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California's Energy Workforce: Needs and Opportunities

Technical Appendix

CONTENTS

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Supported with funding from Blue Shield of California Foundation and the James Irvine Foundation

Appendix A. Data and Methods

Data Sources

We rely on several publicly available data sources for this report including labor market statistics, household survey data, and occupational information, all of which we describe below.

Labor Market Data

The Bureau of Labor Statistics (BLS) and the California Employment and Development Department (EDD) produce a wide range of labor market statistics that can be disaggregated by industry, occupation, and region to help stakeholders make informed decisions about the state's economy and its workforce.

Occupational Employment and Wage Statistics

The Occupational Employment and Wage Statistics (OEWS) program produces employment, and wage estimates annually for approximately 830 occupations. These estimates are available for the nation, for individual states, and for metropolitan and nonmetropolitan areas; national occupational estimates for specific industries are also available. The OEWS survey covers wage and salary workers in nonfarm establishments and does not include the self-employed, owners and partners in unincorporated firms, household workers, or unpaid family workers. OEWS data are published annually with a May reference date.

For the regional portion of the analysis, we complemented OEWS information from BLS with custom OEWS data from EDD disaggregated by Metropolitan Statistical Areas (MSA) and Metropolitan Divisions (MD).

Quarterly Census of Employment and Wages

The Quarterly Census of Employment and Wages (QCEW) program publishes a quarterly count of employment and wages reported by employers covering more than 95 percent of U.S. jobs available at the county, Metropolitan Statistical Area (MSA), state and national levels by detailed industry. QCEW data is most helpful for identifying industry trends, including employment, job creation/destruction, wages, and hires, among others, but less informative for worker- and occupation-specific research questions.

Household Survey Data

The demographic profiles of energy workers and the labor market trajectories analysis use household survey data collected by the US Census Bureau and designed to be representative of the population. These surveys collect detailed information about individuals and their households and include questions about employment and job characteristics. All information on jobs is self-reported by the respondent and occupation codes are assigned by the people at agencies who process the data.

American Community Survey (ACS)

The American Community Survey (ACS) is an ongoing household survey designed to produce reliable estimates at the state and sub-state levels due to its relatively large sample size; the California sample includes data on about 350,000 individuals and households annually. We analyzed the public use microdata sample (PUMS) 1-year files for the years 2018 – 2023 to examine the characteristics of energy workforce and their employment circumstances in California. We combined the six years to increase the size of our sample given the small sample sizes when separating the data at the industry and/or occupation levels.

Occupational Data

Occupational data provides important information on characteristics and worker requirements across the labor market. The BLS has a program that regularly updates databases with detailed information on skills, knowledge, and abilities requirements associated to an important number of occupations in the economy. This information is collected and updated through ongoing surveys of workers in each occupation supplemented in some cases by occupation experts.

Occupational Information Network

The Occupational Information Network (O*NET) is a comprehensive database of worker attributes and job characteristics and the nation's primary source of occupational information. O*NET data contains hundreds of standardized and occupation-specific descriptors on 923 occupations covering the entire U.S. economy. This includes a rich set of variables that describe job and worker characteristics, like knowledge, skills, and abilities they require, as well as how the work is performed in terms of tasks, work activities, and other descriptors.

O*NET also provides occupational data on typical education needed for entry, work experience in a related occupation, and typical on-the-job training needed to attain competency in the occupation that can be used to characterize the workforce.

Finally, O*NET also provides a list with the top twenty most similar occupations to each of the occupations in their database. The list is developed using an approach which includes three contributors to occupational similarity: what people in the occupations do, what they know, and what they are called.

Integrated Postsecondary Education Data System

The Integrated Postsecondary Education Data System (IPEDS) is a system of interrelated surveys conducted annually by the U.S. Department of Education's National Center for Education Statistics (NCES). IPEDS gathers information from every college, university, and technical and vocational institution that participates in the federal student financial aid programs. IPEDS provides information on institutional characteristics, like levels of awards and types of programs offered, enrollment data, and completion of postsecondary education programs.

Energy Workforce Definition

As described in the report, we rely on existing research and expert interviews intersected with available state-level official jobs data to define and quantify the energy sector workforce.

We start by identifying a list of 30 4-digit North American Industry Classification System codes (NAICS) closely related to energy sector activities: clean energy generation, manufacturing, and construction; energy efficiency; environmental management, conservation, and regulation; fossil fuels industries; and scientific, technical, and construction services. While related national research often relies on 6-digit NAICS codes, these are limiting for a California-specific analysis due to suppression for privacy, hence our use of slightly more aggregated industries. This allows us to more fully capture sectors that would be omitted from a 6-digit industry analysis, though we also include some subsectors less attached to energy activities.[1]

Table A1 lists all the sectors included in our analysis.

[1] Using a list of 116 6-digit level industry codes identified by relevant research sources mentioned in the report, we find that only 53 codes can be matched in the OEWS data for California in 2023, a little less than 50% of the codes. While additional industry detail is available in the QCEW, we need to use OEWS data to get occupational and worker-level information. However, we use QCEW industry detail to refine which 4-digit NAICS codes are relevant to energy. When aggregated 6-digit level industry employment is at least 50% of the 4-digit level industry, we count the 4-digit industry as energy; otherwise, we drop the 4-digit sector. The only exception made was for the energy generation fossil fuel, were instead of using the 4-digit NAICS (2211 - Electric power generation, transmission, and distribution) we kept the 6-digit level one (221112 - Fossil Fuel Electric Power Generation).

TABLE A1

Sectors included in our definition of the energy workforce

Group	NAICS	NAICS Title
All energy	2111	Oil and Gas Extraction
All energy	2131	Support Activities for Mining
All energy	2211	Electric power generation, transmission, and distribution
All energy	2212	Natural Gas Distribution
All energy	2213	Water, Sewage and Other Systems
All energy	2361	Residential Building Construction
All energy	2362	Nonresidential Building Construction
All energy	2371	Utility System Construction
All energy	2372	Land Subdivision
All energy	2379	Other heavy and civil engineering construction
All energy	2382	Building Equipment Contractors
All energy	2389	Other Specialty Trade Contractors
All energy	3241	Petroleum and coal products manufacturing
All energy	3336	Engine, turbine, and power transmission equipment manufacturing
All energy	3344	Semiconductor and other electronic component manufacturing
All energy	3351	Electric lighting equipment manufacturing
All energy	3352	Household Appliance Manufacturing
All energy	3353	Electrical Equipment Manufacturing
All energy	3359	Other electrical equipment and component manufacturing
All energy	3362	Motor vehicle body and trailer manufacturing
All energy	3363	Motor Vehicle Parts Manufacturing
All energy	3365	Railroad Rolling Stock Manufacturing
All energy	4861	Pipeline Transportation of Crude Oil
All energy	4862	Pipeline Transportation of Natural Gas
All energy	4869	Other Pipeline Transportation
All energy	5413	Architectural, engineering, and related services
All energy	5417	Scientific research and development services
All energy	5621	Waste Collection
All energy	5622	Waste Treatment and Disposal
All energy	5629	Remediation and other waste management services
Fossil fuels	2111	Oil and Gas Extraction
Fossil fuels	2131	Support Activities for Mining
Fossil fuels	221112	Fossil Fuel Electric Power Generation
Fossil fuels	2212	Natural Gas Distribution
Fossil fuels	2371	Utility System Construction
Fossil fuels	3241	Petroleum and coal products manufacturing
Fossil fuels	3353	Electrical Equipment Manufacturing
Fossil fuels	4861	Pipeline Transportation of Crude Oil
Fossil fuels	4862	Pipeline Transportation of Natural Gas
Fossil fuels	4869	Other Pipeline Transportation

Within these sectors, we then identify all occupations at the six-digit level using Standard Occupational Classification (SOC) codes. In total, we find 332 occupations that represent 1.2 million jobs in the state in 2023. For the fossil fuels subsector, the number of occupations and jobs are 150 and 103,000, respectively.

