



**2021**

**Pennsylvania Energy  
Employment Report**

PRODUCED FOR THE PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL  
PROTECTION ENERGY PROGRAMS OFFICE

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PARTNERSHIP

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## Introduction

The 2021 Pennsylvania Energy Employment Report is a follow up to the 2020 report that tracks energy employment across the state. This report provides energy employment data from 2017 through 2020 for the major energy technology sectors<sup>1</sup>, their component sub-technologies, as well as key industry crosscuts, including natural gas, petroleum, coal, and nuclear. This year's report is especially important as it follows the aftermath of the global Coronavirus (COVID-19) pandemic and provides important information on the state of Pennsylvania's energy labor market and the impacts of the pandemic on energy sector employment.

The Pennsylvania Department of Environmental Protection (DEP) Energy Programs Office commissioned BW Research Partnership to produce this second installment of the Pennsylvania Energy Employment Report. The DEP works to protect Pennsylvania's air, land, and water from pollution, restore these natural resources, and provide for the health and safety of its citizens through a cleaner environment. Advancing this mission, the DEP Energy Programs Office is the primary entity under the Governor's jurisdiction for the implementation of programs that promote knowledge and adoption of energy efficiency and energy conservation technologies and indigenous, clean, diverse, and alternative fuels, including energy production and use technologies. One of its core functions is to work with partners to gather data and develop resources to enable policymakers, planners, and other leaders throughout Pennsylvania to achieve informed and best-outcome decisions related to energy.

All data presented are based on the 2021 United States Energy and Employment Report (USEER) data collection, a joint project of the National Association of State Energy Officials (NASEO) and the Energy Futures Initiative (EFI).<sup>2</sup> For more information on the methodology, please refer to Appendix A. For a detailed list of energy sub-technologies included in this report, please refer to Appendix B.

*Acknowledgments: This material is based on work supported by the United States Department of Energy, Office of Energy Efficiency and Renewable Energy, under State Energy Program Award Number EE0008293.*

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<sup>1</sup> The major energy technology sectors are as follows: (1) electric power generation; (2) transmission, distribution, and storage; (3) fuels; (4) energy efficiency; and (5) motor vehicles.

<sup>2</sup> <https://www.usenergyjobs.org/>.

## Pennsylvania Energy Jobs Overview

At the end of 2020, there were 249,890 energy workers across the state of Pennsylvania accounting for 4.5 percent of all jobs.<sup>3</sup> Total energy employment declined by about seven percent, or nearly 19,400 jobs, compared to the last quarter of 2019, returning Pennsylvania back to a level of jobs seen in 2017. Energy employment in Pennsylvania is now half a percent lower compared to the 2017 baseline. Job losses in the energy sector are on par with the statewide average. Between 2019 and 2020, Pennsylvania's overall labor market also declined by roughly seven percent, shedding nearly 425,000 jobs.<sup>4</sup> However, despite net job loss in 2020, employment declines were largely concentrated in Q2 2020 from March through May, at the peak of the economic contraction. Throughout the rest of the year, modest job gains were witnessed between June through December 2020, and in the first quarter of 2021, energy employment in Pennsylvania grew by an additional 0.7 percent, indicating that the energy sector will likely continue on a growth and recovery trend throughout the remainder of 2021.

**The fuels sector shed the highest number of jobs, followed by energy efficiency, at a 16 percent and nine percent decline, respectively; the remaining three sectors shed jobs at a rate of roughly one to seven percent.** Employment in the fuels sector, which is the third largest energy sector, declined by 8,500 workers from 2019 through 2020—a decline of 16 percent in 12 months. To date, fuels employment represents almost 18 percent of all energy jobs in Pennsylvania. Energy efficiency firms shed just over 6,000 jobs for a loss of nearly nine percent between the last quarters of 2019 and 2020. Energy efficiency jobs account for just over a quarter of total energy employment across the state. Employment in electric power generation declined by about four percent from 2019 through 2020. To date, there are now roughly 19,700 electric power generation workers in the state, representing about eight percent of all energy jobs. The motor vehicles sector is the largest source of energy employment in Pennsylvania, comprising almost a third of all energy jobs at the end of 2020. Compared to the last quarter of 2019, motor vehicles employment declined by 1.3 percent or just over 1,000 jobs. Transmission, distribution, and storage accounts for almost 17 percent of total energy employment and declined by roughly 3,000 jobs, or almost seven percent, between 2019 and 2020.

**All industry crosscuts shed jobs between 2019 and 2020, with the petroleum and natural gas industries exhibiting the largest losses.** Petroleum jobs, including production and extraction, transportation, storage, and electricity generation, declined by 14 percent—a loss of almost 3,400 workers. Following petroleum, the natural gas industry shed just over 2,700 jobs for a decline of 11.4 percent while coal firms lost almost 1,200 jobs for a decline of 11.2 percent. A smaller industry, nuclear employment declined by just over 300 jobs, or six percent.

**Nearly all sub-sectors with the exception of electric and hybrid electric vehicles saw job losses between 2019 and 2020, and solar jobs were largely unaffected by economywide employment losses.** Despite industry-wide employment declines, the electric and hybrid electric vehicle sub-sectors actually saw employment growth. Hybrid electric vehicle firms experienced a five percent growth in jobs, roughly 180 workers, while electric vehicle firms grew by seven percent, for an increase of 125 jobs in 12 months.

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<sup>3</sup> Total state employment is taken from the Bureau of Labor Statistics, Quarterly Census of Employment and Wages. Data was accessed in March 2021. As of September 2020, there were a total of 5.5 million workers in Pennsylvania.

<sup>4</sup> *Id.*

Employment in the solar sub-sector, the largest source of electric power generation jobs in Pennsylvania, remained steady from 2019 through 2020, declining by less than half a percent.

