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# Kern Economic Journal

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2020 Third Quarter



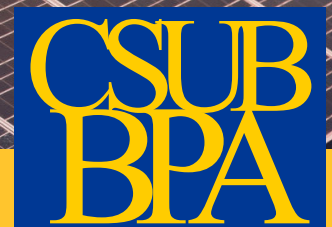
## Featured Article:



The Beginning of the End:  
Vaccine Development and  
COVID-19



Solar Energy in California:  
Production, Benefits and  
Costs



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*KERN ECONOMIC JOURNAL* is a quarterly publication (February, May, August, November) of California State University, Bakersfield. Its purpose is to track local trends and analyze regional, national, and global issues that affect the economic well-being of Kern County. The journal provides useful information and data that can help the community make informed economic decisions. Sources of funding for this journal include university contributions and sponsorship and subscription fees.

Editorial and analytical articles on important local, regional, national, and international issues and trends are invited for consideration of publication in the journal. Articles (not exceeding 800 words in length) must be submitted to the Managing Editor in electronic copy. Individual authors are responsible for the views and research results.

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# Kern Economic Journal



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# Economy at a Glance!

2020 THIRD QUARTER  
BY DR. NYAKUNDI MICHIEKA  
& DR. RICHARD S. GEARHART III

## National Economy<sup>1</sup>

U.S. GDP increased at an annual rate of 33.1 percent in the third quarter of 2020. In the second quarter of 2020, real GDP decreased by 31.4 percent. The increase in the third quarter GDP reflected efforts to reopen businesses and resume activities that were restricted due to COVID-19.

The uptick in the real GDP reflected increases in personal consumption expenditures (health care, food services and accommodations, motor vehicles, clothing and footwear), private inventory investment (motor vehicle dealers), exports (automotive vehicles, engines and capital goods), nonresidential fixed investment (transportation equipment), and residential fixed investment (brokers' commissions and other ownership transfer costs) that were partly offset by decreases in federal government spending (reflecting fewer fees paid to administer the Paycheck Protection Program loans) and state and local government spending. Imports also increased.

Current-dollar GDP increased 38 percent (or \$1.64 trillion) in the third quarter to a level of \$21.16 trillion. In the second quarter, GDP decreased by 32.8 percent or \$2.04 trillion.

Current-dollar personal income decreased by \$540.6 billion (0.4 percent) in the third quarter compared to an increase of \$1.45 trillion in the second quarter. Real disposable personal income, which is adjusted for inflation and taxes, decreased by 16.3 percent in compared to a 46.6 percent increase.

Personal saving was \$2.78 trillion in the third quarter compared with \$4.71 trillion in the second quarter. The BEA derives the personal saving rate by calculating personal saving as a percentage of disposable personal income.

The Conference Board's Index of Leading Economic Indicators – a measure of future economic activity – increased 0.7 percent in October to 108.2 following a 0.7 percent increase in September and a 1.6 percent increase in August.

<sup>1</sup> U.S. economic numbers were obtained from the Bureau of Economic Analysis "U.S. Economy at a Glance". This is found at <http://www.bea.gov/newsreleases/glance.htm>. The information for the Index of Leading Economic Indicators is found at <https://www.conference-board.org/data/bcicountry.cfm?cid=1>. The University of Michigan Consumer Sentiment Index is found at <http://www.sca.isr.umich.edu/tables.html>.

The University of Michigan's Consumer Sentiment Index increased from 74. in the second quarter of 2020 to 75.6 in the third quarter 2020. The value for the index in the third quarter of 2019 was 93.8 compared to 98.1 in (the third quarter of) 2018.

## State Economy<sup>2</sup>

In California, the unemployment rate dropped to 11 percent compared to 15.1 percent in June 2020. Among counties, only Lassen (6.3 percent), Marin (6.5 percent), Modoc (6.5 percent), Sierra (6.7 percent) and Trinity (6.7 percent) counties had unemployment rates below 7 percent. The counties with highest unemployment rates in September 2020 were Imperial County (21.5 percent) and Los Angeles County (15.1 percent)

Counties with unemployment rates between 10 and 12.4 percent included Alpine (10.7 percent), Colusa (10.6 percent), Fresno (10.4 percent), Kern (12.4 percent), Kings (10.3 percent), Merced (10.6 percent), Mono (11.2 percent), Riverside (10.5 percent), San Bernardino (10.3 percent), San Joaquin (11.4 percent), Stanislaus (10.3 percent), Tulare (12.2 percent) and Sutter (10.3 percent) and Yuba (10.6 percent).

California's labor force increased by 33,200 in the third quarter of 2020 after decreasing by 710,967 in the second quarter. During the same period, civilian employment increased by 776,133 from 15.7 to 16.5 million. A total of 2.2 million people were jobless (unemployed) in the third quarter. Nonfarming and farming enterprises hired 2,500 and 608,600 more workers, respectively. The mining and logging sector hired 667 less workers while construction and manufacturing sectors hired 32,200 and 21,533 more workers, respectively. Service sector employment increased from 13.2 to 13.8 million between the second and third quarter of 2020. The federal and local government lost 21,467 and 23,933 workers, respectively.

## Local Economy

The local economy saw a decrease in the labor force, from 371,367 in the second quarter of 2020 to 369,300 in the third quarter of 2020. Employment increased by 14,267 from 304,300 in the second quarter of 2020 to

<sup>2</sup> The California economic numbers were obtained from the Bureau of Labor Statistics "Local Area Unemployment Statistics Map". This is found at <https://data.bls.gov/map/Map-ToolServlet?survey=la&map=county&seasonal=u>.



318,567 in the third quarter of 2020. A large part of the increase was driven by efforts to reopen businesses and resume activities that were restricted due to COVID-19. Nonfarm employment increased by 5,733 while farm employment rose by 6,033.

In Bakersfield, nonfarm employment changed in the following manner: mining and logging lost (267 workers), construction added (500 workers), manufacturing added (100 workers) and service added (5,400 workers). Within the service sector, trade, transportation and utilities added (2,467 workers), financial activities added (67 workers), Professional & Business Services added (767 workers), education and health services added (1,700 workers) while leisure and hospitality added (3,500 workers). Within the government, federal government added (533 workers), state and local government lose (4,067 workers) and local government lost (3,567 workers)

Total Salaries and wages in Kern County increased from \$285,033 in the second quarter of 2020 to \$297,333 (4 percent rise) in the third quarter of 2020. Compared to four quarters ago, salaries were lower by \$46,367 or 13 percent.

The rate of unemployment varied considerably across cities, ranging from 6.37 percent in Ridgecrest to 29.27 percent in Mojave. All cities in Kern County showed a decrease in the unemployment compared to the second quarter of 2020. The biggest quarter to quarter decrease in the unemployment rate occurred in Delano, decreasing from 34.17 percent to 19.2 percent. In Bakersfield, the unemployment rate was 14.03 percent in the third quarter of 2020 compared to 16.7 percent in the second quarter.

In the third quarter of 2020, the median home price in Bakersfield was \$278,000 compared to \$267,000 in the second quarter. Home prices are \$24,628 higher than they were four quarters ago. Within the region, median home prices in Taft are the lowest at \$140,500 compared to 286,167 in Tehachapi.

The weighted price index for the five publicly traded companies doing business in Kern County (Sierra Bancorp, Tejon Ranch Company, Chevron Corporation U.S., Granite Construction, and Wells Fargo Company) dropped by 10.8 percentage points from 68.7 to 61.3. The index is 40.3 percentage points lower than what it was four quarters ago. All companies gained/lost as follows: Chevron (decreased 19.3-percent quarter-over-quarter), Tejon Ranch (decreased 1.7-percent quarter-over-quarter), Granite Construction (decreased 8-percent quarter-over-quarter), Wells Fargo (decreased 8.2-percent quarter-over-quarter) and Sierra Bancorp (decreased 11.1-percent quarter-over-quarter).

The average retail price of gasoline increased by \$0.35 to \$3.06. Gas prices were 18.2 percent lower than they were four quarters ago when they averaged \$3.75 a gallon. The unit price of California's Class III milk was \$20.25 in the third quarter of 2020 compared to \$15.42 in the second quarter. The Index of Farm Price Parity in the third quarter of 2020 were similar to those in the second quarter of 2020.

