Union of Concerned Scientists

FACT SHEET

Turning Down the Gas in California

The Role of Natural Gas in the State's Clean Electricity Future

HIGHLIGHTS

California is investing in clean and affordable renewable electricity, reducing dependence on fossil fuels and addressing climate change. Yet the state still depends on natural gas generation to meet one third of its electricity needs. The Union of Concerned Scientists analyzed plant operations and grid reliability to measure how much gas generation capacity could be retired by 2030—while meeting the state's global warming emissions reduction target. Several plants could retire; many others would run much less. However, many would stop and start more frequently, likely emitting more air pollution even as overall carbon emissions decline.

To meet its climate change goals and avoid increasing air pollution from gas plants, California must deploy clean grid management solutions that can reduce reliance on natural gas generation to provide energy and grid reliability.

California has firmly established itself as a global clean energy leader by advancing new technologies and "clean tech" jobs while reducing global warming emissions, diversifying its fuel mix, and growing its economy to become the fifth largest in the world. Driving these efforts are California's law to reduce emissions throughout its economy to 40 percent below 1990 levels by 2030 (California Legislature 2016) and its longer-term goal to reduce emissions to 80 percent below 1990 levels by 2050 (Schwarzenegger 2005).

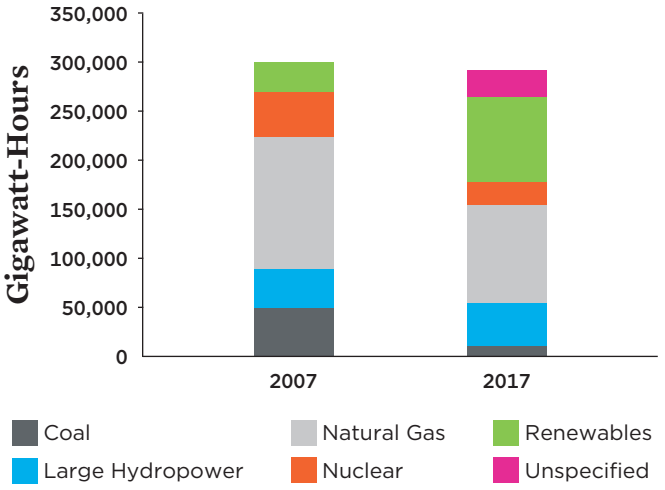
To transition to a safer and cleaner electricity system and meet California's ambitious climate goals, the state must use less fossil fuel and instead rely on cleaner sources of energy that do not emit global warming gases. In the electricity sector, this means using less electricity produced by natural gas–fired power plants and more from renewable sources such as solar, wind, geothermal, low-carbon biomass, and biogas. Replacing vehicles currently running on gasoline and diesel with vehicles powered by renewable electricity will significantly reduce air pollutants such as nitrogen oxides (NO_x), carbon monoxide, and particulate matter, which cause cancer and chronic respiratory diseases including asthma. In addition, the state now depends on natural gas to heat most homes and buildings; affordable renewable electricity will also provide a cleaner fuel source for these needs.

In the past decade, California has made significant investments in renewable electricity generation. In 2017, renewables comprised 29 percent of the state's electricity mix (Figure 1, p. 2) (CEC 2018). Most utilities in the state are on track to meet—and even exceed—the current requirement to serve 50 percent of electricity demand from renewables by 2030 (California Legislature 2015). But California still relies on natural gas–fired generation to meet a substantial portion of its electricity needs: in 2017, natural gas made up 33 percent of the state's electricity mix (CEC 2018).

David Danelski

Southern California Edison's Mountainview Generating Station is one of the nearly 200 grid-connected natural gas power plants in California.

FIGURE 1. California Electricity Mix, 2007 and 2017



Renewable energy generation in California has increased significantly since 2007, but natural gas remains a key component of the state's electricity supply.

Note: "Unspecified" sources of power include spot market purchases, wholesale power purchases, and purchases from pools of electricity where the original source cannot be determined.

SOURCE: CEC 2018.

