



The Ivanpah Solar Power Facility in the Mojave Desert, shown here with the Primm Golf Course in the foreground.

PHOTOGRAPH COURTESY OF BRIGHTSOURCE ENERGY.

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# A Future Climate and Energy Report

Which do you want first: The good news or the bad?

**I**t will be hotter. It will be drier, at times, and wetter at others. We'll get less water from the Sierra Nevada snowpack, and the Pacific Ocean will rise and creep inland. But beyond those brute certainties, scientists, futurists, technologists, and entrepreneurs offer competing visions about how climate change will affect California in the decades to come.

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Average present-day snowfall in the Los Angeles region. PHOTOGRAPH BY BOB BERNAL; RENDERING BY JACOB COOPER, CLIMATE RESOLVE.

“The choice before us is not to stop climate change,” says Jonathan Parfrey, executive director of Climate Resolve in Los Angeles. “That ship has sailed. There’s no going back. There will be impacts. The choice that’s before humanity is how bad are we going to do it to ourselves?”

So what will it be? Do you want the good news or the bad news first?

The bad news. OK.

If we choose to do nothing, the nightmare scenario plays out something like this: amid prolonged drought conditions, wildfires continuously burn across a dust-dry landscape, while potable water has become such a precious commodity that watering plants is a luxury only residents of elite, gated communities can afford. Decimated by fires, the power grid infrastructure that once distributed electricity—towers and wires—now loom as ghostly relics stripped of function. Along the coast, sea level rise has decimated beachfront properties while flooding from frequent superstorms has transformed underground systems, such as Bay Area Rapid Transit (BART), into an unintended, unmanaged sewer system.

Short of the nightmare, realistically, California, like the rest of the world, will see temperatures rise over the next four decades. The California Climate Change Center predicts a rise in average temperature ranging from 1.8 degrees to 5.4 degrees by mid-century. By contrast, annual average global temperature increased a relatively moderate 1.8 degrees over the preceding 150 years, according to the National Oceanic and Atmospheric Administration. Some areas in California, inland and in the deserts, will get much hotter, with many more super-hot days in the summer.

The sea level will rise along the coast. Polar ice melt-off combined with ocean water that expands in volume as temperatures rise will produce sea level increases from 5 to 24 inches south of Cape Mendocino, and up to 19 inches north of this geo-tectonic pivot point, according to recent simulation models produced by the Ocean Protection Council. The rising ocean will wipe away beaches and wreak havoc on some shoreline communities and infrastructure.

San Francisco Bay Conservation and Development Commission Executive Director Larry Goldzband warns of the damages that could result from a bad weather trifecta in the Bay Area. “What happens if you get increasing sea level, a



Potential impact of global warming on snowfall in the Los Angeles region by 2050. PHOTOGRAPH BY BOB BERNAL; RENDERING BY JACOB COOPER, CLIMATE RESOLVE.

huge storm, and king tides, which happen when earth, sun, and moon come into alignment, all at once?” he asks. “Water from the bay spills into the city.” The Adapting to Rising Tides project predicts that the low-lying Oakland International Airport would be exposed to three or more feet of flooding during storm events with 16 inches of sea level rise.

To the flooding, add fires. California’s three worst fire seasons have all occurred within the last ten years, according to the California Office of Environmental Health Hazard Assessment. Higher heat fosters tinderbox-like conditions that exacerbate human- and lightning-caused flames.

California’s water supply, much of it sourced from snow pack in the Sierra Nevada, will decline. UCLA Institute of the Environment and Sustainability Director Glen MacDonald points out that roughly 80 percent of the state’s water is used to grow food. “When water becomes more scarce because of higher rates of evapotranspiration, how much water will we shift from our fields to our city?” he asks. Wherever our food will come from, it could be more expensive and there may be less of it.

Warmer temperatures also translate into a shorter winter chill period that farmers count on to grow fruit and

nuts in the Central Valley. The delicate balance of sunlight and mild temperatures that fostered ideal conditions for Northern California grape growers could be thrown out of whack. National Academy of Sciences research notes that vintners in Sonoma County and Napa Valley may be forced to relocate farther north as temperatures heat up.

So what’s the good news?

