TECHNICAL APPENDIX

The Renewable Energy Transition in Maryland

Implications for Energy Generating Facilities and Small Businesses

Kathleen M. Kennedy, Stephanie Vo, Kasey Vangelov, Bhavika Buddi, Steven J. Smith, Jiehong Lou, Ryna Cui, Nathan Hultman

01

Table of Contents

Supplementary Information on Small Businesses

Profile of Small Businesses

The profile of small businesses in Maryland was based on the "U.S. & states, 6-digit NAICS" dataset from Census Bureau Statistics of U.S. Businesses (SUSB) in 2021.[1] The dataset is broken down into different codes based on the North American Industry Classification System (NAICS), as well as enterprise sizes. For the purpose of this report, small businesses were classified as having fewer than 500 employees as the enterprise size. Results from this dataset are displayed at the 2-digit NAICS code level, as shown in Table T1.

TABLE T1. Two-digit NAICS code sectors as used in the U.S. Census Bureau Statistics of U.S. Businesses.

Sector	Definition
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

In addition to the employment data presented in the main text, the Census Bureau data also provides information on Maryland businesses in terms of Firms, Establishments, and Annual Payroll. Each firm is a unique legal entity which may have multiple different physical locations. Establishments are unique physical locations, which may include multiple locations owned by the same firm. These data are summarized in Figures T1-T4, with additional detail on the size of businesses provided in the coloration of the bars.

FIGURE T1. Number of firms in Maryland across industries in 2021, with businesses of different sizes shown by number of employees. We define small businesses here as having fewer than 500 employees. *Source: U.S. Census Bureau Statistics of U.S. Businesses*.[1]