The Role of Natural Gas in California's Electricity System Today

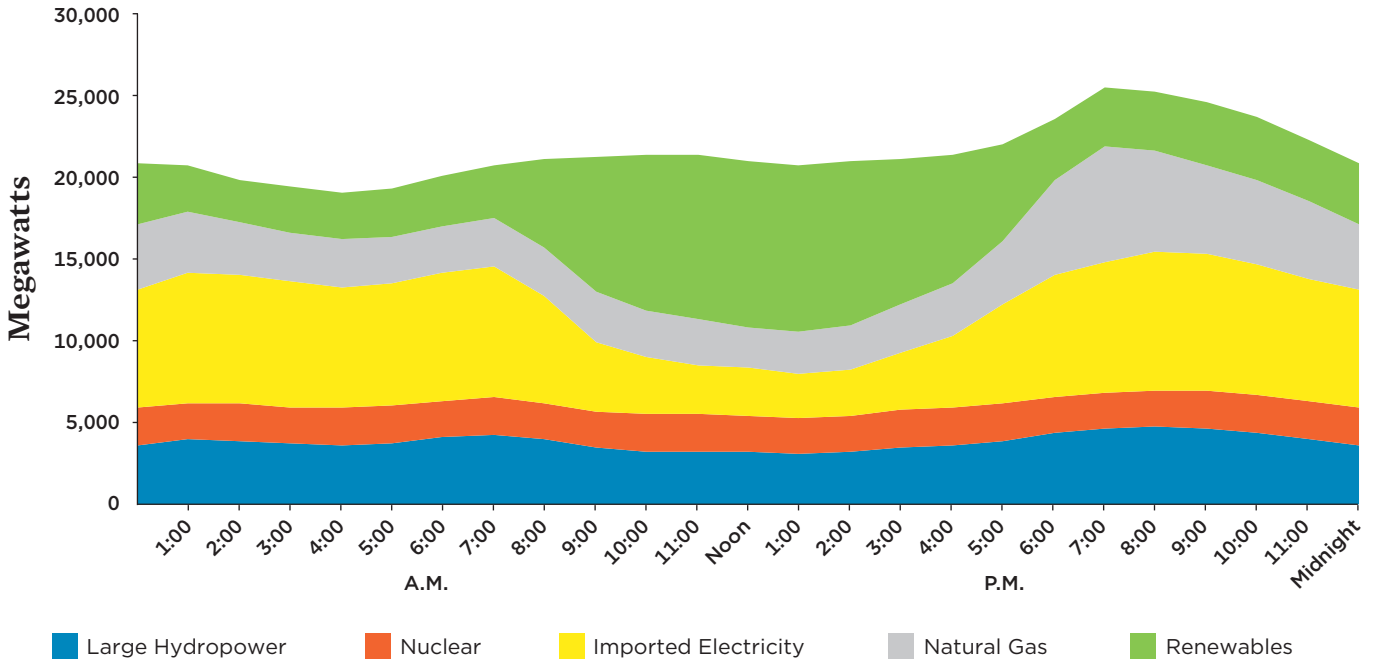
There are nearly 200 utility-scale natural gas–fired power plants in California; together, they provide approximately 39 gigawatts of generation capacity to the grid (S&P Global 2018). Almost all these plants are either simple cycle "peaker" plants or combined cycle gas turbine plants (CCGTs). Peakers are more flexible but less efficient than CCGTs.

Natural gas–fired power plants' flexibility has been useful for California's electric grid operators, who must always match electricity supply and demand. Natural gas can be stored, which means power plant operators can control when a plant generates electricity. In contrast, weather patterns determine wind and solar generation, so electricity supplied by them varies over the course of the day and season. Operators can ramp both peakers and CCGTs up and down in a relatively short amount of time, which helps keep supply matched to demand as solar and wind generation fluctuates. In addition, natural gas plants have historically provided many grid reliability services. These services include fast response to a grid operator's signal as well as "local capacity," or generation to provide power in specific locations in emergencies, such as when a major power plant fails and electricity cannot be imported from outside the local area.[1]

CAISO

At the California Independent System Operator (CAISO) grid control center, electricity supply and demand are constantly balanced to maintain reliability.

FIGURE 2. Hourly Electricity Generation in the CAISO, by Fuel (March 4, 2018)



Renewable energy generation, primarily from solar, can meet much of California's electricity needs during daytime hours, allowing natural gas to supply less.

Note: Generation data represent real-time generation from the California Independent System Operator (CAISO).

SOURCE: CAISO 2018.