FIGURE 1. ENERGY EMPLOYMENT IN PENNSYLVANIA, 2017-2020

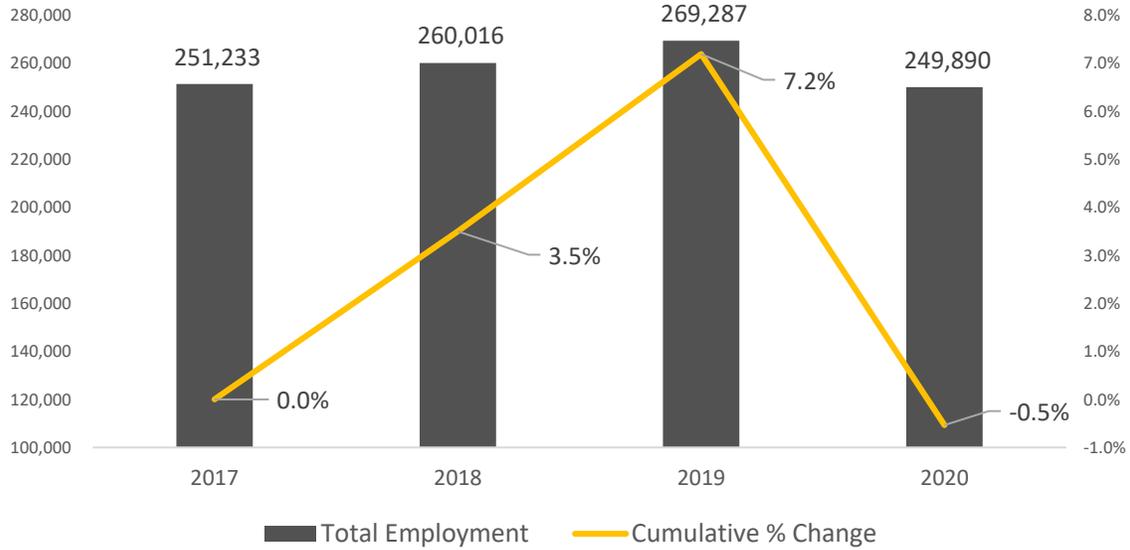
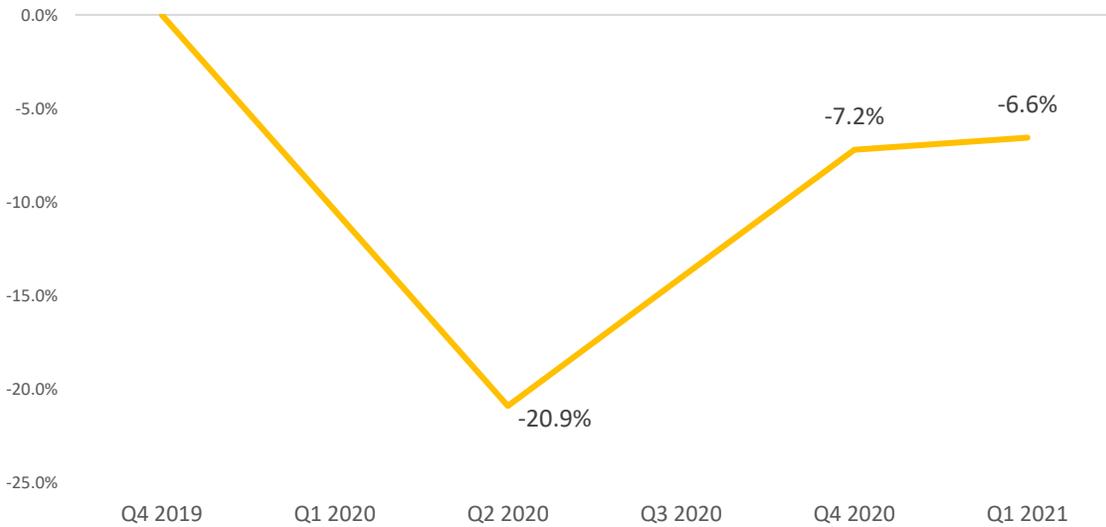
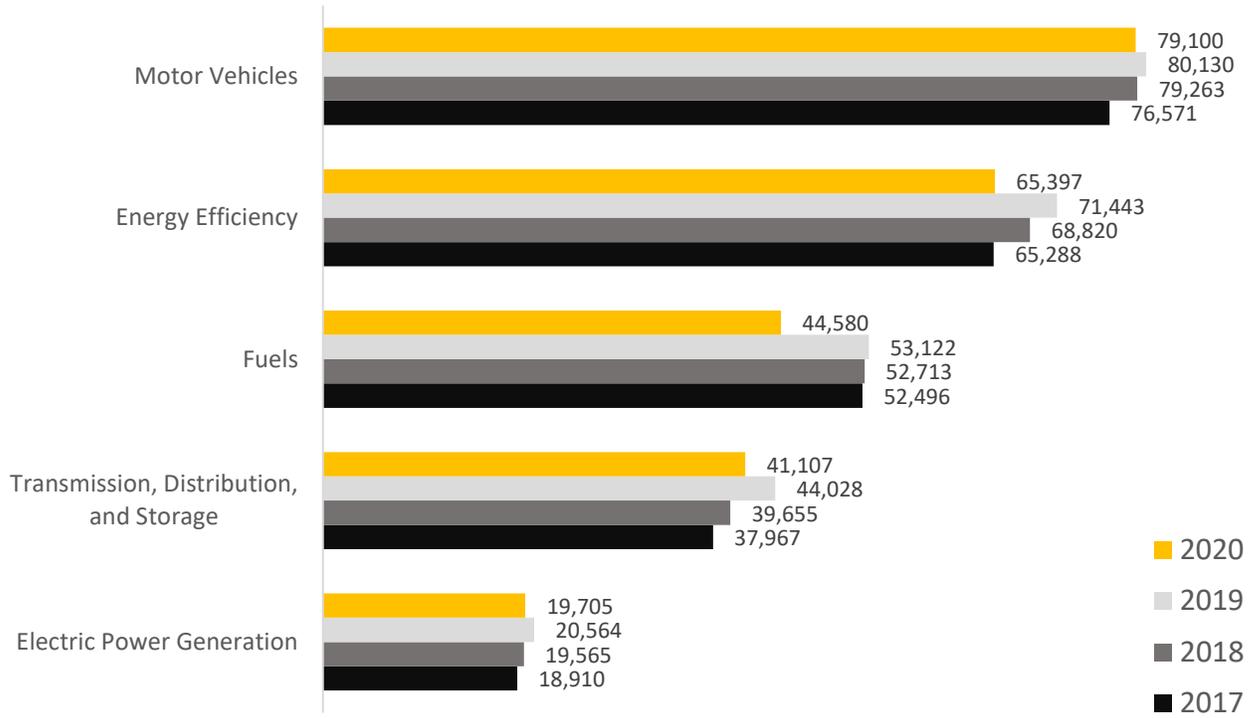


FIGURE 2. QUARTERLY CHANGE IN ENERGY EMPLOYMENT, Q4 2019 – Q1 2021<sup>5</sup>



<sup>5</sup> The data featured in Figure 2 is a combination of two methodologies, both of which are based on publicly-available employment data from the federal government. BW Research conducted monthly energy employment updates throughout 2020 based on UI filings, which can be found at <https://bwresearch.com/covid/>. This methodology differs slightly from the underlying USEER dataset which relies on quarterly data from the BLS QCEW data series. Though the absolute values and percentages differ slightly across both methodologies, the overall trend in employment changes for each quarter is nearly identical. As such, Figure 2 is meant to provide a visual representation of these trends.

FIGURE 3. ENERGY EMPLOYMENT BY TECHNOLOGY, 2017-2020



## Industry Crosscut Employment

The following section provides an update to last year’s “industry crosscut” analysis, which highlights specific industries or fuel sources with jobs that span multiple technology sectors. The aggregation of industry- and fuel-specific jobs is important for sectors like coal or petroleum, as employment related to these fuel sources and technologies is contained across fuels, electric power generation, and transmission, distribution, and storage. For example, coal mining workers are counted in the fuels sector while coal electric power generation workers are counted under the electric power generation sector. At the end of 2020, Pennsylvania’s natural gas, petroleum, coal, and nuclear industries totaled to the following:

Natural Gas Jobs	Petroleum Jobs	Coal Jobs	Nuclear Jobs
<b>21,029</b>	<b>20,328</b>	<b>9,190</b>	<b>4,837</b>

These employment totals include all jobs across fuel extraction and mining, power line transmission and wholesale trade and distribution, fuel storage, and electricity generation from the above sources of energy.

### Petroleum

Following significant employment growth from 2017 through 2019, the petroleum industry in Pennsylvania declined by about 3,400 jobs between 2019 and 2020, placing the industry’s total job count at about 300 jobs lower than the 2017 baseline. Overall, the industry saw employment decline by just over 14 percent compared to the last quarter of 2019; these declines were largely the result of losses from the petroleum fuels sector, as oil electric power generation represents a small segment of jobs in Pennsylvania’s energy industry. Job losses in the state’s petroleum industry came alongside a 21 percent decrease in the field production of crude oil between 2019 and 2020.<sup>6</sup> Nationwide, crude oil production declined by almost 16 percent—from 2.3 quadrillion Btus to 1.9 quadrillion Btus—between December 2019 and November 2020.<sup>7</sup>

### Natural Gas

Natural gas industry employment was generally on the decline prior to COVID-19. From 2017 through 2019, natural gas jobs declined by over seven percent—mostly the result of job losses in the natural gas fuels sector. Between 2019 and 2020 alone, natural gas industry employment declined by more than 2,700 jobs, or about 11 percent. Though Pennsylvania is the nation’s second largest producer of natural gas, producing seven trillion cubic feet in 2019 and accounting for one-fifth of U.S. gas production,<sup>8</sup>

<sup>6</sup> U.S. Energy Information Administration. Pennsylvania Field Production of Crude Oil. Data accessed March 2021.