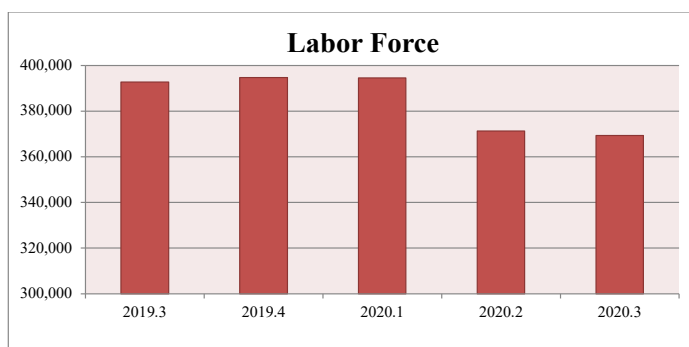
# Tracking Kern's Economy<sup>1</sup>

DR. NYAKUNDI MICHIEKA &  
DR. RICHARD S. GEARHART III

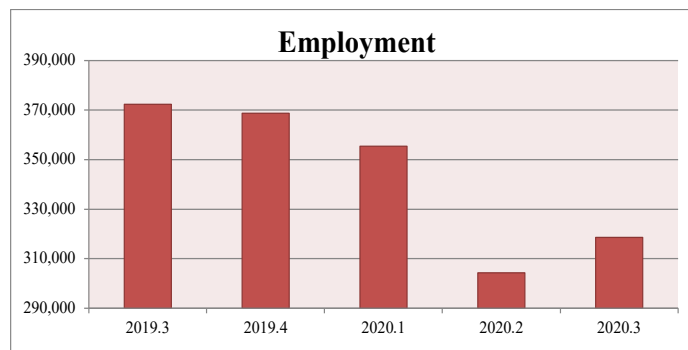
## Labor Market

We adjust published data in three ways. First, we average monthly data to calculate quarterly data. Second, we recalculate quarterly data to take into account workers employed in the “informal” market (i.e., self-employed labor and those who work outside their county of residence). Finally, we adjust quarterly data for the effects of seasonal variations. In this issue, the impact of COVID-19 on Kern County's economy will be quantified.

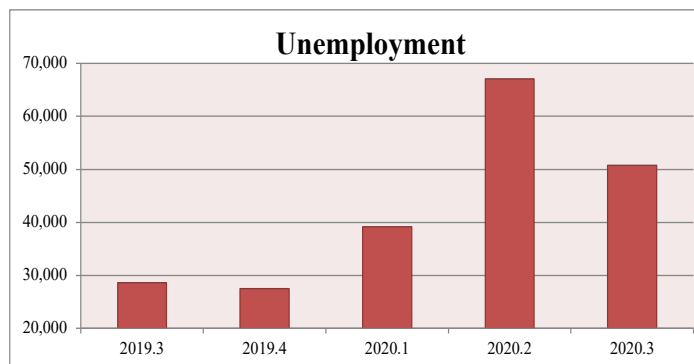
**Labor Force** - The civilian labor force decreased by 2,067 members, from 371,367 in the second quarter of 2020 to 369,300 in the third quarter of 2020. Historical data from 2007 indicates that civilian labor force increases between quarter two and quarter three of every year, except in 2010 when we witnessed a decrease. The labor force estimates are similar to those of the second quarter of 2013 (370,750). The Bureau of Labor Statistics defines the labor force participation rate as the proportion of the working-age population that is either working or actively looking for work. Recessions tend to push labor force participation down as illustrated below.



**Employment** - In the third quarter of 2020, Kern County hired 14,267 more workers as total employment increased from 304,300 to 318,567. This is a 14 percent decrease in employment compared to the third quarter of 2019. Historical data also shows that employment grows between the second and third quarter (of each year).

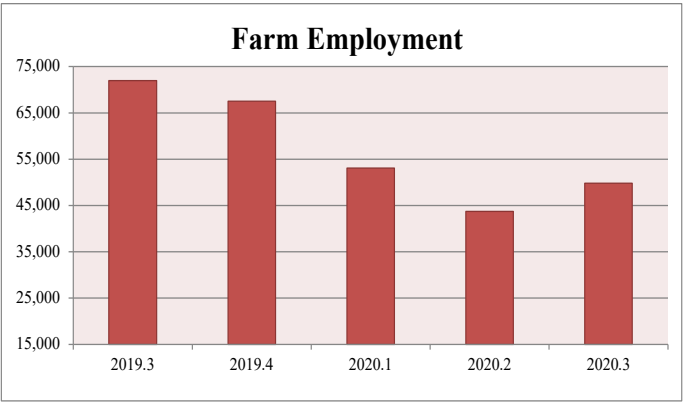
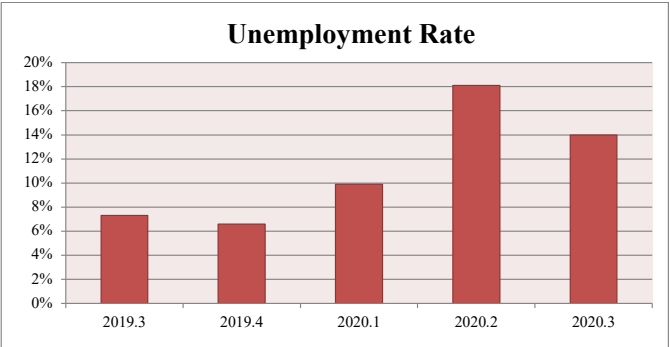


**Unemployment** - In the meantime, quarter to quarter unemployment decreased by 16,333 as the number of jobless workers decreased from 67,100 to 50,767. The number of unemployed workers was up 77 percent compared to four quarters ago. In the third quarter of 2019, there were 28,633 unemployed workers compared to 50,767 this quarter.



**Unemployment Rate** - Kern County's year-to-year unemployment rate rose by 91.88 percentage points from 7.3 percent in the third quarter of 2019 to 14 percent in the third quarter of 2020. The unemployment rate in the third quarter of 2020 was 4.1 percent lower than that of the second quarter of 2020. More specifically, Kern County's unemployment rate was 18.1 percent in the second quarter of 2020 and 14 percent in the third quarter of 2020. Kern County's unemployment rate is higher than that of California which is 12 percent.

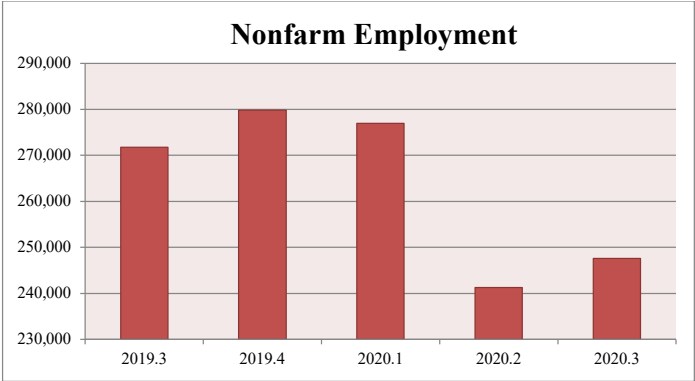




The rate of unemployment varied considerably across cities, ranging from 6.37 percent in Ridgecrest to 29.27 percent in Mojave. All cities in Kern County showed a decrease in the unemployment rate compared to the second quarter of 2020. The biggest quarter to quarter decrease in the unemployment rate occurred in Delano, dropping from 34.17 percent to 19.2 percent. In Bakersfield, the unemployment rate was 14.03 percent in the third quarter of 2020 compared to 16.7 percent in the second quarter.

**Nonfarm Employment** – Local nonfarm industries employed 6,267 more workers in the third quarter of 2020 as the number increased from 241,300 to 247,567. The industries hired 24,200 less workers compared to four quarters ago (8.9 percent less). The number of nonfarm workers usually reduces between the second and third quarter of every year but this year was different, recording an uptick in numbers. The 2020 numbers are similar to pre-COVID figures of 2019.

