothermal, nuclear, hydrogen, and biomass are not weather dependent. Others – including solar, wind, and hydroelectricity – are weather dependent. Weather conditions that are impacted by climate change – such as cloud cover, smoke plumes, wind patterns, and drought – can reduce renewable electricity generation.

Consequently, the supplies of electricity from many of the state's carbon-neutral resources are influenced by the very climate change impacts they are designed to mitigate. Understanding how a changing climate will impact the supply of wind, solar, and hydroelectricity in California is crucial to achieving a zero-carbon, reliable, cost-effective electricity grid.

EXAMPLES OF WEATHER IMPACTS ON CARBON NEUTRAL-RESOURCES

DROUGHT

Drought can lead to lower water levels in reservoirs, leading to reduced hydroelectric generation.

WIND PATTERNS

Changing wind patterns and speeds can lead to more variable wind electric generation.

WILDFIRE SMOKE

Wildfire smoke can occlude the sun and lead to reduced solar electric generation.

CLOUD COVER

Changing cloud cover can lead to more variable solar electric generation.

DUST

Higher temperatures and drier conditions can lead to more dust and lower solar efficiency.

TEMPERATURE

Higher temperatures can lead to decreased efficiency of many electricity generation processes.



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About the CCST Disaster Resilience Initiative:

Ongoing, complex, and intersecting disasters—including climate change, extreme heat, power outages, and the COVID-19 pandemic—are radically disrupting the ways in which Californians live and work. CCST is committed to delivering science and technology advice to improve our resilience to disasters, reduce harm, and improve the lives of all Californians.

SELECT EXPERTS

The following experts can advise on climate impacts on renewable energy production:

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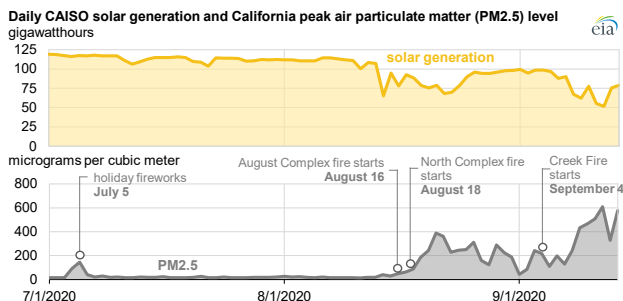


Figure: Solar generation in California decreases during wildfire smoke events | US EIA Today in Energy Sep. 30, 2020

SOLAR GENERATION

Solar electric generation depends on the amount of sunlight reaching the collector. Weather-related conditions including increased cloud cover, wildfire smoke, dust, and other sources of air pollution can all obscure the sun and decrease solar-powered electricity generation.

CAISO reported average solar-powered electricity generation declined nearly 30% in the fall of 2020 when high concentrations of smoke blanketed the state from wildfires including the North Complex and August Complex fires. The risk of large catastrophic wildfires is predicted to worsen with climate change.

WIND GENERATION

Wind electric generation depends on wind patterns and speeds to turn the turbines. Climate change is expected to impact wind patterns but more research is needed to improve our ability to model and predict these patterns. Recent research suggest that terrestrial seasonal wind patterns will become more variable in California with climate change. Wind generation capacity is predicted to increase during the summer and decrease during the fall and winter.

HYDROELECTRIC GENERATION

Hydroelectric generation depends on sufficient water supplies in reservoirs to run the turbines. Weather conditions including lower precipitation and snowpack accumulation, very dry soil, higher temperatures, and increased drought contribute to reduced water supplies in reservoirs and decreased hydroelectric generation.

Historically, California has produced less hydroelectric power during droughts. In the first four months of 2021, hydroelectric generation in California was 71% less than during those months in 2019. The severity of drought in California is predicted to worsen with climate change.

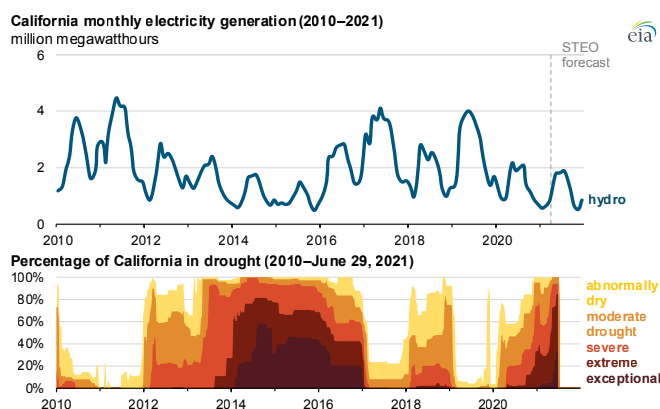


Figure: Hydroelectric generation in California decreases during drought | Modified from US EIA Today in Energy July 7, 2021

CLEAN FIRM GENERATION

Carbon-neutral sources of energy that are not weather dependent and instead available on demand are referred to as 'clean firm power.' Examples of clean firm power include geothermal, nuclear, hydrogen, and biomass sources with carbon capture. Although these sources of electricity are not directly dependent on the weather, higher temperatures can make the processes for generating electricity less efficient.

Learn more: Find this One Pager, further reading, and additional information at [CCST's briefing page](https://www.ccst.us/briefing-page).



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