The Changing Role for Natural Gas

Because natural gas–fired power plants supply a substantial portion of California's current electricity demand and support grid reliability, some natural gas generation will be needed through at least 2030 as cleaner energy sources and other grid reliability technologies come online. But for California to realize the benefits of its clean energy transition and achieve its global warming emissions targets, it needs to reduce its dependence on natural gas electricity generation significantly. This transition should prioritize reducing natural gas generation in communities most negatively affected by the pollution resulting from burning fossil fuels and by the social, economic, and health burdens associated with global warming.

For California to realize the benefits of its clean energy transition, it needs to reduce its dependence on natural gas.

Solar photovoltaics' low cost and availability mean they will make up a significant percentage of new renewable energy resources in California. As solar generation supplies more daytime electricity demand, natural gas will supply less. In many cases, gas plants will be turned off during the day. This shift will provide substantial global warming emissions reduction benefits.

However, as the sun sets, solar generation decreases (Figure 2) (CAISO 2018). Unless cleaner alternatives—such as other renewable generation technologies, energy storage, and load shifting or increased energy efficiency that reduce evening electricity demand—are substituted, gas plants already operating will ramp up generation and other gas plants will be turned back on. A natural gas plant starting up can produce as much as 30 times more NO_x emissions than it will after it has been running for a few hours (Birdsall et al. 2016; Lew et al. 2013). This increase in natural gas plant starts could have a negative effect on air quality and the

> ***UCS found that nearly 24 percent of both CCGT and peaker capacity could be retired without negatively affecting grid reliability.***

communities living near these plants. In addition, gas plants in certain locations on the grid must remain available to be turned on to meet local capacity requirements (LCR) in order to keep the grid reliable during power plant or transmission line failures, unless cleaner resources or transmission upgrades can serve this need.

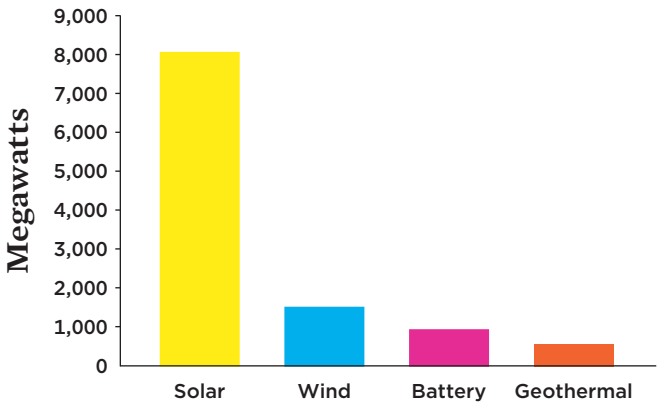
How Much Gas Could California Retire by 2030?

To understand what an orderly and equitable transition away from natural gas generation in California might look like, the Union of Concerned Scientists (UCS) analyzed the operations of the 89 natural gas CCGTs and peakers located in the territory of the California Independent System Operator (CAISO), the grid operator that manages the electricity flow for about 80 percent of the state. UCS used an investment optimization model called GridPath[2] to identify how much gas generation capacity could be economically retired between 2018 and 2030 while meeting the state's mandated 2030 global warming emissions reduction target and maintaining grid reliability.[3] This analysis set the 2030 emissions reduction target for the electricity sector at 42 million metric tons (MMT) of carbon dioxide (CO_2) equivalent.[4] In addition, UCS ran scenarios that enforced LCR and scenarios that did not enforce LCR in order to understand its significance on natural gas generation and gas retirement.[5]

According to the UCS analysis, California does not need to build any additional gas generation capacity in the CAISO territory to meet 2030 energy or grid reliability needs (Figure 3).

In addition, UCS found that 23 percent of the CCGT generation capacity and 24 percent of the peaker capacity—a total of 28 of the 89 plants currently operating in the CAISO territory—could be retired as early as 2018 without negatively affecting grid reliability. Many of the plants that could be retired are in disadvantaged communities in the Central Valley, an area affected by year-round air pollution (Figure 4).[6]

FIGURE 3. New Capacity Investments by 2030, 42 MMT Scenario



Our analysis indicates that no new natural gas capacity is needed to meet 2030 energy or grid reliability needs under the 42 MMT emissions reduction scenario.