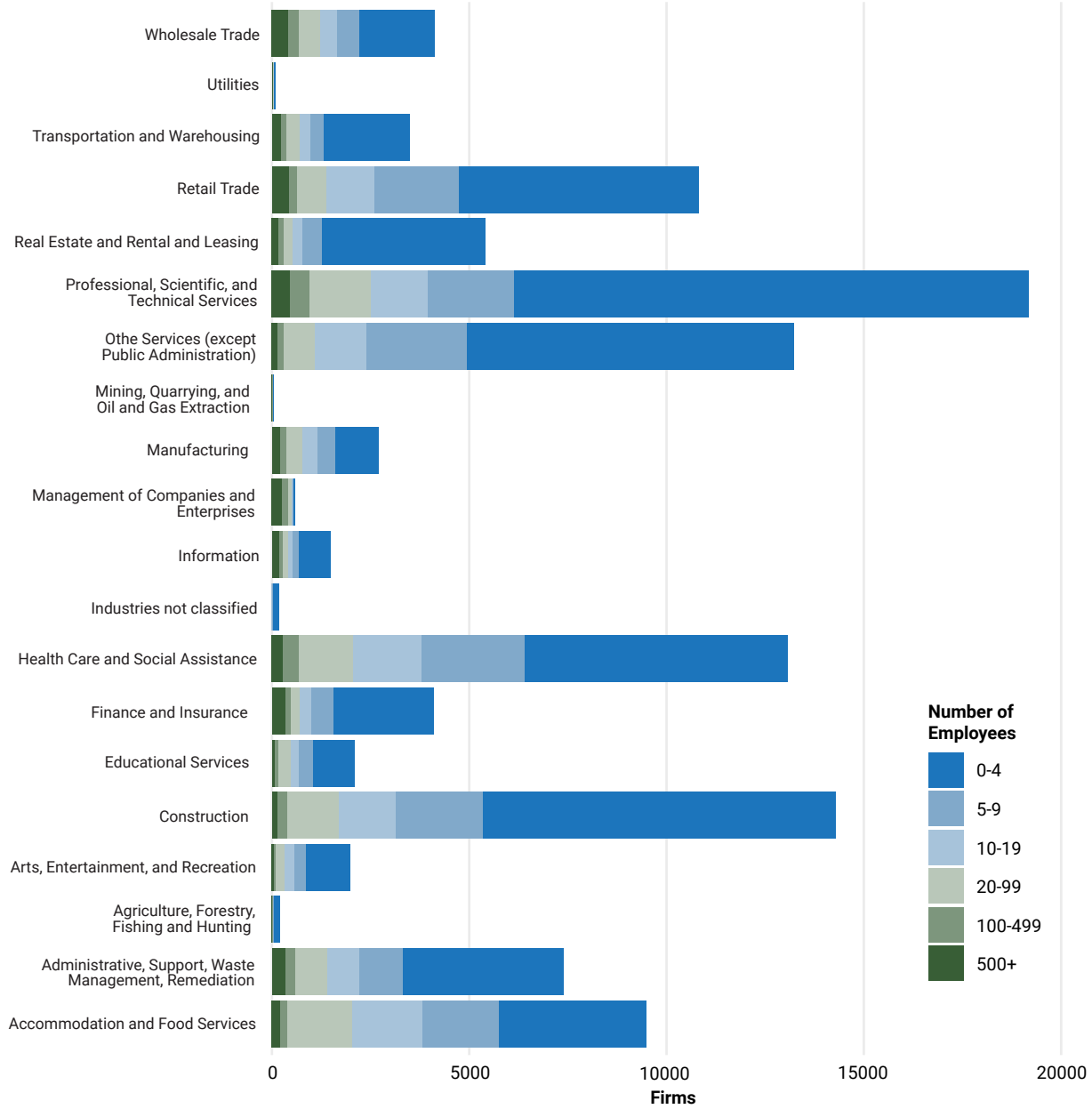


FIGURE T2. Number of business establishments in Maryland across industries in 2021, with businesses of different sizes shown by number of employees. We define small businesses here as having fewer than 500 employees. *Source: U.S. Census Bureau Statistics of U.S. Businesses.*[1]

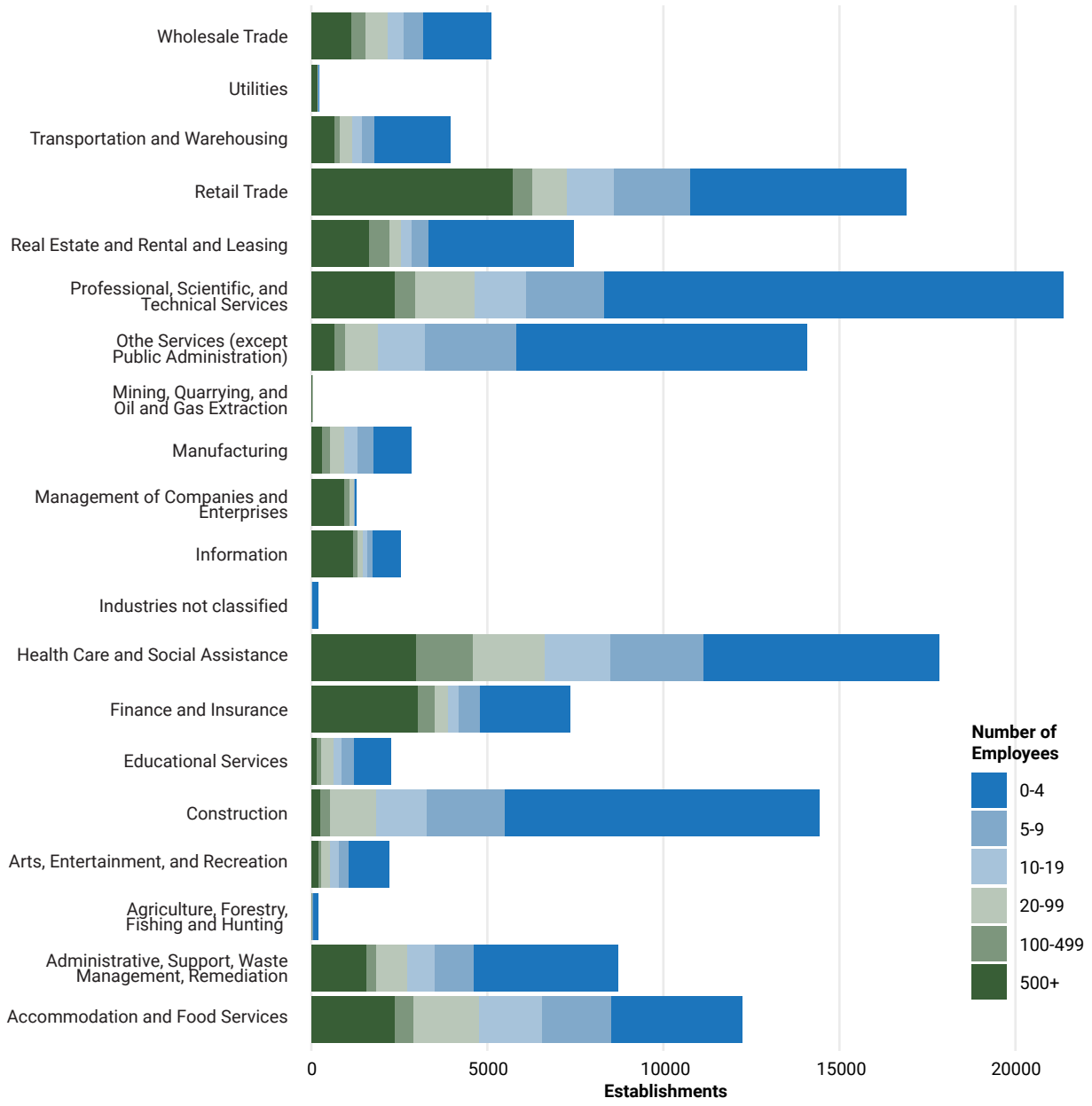


FIGURE T3. Employment in Maryland across industries in 2021, with businesses of different sizes shown by number of employees. We define small businesses here as having fewer than 500 employees. *Source: U.S. Census Bureau Statistics of U.S. Businesses.*[1]