However, as described in the report, we seek to filter out occupations that common across the economy.[2] Following the methodology in Muro et al. (2019) we include only energy jobs with a higher-than-expected concentration in energy relative to that of the economy overall. We calculate a concentration coefficient (CQ) that

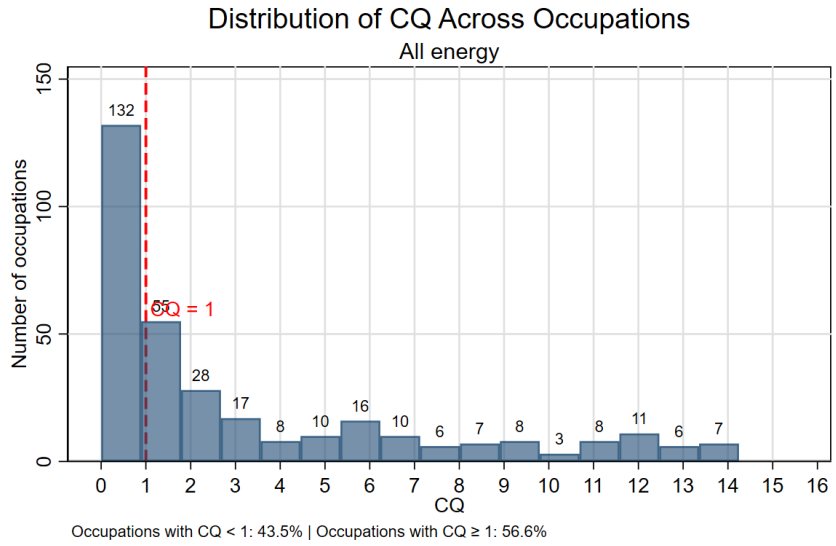
[2] Our approach tries to identify direct energy jobs. However, we acknowledge the importance of the multiplier effect energy jobs have for the economy, especially in regions that are highly dependent on those jobs as a source of income to support livelihoods, through indirect and induced jobs. Indirect jobs are those associated with the provision of intermediate goods and services to the energy sector. Induced jobs are those that result from the support of broader economic needs of the energy workforce or the energy sector, are not part if this analysis.

compares the occupation's share of employment in the energy sector to its share of total state employment. The higher the CQ, the more important the occupation is for the energy sector. We follow an identical approach for the fossil fuels subsector. The concentration coefficient formula is:

$$Concentration\ coefficient\ (CQ) = \frac{Occupation's\ share\ of\ employment\ in\ energy\ sector}{Occupation's\ share\ of\ state\ employment}$$

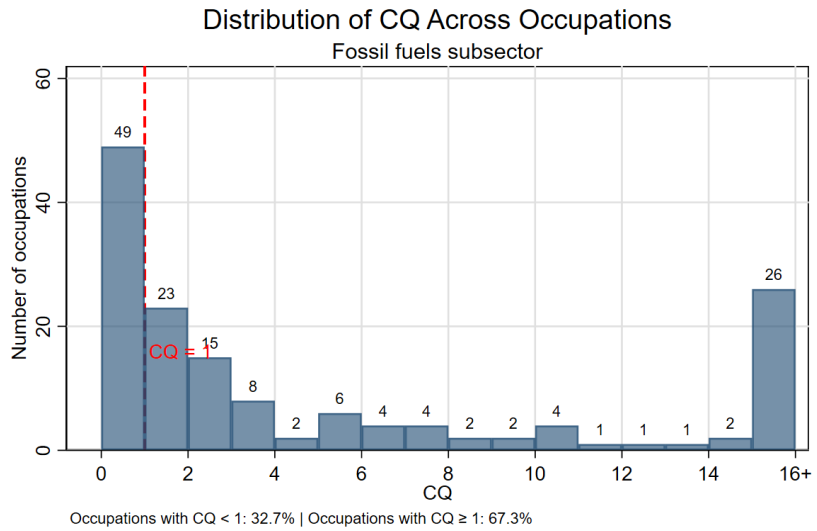
If the CQ is greater than one, we count the occupation in our energy workforce estimate. Examples of occupations omitted because of this condition include lawyers, sales representatives, computer analysts, security guards, and drivers. In total, we drop 144 occupations, equating to about 145,000 jobs in 2023 for the overall energy sector (49 occupations, 9,000 jobs for the fossil fuels subsector). This means that many occupations were adding a very small number of total jobs to the energy sector. Figures A1 and A2 depict the spectrum of CQ for both groups. The fossil fuels subsector has a greater share of occupations that meet the CQ requirement than those in the aggregate energy sector (67% vs 57%). This may be the result of higher levels of specialization required to perform activities in fossil fuel extraction and its processing and distribution, while the broader energy sector has more similarities with other industries.

FIGURE A1



Source: PPIC calculations based on OEWS data, 2023.

FIGURE A2



Source: PPIC calculations based on OEWS data, 2023.

The top 15 occupations based on number of jobs is presented in Table A2. These occupations represent 50% of all energy jobs and 58% of fossil fuels jobs, respectively.

TABLE A2

Largest occupations identified as part of the energy workforce

Sector	Occupation code	Occupation title	# Jobs	CQ	Share of sector (%)	Share of occupation in the energy sector (%)	Median wage ($/hour)
All energy	47-2111	Electricians	63,440	12.9	6.0	87.0	37.0
	47-2061	Construction Laborers	61,310	10.1	5.8	68.2	27.9
	47-2031	Carpenters	56,850	8.2	5.3	55.3	34.7
	47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	45,480	9.4	4.3	63.1	44.3
	13-1082	Project Management Specialists	44,620	5.8	4.2	38.9	55.0
	47-2152	Plumbers, Pipefitters, and Steamfitters	37,360	13.0	3.5	87.9	30.5
	11-1021	General and Operations Managers	33,690	1.8	3.2	12.3	65.7
	49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	29,820	12.4	2.8	83.7	29.7
	11-9021	Construction Managers	28,170	11.3	2.6	76.2	57.7
	17-2051	Civil Engineers	27,690	8.4	2.6	56.5	46.8
	15-1252	Software Developers	26,260	1.3	2.5	8.6	85.3
	43-9061	Office Clerks, General	25,790	1.3	2.4	8.7	23.0
	51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	19,190	7.0	1.8	46.9	21.2
	47-2073	Operating Engineers and Other Construction Equipment Operators	18,750	8.5	1.8	57.4	42.7
	11-9041	Architectural and Engineering Managers	16,680	6.9	1.6	46.8	90.1
	Total, top 15			NA	50		
Fossil fuels	47-2061	Construction Laborers	11,580	22.4	12.3	12.9	30.7
	47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	5,560	13.4	5.9	7.7	43.4
	49-9051	Electrical Power-Line Installers and Repairers	5,030	97.2	5.4	55.9	51.9
	47-2073	Operating Engineers and Other Construction Equipment Operators	4,330	23.0	4.6	13.2	51.6
	13-1082	Project Management Specialists	4,240	6.4	4.5	3.7	58.3
	51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	3,480	164.5	3.7	94.6	50.9
	47-5013	Service Unit Operators, Oil and Gas	3,380	151.9	3.6	87.3	29.1
	47-2152	Plumbers, Pipefitters, and Steamfitters	2,660	10.9	2.8	6.3	36.3
	49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	2,500	99.5	2.7	57.2	48.6
	11-1021	General and Operations Managers	2,000	1.3	2.1	0.7	67.2
	49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	2,000	6.6	2.1	3.8	57.0
	49-9041	Industrial Machinery Mechanics	1,990	12.2	2.1	7.0	49.7
	47-2111	Electricians	1,970	4.7	2.1	2.7	46.6
	13-1199	Business Operations Specialists, All Other	1,920	2.0	2.0	1.2	55.9
	51-1011	First-Line Supervisors of Production and Operating Workers	1,890	6.6	2.0	3.8	67.0
	Total, top 15			NA	58		

Source: PPIC calculations based on OEWS data for California, 2023.

Table A3 presents the top occupations based on their preponderance in the energy sector; these are occupations that are almost entirely in the energy sector and are not commonly found in other sectors. These occupations represent 18% and 20% of total jobs in the energy sector and fossil fuels subsector, respectively. For the overall energy list, we exclude those occupations that are repeated in the fossil fuels subsector.

