Electricity Demand Changes and Grid Infrastructure Vulnerabilities in LA County by 2060

Fact Sheet from "Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat," a report for California's Fourth Climate Change Assessment

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Human-caused climate change is raising air temperatures, and the electric utility industry needs to understand how its systems will be affected so it can maintain reliable services. In the "Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat," researchers at University of California, Los Angeles and Arizona State University investigated how electricity demand could change by 2060, given different scenarios of rising air temperature, growth, and urban development, and assessed where and how neighborhoods could be more vulnerable to outages. This fact sheet summarizes their findings.

Why is this study important?

A reliable electricity grid is essential to the quality of life in and economy of Los Angeles County. The region has experienced several severe heat-related service disruptions in recent years, including in July 2018, when tens of thousands of Los Angeles Department of Water and Power and Southern California Edison customers lost power amid record-setting temperatures. As temperatures rise and heat waves increase in frequency, disruptions are expected to become more common. Increased use of air conditioning and the associated rise in energy demand can strain the electricity grid, and higher temperatures can decrease the capacity of grid components and transmission lines. When grid components fail, blackouts can occur, and power failures can increase the public health toll of a heat wave. This is particularly true in the parts of Los Angeles County, such as the Antelope Valley, northern San Fernando Valley, and San Gabriel Valley, that regularly see high temperatures in the present climate and are difficult to live in without air conditioning.

As the climate warms, population in Los Angeles County is expected to increase as well, leading to new buildings, greater air conditioning penetration and use, and greater electricity demand. Utilities and electricity grid operators need to know where their vulnerabilities lie in the future, and how to prepare.

How will energy demand change in Los Angeles County overall?

To assess energy demand changes, the researchers first used high-resolution climate modeling techniques to project changes in maximum temperatures across Los Angeles County. They focused on two future time periods, 2021–2040 and 2041–2060, comparing them to a baseline historical period of 1981–2000.

They looked at two scenarios of changes in atmospheric levels of carbon dioxide and other greenhouse gases, which trap heat in the atmosphere and lead to climate change. In a *business-as-usual* scenario, greenhouse gas concentrations keep rising sharply through the end of the century. In an *emissions-reduction* scenario, they rise at a slower rate, and level off around mid-century. The emissions-reduction scenario is similar to what would occur with successful implementation of the 2015 Paris Agreement on climate change.

Energy Demand Scenarios

Low-demand:
- Population grows by 1.2 million by 2060
- Residential building turnover is slow, with 0.03% of buildings being replaced per year.
- In new construction, single family units outnumber multifamily units by 11/9.

Medium-demand:
- Population grows by 2.15 million by 2060
- Residential building turnover is faster, with 0.3% of buildings being replaced per year.
- In new construction, multifamily units outnumber single family units by roughly 2 to 1.

High-demand:
- Population grows by 3.1 million by 2060
- Residential building turnover is even faster, with 3% of buildings being replaced per year.
- In new construction, multifamily units outnumber single family units by roughly 9 to 1.

(In all scenarios, all new residential buildings have central air conditioning.)

With climate data in hand, the team developed several scenarios accounting for other factors in energy demand, including:

- Population growth
- Building vintage and density
- Air conditioning penetration and efficiency

These scenarios are described above. (Note that increasing population is paired with increasing ratios of multi- to single-family housing to create plausible densification scenarios.) The resulting changes in peak energy demand are summarized in Table 1.

	Average Maximum Temperature (°F)*	**Low-Demand Scenario** (GW/ **Percentage Increase**)	**Medium-Demand Scenario** (GW/ **Percentage Increase**)	**High-Demand Scenario** (GW/ **Percentage Increase**)
2021–2040 Emissions Reduction	110.7	12.3 **29%**	13.1 **22%**	16.6 **30%**
2021–2040 Business as Usual	111.0	12.3 **29%**	13.2 **23%**	16.7 **30%**
2041–2060 Emissions Reduction	111.6	13.0 **37%**	14.7 **37%**	18.9 **48%**
2041–2060 Business as Usual	112.3	13.1 **38%**	14.9 **39%**	19.2 **50%**

Table 1. Peak energy demand across Los Angeles County for the study's various time periods and scenarios. Peak demand values encompass residential and commercial buildings only; industrial energy use was not included in the analysis. Values are compared to a 1981–2000 historical period, in which annual maximum temperatures ranged from 93 to 110°F. Historical peak demand was estimated at 9.5–12.8 gigawatts (GW); the values used for comparison with the low-, medium- and high-demand scenarios were 9.5, 10.7, and 12.8 GW, respectively.

What factors contribute to energy demand increases?