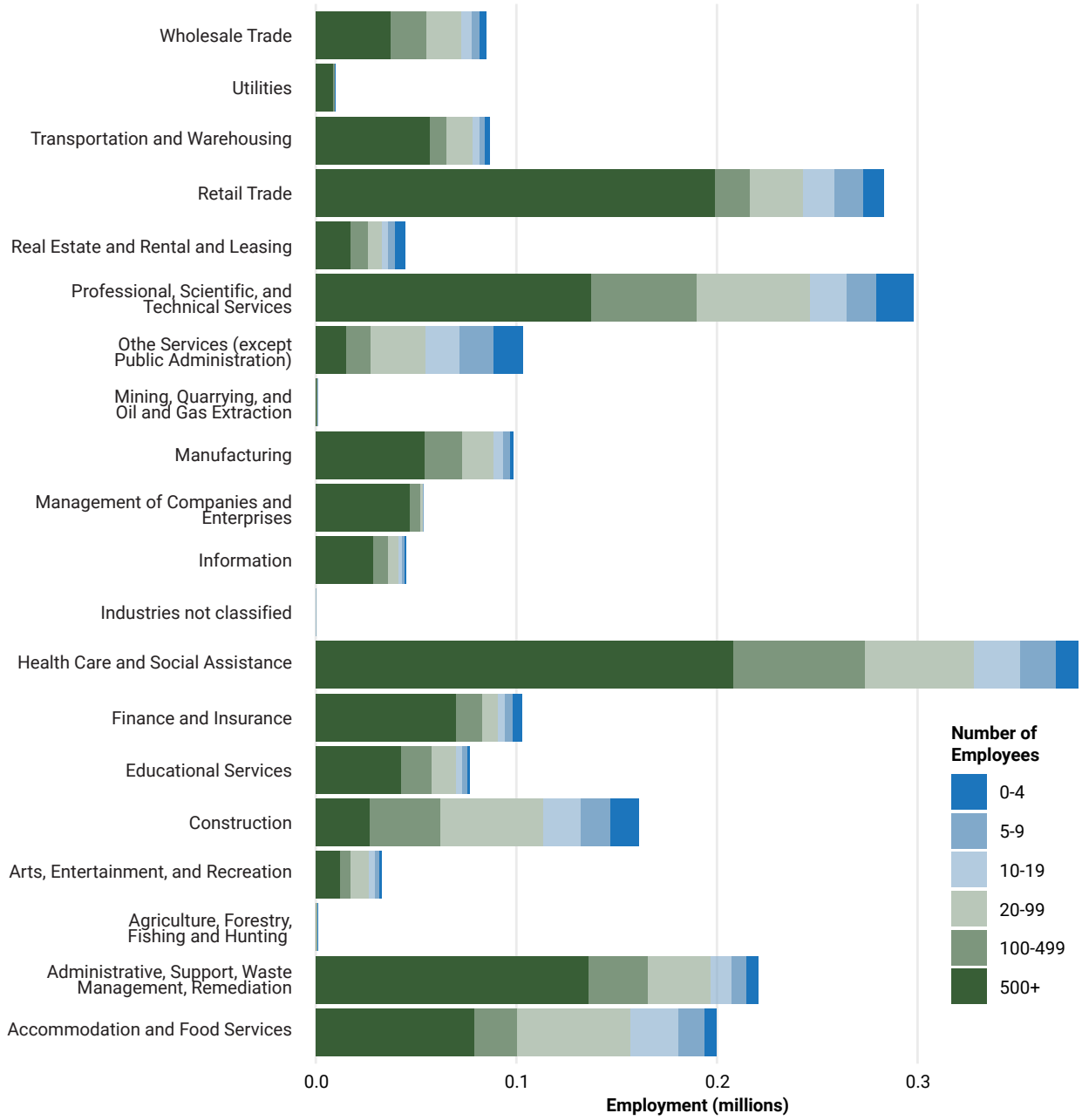
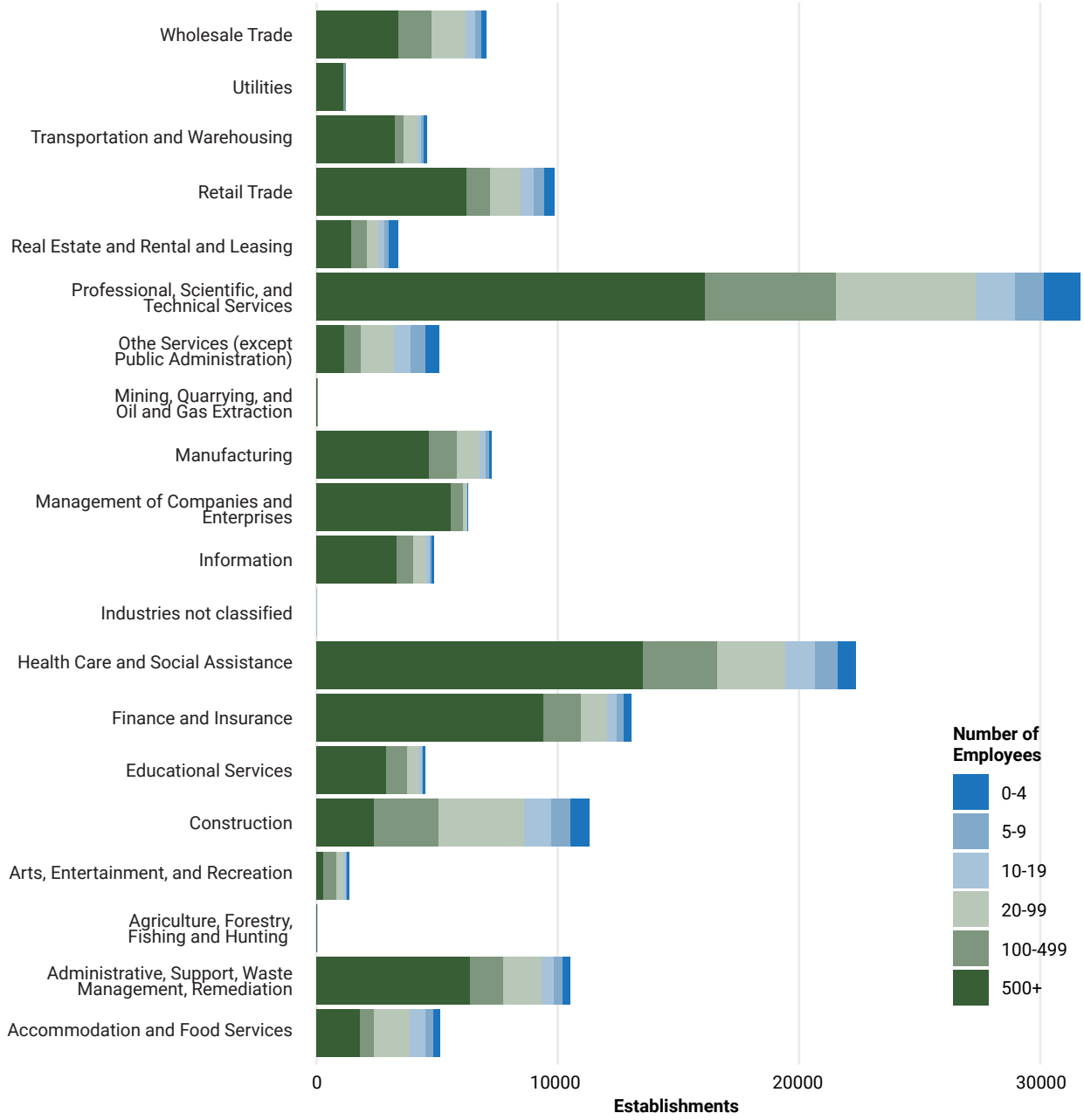