<sup>7</sup> U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source. Monthly Energy Review, February 2021. Data accessed March 2021.

<sup>8</sup> U.S. Energy Information Administration. State Profile and Energy Estimates. Last updated September 2020. Data accessed March 2021.

limited job growth from a downturn in new well fracking may continue to strain employment in the state's natural gas industry.<sup>9</sup>

## Coal

Similar to natural gas, the coal industry in Pennsylvania had seen job losses prior to COVID-19. Between 2017 and 2019, coal industry employment declined by just over three percent, the result of job losses in the coal electric power generation sector. Between 2019 and 2020, coal industry jobs in the state declined by 11 percent, for an additional loss of almost 1,200 jobs. Over the first eight months of 2020, coal production in Pennsylvania was down 23 percent compared to the same period in 2019.<sup>10</sup> Job losses in the coal industry are likely to continue as the state and nation keep trending away from coal fuels for electric power generation. Nationally, coal production has declined by 37 percent from 2000 through 2019. Between December 2019 and November 2020 alone, coal production declined by another 13 percent across the U.S.<sup>11</sup>

## Nuclear

Nuclear industry jobs have slowly been declining in Pennsylvania. From 2017 through 2019, the nuclear industry shed about 240 jobs—a roughly five percent decline in two years. Between 2019 and 2020 alone, the nuclear industry shed another 300 jobs, a decline of six percent in 12 months. The closure of Three Mile Island at the end of 2019 resulted in hundreds of job losses for the state's nuclear industry.<sup>12</sup> Also in 2019, natural gas-fired power plants overtook nuclear power as the number one producer for in-state electricity generation.<sup>13</sup> Nuclear production in general has declined across the United States. Between 2000 and 2019, nuclear electric power production declined by almost eight percent, and from December 2019 to November 2020, nationwide nuclear electric power production declined by almost 16 percent.<sup>14</sup>

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<sup>9</sup> See generally: Deto, Ryan. Report Shows Natural Gas Fracking Didn't Produce Promised Jobs to Pennsylvania and Appalachia. February 2021. <https://www.pghcitypaper.com/pittsburgh/report-shows-natural-gas-fracking-didnt-produce-promised-jobs-to-pa-and-appalachia/Content?oid=18902088> and Ohio River Valley Institute. Fracking Counties Economic Impact Report. February 2021. <https://ohiorivervalleyinstitute.org/new-report-natural-gas-county-economies-suffered-as-production-boomed/>.

<sup>10</sup> U.S. Energy Information Administration. State Profile and Energy Estimates. Last updated September 2020. Data accessed March 2021.

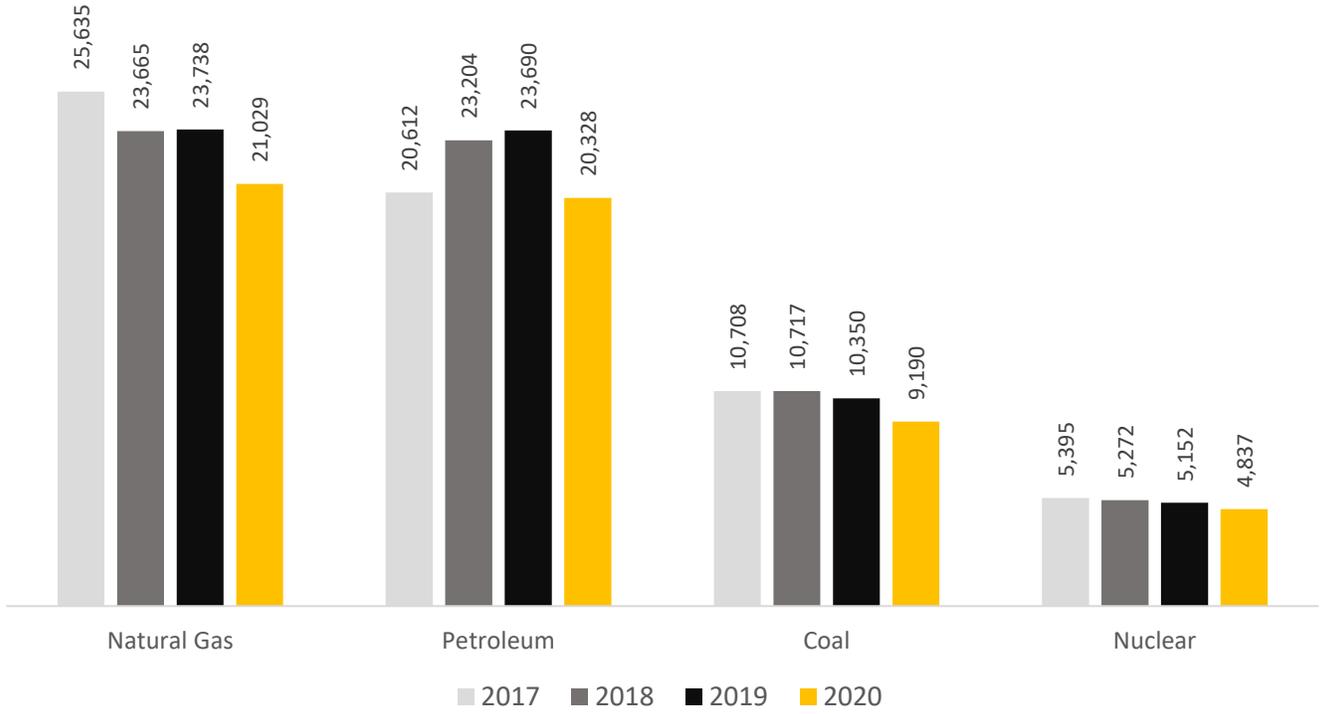
<sup>11</sup> U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source. Monthly Energy Review, February 2021. Data accessed March 2021.

<sup>12</sup> Hawkes, Jeff. Over 100 Three Mile Island Workers Losing Jobs Oct. 1 when Unit 1 Closes, According to Exelon Notice. August 2019. [https://lancasteronline.com/news/local/over-100-three-mile-island-workers-losing-jobs-oct-1-when-unit-1-closes-according/article\\_2464acea-c444-11e9-a5dd-a7119de65deb.html](https://lancasteronline.com/news/local/over-100-three-mile-island-workers-losing-jobs-oct-1-when-unit-1-closes-according/article_2464acea-c444-11e9-a5dd-a7119de65deb.html).

<sup>13</sup> U.S. Energy Information Administration. State Profile and Energy Estimates. Last updated September 2020. Data accessed March 2021.

<sup>14</sup> U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source. Monthly Energy Review, February 2021. Data accessed March 2021.