Although temperature and extreme heat increases play a role in energy demand increases in the future, they are not the dominant factor. The following factors are more important:

Population growth. Increases in population drive new construction and raise the county's overall energy demand.

Building turnover and air conditioning penetration. Currently, an estimated 41% of residential and commercial buildings in Los Angeles County have air conditioning. That percentage is expected to increase as new dwellings are built to replace old stock. When new residential buildings are built, central air conditioning is installed. Air conditioning typically accounts for 60% to 70% of a building's energy use while it is on.

Choices about energy efficiency. Future demand also depends on what types of new buildings are built. For example, multifamily buildings are more energy-efficient per dwelling unit than detached single-family buildings. In addition, the choice of air conditioning unit plays a role. Higher-efficiency units use less electricity to cool the same volume of air to the same degree.

What areas of LA County are particularly affected?

The spatial distribution of electricity demand changes is shown in Figure 1. In general, areas near the coast are less vulnerable to demand increases than areas further inland. The sharpest increases are seen where population is projected to grow the most, such as Palmdale, Lancaster, and Santa Clarita.

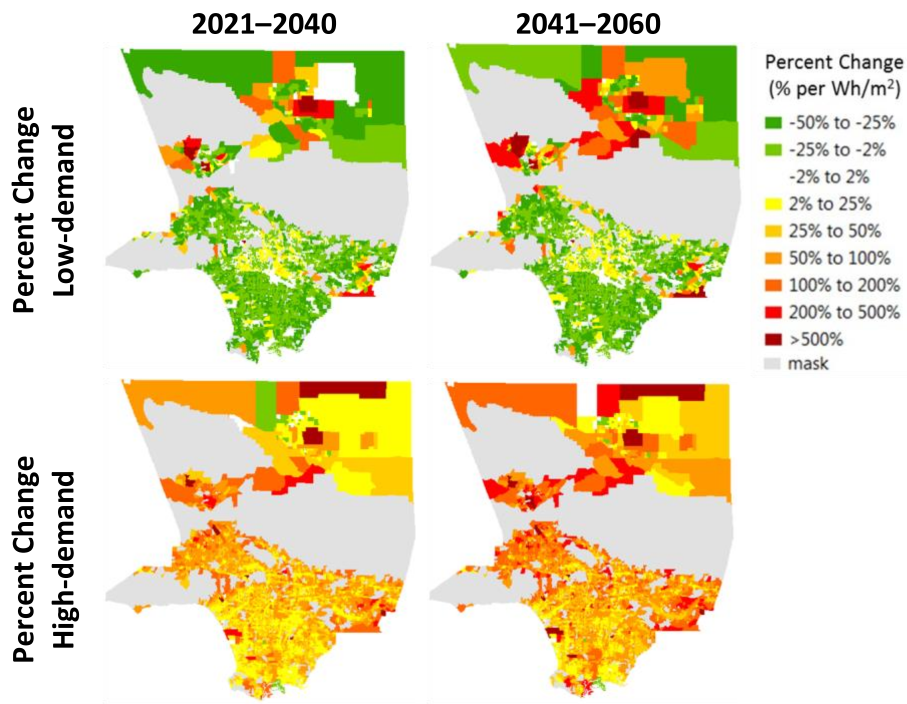

Figure 1. *Change in peak energy demand across Los Angeles County for the two future time periods in the low- and high-demand scenarios. In the low-demand case, results are shown for the emissions-reduction scenario. In the high-demand case, results are shown for business-as-usual emissions. Areas classified as protected lands are masked out.*

What factors contribute to vulnerability of Los Angeles County's electricity grid?

This study considered two main factors that can affect the performance of the electricity grid: temperature and future demand.

Temperature is important because generating electricity produces heat, which dissipates into ambient air. Electric grid components can operate safely only up to certain temperatures; over these thresholds, equipment can become damaged.

Future demand is important because increased demand increases the load that grid components need to handle.

In this study, the researchers assessed three components of the grid system:

- **Power generation plants,** including both natural gas–fired plants and solar plants.
- The **transmission lines** that carry power from generation plants to substations.
- **Substations,** which receive high-voltage transmissions and convert them to low-voltage transmissions to be sent to buildings.

For each component, the researchers assessed the potential *derating,* or electricity capacity loss, due to temperature. They also considered how well the components would be able meet future load demand, given their temperature-induced derating.

What future electricity grid vulnerabilities were found?

The researchers found vulnerabilities in each component of Los Angeles County's grid.

As shown in Figure 2 (top panel), at the County's various power plants, **generation capacity losses** of up to 240 megawatts would occur during a severe mid-century heat wave. Many plants experience significant losses on average as well (bottom panel).