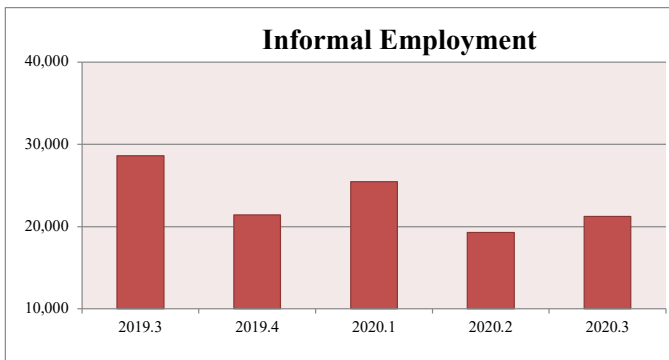
Unemployment Rate of Cities			
Location	Unemployment Rate (%)	Location	Unemployment Rate (%)
<b>KERN COUNTY</b>	13.97%	McFarland	17.47%
Arvin	13.23%	Mojave	29.27%
Bakersfield	14.03%	Oildale	19.93%
California City	26.17%	Ridgecrest	6.37%
Delano	19.20%	Rosamond	16.53%
Edwards	15.80%	Shafter	19.13%
Frazier Park	15.03%	Taft	9.03%
Lake Isabella	18.93%	Tehachapi	9.50%
Lamont	12.83%	Wasco	15.17%
Note: City-level data are not adjusted for seasonality and “informal” market workers.			



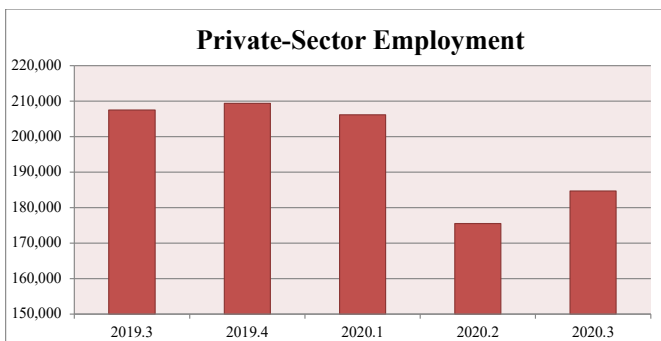
**Farm Employment** –In the third quarter of 2020, Kern County hired 6,033 more farm workers. As a result, farm employment increased from 43,733 in the second quarter of 2020 to 49,767. The year-over-year number of farm workers hired decreased by 22,167 to 49,767.

In Bakersfield, nonfarm employment changed by the following magnitude: mining and logging lost 267 workers; construction added 500 workers; manufacturing added 100 workers while service added 5,400 workers. Within the service sector, trade, transportation and utilities added 2,467 workers; financial activities added 67 workers; professional and business services added 767 workers; education and health services added 1,700 workers while leisure and hospitality added 3,500 workers. The federal government added 533 workers while state and local government lost 4,067 workers. The local government lost 3,567 workers.

**Informal Employment** - Informal employment is the difference between total employment and industry employment. It accounts for self-employed workers and persons employed outside their county of residence. In the third quarter of 2020, the number of informal workers decreased by 1,967 workers compared to the second quarter of 2020. There were 7,400 less informal workers compared to the third quarter of 2019. The number of residents who have sought to create their own jobs continues to slow down. There are currently 21,233 informal workers in Kern County, which is a slight uptick from last quarter's figures which were the lowest in 10 years.

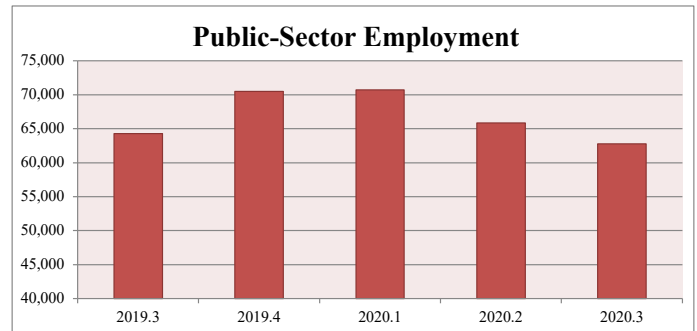


**Private-Sector Employment** - Nonfarm employment is comprised of private- and public-sector employment. In the second quarter of 2020, private companies hired 175,467 workers while the third quarter numbers rose to 184,733 workers. The private sector hired 10.96 percent less workers this quarter than it did four quarters ago. The private sector numbers are similar to those recorded in the third quarter of 2012.

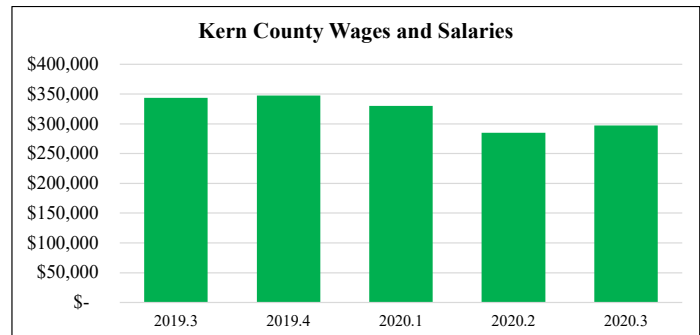


**Public-Sector Employment** - The public sector consists of federal, state, and local government agencies. The local government labor market includes county and city agencies and public education. In the third quarter

of 2020, government agencies hired 3,067 less workers as employment decreased from 65,833 to 62,767 – a 4.66 percent decrease. The year to year decrease in employment was 2.38 percent.



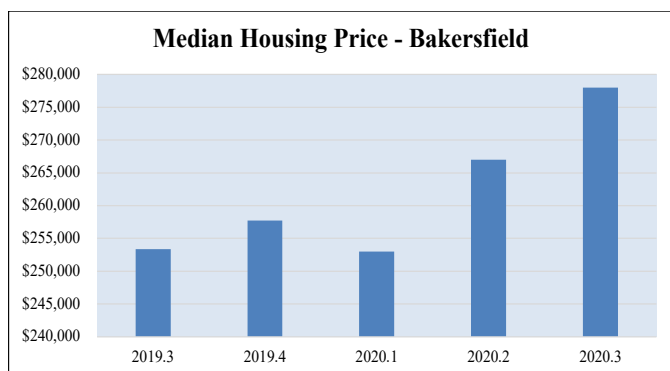
**Salaries and Wages** - Total Salaries and wages in Kern County increased from \$285,033 in the second quarter of 2020 to \$297,333 in the third quarter of 2020 (a 4 percent increase). Compared to four quarters ago, salaries were lower by \$46,367 (or 13 percent).



## Housing Market

**Housing Price** - In the third quarter of 2020, Bakersfield's housing prices were up by \$11,000 (4.12 percent) compared to the second quarter of 2020. The median home price averaged \$278,000 in the third quarter compared to \$267,000 in the second quarter. Prices are \$24,628 higher than they were four quarters ago. This rise in home prices has been fueled by record low interest rates and increased demand.

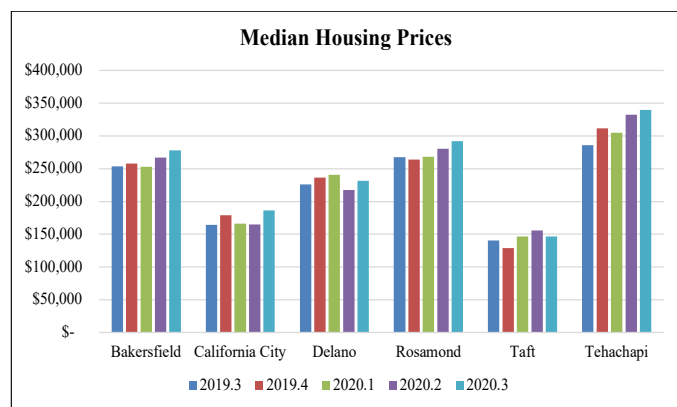
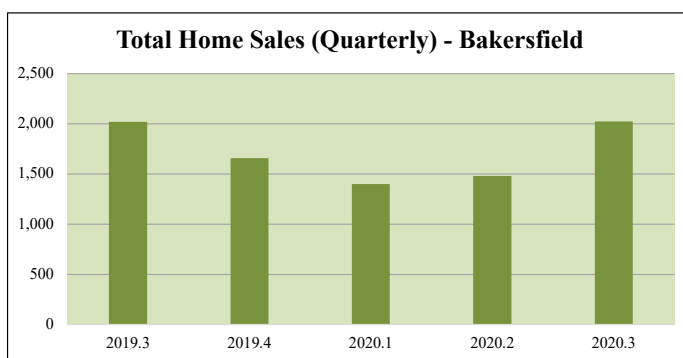




Location	Median Price	Median Price	Price Change (\$)	% Price Change
	2019.3	2020.3	2020.3 - 2020.2	2020.3 - 2020.2
Bakersfield	253,372	278,000	24,628	9.72%
California City	164,000	186,333	22,333	13.62%
Delano	226,250	231,250	5,000	2.21%
Rosamond	267,417	291,833	24,417	9.13%
Taft	140,500	146,667	6,167	4.39%
Tehachapi	286,167	339,667	53,500	18.70%
<b>Averages</b>	<b>191,389</b>	<b>210,824</b>	<b>22,674</b>	<b>9.63%</b>

**Housing Sales** – In Bakersfield, quarter to quarter sales of residential units increased by 543 units, from 1,480 to 2,023. An average of 3 less homes were sold in the third quarter of 2020 compared to the third quarter of 2019.