TABLE A3

Occupations most concentrated in the energy sector

Group	Occupation code	Occupation title	# Jobs	CQ	Share of sector (%)	Share of occupation in the energy sector (%)	Median wage ($/hour)
All energy	47-3013	Helpers--Electricians	3,620	14.2	0.3	96.0	18.9
	47-4021	Elevator and Escalator Installers and Repairers	1,980	14.1	0.2	95.2	64.7
	47-2132	Insulation Workers, Mechanical	460	13.7	0.0	92.0	50.3
	47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	2,360	13.6	0.2	91.8	22.5
	17-1011	Architects, Except Landscape and Naval	14,010	13.5	1.3	91.2	48.2
	47-2231	Solar Photovoltaic Installers	6,840	13.3	0.6	89.9	25.7
	47-2152	Plumbers, Pipefitters, and Steamfitters	37,360	13.0	3.5	87.9	30.5
	47-2111	Electricians	63,440	12.9	6.0	87.0	37.0
	17-3011	Architectural and Civil Drafters	11,420	12.7	1.1	85.5	32.7
	49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	29,820	12.4	2.8	83.7	29.7
	47-4031	Fence Erectors	2,570	12.3	0.2	83.2	21.9
	51-9141	Semiconductor Processing Technicians	2,890	12.2	0.3	82.3	22.5
	53-7081	Refuse and Recyclable Material Collectors	10,350	12.1	1.0	81.5	28.7
	17-3012	Electrical and Electronics Drafters	2,550	12.0	0.2	80.7	34.0
	47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	2,050	11.7	0.2	78.5	22.5
Fossil fuels	51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	3,480	164.5	3.7	94.6	50.9
	47-5081	Helpers--Extraction Workers	310	158.6	0.3	91.2	28.2
	47-5013	Service Unit Operators, Oil and Gas	3,380	151.9	3.6	87.3	29.1
	51-8092	Gas Plant Operators	650	150.7	0.7	86.7	56.5
	47-5012	Rotary Drill Operators, Oil and Gas	300	141.0	0.3	81.1	38.5
	51-8091	Chemical Plant and System Operators	210	135.3	0.2	77.8	53.6
	47-2151	Pipelayers	1,300	129.2	1.4	74.3	39.5
	53-7073	Wellhead Pumpers	80	126.5	0.1	72.7	n/a
	47-5071	Roustabouts, Oil and Gas	550	125.9	0.6	72.4	35.3
	53-7072	Pump Operators, Except Wellhead Pumpers	600	117.3	0.6	67.4	23.5
	47-5099	Extraction Workers, All Other	80	107.0	0.1	61.5	22.5
	49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	2,500	99.5	2.7	57.2	48.6
	49-9051	Electrical Power-Line Installers and Repairers	5,030	97.2	5.4	55.9	51.9
	51-8012	Power Distributors and Dispatchers	510	90.5	0.5	52.0	48.2
	51-2021	Coil Winders, Tapers, and Finishers	340	89.6	0.4	51.5	20.9
	17-2171	Petroleum Engineers	640	71.8	0.7	41.3	60.2
	47-5023	Earth Drillers, Except Oil and Gas	450	69.9	0.5	40.2	30.0

Source: PPIC calculations based on OEWS data for California, 2023.

The majority of our report uses most recent data on jobs, from 2023. Over time, both industry and occupational codes shift to account for growing areas of the economy, which complicates estimation of a time series. We nonetheless took on generating a consistent time series for 2016-2023. We align older industry codes to the 2023 codes in all cases (2017 is the most current version introduced by the U.S. Office of Management and Budget through its Economic Classification Policy Committee). Similarly for occupations, we match to occupation codes in 2023, using the Census crosswalks for the years 2010 and 2018 to account for changes. Table A4 provides the detailed estimates shown graphically in the report.

TABLE A4
Employment in the energy sector in California

	2016	2017	2018	2019	2020	2021	2022	2023
All energy	826,600	861,310	903,060	969,720	972,370	990,480	1,049,570	1,064,750
Fossil fuels	76,750	75,510	72,030	72,290	71,820	88,470	91,130	93,880

Source: PPIC calculations based on OEWS data for California, 2023.

Demographic Characteristics

For the demographic characteristics of the energy workforce, we rely on ACS data for California. We pool 6 years of ACS data, 2018-2023, to achieve larger sample size. The ACS contains rich information about workers in California but for smaller industries or occupations only provides detail at an aggregated level to protect privacy. We match the NAICS and SOC codes in our energy sector definition to the closest codes available in the ACS. For example, ACS only provides data at the 2-digit industry level for construction, so we match any detailed construction sectors in our energy definition to industry code 23. Other industries offer higher levels of disaggregation, like electric power generation, transmission, and distribution (Table A5). For matching occupations, we have a similar issue. Some of our detailed energy sector occupations cannot be matched directly in the ACS except at a more aggregated level. For instance, occupations 172151-Mining and Geological Engineers, Including Mining Safety Engineers and 172171-Petroleum Engineers in ACS are combined in 1721XX-Petroleum, mining, and geological engineers, including mining safety engineers. In that case, the aggregated code almost entirely contains the sub-codes without adding other occupations. In a few cases, using the aggregated occupation code does add jobs to our analysis that are not as likely to be specifically in the energy sector. For example, occupation 152051-Data Scientists is not uniquely identified in ACS and we use instead 1520XX-Other Mathematical Science Occupations.

TABLE A5

ACS industries included in our analysis of the energy sector workforce

ACS Industry code	ACS Industry title
2211P	Electric power generation, transmission, and distribution
2213M	Water, steam, air conditioning, and irrigation systems
23	Construction (The Cleaning of Buildings and Dwellings Is Incidental During Construction And Immediately After Construction)
332M	Structural metals, and boiler, tank, and shipping container manufacturing
3336	Engine, turbine, and power transmission equipment manufacturing
335M	Electric lighting, and electrical equipment manufacturing, and other electrical component manufacturing, n.e.c.
5413	Architectural, engineering, and related services
3279	Miscellaneous nonmetallic mineral products manufacturing
33MS	Not specified metal industries
334M2	Electronic components and products, n.e.c.
336M	Motor vehicles and motor vehicle equipment manufacturing
5416	Management, scientific and technical consulting services
562	Waste management and remediation services
813M	Civic, social, advocacy organizations and grantmaking and giving services
92MP	Justice, public order, and safety activities
211	Oil and gas extraction
2121	Coal mining
213	Support activities for mining
2212P	Natural gas distribution
3241M	Miscellaneous petroleum and coal products
325M	Industrial and miscellaneous chemicals
486	Pipeline transportation
4237	Hardware, and plumbing and heating equipment, and supplies, merchant wholesalers
4441Z	Building material and supplies dealers
5313	Real Estate Property Managers, Offices of Real Estate Appraisers, And Other Activities Related to Real Estate
5414	Specialized design services
5417	Scientific research and development services

The following table shows the demographic characteristics for the energy workforce in California. Because the detail on construction sectors is limited in the ACS and forces us to include some construction workers who are not working in the energy sector, we provide detail with and without the construction sector.

TABLE A6

Demographic characteristics of California's energy sector workforce

	All workers	All energy sector	All energy sector without construction	Fossil fuels subsector	Fossil fuels subsector without construction
Sex					
Male	54	85	70	92	82
Female	46	15	30	8	18
Educational attainment					
High school or less	33	47	17	57	34
Some college	22	20	15	22	25
Associate's degree	8	6	6	6	10
Bachelor's degree or more	37	27	62	15	31
Age group					
18-24	12	7	6	7	5
25-39	36	37	40	36	39
40-54	21	24	21	24	23
50 or older	31	32	33	32	33
Race					
Latino	37	46	24	53	40
Asian	16	10	22	6	14
Black	5	2	3	2	3
White	37	37	46	35	40
Multiracial/Other	5	4	5	4	4
Full-time					
Part-time	34	26	17	27	14
Full-time	66	74	83	73	86
Nationality					
US citizen	67	62	68	62	74
Foreign born	33	38	32	38	26
Insurance					
Uncovered	36	39	18	43	16
Covered	64	61	82	57	84

Source: PPIC calculations based on IPUMS-ACS, 2018-2023.