FIGURE T4. Annual Payroll in Maryland across industries in 2021, with businesses of different sizes shown by number of employees. We define small businesses here as having fewer than 500 employees. *Source: U.S. Census Bureau Statistics of U.S. Businesses.*[1]



The "State by county, 3-digit NAICS" sheet from Census Bureau SUSB 2021 was used for the county graphs (firms and percentage of employment) in Figure 2. As there was no value for <500 for enterprise size, the number of small businesses was calculated based on Total - 500+ for each county.

Categorization of Businesses as Affected by the Energy Transition

To determine which businesses are likely to be affected by the energy transition, each NAICS code was categorized as one of four categories (Direct Supply, Energy Services, Energy Intensive, Other Less Affected) by the authors. Categorizations were separately reviewed by multiple authors, and any conflicts were discussed until reaching unanimous agreement on the final categorizations. There is no overlap of categories to avoid double-counting, and priority is given first to energy supply, then energy services, and lastly to energy intensive businesses. For example, if a business was found to be energy intensive but was already categorized as an energy services business, it was only included in the energy services category. To make the final graphs, the totals for each category were calculated within each 2 digit NAICS. The totals were based on adding up all of the 2 digit NAICS codes together and not the row labeled "Total" in the dataset, as there were some discrepancies between the values. The results of these categorizations are shown in Figures 4 and 5 in the main text. Additional figures showing these categories in terms of Establishments and Annual Payroll are provided in Figures T5 and T6.