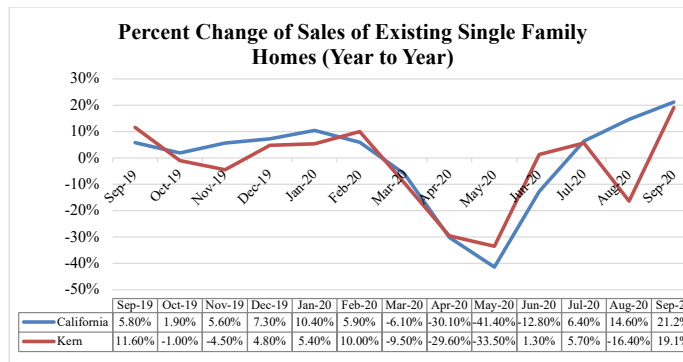
**Regional Housing Prices** - The changes in housing demand felt in Bakersfield are likely to spillover to the surrounding towns as individuals who are on the margin of buying or selling are likely not located in the Bakersfield MSA directly. Year-to-year home prices increased in all cities in Kern County except Taft, where prices fell by 5.98 percent. Prices increased in Bakersfield (4.12 percent), California City (13.22 percent), Delano (6.4 percent), Rosamond (4.1 percent) and Tehachapi (2.16 percent).



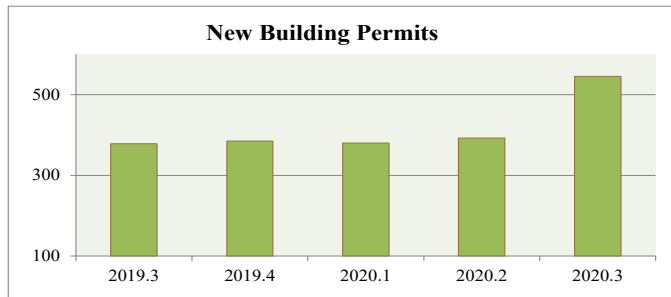
**Growth in Housing Sales** –

**Growth in Housing Sales** – We compare growth in sales of existing single-family homes in Kern County with growth in sales in California. Positive values indicate that more homes were purchased this year compared to last year. In September 2020, sales of single-family homes in Kern County were 21.2 percent higher than they were in 2019 year, while sales were higher in California by 19.1 percent. Average growth in home sales in California between September 2019 and September 2020 were -2.8 percent while the number was -0.9 percent in Kern County.

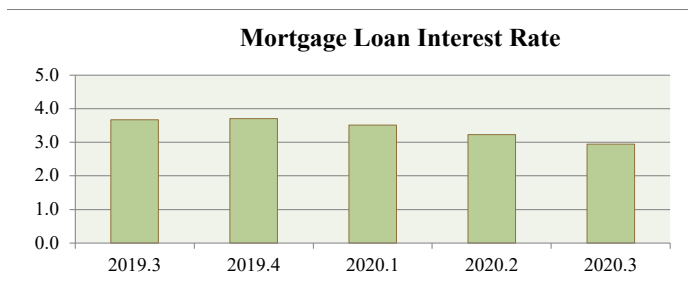
An assessment of second to third quarter changes (2020) in median sales prices indicates that home prices surged in all Kern County cities. Tehachapi recorded the highest rise in prices (18.7 percent) while Delano recorded the lowest rise in prices (2.21 percent). The average price increase was 9.63 percent across all regions. The median home price averaged 191,389 in the third quarter of 2019 compared to 210,824 in the third quarter of 2020.



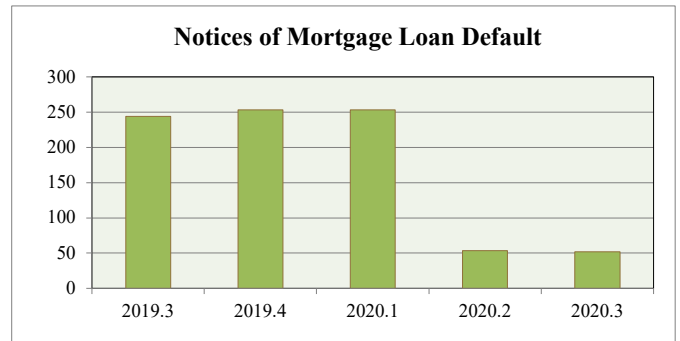
**New Building Permits** –In the third quarter of 2020, Kern County issued 153 more permits for construction of new privately-owned dwelling units compared to the second quarter of 2020. A total of 545 permits were issued this quarter compared to 378 in the third quarter of 2019. This increase indicates a rise in construction plans in Kern County. Over the last five years, and average number of permits issued in the third quarter is 495.



**Mortgage Interest Rate** – In the third quarter of 2020, the interest rate on thirty-year conventional mortgage loans decreased to 2.95 percent from 3.23 percent compared to the second quarter. The current thirty-year mortgage interest rates are the lowest in modern history.

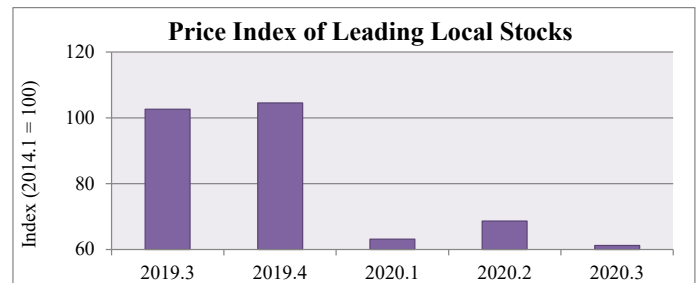


**Housing Foreclosure Activity** –The downtick in foreclosure activity continued as the number of new foreclosures decreased by 1 foreclosure, from 53 in the second quarter of 2020 to 52 in the third quarter of 2020. This number is also 192 filings lower than four quarters ago – 244 filings were recorded in the third quarter of 2019 compared to 52 in the third quarter of 2020. These foreclosure filings are the lowest witnessed in ten years.

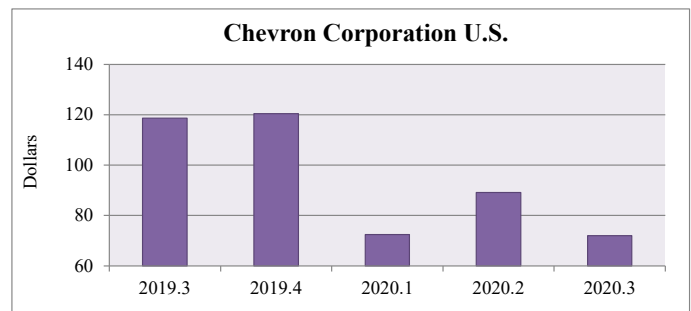


## Stock Market

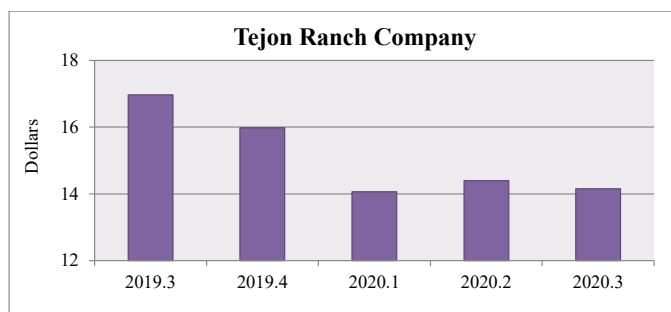
In the third quarter of 2020, the composite price index (2014.1=100) of the five publicly traded companies doing business in Kern County decreased by 10.8 percentage points from 68.7 to 61.3. The index is 40.3 percentage points lower than what it was four quarters ago. Average “close” prices were measured for five local market-movers: Chevron Corporation U.S., Tejon Ranch Company, Granite Construction, Wells Fargo Company, and Sierra Bancorp.