Regional Disaggregation

We obtained custom tabulations of OEWS data from EDD that permit disaggregation by MSA and include 4-digit NAICS level of detail for industries and 6-digit level SOC occupational detail. This level of disaggregation best

balances obtaining detail to capture the energy sector workforce as defined above while also not losing jobs due to privacy restrictions. We compared the number of energy jobs at the state level using this regionally disaggregated dataset and the full statewide OEWS data. We identify a total of 935,000 energy jobs at the state level in the regional dataset—about 130,000 jobs fewer than the 1,065,000 we get using the statewide OEWS dataset. While that is a quite good match in our view, we lose additional jobs when we look only at regions in the regional OEWS data. Specifically, the total energy job count summing across identifiable MSA is 784,000, or 84% of the total energy jobs for California. We believe the regional data is reliable for summarizing the energy workforce overall by MSA but less so for subgroups like the fossil fuel subsector or for specific occupations (or occupational groups). Table A7 summarizes jobs counted by region using the custom MSA-level OEWS data.

TABLE A7

Regional detail on energy sector workforce

Area name	# NAICS matched	# of occupations matched	# of jobs	Share total employment (%)
California	28	151	935,420	5.3
Los Angeles-Long Beach-Anaheim, CA	27	112	228,770	3.8
San Francisco-Oakland-Hayward, CA	22	109	157,590	6.6
San Diego-Carlsbad, CA	18	104	102,100	6.9
San Jose-Sunnyvale-Santa Clara, CA	16	96	89,520	8.1
Riverside-San Bernardino-Ontario, CA	22	77	61,260	3.8
Sacramento--Roseville--Arden-Arcade, CA	16	89	47,580	4.7
Bakersfield, CA	13	66	13,670	4.4
Fresno, CA	13	52	12,270	3.1
Oxnard-Thousand Oaks-Ventura, CA	15	59	11,480	3.8
Santa Rosa, CA	10	41	8,540	4.5
Santa Maria-Santa Barbara, CA	12	56	6,770	3.7
Stockton-Lodi, CA	10	29	6,170	2.4
Modesto, CA	7	40	5,000	2.9
Vallejo-Fairfield, CA	7	30	4,550	3.8
San Luis Obispo-Paso Robles-Arroyo Grande, CA	9	33	4,540	4.4
Salinas, CA	8	25	3,650	2.2
Visalia-Porterville, CA	7	29	3,180	2.1
North Valley-Northern Mountains Region	10	22	3,170	3.4
Santa Cruz-Watsonville, CA	8	26	2,400	3.0
North Coast Region	8	22	2,360	2.6
Napa, CA	7	17	2,200	3.4
Chico, CA	7	17	1,900	3.1
Redding, CA	7	23	1,450	2.6

Eastern Sierra-Mother Lode Region of California nonmetropolitan area	9	16	1,190	2.2
Merced, CA	6	13	1,110	1.7
Yuba City, CA	4	12	630	1.6
El Centro, CA	7	13	540	1.1
Madera, CA	4	11	520	1.2
Hanford-Corcoran, CA	4	4	130	0.4

Source: PPIC calculations based on OEWS data, 2023.

For the fossil fuels subsector, the aggregated job count across MSAs is 64,000, or 70% of the subsector's jobs for California according to our definition (92,500). This may be the result of lower sample sizes for occupations at this level of geographic disaggregation. The results are shown in Table A8.

TABLE A8

Regional detail on the fossil fuel subsector in California

Area name	# NAICS matched	# of occupations matched	# of jobs	Share total employment (%)
California	10	98	92,500	0.5
Los Angeles-Long Beach-Anaheim, CA	9	72	24,140	0.4
Riverside-San Bernardino-Ontario, CA	6	47	11,000	0.7
San Francisco-Oakland-Hayward, CA	6	37	6,230	0.3
Bakersfield, CA	5	40	6,120	2.0
San Diego-Carlsbad, CA	2	43	5,960	0.4
Sacramento--Roseville--Arden-Arcade, CA	2	21	3,710	0.4
San Jose-Sunnyvale-Santa Clara, CA	3	22	1,460	0.1
Fresno, CA	2	20	1,220	0.3
Vallejo-Fairfield, CA	1	8	1,030	0.9
Oxnard-Thousand Oaks-Ventura, CA	5	17	560	0.2
Stockton-Lodi, CA	1	7	320	0.1
Visalia-Porterville, CA	1	5	290	0.2
North Valley-Northern Mountains Region	2	6	280	0.3
Modesto, CA	1	3	240	0.1
Santa Maria-Santa Barbara, CA	3	5	210	0.1
Salinas, CA	1	5	210	0.1
Eastern Sierra-Mother Lode Region of California nonmetropolitan area	2	8	200	0.4
San Luis Obispo-Paso Robles-Arroyo Grande, CA	1	5	170	0.2
Santa Rosa, CA	2	6	120	0.1
Merced, CA	1	2	100	0.2

Chico, CA	1	2	70	0.1
North Coast Region	1	2	50	0.1
Redding, CA	1	2	40	0.1
Santa Cruz-Watsonville, CA	1	2	30	0.0
El Centro, CA	1	1	10	0.0

Source: PPIC calculations based on OEWS data, 2023.

NOTES: Areas not included didn't match NAICS included in our definition for the fossil fuels subsector and/or the occupations related to them.

TABLE A9

Regional detail on the phasing out fossil fuel occupations in California

Area name	# of occupations matched	# of jobs	Share total employment (%)
California	16	22,810	0.13
Los Angeles-Long Beach-Anaheim, CA	7	5,160	0.08
Bakersfield, CA	6	2,420	0.77
Riverside-San Bernardino-Ontario, CA	6	2,310	0.14
San Diego-Carlsbad, CA	5	1,410	0.10
San Francisco-Oakland-Hayward, CA	5	1,340	0.06
Sacramento--Roseville--Arden-Arcade, CA	5	670	0.07
Oxnard-Thousand Oaks-Ventura, CA	3	130	0.04
Fresno, CA	2	120	0.03
Santa Maria-Santa Barbara, CA	1	100	0.05
Santa Rosa, CA	2	50	0.03
Stockton-Lodi, CA	1	40	0.02
Redding, CA	1	40	0.07
San Jose-Sunnyvale-Santa Clara, CA	1	30	0.00
Vallejo-Fairfield, CA	3	30	0.03
North Valley-Northern Mountains Region	1	30	0.03
Hanford-Corcoran, CA	1	20	0.06
Eastern Sierra-Mother Lode Region of California nonmetropolitan area	1	10	0.02

Source: PPIC calculations based on OEWS data, 2023.

NOTES: Areas not included didn't match NAICS included in our definition for the fossil fuels subsector and/or the occupations related to them.

Wage distribution

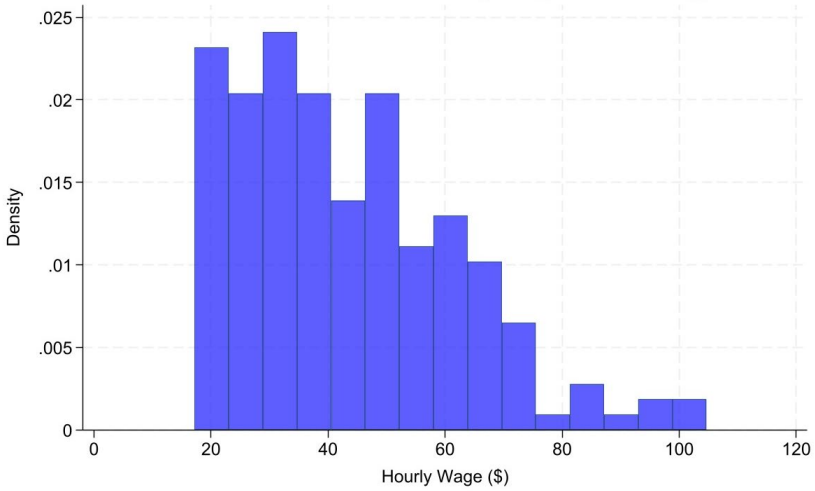
To calculate the distribution of earnings across the energy sector, we rely on OEWS data for California in 2023. While OEWS only provides the 25th, 50th, and 75th percentile points of wages for each occupation, because the wage statistics are also specific to the industry the occupation is in, these data are preferable for our analysis. This

allows us to look at wages specifically for an occupation in fossil fuel sector even if that occupation might also be present in other sectors of the economy.