FIGURE 4. INDUSTRY CROSSCUT EMPLOYMENT, 2017-2020



# Detailed Technology Sector Employment

## Motor Vehicles

The motor vehicles sector includes cars, light- and heavy-duty trucks, trailers, and motor vehicle component parts. Employment in this sector spans multiple industries, including manufacturing, repair and maintenance, wholesale trade, and professional and business services, as well as numerous occupations, such as mechanics and technicians, wholesale trade or manufacturing sales representatives, production workers, machinists, and team assemblers, as well as managers and supervisors of these workers.<sup>15</sup>

There were 79,100 motor vehicle jobs in Pennsylvania at the end of 2020. Gasoline and diesel vehicles remain the largest sub-sector, representing almost eight in ten motor vehicle employees in Pennsylvania, or 62,100 jobs at the end of 2020. Following significant growth from 2017 through 2019, the sub-sector shed just over 1,000 jobs between 2019 and 2020—a decline of almost two percent. The only two sub-sectors that did not experience job losses over this time period were hybrid electric and electric vehicles. In fact, from 2019 through 2020, hybrid electric vehicle firms saw employment grow by five percent or about 180 jobs while electric vehicle firms increased employment by seven percent, or 125 jobs.

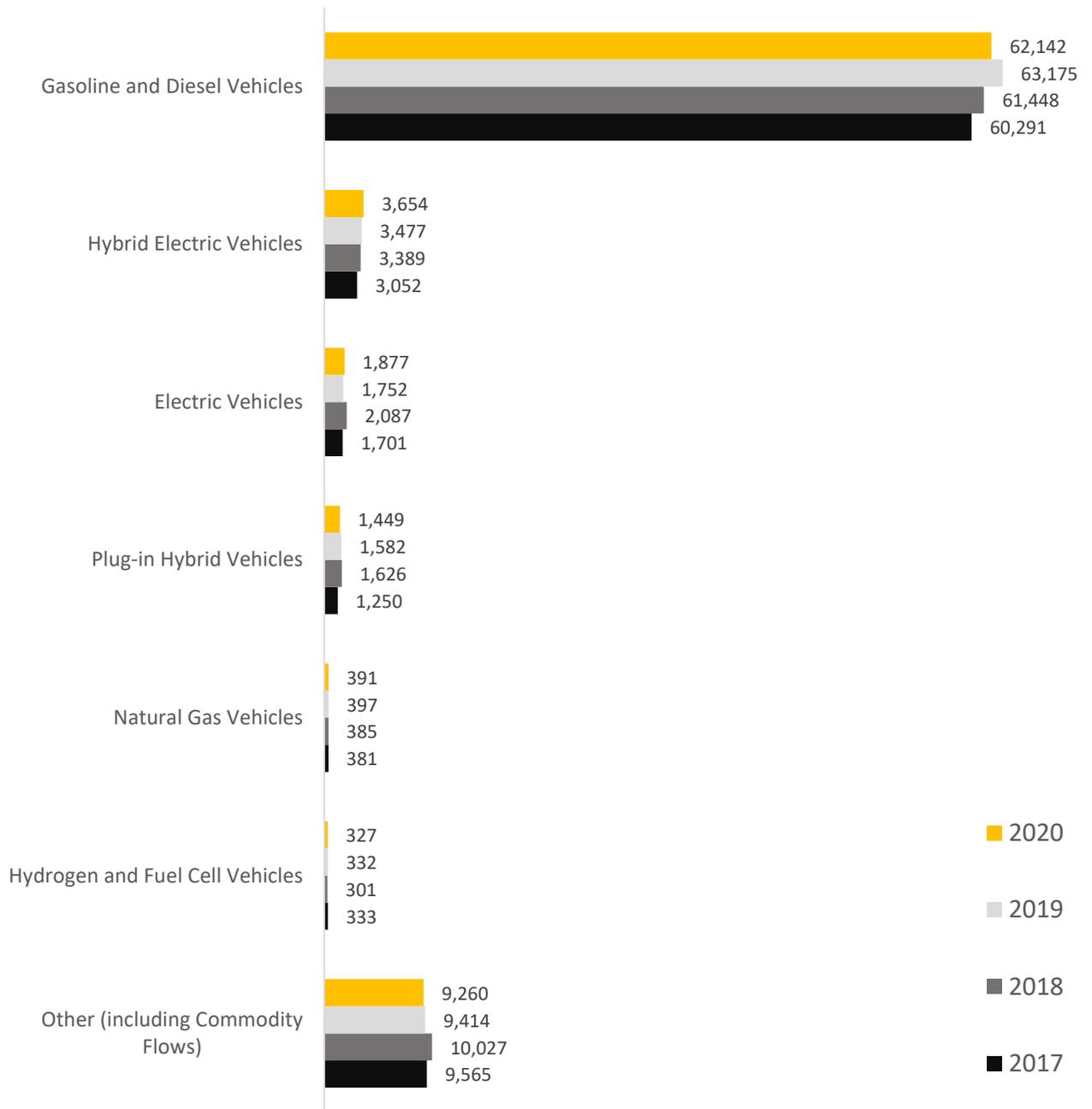
As of November 2020, there were more than 29,000 electric passenger vehicles registered in Pennsylvania. In fact, the number of electric vehicles in the state has doubled since 2017, and in general, annual electric vehicles sales for both plug-in hybrid and battery electric vehicles have increased from under 2,000 in 2015 to about 6,000 in 2019. In 2019 alone, the DEP Alternative Fuel Vehicles Rebate Program provided more than 2,400 rebates totaling roughly \$3.6 million for the purchase of electric or plug-in hybrid vehicles. With further plans to expand consumer rebates and increase electric vehicle sales, employment growth in these two sub-sectors, plug-in hybrid and electric vehicles, is promising.<sup>16</sup>

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<sup>15</sup> Car salesmen and car dealerships are excluded from motor vehicle employment. In general, the USEER data collection effort expressly excludes any employment in retail trade, such as motor vehicle dealerships, appliance and hardware stores, and other retail establishments.

<sup>16</sup> Pennsylvania Department of Environmental Protection. Pennsylvania Electric Vehicle Roadmap: 2021 Update. <https://files.dep.state.pa.us/Energy/OfficeofPollutionPrevention/StateEnergyProgram/PAElectricVehRoadmapBookletDEP5334.pdf>.

FIGURE 5. MOTOR VEHICLE EMPLOYMENT BY SUB-SECTOR, 2017-2020<sup>17</sup>



<sup>17</sup> Commodity flows include air, rail, water, and truck transportation of motor vehicles and motor vehicle component parts. Employers also place their workers in the “other” category when they are unable to assign employees to specific sub-technology/sub-sector for which they spend most of their labor hours. Higher employment in “other” motor vehicles is common, since much of employment is concentrated in repair and maintenance, and motor vehicle repair technicians tend to work across multiple technologies.

## Energy Efficiency

Most energy efficiency jobs are found in the construction trades, though employment also spans other industries, such as professional and business services, manufacturing, and wholesale trade. This sector includes work dedicated to the production and installation of energy-saving products as well as the provision of services that reduce end-use energy consumption. Typical energy efficiency occupations include carpenters, electricians, insulation workers, HVAC workers, sales representatives, engineers, and architects; these are individuals that work with or manufacture ENERGY STAR® products, design buildings to improve natural light and reduce overall energy consumption, provide insulation, or install, maintain, and repair energy-efficient products or software services.