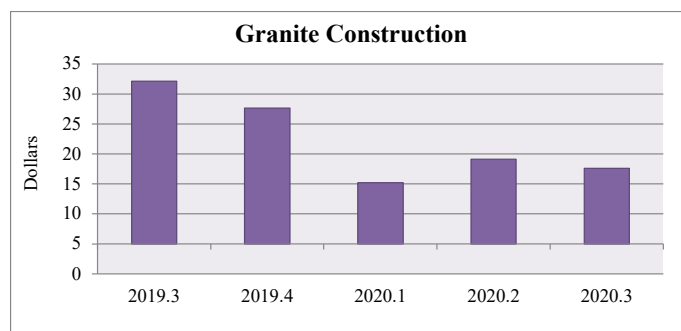
**Chevron Corporation U.S.:** Compared to the last quarter, CVX lost \$17.23 (or 19.3 percent) per share as its price decreased from \$89.23 to \$72. Relative to the third quarter of 2019, CVX was down \$46.60 (or 39.3 percent).



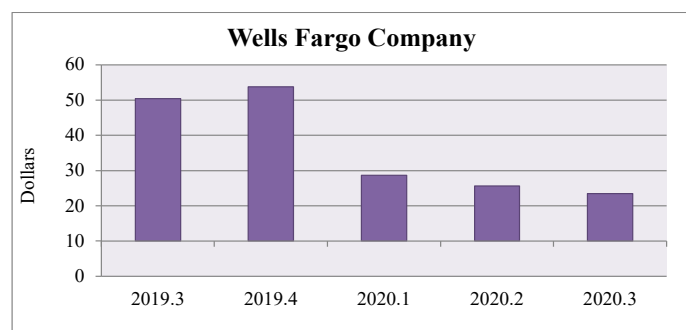
**Tejon Ranch Company:** TRC lost \$0.25 (or 1.7 percent) per share as its stock price decreased from \$14.40 to \$14.15 between the second and third quarter of 2020. Compared to last year, the TRC stock price was down \$2.82 (or 16.6 percent).



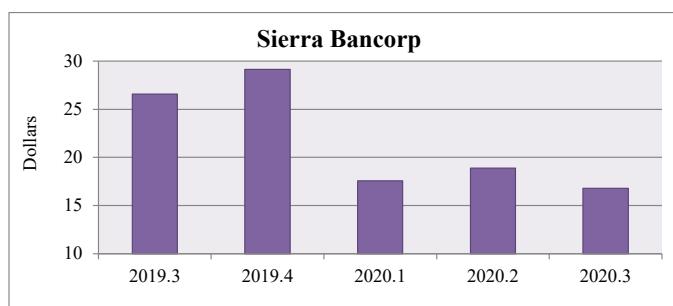
**Granite Construction:** GVA lost \$1.53 (or 8 percent) per share as its stock price decreased from \$19.14 to \$17.61 between the second and third quarter of 2020. Conversely, GVA lost \$14.52 (or 45.2 percent) over the last four quarters.



**Wells Fargo Company:** WFC lost \$2.09 (or 8.2 percent) per share as its stock price decreased from \$25.60 to \$23.51 between the second and third quarter of 2020. Relative to one year ago, WFC was down \$26.93 (or 53.4 percent).

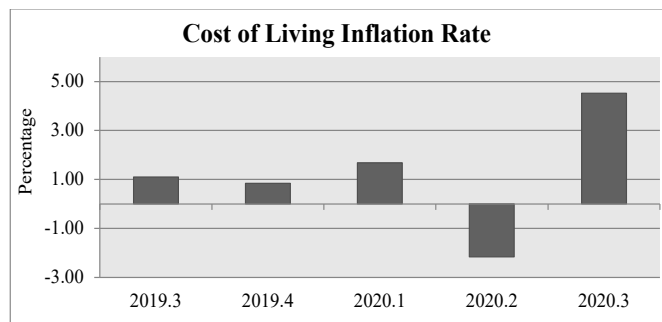


**Sierra Bancorp:** BSRR lost \$2.09 (or 11.1 percent) per share as its price decreased from \$18.88 to \$16.79. Similar to the other companies, BSRR lost \$9.77 (or 36.8 percent) since the third quarter of 2020.

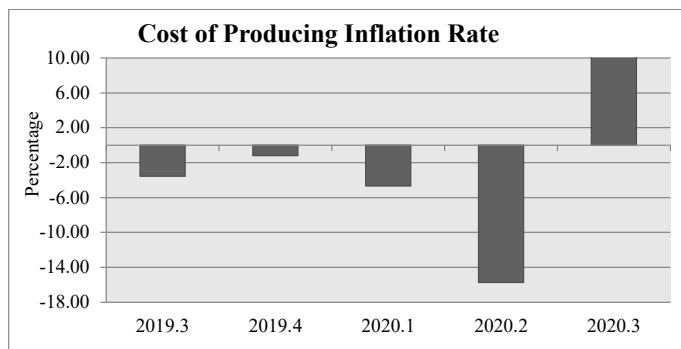


## Inflation

**Cost of Living** – In the third quarter of 2020, the Consumer Price Index for all urban areas (1982-84 = 100) increased from -2.16 to 4.53. These figures are similar to those of the second quarter of 2016, 2018 and 2019.

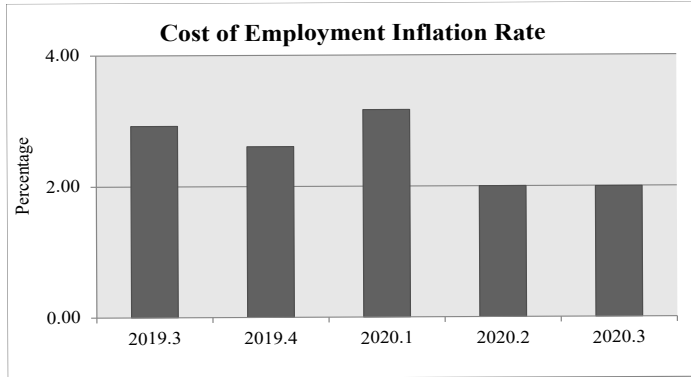


**Cost of Production** – The Producer Price Index for all commodities (1982 = 100) surged between the second and third quarter of 2020. The cost of production inflation rate was -15.74 percent last quarter and -3.58 percent four quarters ago.



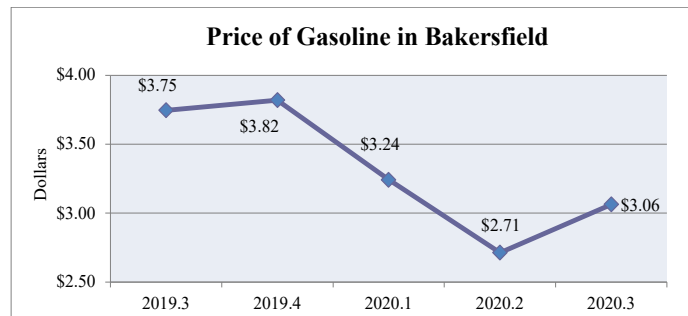


**Cost of Employment** - The Employment Cost Index (December 2005 = 100) for all civilian workers increased from 140.7 in the second quarter to 141.4 in the third quarter, growing at a rate of 1.99 percent. This growth is smaller than that which occurred in the first to second quarter of 2020 (2 percent).

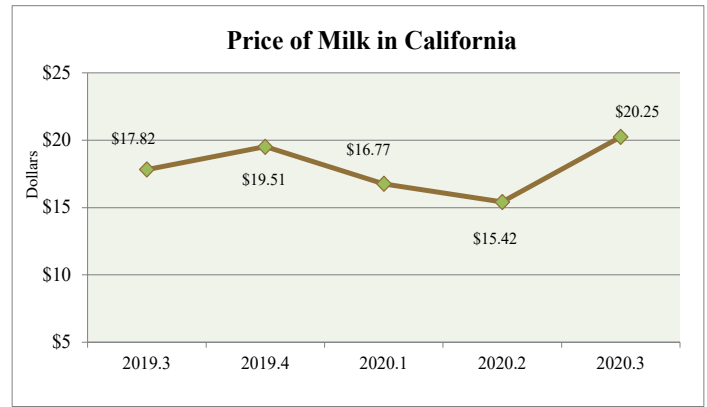


## Commodity Prices

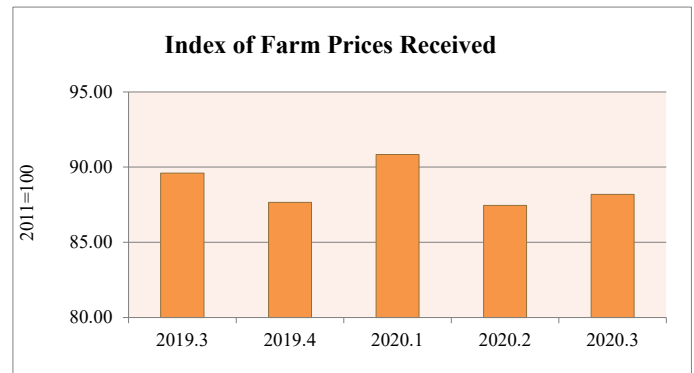
**Price of Gasoline** - In the Bakersfield Metropolitan Statistical Area, the average retail price of gasoline increased by \$0.35 to \$3.06 between the second and third quarter of 2020. Average prices were 18.2 percent less than they were a year ago.