To generate summary statistics, we calculate the weighted average hourly wage at the 25th, 50th, and 75th percentiles using industry-occupation level data, before aggregating to the occupational level. This is done separately for both the overall energy sector and the fossil fuels subsector. Occupations that don't have wage data on OEWS are excluded from the analysis.

FIGURE A3

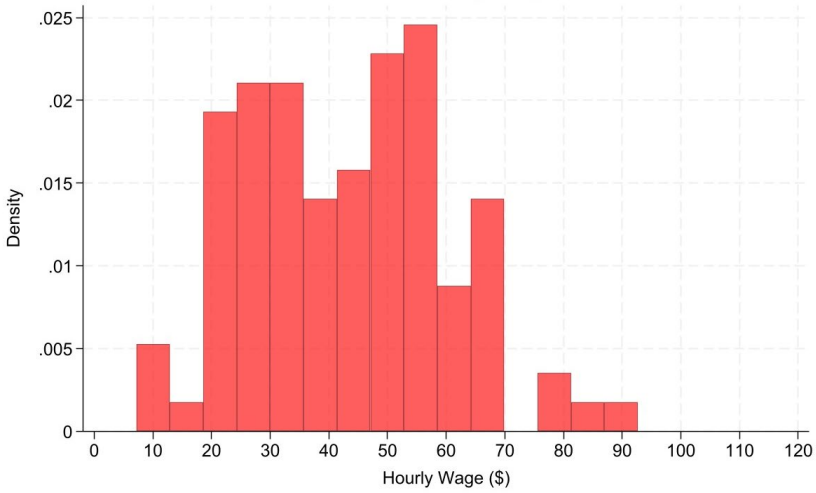
Wage distribution for all energy occupations



Source: PPIC calculations based on BLS Occupation Employment and Wage Statistics (OEWS) Data, 2023.
NOTES: Includes 185 energy occupations (6-digit SOC) with data on wages in OEWS.

FIGURE A4

Wage distribution for fossil fuels subsector occupations



Source: PPIC calculations based on BLS Occupation Employment and Wage Statistics (OEWS) Data, 2023.
NOTES: Includes 100 fossil fuels occupations (6-digit SOC) with data on wages in OEWS.

TABLE A10

Distribution of skills importance scores for energy and non-energy occupations

Element	p25	p50	p75
Non-Energy Occupations			
Communication	58	70	75
Contact with others	58	66	73
Responsibility for others	50	61	71
Conflictual contact	26	30	36
Work setting	30	41	56
Environmental conditions	21	40	58
Job hazards	12	28	39
Body positioning	28	39	50
Protective/specialized gear	26	54	65
Criticality of position	59	66	75
Routine vs. Challenging work	55	59	64
Competition	45	54	61
Pace and scheduling	40	48	61
All Energy Occupations			
Communication	55	71	79
Contact with others	60	70	78
Responsibility for others	45	56	69
Conflictual contact	28	36	46
Work setting	26	33	45
Environmental conditions	15	26	44
Job hazards	7	17	32
Body positioning	29	38	46
Protective/specialized gear	6	26	54
Criticality of position	59	67	75
Routine vs. Challenging work	54	60	66
Competition	40	50	61
Pace and scheduling	37	45	57
Fossil Fuels Occupations			
Communication	60	70	76
Contact with others	62	67	72
Responsibility for others	53	64	74
Conflictual contact	27	31	37
Work setting	34	46	59
Environmental conditions	22	43	63
Job hazards	12	31	43

Body positioning	30	39	50
Protective/specialized gear	28	56	69
Criticality of position	65	71	76
Routine vs. Challenging work	57	62	65
Competition	44	50	60
Pace and scheduling	41	51	64

SOURCE: ONET 28.2 Database, ONET Resource Network
NOTES: Includes 138 energy occupations (SOC 6-digit) and 575 non-energy occupations. Skill importance to recorded on a scale from 1 (least important) to 5 (most important) and converted to a standardized score from 0 – 100.

TABLE A11
Distribution of skills importance scores for fossil fuel occupations likely to shrink

Skill	p25	p50	p75
Energy Occupations			
Installation	0	0	13
Programming	0	5	12
Technology Design	5	9	15
Science	0	11	35
Management of Financial Resources	7	11	18
Management of Material Resources	10	15	23
Operations Analysis	9	16	34
Equipment Maintenance	0	20	39
Repairing	0	20	38
Equipment Selection	7	24	31
Troubleshooting	19	26	42
Negotiation	21	28	38
Persuasion	23	30	41
Management of Personnel Resources	23	32	38
Systems Evaluation	21	33	43
Learning Strategies	24	34	42
Service Orientation	26	34	40
Mathematics	23	36	46
Systems Analysis	22	36	44
Operation and Control	21	36	42
Instructing	26	36	42
Social Perceptiveness	33	39	42
Quality Control	29	40	45
Operations Monitoring	31	40	47
Active Learning	33	41	50

Coordination	40	42	45
Time Management	38	42	44
Writing	27	42	53
Judgment and Decisionmaking	37	42	50
Complex Problem Solving	37	43	52
Speaking	38	44	59
Monitoring	41	44	53
Active Listening	42	46	60
Reading Comprehension	38	46	62
Critical Thinking	42	50	60
Non-Energy Occupations			
Installation	0	0	0
Programming	0	2	8
Technology Design	1	7	11
Science	0	7	23
Management of Financial Resources	5	10	18
Management of Material Resources	7	14	20
Operations Analysis	5	15	29
Equipment Maintenance	0	0	24
Repairing	0	0	22
Equipment Selection	0	3	22
Troubleshooting	0	15	29
Negotiation	23	33	42
Persuasion	26	38	43
Management of Personnel Resources	23	31	40
Systems Evaluation	22	31	43
Learning Strategies	26	38	45
Service Orientation	32	42	48
Mathematics	21	27	39
Systems Analysis	22	33	43
Operation and Control	0	18	39
Instructing	27	39	47
Social Perceptiveness	36	43	54
Quality Control	14	24	39
Operations Monitoring	14	26	42
Active Learning	34	43	54
Coordination	39	42	49
Time Management	38	42	47

Writing	35	44	58
Judgment and Decisionmaking	38	43	53
Complex Problem Solving	37	43	53
Speaking	42	53	63
Monitoring	42	46	56
Active Listening	43	56	63
Reading Comprehension	41	52	63
Critical Thinking	43	52	61

SOURCE: ONET 28.2 Database, ONET Resource Network

NOTES: Includes 165 energy occupations (SOC 6-digit), 575 non-energy occupations, and 89 fossil fuels occupations. Work context importance is recorded on a scale from 1 (least important) to 5 (most important) and converted to a standardized score from 0 – 100.

TABLE A12

Entry level, job training, and work experience requirements

Job training requirement	All energy		Fossil fuels		Growing energy		Shrinking fossil fuels	
	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)
Apprenticeship	4	16	2	5	7	14	-	-
Internship	2	2	-	-	-		-	-
On-the-job train	49	39	59	61	33	48	94	97
None	45	44	39	34	60	38	6	3
Work experience requirement	**All energy**		**Fossil fuels**		**Growing energy**		**Shrinking fossil fuels**	
	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)	Occupations (%)	Jobs (%)
5 years or more	5	12	7	10	9	8	-	-
Less than 5 years	5	3	11	9	2	4	12	3
None	90	84	82	81	88	89	88	97

SOURCES: PPIC calculations based on EDD Occupational Employment and Wage Statistics Data, 2023, and Employment Projections program, U.S. Bureau of Labor Statistics.