At the end of 2020, there were almost 65,400 energy efficiency workers across Pennsylvania. Traditional HVAC<sup>18</sup> and high efficiency HVAC and renewable heating and cooling account for the largest share of workers, at 28 and 23 percent of total energy efficiency jobs, respectively. In 2020, Pennsylvania ranked 19<sup>th</sup> in the nation in terms of energy efficiency policies and programs—one position lower compared to the 2019 scorecard.<sup>19</sup>

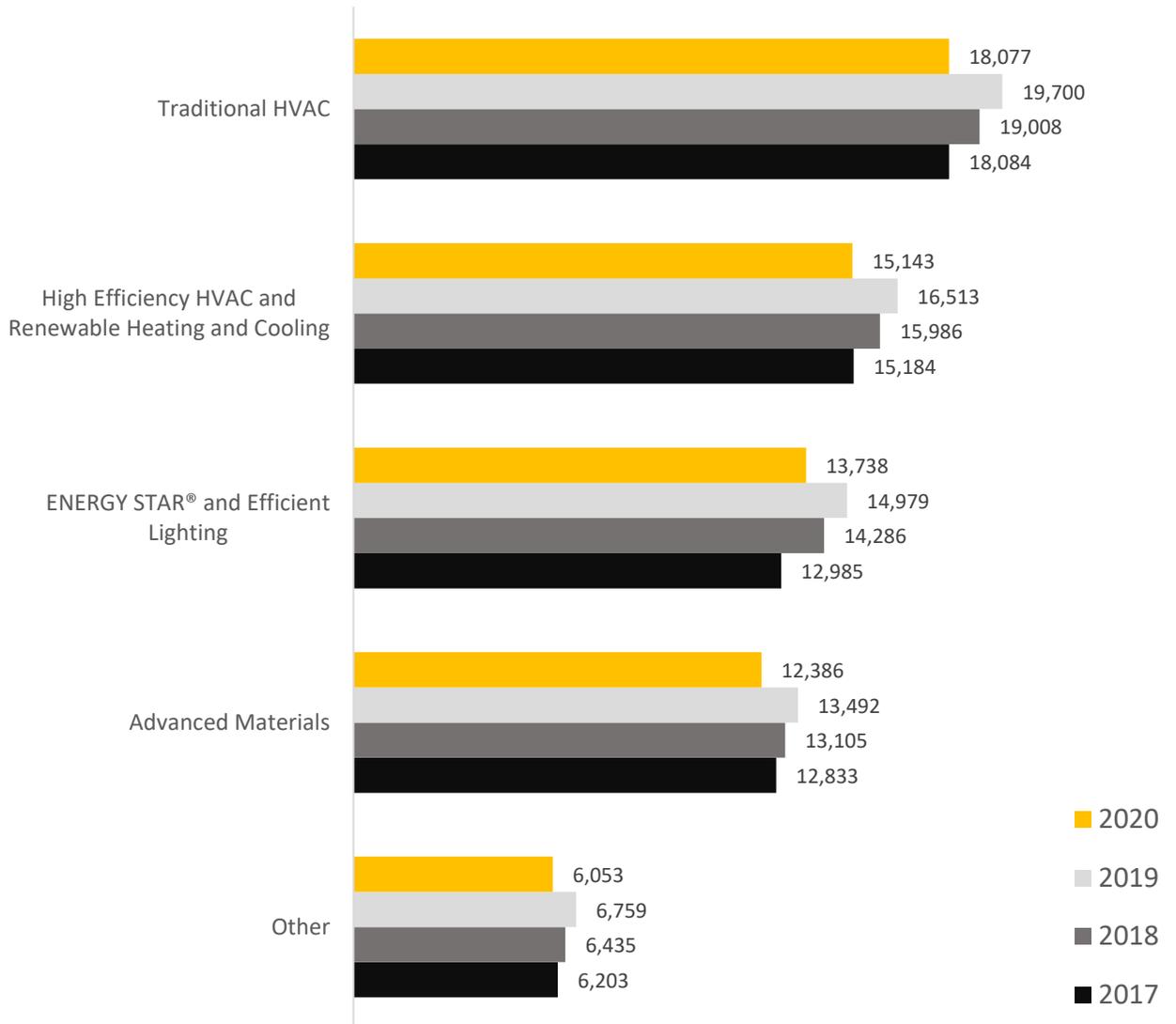
Between 2017 and 2019, all energy efficiency sub-sectors experienced employment growth. However, from 2019 through 2020, all sub-sectors saw job losses. Traditional HVAC firms shed just over 1,600 jobs from the last quarter of 2019 to the last quarter of 2020, a decline of roughly eight percent. Employment in the high efficiency HVAC and renewable heating and cooling sub-sector also declined by just over eight percent—a loss of nearly 1,400 jobs—while ENERGY STAR® and efficient lighting firms shed more than 1,200 jobs. The advanced materials sub-sector lost roughly 1,100 workers and the “other” energy efficiency sub-sector shed about 700 jobs for a decline of just over 10 percent in 12 months.

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<sup>18</sup> Traditional HVAC workers are those that spend a portion of their time on efficient HVAC goods and services, but do not spend the majority of their labor hours on energy-efficient HVAC technologies.

<sup>19</sup> American Council for an Energy-Efficiency Economy. 2020 State Energy Efficiency Scorecard. [https://www.aceee.org/sites/default/files/pdfs/ACEEE\\_ScrSht20\\_Pennsylvania.pdf](https://www.aceee.org/sites/default/files/pdfs/ACEEE_ScrSht20_Pennsylvania.pdf).

FIGURE 6. ENERGY EFFICIENCY EMPLOYMENT BY SUB-SECTOR, 2017-2020<sup>20</sup>



<sup>20</sup> The “other” energy efficiency sub-sector includes design, consulting, software, auditing, rating, monitoring, metering, leak detection, and political and non-profit services that are not specific to a detailed technology. This category also includes workers that cannot be classified to a single category where they spend the majority of their labor hours.

## Fuels

The fuels sector encompasses any work related to fuel extraction, mining, and processing, including petroleum refineries and businesses that support coal mining, oil, and gas field machinery manufacturing. The sector also includes forestry and agriculture workers who support fuel production, such as corn ethanol, biodiesel, and wood fuels. Fuels employment spans several industries including mining and extraction, manufacturing, professional and business services, wholesale trade and distribution<sup>21</sup>, agriculture and forestry, and construction.

At the end of 2020, there were almost 44,600 jobs in the fuels sector. The petroleum sub-sector remains the largest employer of fuels workers in Pennsylvania, representing just over a third, or roughly 35 percent, of total fuels jobs across the state. At the end of 2020, the petroleum fuels sector employed almost 15,500 workers—a decline of nearly 17 percent, or more than 3,000 jobs, compared to the last quarter of 2019. Following petroleum fuels, the natural gas fuels sub-sector accounts for just over a quarter, or 26 percent, of total fuels employment in Pennsylvania. Following declining employment trends since 2017, job losses from 2019 through 2020 in the natural gas fuels sector totaled to almost 2,500 workers—an 18 percent decline in jobs over 12 months.

Coal fuels account for roughly one in ten fuels jobs in Pennsylvania, or about 12 percent of the fuels workforce. Between 2019 and 2020, coal fuels employment shrank by just over 1,000 workers—a 17 percent decline.