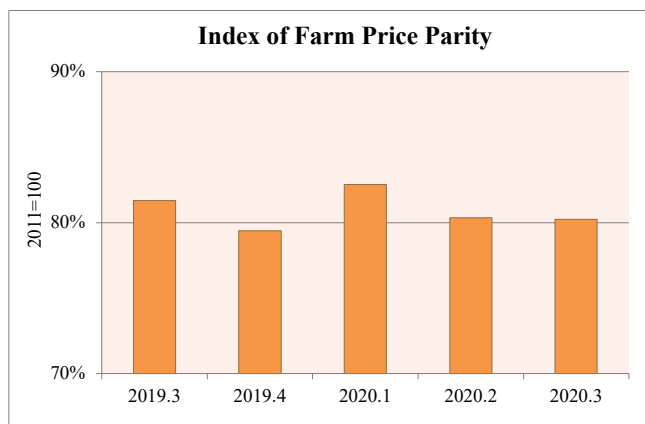
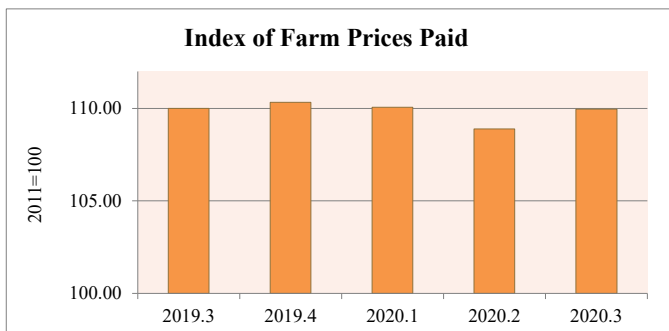
**Price of Milk** - The unit price of California's Class III milk increased in the third quarter of 2020 by \$4.83 to \$20.25. Noticeably, milk prices are crossed the \$20 price range. The last time prices were this high was in 2014 when they averaged \$22. Nonetheless, prices are 15 percent or \$2.43 higher than they were four quarters ago (when they were \$17.82).



**Farm Prices** - In the third quarter of 2020, the National Index of Prices Received by Farmers for all farm products (2011 = 100) increased by 0.73 points to 88.2 compared to the 87.4 recorded in the second quarter of 2020. This is a 1.40 point decrease from the 89.6 points recorded in the third quarter of 2019.

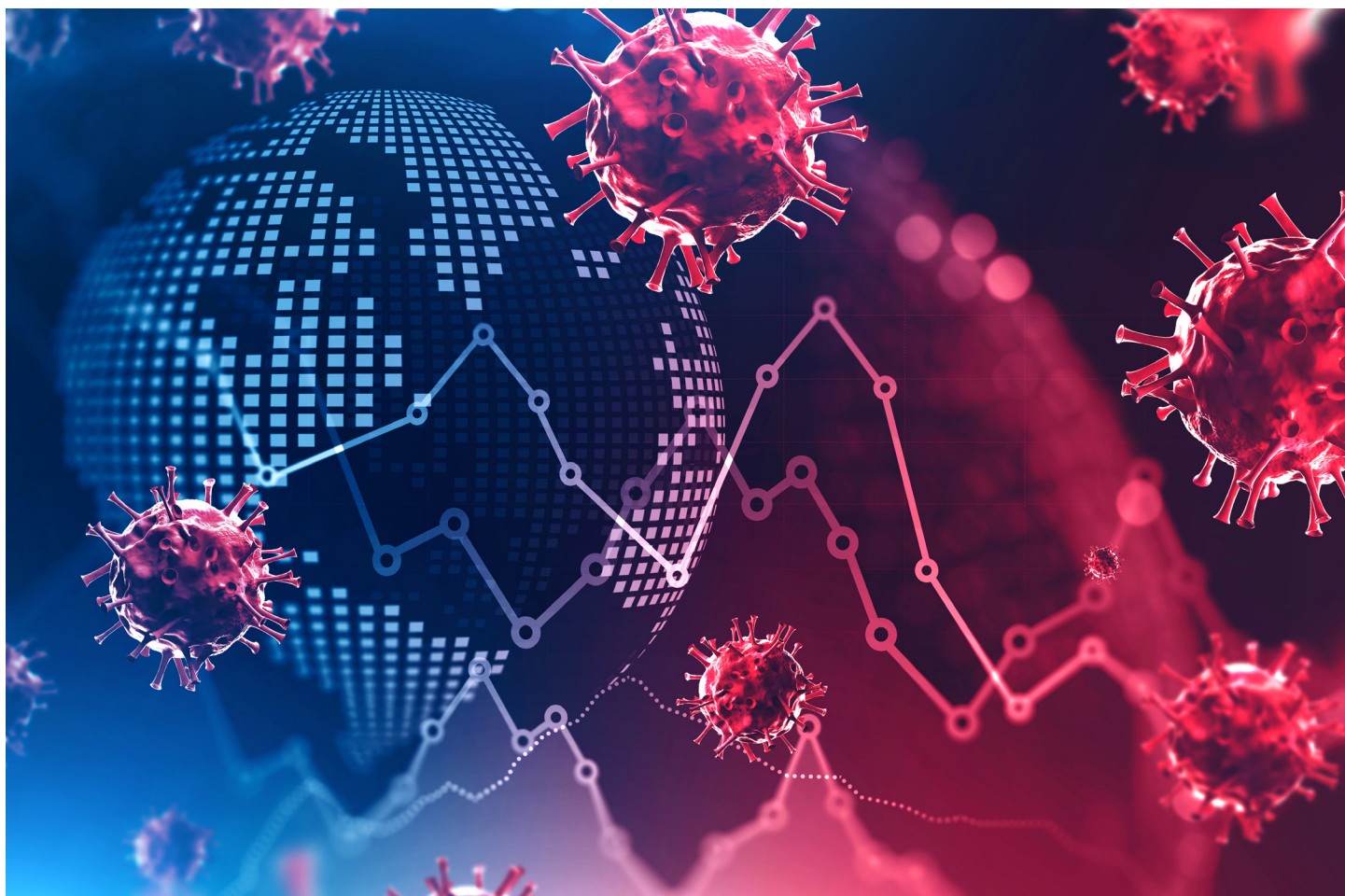


Meanwhile, the National Index of Prices Paid by farmers for commodities, services, interest, taxes, wages, and rents increased by 0.97 percent (compared to last quarter), increasing 1.07 points to reach 109.97. This means that farmers are worse off this quarter compared to last. Nonetheless, they are well off today compared to the third quarter of 2020.



We measure the Index of Farm Price Parity as the ratio Index of Prices Received to the Index of Prices Paid. In the third quarter of 2020, the gap between prices paid and prices received did not change when compared to the second quarter. These parity levels are similar to those witnessed in the fourth quarter of 2018. Four quarters ago, the price ratio was 81 percent.

<sup>1</sup> Source – Online databases: <http://www.labormarketinfo.edd.ca.gov>; [www.usda.com](http://www.usda.com); [www.bakersfieldgasprices.com](http://www.bakersfieldgasprices.com); [www.bea.gov](http://www.bea.gov); [www.car.org](http://www.car.org); [www.trulia.com](http://www.trulia.com); [www.census.gov](http://www.census.gov); <https://www.redfin.com>; <https://www.cafmmo.com>; [www.bls.gov](http://www.bls.gov)



# The Beginning of the End: Vaccine Development and COVID-19

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When we look at the history of the 21st century, attention will be focused on the COVID-19 pandemic of 2020 and 2021. The impacts of the disease, felt socially, economically, politically, and through untold stories of suffering, will be felt for decades to come. The vaccines (at the point in writing, the Pfizer vaccine has been deployed, with the Moderna vaccine hopefully being deployed in the upcoming days) have been developed in record time. This short essay is an attempt to support large-scale vaccination efforts.