TABLE A13

Summary top 10 closely related jobs to fossil fuel jobs likely to shrink

Code	Title	Number of energy sector (non-fossil) occupations among the 10 closest	Employment in 10 closest occupations	Percent of employment in energy sector (non-fossil) occupations
17-2171	Petroleum Engineers	10	235,930	100.0
47-2151	Pipelayers	9	159,470	99.8
47-5012	Rotary Drill Operators, Oil and Gas	3	45,760	78.6
47-5013	Service Unit Operators, Oil and Gas	4	72,460	90.3
47-5023	Earth Drillers, Except Oil and Gas	4	132,880	93.3
47-5071	Roustabouts, Oil and Gas	5	153,700	95.2
47-5081	Helpers--Extraction Workers	5	82,240	62.0
47-5099	Extraction Workers, All Other	NA	NA	NA
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	4	93,360	79.6

49-9051	Electrical Power-Line Installers and Repairers	5	96,460	95.4
51-2021	Coil Winders, Tapers, and Finishers	4	23,990	32.1
51-8012	Power Distributors and Dispatchers	4	97,370	53.5
51-8091	Chemical Plant and System Operators	1	47,600	3.3
51-8092	Gas Plant Operators	2	105,650	46.5
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	1	70,100	35.1
53-7072	Pump Operators, Except Wellhead Pumpers	1	46,380	0.5
53-7073	Wellhead Pumpers	0	67,210	0.0

SOURCES: PPIC calculations based on EDD Occupational Employment and Wage Statistics Data, 2023, and O*NET.

NOTES: Closely related occupations (and associated employment) may be duplicated across rows if they match with multiple fossil fuel occupations likely to shrink.

TABLE A14

Top 5 most proximate jobs for fossil fuel jobs likely to shrink

Fossil fuel sector occupation					Most similar occupations			
Code	Title	Share of jobs in the fossil fuels subsector	Total jobs	Average median hourly wage	Code	Title	Average median hourly wage	Change in jobs 2022-2032
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	94.6	3,480	50.9	53-7071	Gas Compressor and Gas Pumping Station Operators	26.5	0
					51-8013	Power Plant Operators	47.1	-100
					51-8013	Biomass Plant Technicians	47.1	-100
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					51-8099	Biofuels Processing Technicians	33.3	0
47-5081	Helpers--Extraction Workers	91.2	310	28.2	49-9098	Helpers--Installation, Maintenance, and Repair Workers	18.5	700
					51-9198	Helpers--Production Workers	18.9	-1,700
					47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	21.2	200
					47-3012	Helpers--Carpenters	22.2	100
					47-5041	Continuous Mining Machine Operators	29.3	0
47-5013	Service Unit Operators, Oil and Gas	87.3	3,380	29.1	53-7071	Gas Compressor and Gas Pumping Station Operators	26.5	0
					51-8013	Power Plant Operators	47.1	-100
					47-2073	Operating Engineers and Other Construction Equipment Operators	39.6	4,500
					49-9041	Industrial Machinery Mechanics	32.1	5,000
					47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	22.6	400
51-8092	Gas Plant Operators	86.7	650	56.5	51-8013	Power Plant Operators	47.1	-100
					53-7071	Gas Compressor and Gas Pumping Station Operators	26.5	0
					51-8013	Biomass Plant Technicians	47.1	-100
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					51-8013	Hydroelectric Plant Technicians	47.1	-100
47-5012	Rotary Drill Operators, Oil and Gas	81.1	300	38.5	47-5011	Derrick Operators, Oil and Gas	28.1	0
					51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	22.6	0
					47-5041	Continuous Mining Machine Operators	29.3	0
					49-9043	Maintenance Workers, Machinery	29.9	400
					47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	31.0	0

51-8091	Chemical Plant and System Operators	77.8	210	53.6	51-9011	Chemical Equipment Operators and Tenders	24.2	0
					51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	27.6	900
					51-8013	Power Plant Operators	47.1	-100
					51-8031	Water and Wastewater Treatment Plant and System Operators	38.0	-500
					51-8013	Biomass Plant Technicians	47.1	-100
47-2151	Pipelayers	74.3	1,300	39.5	47-2152	Plumbers, Pipefitters, and Steamfitters	30.3	3,900
					47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	21.2	200
					47-2061	Construction Laborers	27.3	19,900
					47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	22.6	400
					47-2131	Insulation Workers, Floor, Ceiling, and Wall	28.9	100
53-7073	Wellhead Pumpers	72.7	80	n.a.	53-7071	Gas Compressor and Gas Pumping Station Operators	26.5	0
					51-8013	Power Plant Operators	47.1	-100
					51-8013	Hydroelectric Plant Technicians	47.1	-100
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					51-8013	Biomass Plant Technicians	47.1	-100
47-5071	Roustabouts, Oil and Gas	72.4	550	35.3	49-9096	Riggers	40.6	100
					47-2073	Operating Engineers and Other Construction Equipment Operators	39.6	4,500
					49-9043	Maintenance Workers, Machinery	29.9	400
					47-5011	Derrick Operators, Oil and Gas	28.1	0
					47-2061	Construction Laborers	27.3	19,900
53-7072	Pump Operators, Except Wellhead Pumpers	67.4	600	23.5	53-7071	Gas Compressor and Gas Pumping Station Operators	26.5	0
					51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	27.6	900
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					51-8013	Power Plant Operators	47.1	-100
					53-7121	Tank Car, Truck, and Ship Loaders	28.4	0
47-5099	Extraction Workers, All Other	61.5	80	22.5	n.a.	n.a.	n.a.	n.a.
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	57.2	2,500	48.6	49-2092	Electric Motor, Power Tool, and Related Repairers	29.3	100
					49-9041	Industrial Machinery Mechanics	32.1	5,000
					51-2031	Engine and Other Machine Assemblers	22.9	-100
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					49-9043	Maintenance Workers, Machinery	29.9	400
49-9051	Electrical Power-Line Installers and Repairers	55.9	5,030	51.9	49-9052	Telecommunications Line Installers and Repairers	39.7	1,300
					47-3013	Helpers--Electricians	19.1	100
					47-2111	Electricians	37.3	10,400
					49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	54.4	200
					49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	39.4	0
51-8012	Power Distributors and Dispatchers	52.0	510	48.2	51-8013	Power Plant Operators	47.1	-100
					51-8013	Hydroelectric Plant Technicians	47.1	-100
					49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	54.4	200
					51-8021	Stationary Engineers and Boiler Operators	27.9	1,600
					49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	39.4	0

51-2021	Coil Winders, Tapers, and Finishers	51.5	340	20.9	51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	23.3	-200
					51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	22.2	-100
					51-6091	Extruding and Forming Machine Setters, Operators, and Tenders, Synthetic and Glass Fibers	23.1	0
					51-4194	Tool Grinders, Filers, and Sharpeners	23.6	0
					51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	19.9	100
17-2171	Petroleum Engineers	41.3	640	60.2	17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	64.5	100
					17-2041	Chemical Engineers	53.3	0
					17-2051	Water/Wastewater Engineers	50.5	6,200
					11-3051	Geothermal Production Managers	62.0	1,000
					17-2112	Industrial Engineers	53.7	3,800
47-5023	Earth Drillers, Except Oil and Gas	40.2	450	30.0	47-5041	Continuous Mining Machine Operators	29.3	0
					51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	22.6	0
					47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	31.0	0
					47-2073	Operating Engineers and Other Construction Equipment Operators	39.6	4,500
					47-5032	Explosives Workers, Ordnance Handling Experts, and Blasters	37.0	0

SOURCES: PPIC calculations based on EDD Occupational Employment and Wage Statistics Data, 2023, Employment Projections program, U.S. Bureau of Labor Statistics, and O*NET.