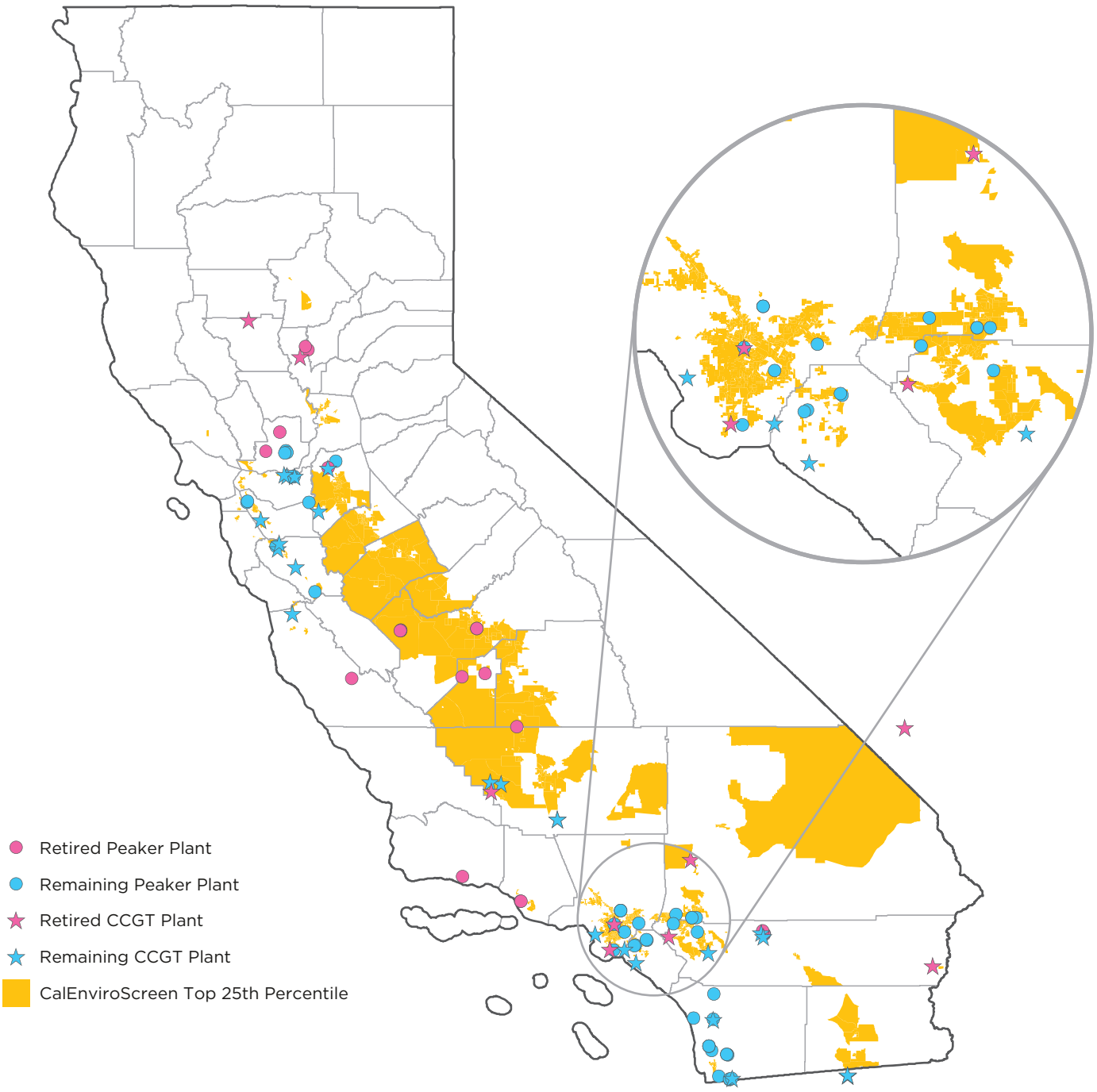
Note: Biomass, pumped storage, CCGT, and peaker capacity were also available in the model as investment options. However, none of these options were found to be necessary investments under this scenario.