There are three large issues with respect to pharmaceutical development:

1. Proprietary data; pharmaceutical companies are loathe to share proprietary data on diseases and drugs.
2. Regulatory red tape
3. Financial costs

The success of these vaccines come from the unprecedented efforts to eliminate these three hurdles. Given that pharmaceutical companies spend about 16 to 25 percent of their budget on research and development (R&D) related to #3 (comparable estimates are 3.9 percent for aerospace; 6.4 percent for telecommunications), this massive undertaking has been nothing short of miraculous.

Traditionally, vaccine development takes 12 to 15 years, with the remaining patent life (where the profit is made) being 5 to 8 years. Researchers have noted that for every 5,000 compounds that are sent for review to the FDA, only one will eventually receive FDA approval as a drug, with only 2 out of these 10 medicines generating a profit that covers average R&D costs. In fact, the likelihood of recouping R&D costs on a marketable drug are less than 33 percent.<sup>2,3</sup>

The fully capitalized costs of a drug during its 12 year approval process is \$1.9 billion (in 2009 dollars). In fact, the following table details the lengthy and expensive process of generating a pharmaceutical:

Testing Phase	Mean Phase Length (Years)	2008 Spending (Billions)
Discovery	6.5	\$12.8
Phase I Clinical Trials	1.5	\$3.9
Phase II Clinical Trials	2.0	\$6.1
Phase III Clinical Trials	3.5	\$15.4
FDA Review	1.5	\$2.2

<sup>1</sup> Vernon, Golec, and DiMasi (2010). "Drug Development Costs when Financial Risk is Measured Using the Fama-French Three-Factor Model". *Health Economics* 19: 1002-1005.

<sup>2</sup> DiMasi, Hansen, and Grabowski (2003). "The Price of Innovation: New Estimates of Drug Development Costs". *Journal of Health Economics* 22: 151-185.

<sup>3</sup> Grabowski, Vernon, and DiMasi (2002). "Returns on Research and Development for 1990's New Drug Introductions" *Pharmacoeconomics* 20(3): 11-29.





This highlights the tremendous difficulty in achieving a vaccine, but the tremendous safety and work put into it. For instance, Phase I clinical trials require 20 to 100 healthy volunteers; Phase II clinical trials requires 100 to 500 volunteers; and Phase III clinical trials require 1,000 to 5,000 patients (though COVID-19 vaccine trials have gotten >30,000 participants).

For the Pfizer vaccine, there were 36,523 participants that had no evidence of prior COVID-19 infection on blood testing prior to randomization. Out of those participants there were 8 COVID-19 infections in the vaccine group and 162 among the placebo group. Adding in those who did have prior evidence of COVID-19 infection increased those numbers to 9 and 169. To put it simply, the vaccine worked at drastically decreasing your risk of symptomatic infection. Additionally, there was 1 person in the vaccine arm and 7 in the placebo arm who acquired second COVID-19 infections during trial participation. This data may help inform the decisions of those who have had prior COVID-19 infections.

In regards to severe COVID infections, there were 9 cases in the placebo arm and only 1 case in the vaccine arm. The 1 case of serious COVID-19 in the vaccine arm occurred between the first and second injections, so the immune response was not fully developed. Overall, the Pfizer vaccine appears to prevent severe infection once you have had both shots. Overall, initial assessments of the Moderna vaccine are similar to that of Pfizer.

We are entering an era where we have showcased the incredible ability of humans to innovate, when our minds are focused. Though (at the time of this writing) close to 3,000 Americans are dying daily from COVID-19 (with over 300,000 total deaths), we are near the end. In summation: take the vaccine.

# Solar Energy in California: Production, Benefits and Cost

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## Introduction

In this essay, an overview of solar energy production in California is discussed. I start by describing commonly used terminologies in solar energy before outlining reasons why California leads the country in solar energy production. Then, the environmental benefits and costs of utility-scale solar energy (USSE) are discussed.

## Solar Energy Production in California

Electricity production from solar in California falls in two categories – solar thermal and solar photovoltaic (California Energy Commission 2020). Solar thermal power systems use reflectors to capture and focus sunlight to a receiver which heats a fluid that creates steam to power a generator and produce electricity (U.S. Energy Information Administration 2020a). In California, solar thermal plants are located in Mojave desert (California Energy Commission 2020). Solar photovoltaic (PV) systems convert light (photons) to electricity (voltage). The smallest PV systems power calculators and wrist watches while larger systems power communication equipment or supply electricity to residential and commercial properties (National Renewable Energy Laboratory 2020).

In 2019 solar PV and solar thermal power plants generated 14.2% of California's electricity (U.S. Energy Information Administration 2020b). Natural gas, hydroelectric, nuclear and wind contributed 43%, 19%, 8% and 7% of electricity respectively (see Figure 1). These figures were significantly different 30 years ago. In 1990, solar contributed 0.22% of California's electricity and averaged 0.3% of the states in the years that followed (1991 – 2012) until 2013 when it contributed 1.9%. Data from the U.S. Energy Information Administration (2020b) indicates that

solar's contribution to electricity grew to average 10.3% between 2013 and 2019. Coal, nuclear and petroleum's contribution to electricity generation decreased from 1.6%, 19.7% and 3.3% in 1990, to 0.1%, 8% and 0.03% in 2019 respectively. Data also shows that natural gas production has dominated California's electricity portfolio, contributing an average of 49% of electricity since 1990.

Figure 1: California Electricity by Source (2019)

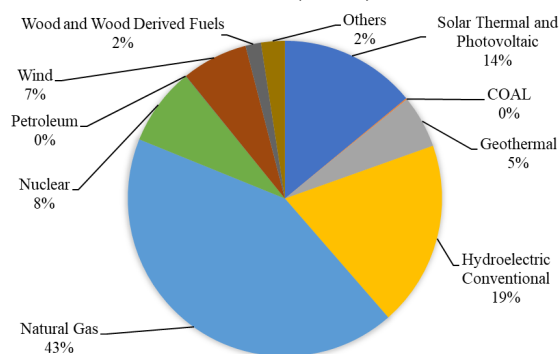
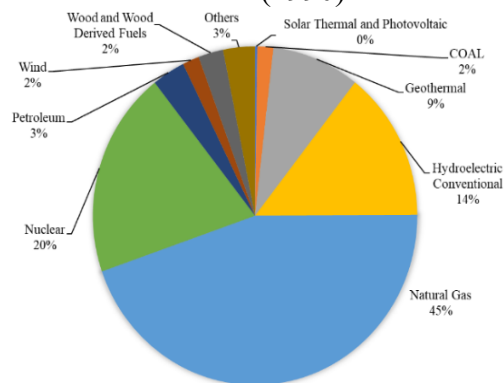


Figure 2: California Electricity by Source (1990)



Source: U.S. Energy Information Administration (2020b)

At the county level, Kern, San Bernardino, Imperial and San Luis Obispo counties lead the state in solar “Capacity”. Capacity refers to the amount of solar that can be produced under ideal conditions (U.S. Department of Energy 2020). Data from the California Energy Commission (2020) indicates that in 2019, Kern County had the potential to produce 21% of the state’s solar energy while San Bernardino and the other counties’ potential ranged from seven to 11% (Figure 3). Net generation refers to the amount to electricity produced over a specific period of time and is measured in kilowatt-hours (KWh) or megawatt-hours (MWh) (U.S. Department of Energy 2020). Kern County is the highest producer of solar energy in the state, producing 7,086,345 MWh or 22% of the state’s energy in 2019 (California Energy Commission 2020). Other top producers include Imperial, Riverside, San Bernardino LA and San Luis Obispo Counties as shown in Figure 4.