There is a clean, green, utopian scenario. Gasoline-fueled gridlock becomes the stuff of ancient urban legend as freeways set aside zero-carbon lanes for hydrogen-fueled vehicles and bicyclists. Agribusiness responds to arid conditions with hyperintensive farming techniques fertilized by their on-the-farm organic waste byproducts. Houses and commercial buildings generate their own power supplies with solar-paneled roofing, so homeowners happily share kilowatt surpluses with neighbors on a networked energy grid as easily as Facebook users now share online content, restaurant and reading recommendations, and instant messages.

As temperatures rise in California, more optimistic futurists count on green production and consumption

technologies to soften the impact. “Cool roofs” and pavement made of reflective materials will improve energy efficiency in buildings, for example. In Los Angeles, 40 percent of the city’s land mass is street, parking lot, or playground, and much of that is paved in asphalt. “That grabs the heat from the sun and keeps it at surface level because it’s black and absorbs heat,” says Climate Resolve’s Parfrey. “If we remake our streets so they’re more reflective, then we could cool down the urban heat island effect, which adds between 3 to 22 degrees Fahrenheit to a cityscape.”

People will abandon their cars for other ways of getting around these green streets. In the Next 10.org study “Unraveling Ties to Petroleum,” UCLA-based lead author Juan Matute points out that public infrastructure has for decades rewarded the one-person-per-gas-fueled car lifestyle with hidden incentives. Envisioning the day when \$80,000 parking privileges might become commonplace, Matute notes that the “Lone Driver” model historically flourished because consumers did not bear the true cost of public space devoted to free or cheap parking. In the future, he says, “If we reduce incentives for people to park on the street and decide that parking has a cost, we’ll probably see more transition to transit and ride-sharing.” The “ride share” concept, stubbornly ignored since its origins in the 1970s, is already quickly gaining traction thanks to profit-motivated, peer-to-peer jitney services like Uber, Lyft, and Sidecar.

Matute’s study projects that by 2050, only about one third of personal travel miles will be attributable to gas-fueled cars. In place of the combustion engine technology that powered Californians’ twentieth century self-image as a free-wheeling, hypermobile society, large gas-fueled vehicles will give way to electric cars, bicycles, scooters, bullet trains, mass transit, and neighborhood electric vehicles described by Matute as “fast golf carts.”

Matute produced a carbon-neutral scoping plan for Hermosa Beach pegged to the year 2075. “We assume

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a 95 percent transition to electric vehicles over that time period,” he says. “That seems to be the way things are going.” Since 2002, when GM crushed dozens of its experimental electric EV1 vehicles due to insufficient market demand, electric car fortunes have already rebounded, signaling a dramatic reduction in vehicular greenhouse gas emissions. In 2013 Tesla reported record revenues and announced plans for a lower-cost \$35,000 electric car to supplement its Model S sedan. IBM’s Battery 500 Project aims to design lithium-air batteries that would boost the ability of electric cars to drive without a charge beyond their current 500-mile limit.

The Environmental Protection Agency’s 1970 Clean Air Act dragged car manufacturers kicking and screaming into a forced-innovation mode that put an end to the smog alerts and spared Californians the pollution-clogged scenarios currently facing Mexico City, Beijing, and other exhausted urban centers. In the twenty-first century, government-engineered carrot-and-stick programs aim to similarly spur private sector ingenuity.

While it’s too late to halt climate change in its tracks, state government policy encourages entrepreneurs, businessman, technologists, homeowners, and consumers to get with the same low- and even no-carbon vision for California. The California Energy Commission’s alternative and renewable fuel and vehicle technology program (created by Assembly Bill 118) invests nearly \$90 million during the 2013 fiscal year to develop new transportation technologies, alternative and renewable fuels. California’s renewable portfolio standards mandate that 33 percent of the state’s energy production must come from renewable energy sources by the year 2020. The California Global Warming Solutions Act of 2006 mandates that greenhouse gas emissions shall be 80 percent below 1990 levels by 2050. University of California, Los Angeles, researchers hope to wean Los Angeles completely from fossil fuels by then.

Forum for the Future Director Jonathon Porritt, who outlines an “aspirational” view of the year 2050 in his new book, *The World We Made*, sees California as an exceptionally hospitable environment for photo-voltaic cells, already widely used in solar panel roofing, as well as solar-concentrated plants that deploy satellite-shaped dishes, parabolic troughs, or towers to collect energy from the sun. Porritt says, concentrated solar power is “a phenomenal technology. It is



Smoke from the Rim Fire blowing east, as seen from the International Space Station on August 26, 2013. PHOTOGRAPH COURTESY OF NASA.

very expensive in that every single one of those reflecting glass panels has to be pretty much handmade, so it's not a mass technology yet; but once it is, there will be no limit to the amount of sunshine that can be harnessed."