California Could Retire More Gas Plants If Cleaner Alternatives Meet Energy and Local Reliability Needs

The "LCR Enforced" scenarios showed that LCR, which is critical for ensuring reliability on the grid, may prevent the cost-effective retirement of many peakers in the CAISO territory. To measure the effect of enforcing LCR on potential gas plant retirement, UCS compared the results of "LCR Enforced" scenarios with "No LCR" scenarios. In a 42 MMT "LCR Enforced" scenario, 23 percent of CCGT capacity and 24 percent of peaker capacity could be retired by 2030. But in an equivalent "No LCR" scenario, more than double the amount of peaker capacity could be retired; the amount of CCGT capacity that could be retired remained roughly the same. Allowing new energy storage in the form of batteries that could discharge electricity for at least four hours to provide LCR did not change retirement results.

UCS also ran scenarios to understand how many more natural gas plants could be retired if California's electricity sector met a more aggressive emissions reduction goal: 30 MMT of CO_2 equivalent by 2030 instead of 42 MMT. In the 30 MMT scenario, more batteries are required because more carbon-free electricity generation is needed to replace natural gas generation in the evening. When batteries were not allowed to satisfy LCR, gas plant capacity retirement was similar to the results in the 42 MMT case: 25 percent of

FIGURE 4. Natural Gas Plant Retirements by 2030, 42 MMT Scenario



Twenty-eight natural gas plants in the CAISO territory could be retired while still meeting energy and reliability requirements. Twelve of the plants that could be retired are located in communities, shown in orange, that are disproportionately burdened by air pollution.

Note: Figure assumes a 42 MMT scenario with LCR enforced and four-hour batteries allowed for LCR. Orange shading indicates the top 25th percentile of California census tracts that are disproportionately burdened by, and vulnerable to, multiple sources of pollution according to CalEnviroScreen, an environmental, health, and socioeconomic mapping tool. Plants shown outside of state boundaries are plants that supply electricity to the CAISO grid.

SOURCES: OEHHA 2017 (CALENVIROSCREEN 3.0); UCS ANALYSIS.

> ***Even as natural gas plants in the state run for less time overall, many may start and stop much more frequently in 2030 than they did in 2018, potentially resulting in more NO_x emissions.***

CCGT capacity and 24 percent of peaker capacity was retired. However, when new batteries built for the 30 MMT scenario were also allowed to satisfy LCR, slightly more CCGT capacity and more than three times as much peaker capacity was retired. More details on the scenario and its findings are in our technical appendix, online at *www.ucsusa.org/turning-down-CA-gas*.

These results show that strategically locating energy storage, or other clean energy resources, to provide energy and also fulfill LCR could accelerate the retirement of peaker plants.

The Changing Dynamics of Gas Plant Operations

In the 42 MMT by 2030 scenario (when LCR is enforced and new batteries are allowed for LCR), UCS analysis indicates that as more renewable generation capacity is installed between 2018 and 2030, natural gas generation will decrease by 4.2 million gigawatt-hours, or 8 percent, which will result in reduced global warming emissions.

But even as natural gas plants in the state run for less time overall, many may start and stop much more frequently in 2030 than they did in 2018, potentially resulting in more NO_x emissions even as overall carbon emissions decline. In our analysis of the 42 MMT by 2030 scenario (when LCR is enforced and new batteries are allowed for LCR), 16 of the remaining 23 CCGTs modeled would go from starting and stopping close to zero times in 2018 to at least 200 times per year by 2030 (Figure 5).

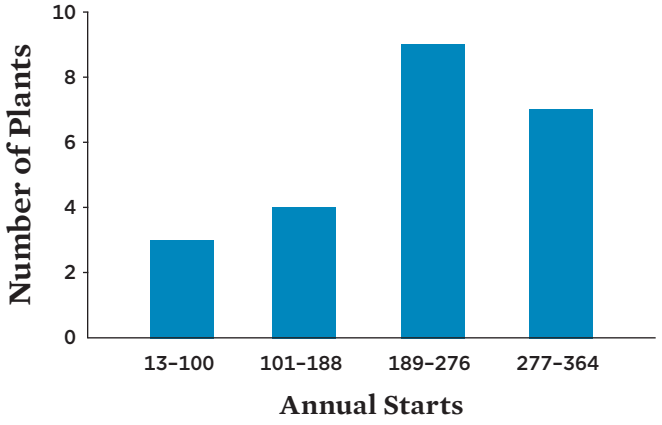
Our analysis suggests that by 2030, in order to meet the 42 MMT global warming emissions target, CCGTs will have to start more often than peakers because they are more efficient and therefore produce less global warming emissions. The peaker plants that cannot be retired by 2030 are kept on the grid to meet LCR needs but are run very infrequently.