TABLE A15

Distribution of education, experience, and training scores

Job Requirement	Min	p25	p50	p75	Mean	Max
Energy occupations						
Required Level of Education	3.4	11.0	18.0	37.0	24.4	68.2
Related Work Experience	8.1	35.9	46.4	53.9	44.9	82.3
On-the-Job Training	19.5	37.7	44.6	51.5	44.4	73.5
On-Site or In-Plant Training	10.8	28.3	35.4	44.7	36.1	62.4
Non-energy occupations						
Required Level of Education	3.2	12.5	23.8	46.9	32.8	97.9
Related Work Experience	2.5	28.7	42.0	53.7	41.7	91.2
On-the-Job Training	4.7	26.0	34.1	41.4	33.8	71.2
On-Site or In-Plant Training	6.0	21.8	28.9	35.9	29.2	67.8

SOURCE: ONET 28.2 Database, ONET Resource Network

NOTES: Required level of education is measured on a scale from 1 (less than a high school diploma) to 12 (post-doctoral training). Related work experience is measured on a scale from 1 (none) to 11 (over 10 years). On-the-Job training and on-site/in-plant training are measured on a scale from 1 (none) to 9 (over 10 years). All scores are standardized to a scale from 0 – 100 where score of 50 is equivalent to bachelor's degree for education, 1 to 2 years for related work experience, and 6 months to 1 year for on-the-job and on-site training.

TABLE A16

Energy occupations used by Popp et al. (2024) to identify job growth

SOC Code	Occupation	In our definition of growing energy jobs
11-3071.00	Transportation, Storage, and Distribution Managers	
11-9021.00	Construction Managers	Yes
11-9041.00	Architectural and Engineering Managers	Yes
11-9041.01	Biofuels/Biodiesel Technology and Product Development Managers	Yes
11-9199.01	Regulatory Affairs Managers	Yes
11-9199.02	Compliance Managers	Yes
11-9199.09	Wind Energy Operations Managers	Yes
11-9199.10	Wind Energy Development Managers	Yes
13-1041.07	Regulatory Affairs Specialists	Yes
17-2011.00	Aerospace Engineers	Yes
17-2051.00	Civil Engineers	Yes
17-2051.01	Transportation Engineers	Yes
17-2071.00	Electrical Engineers	Yes
17-2072.00	Electronics Engineers, Except Computer	Yes
17-2081.00	Environmental Engineers	Yes
17-2141.00	Mechanical Engineers	Yes
17-2141.01	Fuel Cell Engineers	Yes
17-2141.02	Automotive Engineers	Yes
17-2161.00	Nuclear Engineers	
17-2199.03	Energy Engineers, Except Wind and Solar	Yes
17-2199.10	Wind Energy Engineers	Yes
17-2199.11	Solar Energy Systems Engineers	Yes
17-3023.00	Electrical and Electronic Engineering Technologists and Technicians	Yes
17-3027.01	Automotive Engineering Technicians	Yes
17-3029.08	Photonics Technicians	Yes
19-2021.00	Atmospheric and Space Scientists	
19-2041.01	Climate Change Policy Analysts	Yes
19-2099.01	Remote Sensing Scientists and Technologists	Yes
19-3051.00	Urban and Regional Planners	Yes
19-4042.00	Environmental Science and Protection Technicians, Including Health	Yes
19-4043.00	Geological Technicians, Except Hydrologic Technicians	Yes
19-4051.00	Nuclear Technicians	
19-4099.03	Remote Sensing Technicians	Yes
41-4011.07	Solar Sales Representatives and Assessors	Yes
47-2061.00	Construction Laborers	Yes
47-2152.04	Solar Thermal Installers and Technicians	Yes
47-2181.00	Roofers	
47-2211.00	Sheet Metal Workers	Yes

47-2231.00	Solar Photovoltaic Installers	Yes
47-4011.00	Construction and Building Inspectors	Yes
47-4011.01	Energy Auditors	Yes
47-4099.03	Weatherization Installers and Technicians	
49-3023.00	Automotive Service Technicians and Mechanics	
49-9021.00	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Yes
49-9071.00	Maintenance and Repair Workers, General	
49-9081.00	Wind Turbine Service Technicians	
49-9099.01	Geothermal Technicians	
51-8011.00	Nuclear Power Reactor Operators	
51-8013.00	Power Plant Operators	
51-8013.03	Biomass Plant Technicians	
51-8013.04	Hydroelectric Plant Technicians	
51-8099.01	Biofuels Processing Technicians	
53-6051.07	Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation	

NOTE: Occupations in our definition that match Popp's list at the 6-digitit level.

TABLE A17

Fossil fuel occupations used by Greenspon and Raimi (2025) that are included in this report's definition of occupations likely to shrink

SOC Code	Occupation	In our definition of shrinking fossil jobs
17-2041	Chemical Engineers	
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	
17-2171	Petroleum Engineers	Yes
17-3028	Calibration Technologists and Technicians	
19-2042	Geoscientists, Except Hydrologists and Geographers	
19-4043	Geological Technicians, Except Hydrologic Technicians	
47-5011	Derrick Operators, Oil and Gas	
47-5012	Rotary Drill Operators, Oil and Gas	Yes
47-5013	Service Unit Operators, Oil and Gas	Yes
47-5021	Earth Drillers, Except Oil and Gas	
47-5041	Continuous Mining Machine Operators	
47-5049	Underground Mining Machine Operators, All Other	
47-5071	Roustabouts, Oil and Gas	Yes
47-5081	Helpers—Extraction Workers	Yes
47-5099	Extraction Workers, All Other	Yes
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	Yes
49-9041	Industrial Machinery Mechanics	
49-9096	Riggers	

51-8012	Power Distributors and Dispatchers	Yes
51-8013	Power Plant Operators	
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Yes
51-8099	Plant and System Operators, All Other	
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	
53-7011	Conveyor Operators and Tenders	
53-7032	Excavating and Loading Machine and Dragline Operators, Surface Mining	
53-7033	Loading and Moving Machine Operators, Underground Mining	
53-7072	Pump Operators, Except Wellhead Pumpers	Yes
53-7073	Wellhead Pumpers	Yes
53-7121	Tank Car, Truck, and Ship Loaders	

NOTE: Occupations in our definition must match the Greenspon and Raimi (2025) list at the 6-digit level (meaning their employment in California is sufficiently large to be separately identified in OEWS) and must meet our requirement of being especially concentrated in the California fossil fuel sector (we use a cutoff of 40%, meaning that the occupation must have at least 40% of jobs statewide in the fossil fuel subsector to be considered concentrated).

Stakeholders consulted

A range of conversations were held with energy and workforce experts through the course of this research. The discussions centered around methodological approaches to quantify and characterize the energy workforce, as well as their limitations. Also, discussions sought to surface perspectives from various stakeholders on the ground in the energy sector about the skills that are needed to support the energy sector and what barriers they face to recruiting and retaining a skilled workforce. Discussions included the transition of oil and gas workers to other jobs within the energy sector or to other economic sectors and potential approaches to supporting this transition. Finally, discussions provided insights on policy alternatives to continue developing career and education pathways that lead to growing opportunities jobs in the energy sector.

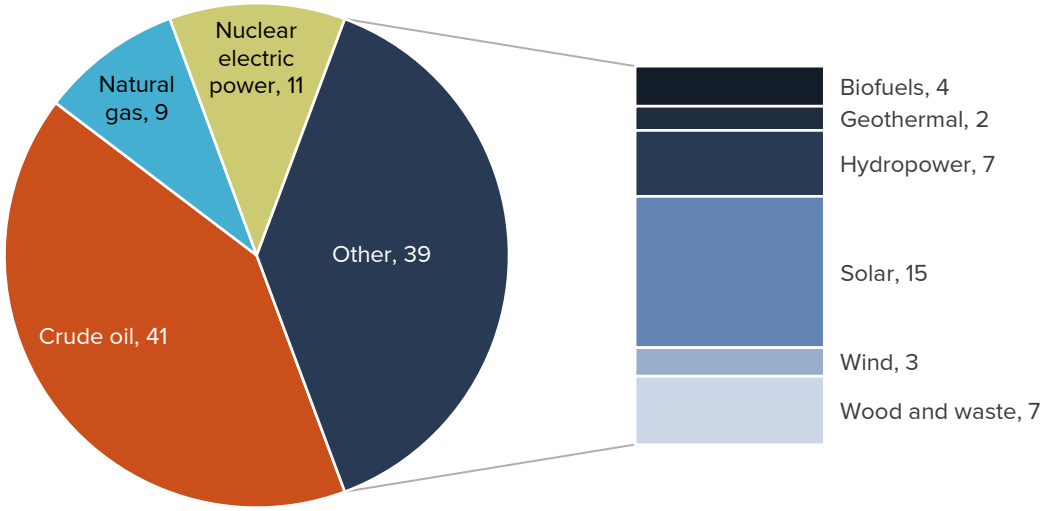
Some of the stakeholders consulted during the elaboration of this report included: academics and policy researchers, union leaders, business organizations in the energy sector, individual energy businesses and their representatives, and state and federal energy agency staff.