FIGURE T5. Number of small business establishments affected by the energy transition, broken out by NAICS activity and category of impact. *Source: Authors' analysis of 2021 U.S. Census Bureau Statistics of U.S. Businesses.*[1]

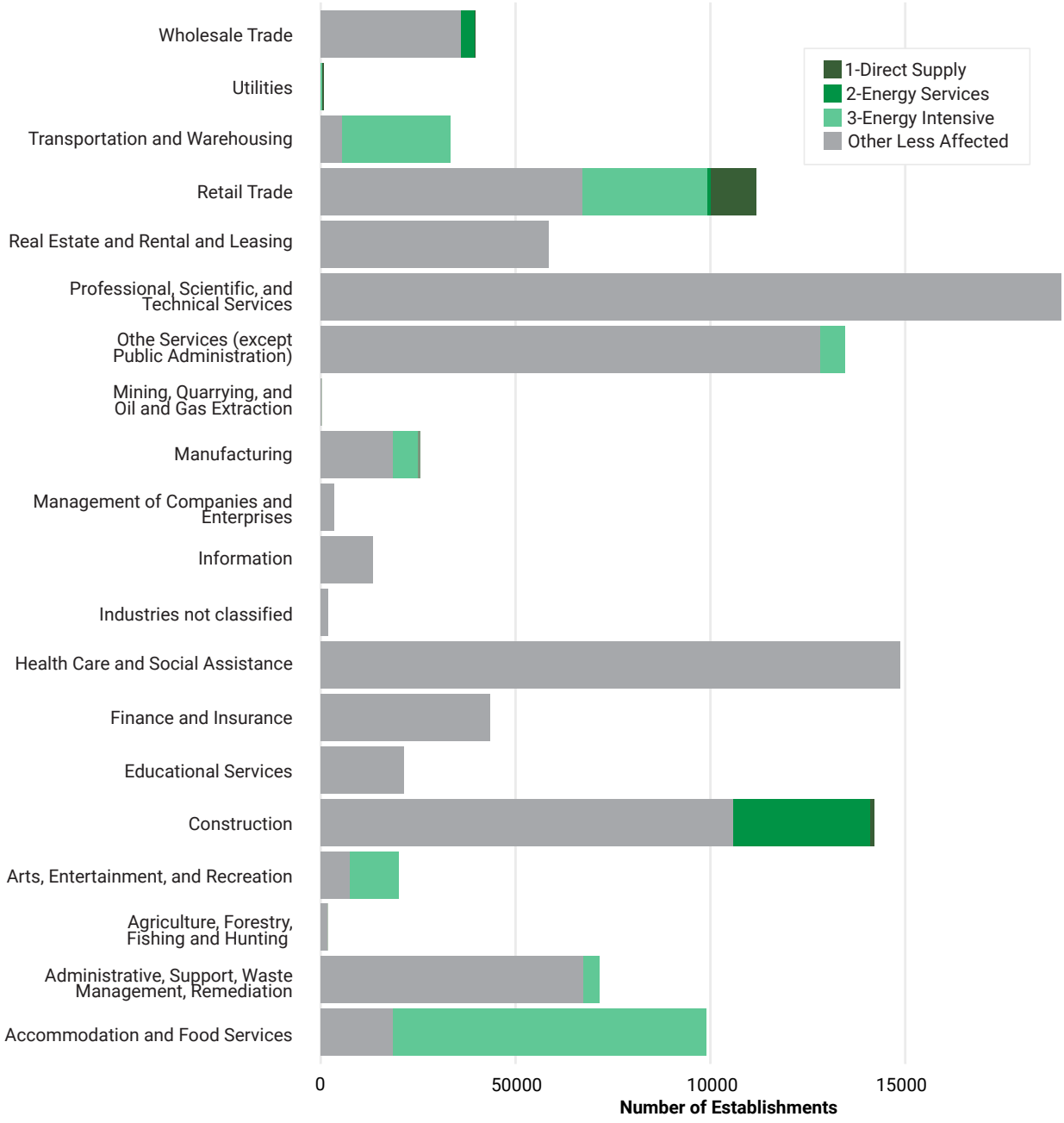
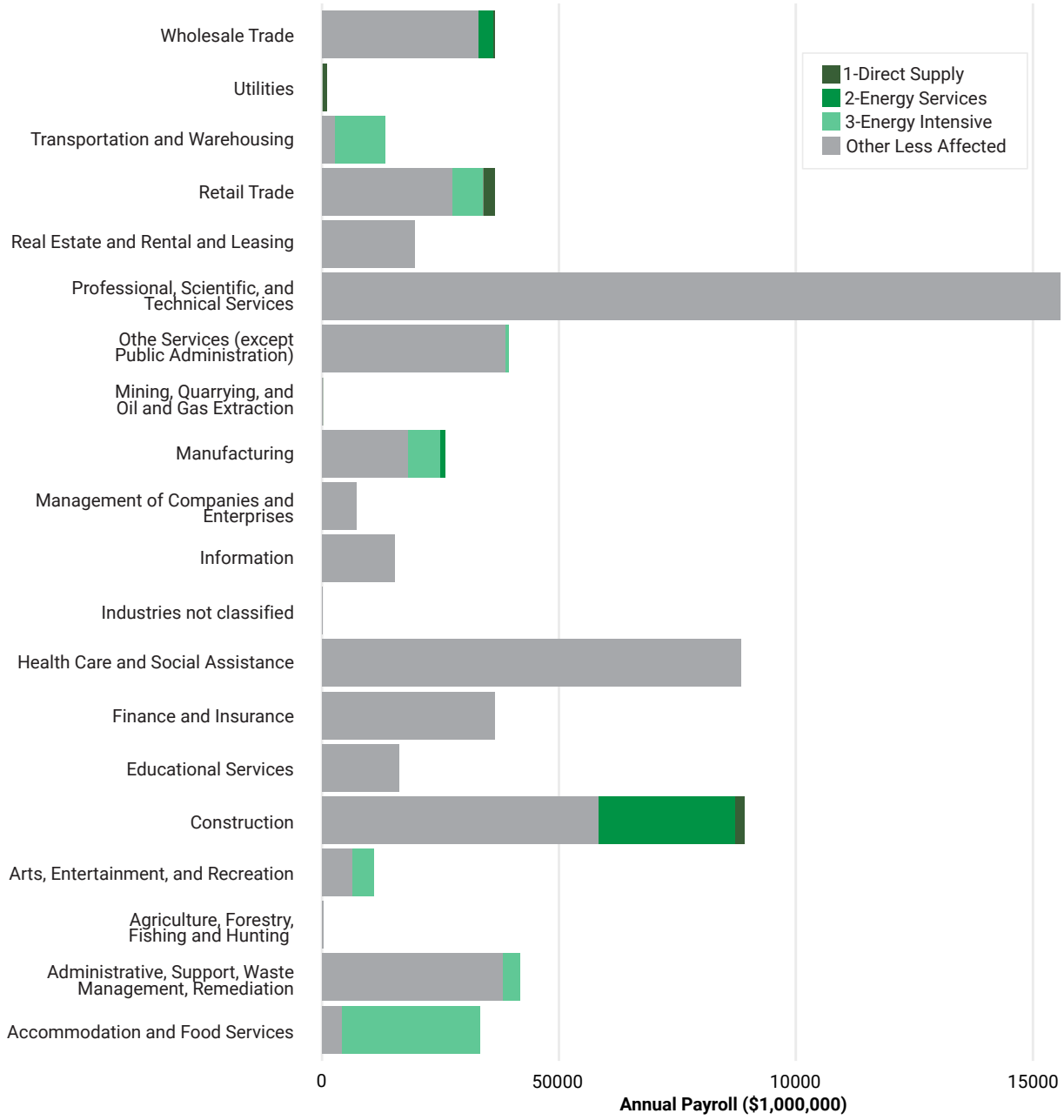