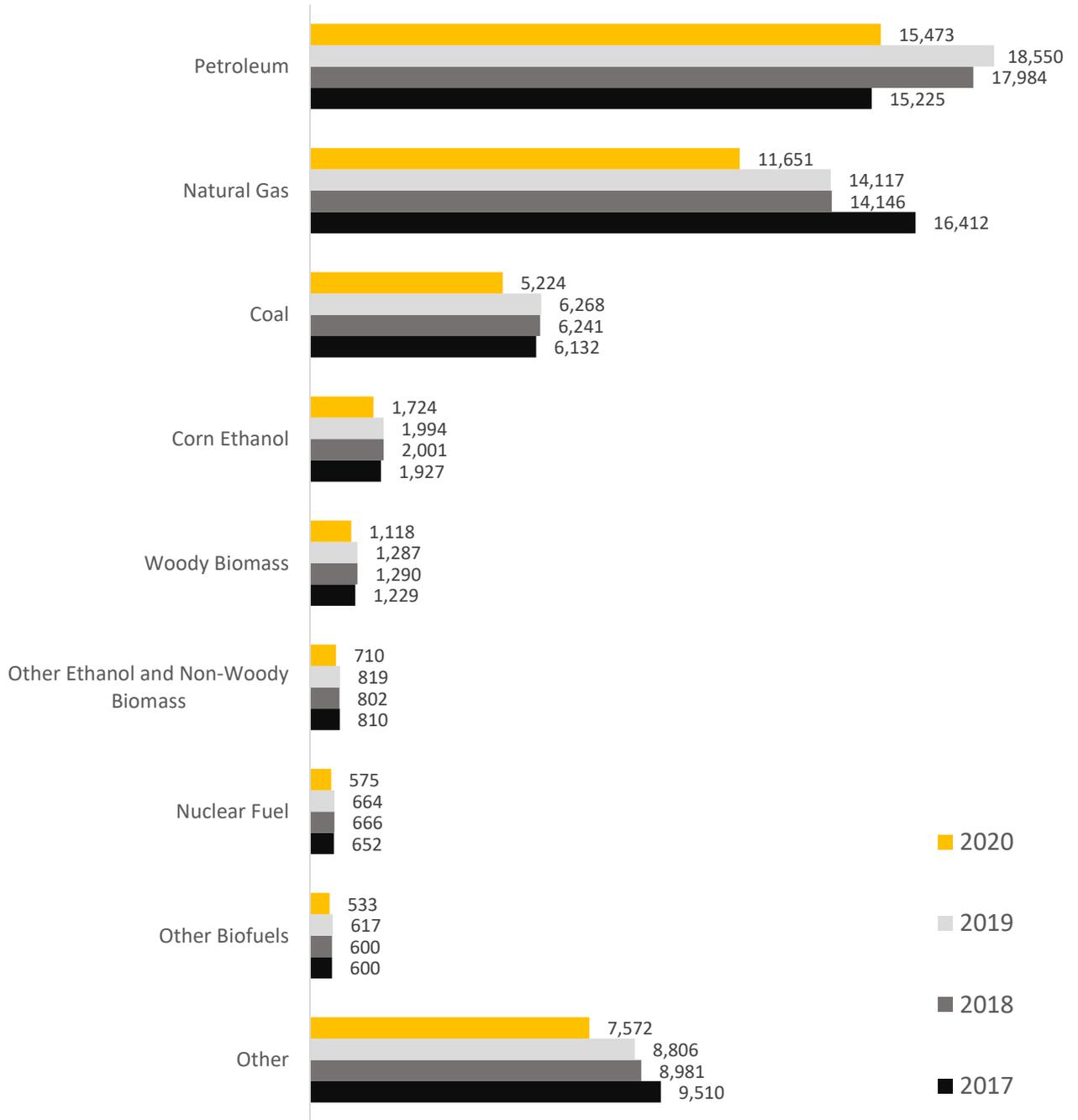
The remaining sub-sectors of corn ethanol, woody biomass, non-woody biomass, nuclear fuel, “other” fuels, and other biofuels<sup>22</sup> accounted for just over a quarter, or 27 percent, of all fuels jobs. Altogether, these sub-sectors shed almost 2,000 jobs between 2019 and 2020.

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<sup>21</sup> As with motor vehicles, retail trade workers—such as gas pump and convenience store employees—are excluded from the employment estimates.

<sup>22</sup> Other biofuels include any other fuel that is derived directly from living matter.

FIGURE 7. FUELS EMPLOYMENT BY SUB-SECTOR, 2017-2020<sup>23</sup>



<sup>23</sup> The “other” fuels category is comprised mostly of propane with the remaining jobs spread across waste gas, such as landfill, food, or agricultural; hydrogen; and other fuels like alcohol or ammonia. Additionally, for any jobs that could not be assigned to a single sub-sector based on majority of labor hours, employers typically select “other” when their employees work with multiple sub-technologies.

## Transmission, Distribution, and Storage

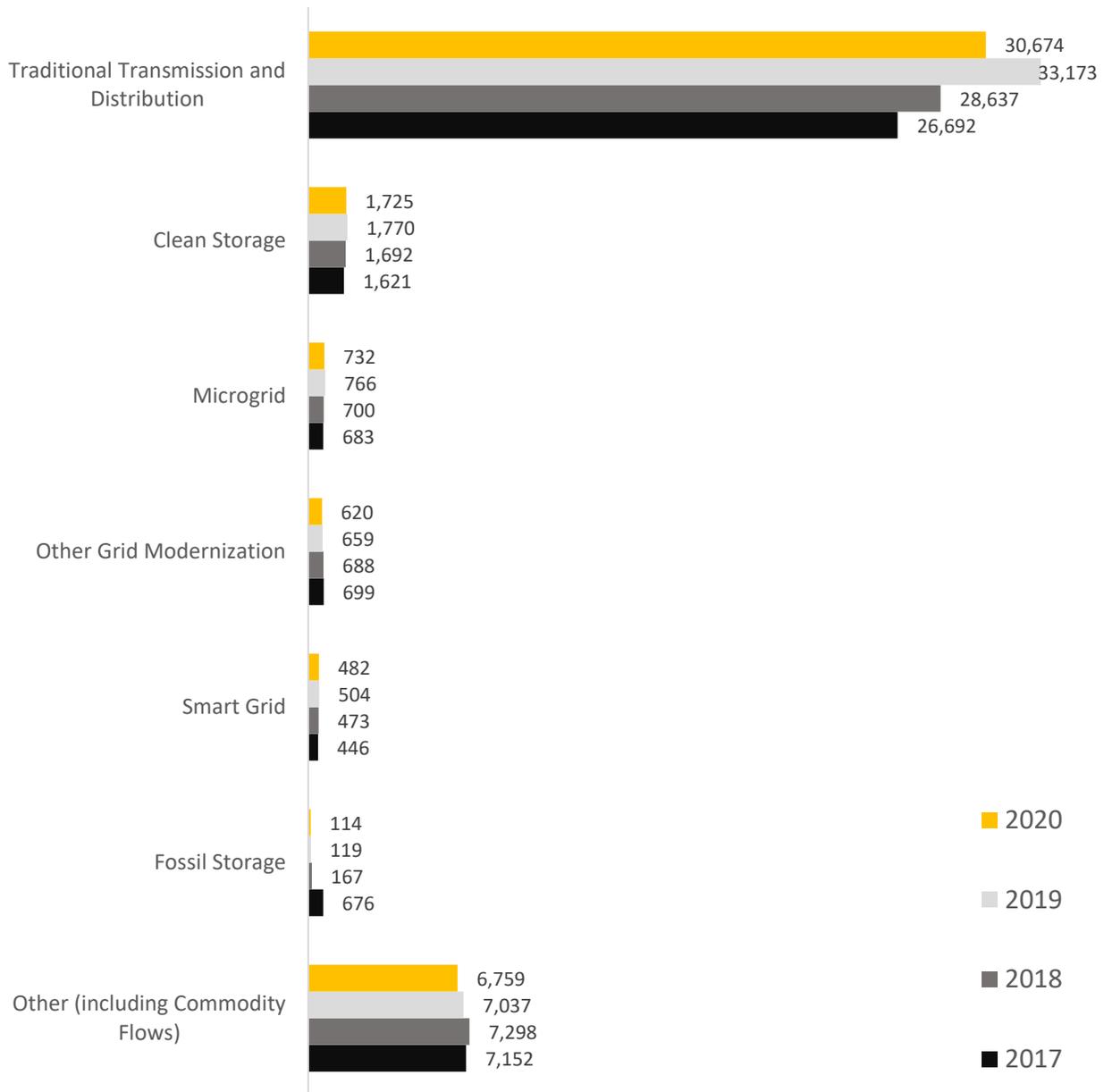
Transmission, distribution, and storage includes all infrastructure for electric power and fuel energy supplies to intermediate and end users. This includes interstate and intrastate pipelines, natural gas storage facilities, ports and railways that handle petroleum products, as well as high-voltage transmission and distribution lines. Employment in this sector is mostly concentrated in construction and utilities, but also includes professional and business services, wholesale trade and distribution, and manufacturing. Occupations include professional service workers such as engineers, analysts, business operations specialists, and chief executives, as well as sales representatives, accountants, construction workers, technicians, mechanics, and repairmen.