Figure 3: Solar Producing Counties in CA in 2019 by Capacity (MW)

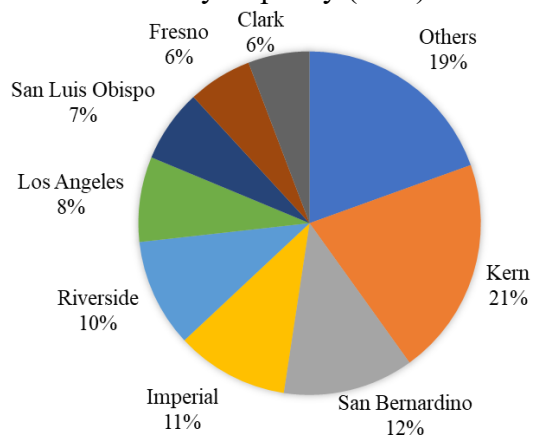
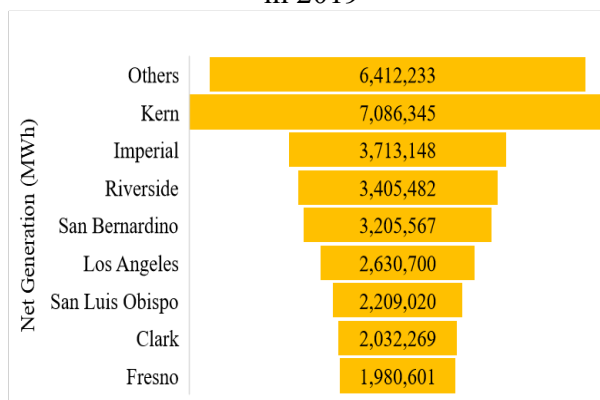


Figure 4: Top Solar Producing Counties in CA in 2019



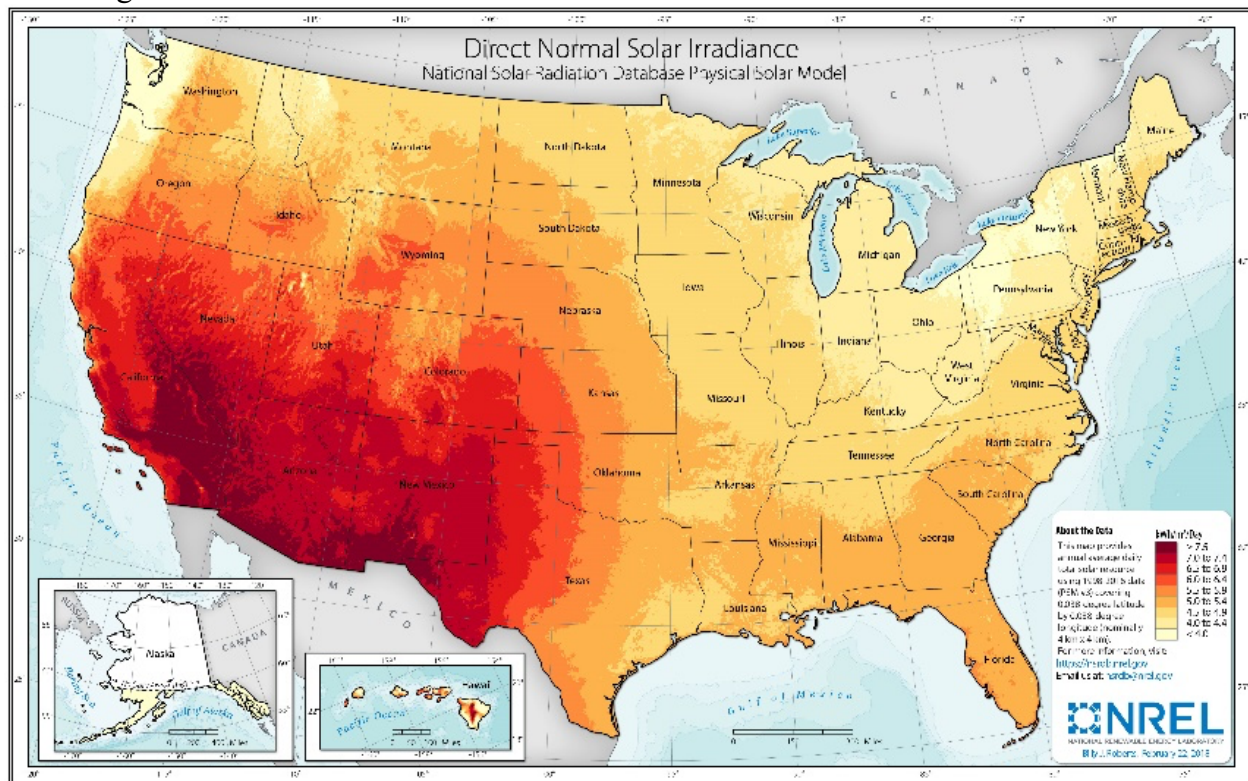
Source: California Energy Commission 2020

## So why is California a leader in Solar?

California’s consistently high levels of air pollution have caused the state to lead in air pollution regulation and energy transition development (Hess and Lee 2020). The renewable portfolio standard (RPS) program established in 2002 (Senate Bill SB 1078) required that 20% of electricity sales be served by renewable sources by 2017. In 2015 SB 350 mandated a 50% RPS by 2030, increasing the momentum set by the 2002 mandate (California Public Utilities Commission 2020). Later in 2018, SB 100 established a policy requiring that 100% of electric retail sales to end use customers come from renewable energy and zero-carbon resources by 2045 (California Energy Commission 2020). The favorable policy environment for renewable energy coupled with solar irradiance make solar a viable source of energy in California.

Solar models developed by Sengupta, Xie et al. (2018) indicate that the greatest solar resource potential in the U.S. occurs in the Southwest portion of the country – Colorado, New Mexico, Utah, Arizona, Nevada and California (Figure 5). Most of the installed solar facilities in the U.S. are located within these states (Walston, Rollins et al. 2016). The average Direct Normal Irradiation (DNI) in these region is 7 kWh/m<sup>2</sup>/day which makes them suitable for solar projects. DNI as the amount of solar radiation received per unit area by a surface held perpendicular to the rays that come in a straight line from the direction of the sun at its current position in the sky (The Handbook of Energy 2013, Blanc, Espinar et al. 2014).





## Negative Effects of Solar Energy

The negative environmental impacts associated with solar systems depend on whether they are utility-scale solar energy (USSE), residential or commercial rooftop. The environmental impacts associated with USSEs occur during construction, operation and decommissioning of powerplants whose lifespan varies between 25 and 40 years (Hernandez, Easter et al. 2014). Construction of USSEs affect biodiversity through fragmentation of habitats and limitation of wildlife movement. It involves vegetation removal, land grading and soil compaction, which increase the likelihood of soil erosion and lead to dust deposition which decreases the amount of solar radiation absorbed by PV cells (Goossens and Van Kerschaever 1999, Belnap, Munson et al. 2011). Road construction and development of transmission corridors also cause soil disturbance and interfere with species' habitats (Lathrop and Archbold 1980).

These activities release pathogens, particulate matter, which reduce visibility and contaminate of water resources (Pepper, Gerba et al. 2009) (Lovich and Ennen 2011, Hernandez, Easter et al. 2014). They also poses hazards to air quality and affects workers' health. During operation, there is increased use of water for panel washing and dust suppression in areas where dust deposition is a challenge (Fthenakis and Kim 2010).

Studies have also found that large USSE facilities contribute to bird mortality through direct contact of the bird with a solar project structure or solar flux related mortality (singeing of flight feathers impacting flight ability which reduces ability to forage or avoid predators) (Kagan, Viner et al. 2014, Kazem, Chaichan et al. 2014).

The decommissioning phase of PV cells pose an environmental challenge since cells contain toxic materials such as cadmium, arsenic and silica (Fthenakis 2000).

Apart from the aforementioned environmental costs, solar facilities have low efficiency, high initial costs and require energy storage equipment (Guangul and Chala 2019).

## Positive Effects of Solar Energy

Apart from reducing greenhouse gases and creating jobs, USSEs provide numerous environmental benefits (Trieb, Schillings et al. 2012). Degraded lands such as brownfields, landfills and mine sites provide viable space for their development. For example, Westlands Solar Park sits on 20,000 acres of contaminated agricultural land in the San Joaquin Valley (<http://www.westlandssolarpark.com/>). USSE facilities can co-exist with livestock by providing grazing habitats thus curtailing the need for vegetation removal while preventing soil erosion (Dale, Efrogmson et al. 2011). The studies by Macknick, Beatty et al. (2013) and Sioshansi and Denholm (2013) outline the benefits of collocating solar and wind facilities.

Photovoltaics may be embedded in architectural elements by serving as noise barriers along highways or railways in Belgium (De Schepper, Van Passel et al. 2012). Their use on rooftops in residential and commercial properties provides users with net energy and saves them money while serving as a symbol of social status (Abreu, Wingartz et al. 2019). They can also provide electricity in off-grid settings (Ulsrud, Winther et al. 2015) and improve quality of life in developing regions (Burney, Woltering et al. 2010).

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