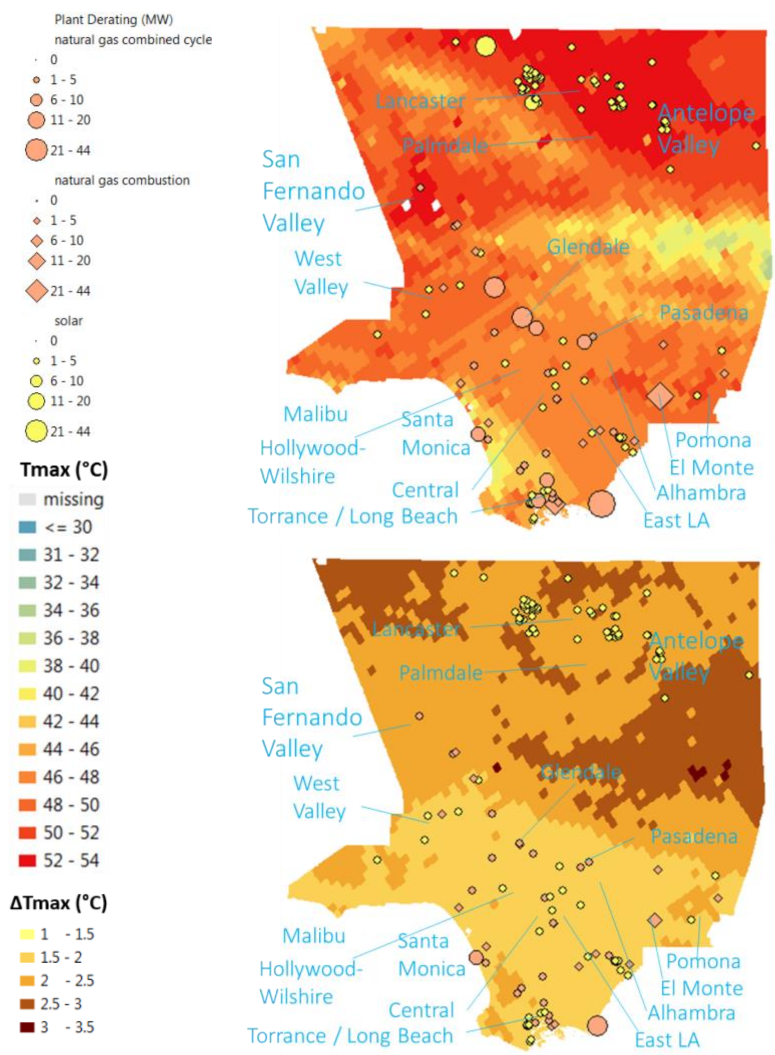

***Figure 2.** Generation plant derating, shown in megawatts lost, by 2060 under business-as-usual warming. Top panel shows loss during a severe heat wave; bottom panel shows loss on average.*

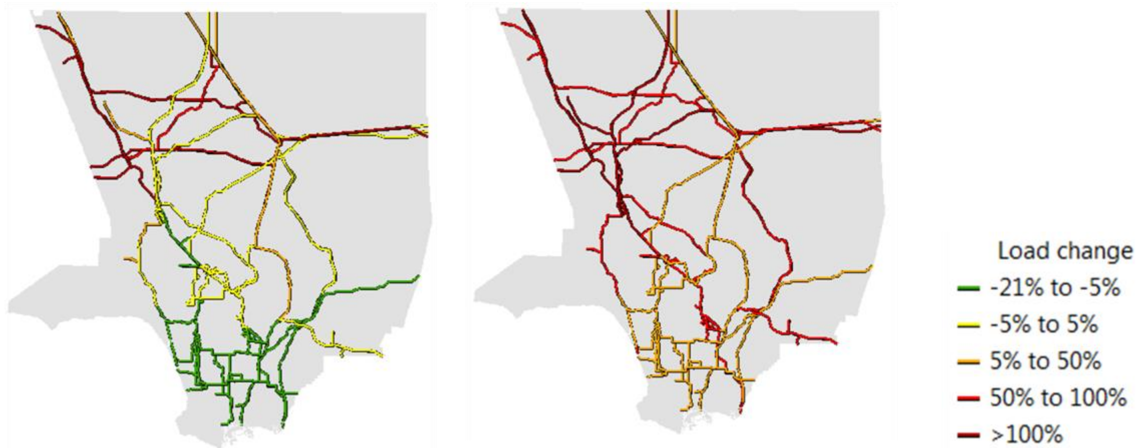

Figure 3. *Change in electricity load over transmission lines in Los Angeles County by 2060 under business-as-usual warming. Left panel depicts Low-Demand Scenario; right depicts High-Demand.*

Transmission lines are projected to lose capacity in a changing climate. By 2060 under business-as-usual warming, nearly all transmission lines are vulnerable to temperatures that reduce their safe operating capacity. High-voltage transmission lines in the Antelope and San Fernando Valleys would lose 2% to 13% of their capacity during heat waves; lower-voltage lines would lose 6% to 20%.