FIGURE T6. Annual payroll of small businesses affected by the energy transition, broken out by NAICS activity and category of impact. *Source: Authors' analysis of 2021 U.S. Census Bureau Statistics of U.S. Businesses.*[1]



Energy Intensive Industries

The U.S. Department of Commerce's Bureau of Economic Analysis (BEA) Input-Output Accounts Data[2] was used to determine which NAICS industries are the most energy intensive. The DOE's Energy Information Administration provides the basis for BEA's input-output allocations for energy consumption to final-use categories.

The 2017 Use Table after Redefinitions was used to calculate industry direct requirements for relevant commodities: coal (212100), electricity (221100), natural gas (221200), and petroleum (324110). Note that the BEA adds zeros to the end of NAICS code values to achieve uniform 6-digit values, and these may need to be removed to match with other data sources. Use tables show the commodities consumed by each industry end user. The reallocated use table after redefinition was used because it shows secondary products that have been redefined and reassigned to the industry for which the product is primary.[3] In the use table, the sum of entries in a column is that industry's total output. To calculate direct requirements ratios, the relevant commodity inputs for each industry is divided by that industry's total output. The resulting ratio shows the amount of a commodity (in dollars) that is required by an industry to produce one dollar of the industry's output. This value gives a normalized estimate of the amount of energy an industry needs relative to its outputs. It also can be broken down by commodity, which shows the type of energy each industry is using. This data is at the national level and was assumed to be representative of industries in Maryland for the purposes of the report.