There are tradeoffs between power plant flexibility, costs, and global warming emissions that will affect when natural gas peakers or CCGTs will be used. Unless investments are made in clean energy resources to reduce and satisfy evening-ramp electricity needs, California's gas fleet will cycle on and off much more frequently than it does today. While gas generation overall will decline as more renewable energy is installed on the grid, stopping and starting natural gas plants much more frequently could result in increased NO_x emissions. More analysis is required to understand how stopping

Duke Energy

Strategically locating energy storage, or other clean energy resources, to fulfill local capacity requirements could accelerate the retirement of peaker plants.

FIGURE 5. Frequency of CCGT Starts in 2030



Under a 42 MMT scenario, many combined-cycle natural gas plants will start and stop much more frequently in 2030 compared with today. Some plants will go from close to zero starts today (i.e., non-stop generation) to starting once nearly every day of the year.

Note: Figures assume a 42 MMT scenario with LCR enforced and four-hour batteries allowed for LCR.

Sarah Swenty/USFWS

More electricity demand should be shifted to daytime hours to take advantage of the state's abundant solar generation.

and starting natural gas plants more frequently will affect air quality and the public health of communities living near these plants. Future analysis should also consider how changes in air pollution associated with electricity generation may be offset by pollution reduction associated with vehicle electrification.

Grid Solutions to Reduce Natural Gas Generation

California is on track to supply substantially more electricity needs with renewable energy generation, which will reduce global warming emissions and provide new clean resources to power the state's growing electric vehicle market. Our analysis finds that no additional natural gas generation capacity is needed to keep the CAISO grid reliable even if California adds significant amounts of renewables to its electricity mix to meet its 2030 global warming emissions target. Indeed, nearly a quarter of the existing natural gas generation capacity in the CAISO could be taken offline today, depending on how future LCR is met.

However, as natural gas generation declines overall, failure to invest further in nonfossil-fuel grid reliability technologies could lead to individual natural gas power plants cycling on and off much more frequently to meet evening energy needs, which may result in increased NO_x emissions from these plants. In addition, the need to fulfill LCR could prevent the retirement of some gas plants. For these reasons, California should deploy several strategies that are specifically targeted to reduce such reliance on natural gas generation:

- Shift more evening electricity demand to daytime hours and target energy efficiency to lower evening demand.
- Invest in more energy storage that saves excess solar generation for use after sundown.
- Invest in a more diverse portfolio of renewable generation technologies to spread clean energy generation evenly throughout all hours of the day to reduce evening ramp needs and the need to cycle in-state gas plants.
- Allow California's grid operators greater access to clean energy generation resources outside the state to help further reduce the need to cycle in-state gas plants.
- Target specific locations for clean energy investment so that new generation resources can meet LCR, which can hasten the retirement of natural gas plants.

> ***UCS analysis finds that no additional natural gas generation capacity is needed by 2030 to keep the CAISO grid reliable.***

Global climate change is one of the biggest threats to California's economy and the health and well-being of its residents. Reducing heat-trapping emissions and air pollution by transitioning away from fossil fuels is one of the most necessary actions our state, country, and world can take to improve public health and avoid the worst consequences of climate change. California is a global leader in climate change reduction and renewable energy investments. Now is the time for state policymakers and electricity providers to expand efforts to bring online clean energy resources that can help reduce the state's reliance on natural gas. Clean energy investments and policy decisions made in California to achieve a clean and reliable electricity grid will chart a path that other states and countries can follow to meet our shared goal of a healthy, thriving, and climate-resilient future.