While safe operating capacity decreases, projected load over transmission lines increases, thanks to the energy demand increases associated with rising temperatures and a growing population. Figure 3 shows the change in load across transmission lines. Lines in northern Los Angeles County are particularly vulnerable to extra loading.

Substation load capacity is vulnerable to rising temperatures as well. The vast majority of substations in Los Angeles County—99%—are projected to experience some load capacity reduction in the future, when they are more commonly exposed to air temperatures above 104°F. (This is the maximum temperature that Southern California Edison currently plans its operations around.) By 2060 under business-as-usual warming, most substations—70%—would lose 1.5% to 3% of their load capacity on average, while 60% lose 6% to 12% during heat waves.

Figure 4 (see next page) shows how decreasing load capacity plus increasing peak energy demand at the same time could affect substations during a mid-century heat wave. The metric, which combines both of those effects, is the *derated load factor.* The higher the load factor, the higher the risk of outage. A load factor greater than one (red color) indicates that substations are thermally overloaded, parts are wearing quickly, and a safety device could trip to prevent permanent damage. If the load factor is greater than 2 (black color) a safety device will automatically trip, resulting in an outage. As shown in Figure 4, the western San Fernando Valley, Antelope Valley, and San Gabriel Valley are most vulnerable to outages.

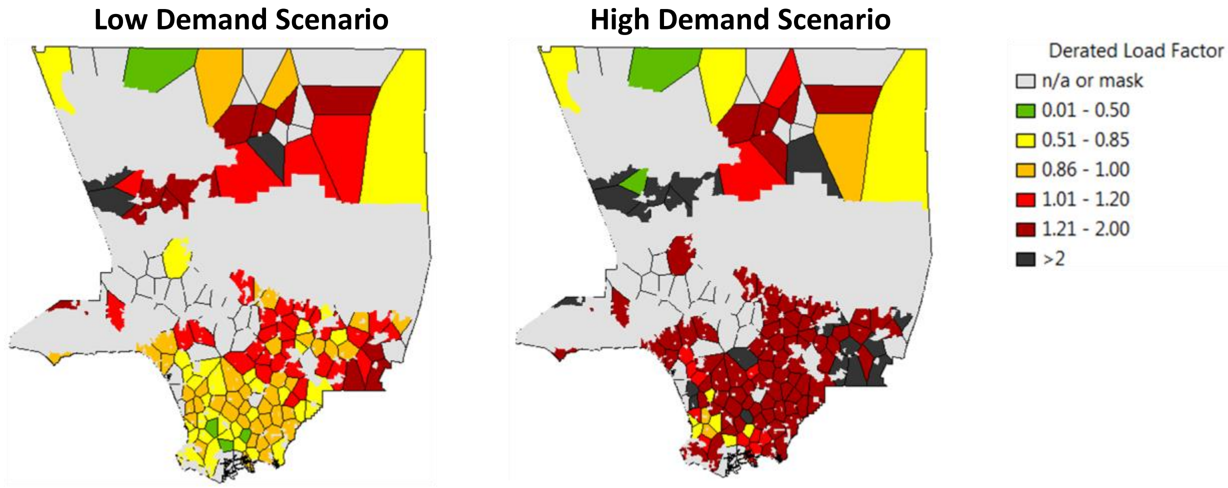

Figure 4. *Derated load factor, a metric of substation heat stress and risk of outage, during a severe heat wave in the 2041–2060 period under business-as-usual warming. Above 0.86, heat stress is nonnegligible and outage risk increases. A factor above 2 indicates certain outage.*

What implications does this work have for energy policy in Los Angeles County?

The policy implications of this research are discussed in "Electricity Demand Changes and Grid Infrastructure Vulnerabilities in LA County by 2060: Policy Brief."

How was the research performed?

First, the researchers used innovative climate modeling techniques to project temperature increases over Los Angeles County at high spatial resolution. Then, they incorporated this data, along with data on the buildings that exist in Los Angeles, into a model to simulate individual buildings' energy demand. Finally, they incorporated temperature and energy demand change data into models simulating electricity grid component operations.

A detailed description of the study's methodology can be found in its final report: *Burillo D, M Chester, S Pincetl, E Fournier, DB Walton, F Sun, M Schwartz, KD Reich, and A Hall, 2018: Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: CCCA4-CEC-2018-013*.

More about this work

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