Direct requirements ratios were calculated at the three- to six-digit NAICS code level, and the median was determined to be M = 0.0107. All industries above this median are considered more energy intensive, while industries below are less energy intensive. This is a broad characterization of energy intensive industries, and it should be taken as the upper end of the number of industries that could fit this category. Figure T7 shows aggregated direct requirements ratio at the two-digit NAICS code level. Notably, the top two industries in Maryland, Health Care and Social Assistance and Professional, Scientific, and Technical Services, are not energy intensive industries, and their usage is predominantly electricity. The transportation sector is the most energy intensive industry, requiring about six cents of energy inputs for every dollar of output it produces. Detailed numerical results of direct requirements for two-digit NAICS codes are provided in Table T2.

FIGURE T7. Relative amount of energy purchased (in dollars per dollar of industry output, otherwise known as the direct requirements ratio) nationally, shown by type of energy. *Source: Input-Output Accounts Data from BEA*[2]

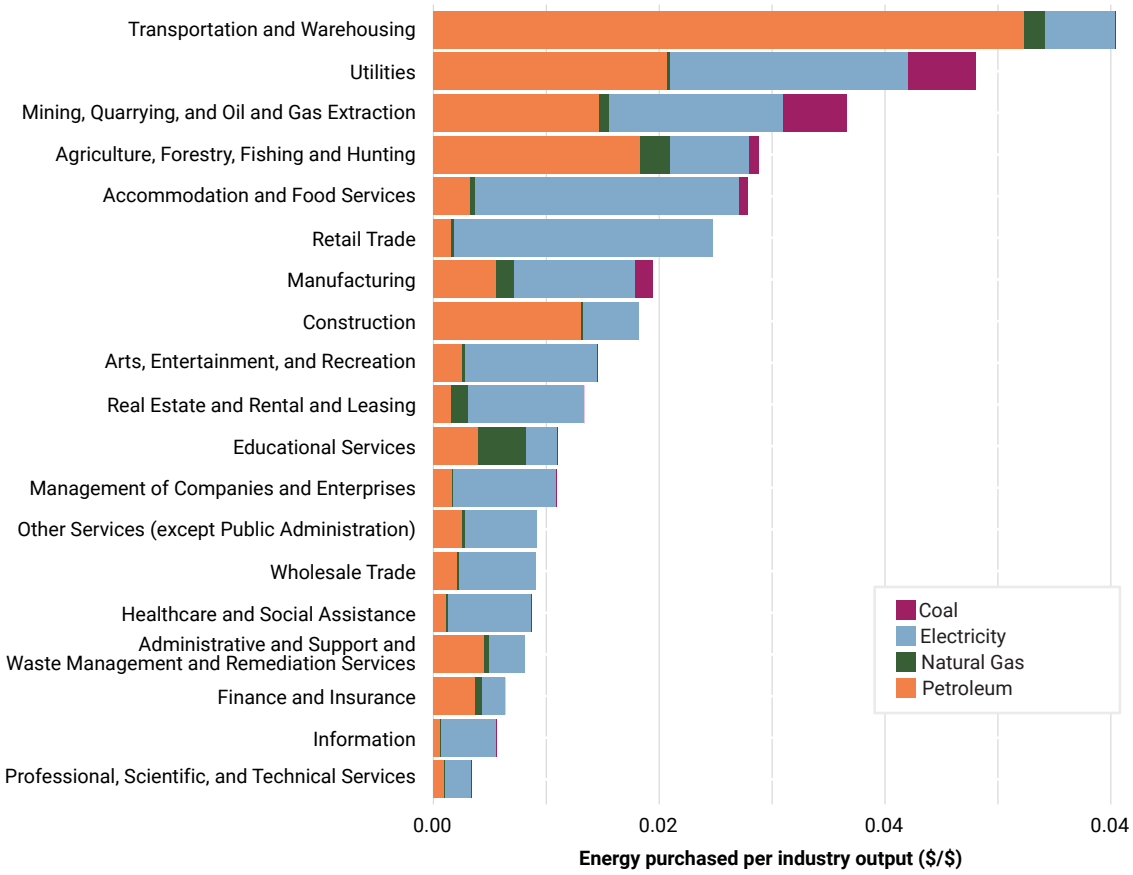


TABLE T2. Direct requirements (DR) for industries at the 2-digit NAICS code, by energy commodity type