Appendix B. Supplementary Figures and Tables

FIGURE B1

Energy production California, 2023

%



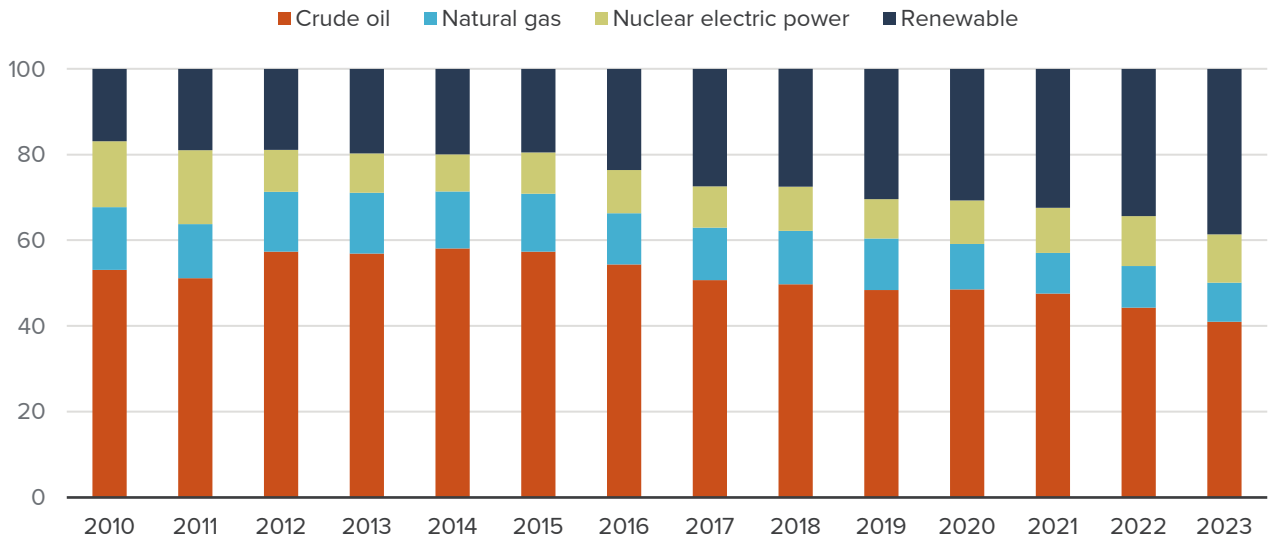
Source: Source: US Energy Information Administration, State Energy Data System, as of 2023.

Notes: percentage of Btu shown.

FIGURE B2

Energy production in California, 2010–2023

%



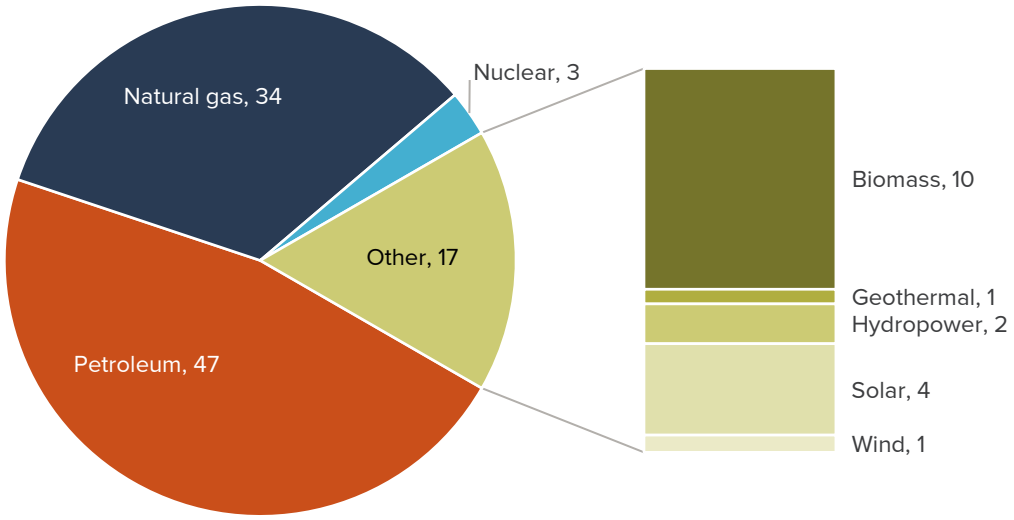
Source: US Energy Information Administration, State Energy Data System, as of 2023.

Notes: Percentage of Btu shown. Renewable includes biomass, geothermal, hydropower, solar, wind, and wood and waste energy.

FIGURE B3

Energy consumption in California, 2023

%

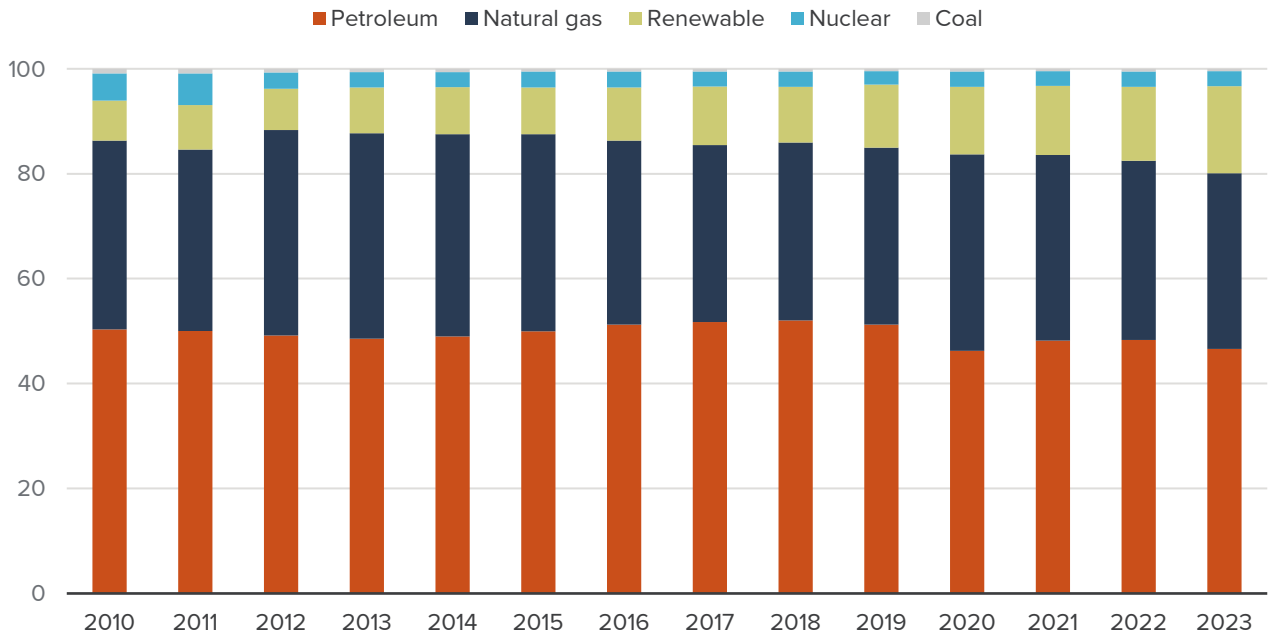


Source: US Energy Information Administration, State Energy Data System, as of 2023.Note: Percentage of Btu shown. Petroleum is a broader term for consumption products (gasoline, diesel, and jet fuel), refined from crude oil, which is referenced in the prior figure.

FIGURE B5

Energy consumption in California, 2010–2023

%



Source: US Energy Information Administration, State Energy Data System, as of 2023.

Notes: Percentage of Btu shown. Renewable includes biofuels, wood and waste, geothermal, hydroelectric power, solar, and wind energy.

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