Laura Wisland *is the senior manager of western states energy for the UCS Climate and Energy Program.*

ENDNOTES

1. For more on local capacity requirements, see *www.caiso.com/informed/Pages/StakeholderProcesses/LocalCapacityRequirementsProcess.aspx*.
2. GridPath is a grid analytics platform capable of several types of power system modeling approaches, including multistage production-cost simulation, long-term capacity expansion, and price-based asset valuation. Here, we used GridPath in capacity-expansion mode to identify cost-effective deployment of new system resources and retirement of existing infrastructure to meet load, reliability, and policy goals for the CAISO power system. For more information on GridPath, see *https://gridpath.io*.
3. For this study, GridPath allowed for the economic retirement of peakers and CCGTs in each study period. Keeping a plant available requires incurring an annual fixed operations and maintenance (O&M) cost; GridPath will retire a plant if the total value of the plant (i.e., system benefit from all value streams, including energy, ancillary services, system capacity, local capacity, etc.) is lower than the cost to cover the fixed O&M cost. For this analysis, we assume a fixed O&M cost of $10 per kilowatt-year (kW-yr) for plants classified as CCGT and $6 per kW-yr for plants classified as peaker. For more information on inputs, assumptions, and GridPath methodology, see our technical appendix at *www.ucsusa.org/turning-down-CA-gas*.
4. UCS used 42 MMT as the 2030 global warming emissions planning target in its analysis because this is the target the California Public Utilities Commission (CPUC) adopted for all electricity providers for the Integrated Resource Planning (IRP) process. More on the IRP and the CPUC's global warming planning target can be found in Decision 18-02-018, issued February 8, 2018, and available here: *http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=209771632*.
5. We based the LCR for 2018 on the CAISO's 2018 *Local Capacity Technical Report,* available at *www.caiso.com/Documents/Final2018LocalCapacityTechnicalReport.pdf*; see p. 2. We calculated the LCR for 2022, 2026, and 2030 on the CAISO *2016-2017 Transmission Plan, Appendix D*, available at *www.caiso.com/Documents/AppendixD_BoardApproved_2016-2017TransmissionPlan.pdf*. For more information on inputs, assumptions, and GridPath methodology, see our technical appendix at *www.ucsusa.org/turning-down-CA-gas*.
6. The CPUC considered "disadvantaged communities" those that are in the top 25th percentile of the CalEnviroScreen 3.0 (OEHHA 2017).

REFERENCES

Birdsall, B., S. Lee, E. Capello, F. Golden, H. Blair, T. Popiel, S. Debauche, and N. Vahidi. 2016. *Senate bill 350 study: The impacts of a regional ISO-operated power market on California*. Volume IX: Environmental study. San Francisco, CA: Aspen Environmental Group. Online at *www.caiso.com/Documents/SB350Study-Volume9EnvironmentalStudy.pdf,* accessed May 22, 2018.

California Energy Commission (CEC). 2018. Total system electricity generation in gigawatt hours. Online at *www.energy.ca.gov/almanac/electricity_data/total_system_power.html,* accessed May 22, 2018.

California Independent System Operator (CAISO). 2018. Hourly breakdown of total production by resource type (MW). Folsom, CA. Online at *www.caiso.com/market/Pages/ReportsBulletins/RenewablesReporting.aspx,* accessed May 22, 2018.

California Legislature. 2016. *California Global Warming Solutions Act of 2006: Emissions limit*. Senate Bill 32. Online at *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32*, accessed June 6, 2018.

California Legislature. 2015. *Clean Energy and Pollution Reduction Act of 2015*. Senate Bill 350. Online at *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350*, accessed July 2, 2018.

Lew, D., G. Brinkman, E. Ibanez, A. Florita, M. Heaney, B.-M. Hodge, M. Hummon, and G. Stark. 2013. *The western wind and solar integration study phase 2*. NREL/TP-5500-55588. Golden, CO: National Renewable Energy Laboratory. Online at *www.nrel.gov/docs/fy13osti/55588.pdf,* accessed May 22, 2018.

Office of Environmental Health Hazard Assessment (OEHHA). 2017. CalEnviroScreen 3.0: California Communities Environmental Health Screening Tool. January 30. Online at *https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30*, accessed June 21, 2018.

S&P Global Market Intelligence (S&P Global). 2018. Online at *https://platform.mi.spglobal.com/web/client?auth=inherit#office/screener* (subscription required), accessed May 22, 2018.

Schwarzenegger, A. 2005. California Executive Order S-03-05. Online at *www.climatechange.ca.gov/state/executive_orders.html,* accessed May 22, 2018.

Union of Concerned Scientists

FIND THIS DOCUMENT AND TECHNICAL APPENDIX ONLINE:
www.ucsusa.org/turning-down-CA-gas

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
500 12th St., Suite 340
Oakland, CA 94607-4087
Phone: (510) 843-1872
Fax: (510) 451-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: www.ucsusa.org