Wind farms will also figure into the mix with more bird-friendly turbines than some of the older models that line California ridges. With an 840-mile coastline, California could also exploit tidal and wave energy technologies. "We will see a lot of small, discrete on-shore plants that capture the power of the wave as it hits the shore," says Porritt, "although you would have to do that without causing huge visual impairment of that beautiful coastline. People would not take kindly to that."

One big challenge for renewable energy production is storage. "You need to smooth out the intermittency of renewables such as wind and solar that depend on variable weather conditions," Porritt says. Assuming that storage systems catch up with production, Porritt figures renewable energy could

provide all of humanity's energy needs by the end of the century. "It won't be because we've run out of oil," he adds, "but because people have figured out better alternatives."

Many renewable advocates regard nuclear energy as a dead issue in California, where state law prohibits the building of any new nuclear plants. But a contrarian cadre of environmentalists, including Whole Earth Catalog founder Stewart Brand, believe in the potential of fourth-generation nuclear reactors. Following California's now-shuttered San Onofre reactor dysfunction and Japan's catastrophic Fukushima meltdown, anti-nuke investors, politicians, and citizens will need a lot of convincing. Oakland-based Breakthrough Institute's Michael Shellenberger, who produced a feasibility study on "How to Make Nuclear Cheap," contends that nuclear energy deserves a second look. "New reactors need to be safe, need to be modular, and they need to be efficient," he says—and he believes they can be.

Department of Energy grant winner Transatomic, run by two MIT-schooled technologists, promises a “walk-away safe” reactor that revives the use of molten salt coolants, introduced in the 1960s, to eliminate radioactive rods that currently bedevil nuclear waste management. Microsoft mogul Bill Gates’s TerraPower start-up markets “traveling wave reactors” as being cheaper and safer than its predecessors. Shellenberger says, “I think you’re going to see a generation of environmentalists who were born after Three Mile Island who don’t remember Chernobyl and grew up worrying about climate change, not about nuclear energy.”

Energy policy at the mid-century mark will not be shaped only by shifting patterns in production and consumption technologies. The stealth game-changer may turn out to be distribution. In place of the long-established central power grid, some seers favor a smaller-is-better paradigm. Kathi Vian, lead author of the “California Dreaming” forecast produced by the Palo Alto-based Institute for the Future, UC Berkeley, and UC San Diego, pictures the rise of a “trusted friend” network that enables consumer/producer civilians to share energy with one another. “Our best case scenario is that we’ll develop a smart grid like the Internet,” she says. “You could use a backyard waste digester to generate energy, and if you had a few extra kilowatts you didn’t need, you could plug that in to the grid and donate or lend them to somebody else in the system. Once you get that smart grid hooked up with an open application layer, you could imagine a Facebook app where you assign rights for your energy to someone else. People would start to play with energy in the same way they now play with information on the Internet.”

British futurist Porritt figures that a middle-of-the-road option will gain currency in the decades ahead that would

## Utopian and dystopian visions of the future can provide powerful motivations.

still allow individuals to take better control of their own energy usage and consume less as a consequence. “My hypothesis is that we will move much faster than people would think toward micro-grids. We’ll see small-scale, community-based grids where people won’t go to complete off-grid self-sufficiency as they do in survivalist communities, but they also won’t depend on a central grid system. Instead, people will use distributed energy sources—wind, solar, biomass—to create systems that are just as reliable if not more reliable than the current central systems, and are nearly CO<sub>2</sub> free.”

Utopian and dystopian visions of the future can provide powerful motivations. But California’s response to climate change may ultimately succeed or fail on the strengths of another West Coast archetype: the entrepreneurial innovator. A three-person Los Angeles operation called Beehive Lighting, for example, is working right now to revolutionize movie and TV production with a line of plasma lights that reduce on-set energy consumption by 50 percent. As future-casting geologist MacDonald notes, “Americans are ingenious inventors and also good capitalists. If people see climate change as a challenge, there will be opportunities to save the world and make a pretty good profit on it.”

So what will it be? The good news? Or the bad news?

Let’s not sit around waiting to find out. **B**