Transmission, distribution, and storage technologies employed just over 41,100 workers at the end of 2020. Traditional transmission and distribution is the largest component of the transmission, distribution, and storage sector, accounting for three-quarters of the total workforce. Following significant growth from 2017 through 2019, the sub-sector shed 2,500 jobs for a decline of almost eight percent between 2019 and 2020. The smart grid, microgrid, and clean storage<sup>24</sup> sub-sectors together lost about 100 jobs over the same time period, while the “other” sub-sector, which includes commodity flows, declined by about four percent or 280 jobs.

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<sup>24</sup> “Smart grid” is an electricity supply network that uses digital communications technology to detect and react to local changes in usage. “Microgrids” are a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. “Clean storage” includes pumped hydropower storage, battery storage (including battery storage for solar generation), mechanical storage, thermal storage, as well as storage of biofuels (including ethanol and biodiesel) and nuclear fuels.

FIGURE 8. TRANSMISSION, DISTRIBUTION, AND STORAGE EMPLOYMENT BY SUB-SECTOR, 2017-2020<sup>25</sup>



<sup>25</sup> The “other” employment sub-sector includes commodity flows, which are defined as the air, rail, water, and truck transportation of energy commodities such as coal, fuel, oil, gas, and petroleum. The sub-sector also includes system efficiency, software, site selection, disaster response plans (DRP), incident response plans (IRP), as well as any workers that cannot be classified to a single category where they spend the majority of their labor hours.

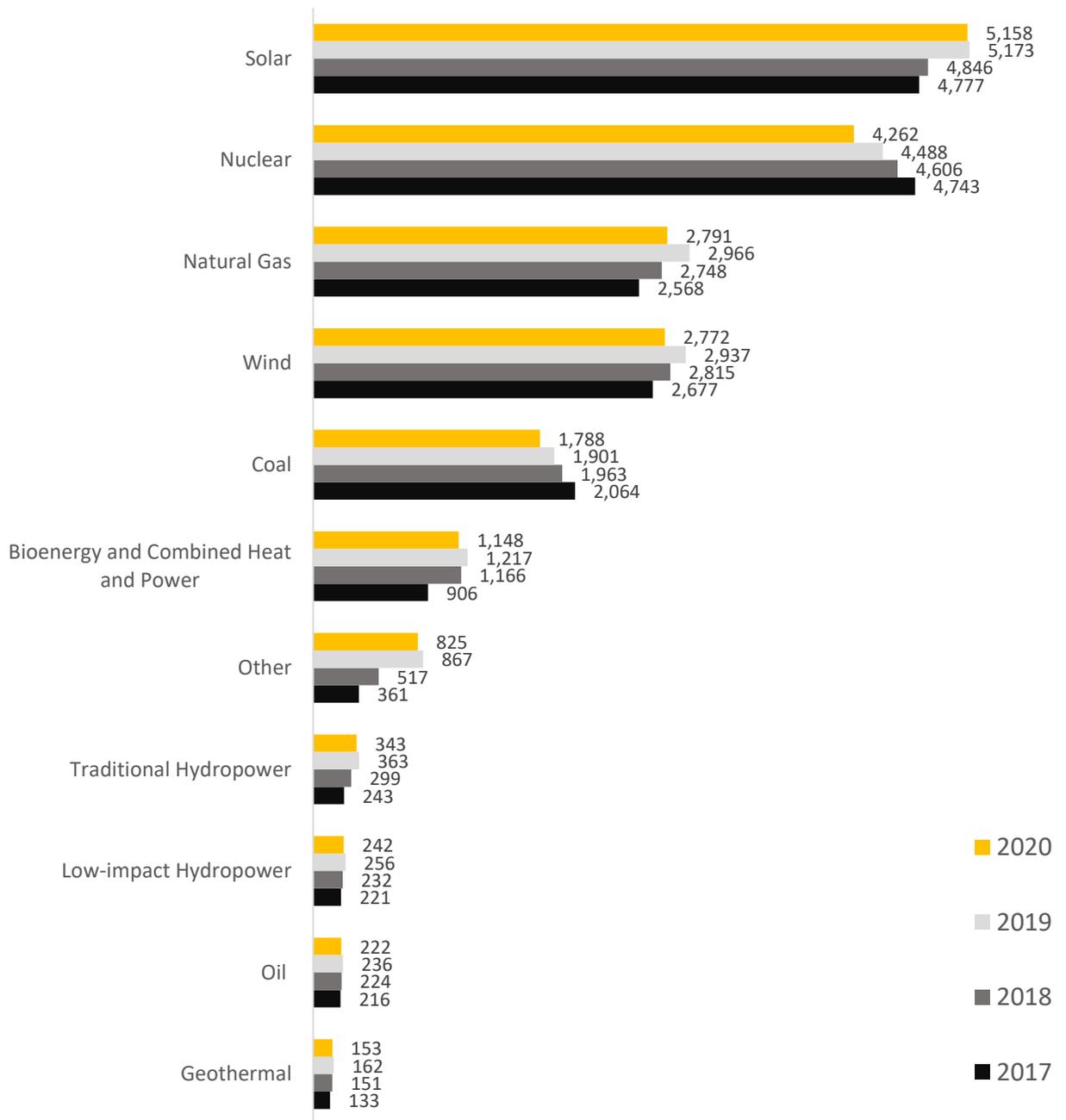
## Electric Power Generation

Electric power generation jobs cover all utility and non-utility employment for electricity-generating technologies. Included in these employment estimates are any firms engaged in facility construction, turbine and other generation equipment manufacturing, and wholesale parts distribution for all electricity-generating technologies as well as professional and business services such as consulting, finance, administrative, and legal support.

In total, there were about 19,700 electric power generation workers across Pennsylvania at the end of 2020. Solar and nuclear jobs account for almost half, or 48 percent, of total electric power generation employment in Pennsylvania. The solar sub-sector exhibited strong growth from 2017 through 2019, and remained fairly steady between 2019 and 2020, declining by less than half a percent during these 12 months despite economywide job losses.

The nuclear generation sub-sector declined by roughly five percent, or 230 jobs, followed by natural gas electric power generation, which shed 180 jobs for a decline of six percent in 12 months. The wind sub-sector also declined by about six percent or roughly 160 jobs and coal electric power generation jobs shrunk by just over 100 workers. The remaining sub-sectors shed a collective 170 jobs from 2019 through 2020.

FIGURE 9. ELECTRIC POWER GENERATION EMPLOYMENT BY SUB-SECTOR, 2017-2019<sup>26</sup>



<sup>26</sup> The “other” sub-sector includes generation from incineration of other fuels, such as waste. It also includes workers that cannot be classified into a single sub-sector where they spend the majority of their time.

## Appendix A: Research Methodology

### EMPLOYMENT DATA

This Pennsylvania Energy and Employment Report (PAEER) is based on data collection for the 2021 United States Energy and Employment Report (USEER). The 2021 USEER utilized data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages (BLS QCEW 2020 Q2), as well as survey data. The survey was designed and implemented by BW Research Partnership, with management from Energy Futures Initiative (EFI) and the National Association of State Energy Officials (NASEO). For the past decade, national, state, and local energy-related data collection and analysis efforts have used this survey methodology.

The survey uses a stratified sampling plan based on industry code (North American Industry Classification System or NAICS), establishment size, and geography to determine the proportion of establishments that work with specific energy related technologies, as well as the proportion of workers in such establishments that work with the same. These data are then analyzed and applied to existing public data published by the BLS QCEW, effectively constraining the potential universe of energy establishments and employment.

The survey was administered by phone and by web, with more than 20,000 outbound calls and 3,500 emails sent to potential participants across Pennsylvania. The phone survey was conducted by ReconMR. The web instrument was programmed internally, and each respondent was required to use a unique ID in order to prevent duplication.

The sample was split into two categories, the known and unknown universes. The known universe includes establishments that have previously identified as energy-related, either in prior research or some other manner, such as membership in an industry association or participation in government programs. These establishments were surveyed census-style, and their associated establishment and employment totals were removed from the unknown universe for both sampling and resulting employment calculations and estimates. Over the summer of 2020, BW Research cleaned, deduplicated, added to, and refined its database to reflect churn (companies out of business, moved, no longer in energy), unverified (no answer, answering machine, fast-busy, disconnect, etc.), verified, and other available demographic tags (industry, technology, sub-technology/sub-sector, size, etc.).

In addition to cleaning the original known energy database, BW Research also supplemented with industry association contact lists by technology (biofuels, coal, oil, and gas, energy storage, energy efficiency, solar, and wind), new companies from the unknown database that took the 2020 survey, and contact lists from subcontractors. BW Research also appended contact information, including six-digit NAICS codes, contact, employment, and location information.

The unknown universe includes thousands of businesses in potentially energy-related NAICS codes, across agriculture, mining, utilities, construction, manufacturing, wholesale trade, professional services, and repair and maintenance. Each of these segments and their total reported establishments (within the BLS QCEW) were carefully analyzed by size (employment – provided by the Census Bureau’s County Business Patterns) and state to develop representative clusters for sampling.

In total, 1,199 business establishments in Pennsylvania participated in the survey effort. These responses were used to develop incidence rates among industries as well as to apportion employment across various industry categories in ways currently not provided by state and federal labor market information agencies. The margin of error is +/- 2.82 percent for Pennsylvania at a 95 percent confidence interval.

With clean data files in place, BW Research developed a general methodology for state employment estimation that has a few variations depending on sub-technology. Steps in the process are listed below.

**100% NAICS A**

These are NAICS codes where 100% of the reported employment is energy related AND 100% are allocated to a specific sub-technology. Examples include solar electric power generation, hydroelectric power generation, and motor vehicle manufacturing.

**Actual Survey Responses**

These include the reported sub-technology employment totals by company location. Responses from establishments in 100% NAICS codes are excluded.

**Known Database**

Employment is allocated by location for verified establishments in the known when the following conditions are met: 1) Have InfoUSA or DatabaseUSA appended data; 2) did not take survey (or actual survey response would be used), and 3) are not in a 100% NAICS.

**Remainder**

This represents remaining employment based on statistical extrapolation.

**Industry Mix**

Industry mix is the national proportion of industries that contribute to sub-technology employment. The mix of these industries (by 6-digit NAICS) is used to create proportions by state and remainder employment is allocated by these proportions. This “industry mix” was developed by analyzing completed survey incidence nationally for all clean energy sub-technologies.

## Appendix B: Energy Technology List

An energy job is defined as any worker that is directly involved with the research, development, production, manufacture, distribution, sales, implementation, installation, or repair of components, goods, or services related to the following sectors of Electric Power Generation; Electric Power Transmission, Distribution, and Storage; Energy Efficiency; Fuels; and Transportation. These jobs also include supporting services such as consulting, finance, tax, and legal services related to energy. Included in these sectors are the following sub-technologies that are currently considered to be energy-related activities.

### ELECTRIC POWER GENERATION

- Solar Photovoltaic Electric Generation
- Concentrated Solar Electric Generation
- Wind Generation
- Geothermal Generation
- Bioenergy/Biomass Generation
- Low-Impact Hydroelectric Generation, including wave/kinetic generation
- Traditional Hydroelectric Generation
- Advanced/Low-Emission Natural Gas
- Nuclear Generation
- Coal Generation
- Oil and Other Petroleum Generation
- Natural Gas Generation
- Combined Heat and Power
- Other Generation

### ELECTRIC POWER TRANSMISSION, DISTRIBUTION, AND STORAGE

#### Electric Power Transmission and Distribution

- Traditional Transmission and Distribution
- Smart Grid
- Microgrids
- Other Grid Modernization
- Other Transmission

#### Storage

- Pumped Hydropower Storage
- Battery Storage, including battery storage for solar generation
  - Lithium Batteries
  - Lead-Based Batteries
  - Other Solid-Electrode Batteries
  - Vanadium Redox Flow Batteries
  - Other Flow Batteries
- Mechanical Storage, including flywheels, compressed air energy storage, etc.
- Thermal Storage
- Liquefied Natural Gas
- Compressed Natural Gas

- Crude Oil
- Refined Petroleum Fuels (liquid)
- Refined Petroleum Fuels (gas)
- Coal Storage (piles, domes, etc.)
- Biofuels, including ethanol and biodiesel
- Nuclear Fuel
- Other Gas Fuel
- Other Liquid Fuel
- Other Storage

## ENERGY EFFICIENCY

- ENERGY STAR Certified Appliances, excluding HVAC
- ENERGY STAR Certified Heating Ventilation and Air Conditioning (HVAC), including boilers and furnaces with an AFUE rating of 90 or greater and air and central air conditioning units of 15 SEER or greater
- Traditional HVAC goods, control systems, and services
- ENERGY STAR Certified Electronics (TVs, Telephones, Audio/Video, etc.)
- ENERGY STAR Certified Windows and Doors
- ENERGY STAR Certified Roofing
- ENERGY STAR Certified Seal and Insulation
- ENERGY STAR Certified Commercial Food Service Equipment
- ENERGY STAR Certified Data Center Equipment
- ENERGY STAR Certified LED Lighting
- Other LED, CFL, and Efficient Lighting
- Solar Thermal Water Heating and Cooling
- Other Renewable Heating and Cooling (geothermal, biomass, heat pumps, etc.)
- Advanced Building Materials/Insulation
- Recycled Building Materials
- Reduced Water Consumption Products and Appliances
- Other Energy Efficiency

## FUELS

- Coal
- Petroleum
- Natural Gas
- Other Fossil Fuels
- Corn Ethanol
- Other Ethanol/Non-Woody Biomass, including biodiesel
- Woody Biomass/Cellulosic Biofuel
- Other Biofuels
- Nuclear Fuel
- Other Fuels

## TRANSPORTATION

- Gasoline and Diesel Motor Vehicles, excluding freight transport
- Hybrid Electric Vehicles
- Plug-In Hybrid Vehicles
- Electric Vehicles

- Natural Gas Vehicles
- Hydrogen Vehicles
- Fuel Cell Vehicles
- Other Vehicles
- Transportation Vehicle Engine and Drive Parts
- Transportation Vehicle Exhaust System Parts
- Transportation Vehicle Body Parts
- Other Transportation Vehicle Parts