Industry	Coal DR	Electricity DR	Natural Gas DR	Petroleum DR	Total DR
Accommodation and Food Services	0.00077	0.02341	0.00045	0.00322	0.02784
Administrative and Support and Waste Management and Remediation Services	0.00002	0.00321	0.00044	0.00445	0.00812
Agriculture, Forestry, Fishing and Hunting	0.00095	0.00701	0.00260	0.01829	0.02884
Arts, Entertainment, and Recreation	0.00003	0.01174	0.00019	0.00257	0.01452
Construction	0.00000	0.00493	0.00012	0.01311	0.01816
Educational Services	0.00005	0.00273	0.00430	0.00391	0.01100
Finance and Insurance	0.00000	0.00204	0.00061	0.00371	0.00636
Health Care and Social Assistance	0.00002	0.00741	0.00012	0.00111	0.00866
Information	0.00000	0.00495	0.00003	0.00059	0.00557
Management of Companies and Enterprises	0.00007	0.00909	0.00014	0.00160	0.01090
Manufacturing	0.00153	0.01078	0.00161	0.00549	0.01942
Mining, Quarrying, and Oil and Gas Extraction	0.00566	0.01543	0.00087	0.01466	0.03662
Other Services (except Public Administration)	0.00003	0.00635	0.00031	0.00249	0.00917
Professional, Scientific, and Technical Services	0.00004	0.00232	0.00003	0.00097	0.00335
Real Estate and Rental and Leasing	0.00000	0.01032	0.00143	0.00159	0.01335
Retail Trade	0.00000	0.02295	0.00022	0.00158	0.02475
Transportation and Warehousing	0.00000	0.00627	0.00186	0.05226	0.06040
Utilities	0.00610	0.02111	0.00019	0.02069	0.04809
Wholesale Trade	0.00001	0.00684	0.00009	0.00210	0.00904

Energy Generating Facilities

Data Sources for Generators

The primary data sources used in this report to describe energy generating facilities are Form 860 and Form 923 from the Energy Information Administration (EIA).[4,5] Form 860 provides monthly and yearly datasets on operating, retired, and proposed electricity generators across the United States. It includes information on generator age, nameplate capacity, fuel type, prime mover type, and other key variables. Form 923 provides monthly and yearly datasets on fuel consumption and electricity generation at the generator level. It also includes information on co-pollutant emission rates and emission control technologies.

Employment Estimates

We use two methods to estimate employment in the energy generating facilities section of the report. First, we use the Department of Energy's U.S. Energy and Employment Report (USEER) at the state level to estimate the employment for an industry cross-cut of each generation technology (e.g., solar, wind, coal, natural gas).[6] Each crosscut includes jobs related to that generation technology from different NAICS industries, including installation, manufacturing, professional services, and wholesale trade.[7] Second, we use employment factors from the Pacific Northwest National Laboratory (PNNL) to estimate plant-level employment for thermal generators in Maryland.[8]

Publicly accessible data on employment at the facility level is not readily available. For example, Funderburg (2024) triangulates Illinois plant employment data from multiple sources, including plant owners, the National Establishment Time Series, and Reference USA–the latter two being proprietary sources.[9] While we were able to confirm some employment numbers for facilities,[10–12] we were unable to find numbers for all facilities in Maryland. Cross-checking the known employment levels at facilities with our employment estimates confirmed that they are comparable and on the same order of magnitude.

We obtained Maryland operations and maintenance-based employment factors (O&M EF) from the PNNL in order to estimate full-time, direct employment numbers at the facility level.8 We focus on O&M jobs because they are typically long-term and permanent, as compared to construction jobs that may be for a limited period of time. The O&M EF are derived from onsite labor estimates and nameplate capacities from the NREL JEDI model.[13] PNNL assumes that O&M EF are composed of both fixed and variable O&M employment and uses fixed and variable O&M costs by fuel technology from the Global Change Analysis Model (GCAM) to disaggregate the O&M EF values acquired from JEDI into fixed O&M EF and variable O&M EF. These O&M EF are provided in Table T3.

When calculating employment numbers for each plant, fixed O&M EF are associated with nameplate capacity and variable O&M EF are associated with operational capacity, or nameplate capacity multiplied by the plant's capacity factor. This is to account for temporary profit-driven shutdowns when fixed O&M jobs remain while variable O&M jobs are reduced.

TABLE T3. Maryland 2020 Employment Factors by fuel, technology, and load. CT = combustion turbine. IGCC = integrated gasification combined cycle. CC = combined cycle.

GCAM Subsector	Fuel	Fixed O&M EF	Variable O&M EF
PV_base_storage	PV	0.184634	0
PV_int	PV	0.184634	0
PV_peak	PV	0.184634	0
PV_subpeak	PV	0.184634	0
biomass_base_IGCC	biomass	0.120476	0.042744
biomass_base_conv	biomass	0.11917	0.04405
biomass_int_IGCC	biomass	0.145651	0.005974
biomass_int_conv	biomass	0.144998	0.006196
coal_base_conv pul	coal	0.069493	0.074002
coal_int_conv pul	coal	0.105352	0.012969
gas_base_CC	gas	0.0172	0.033448
gas_int_CC	gas	0.030489	0.006854
gas_peak_CC	gas	0.046993	0.000146
gas_peak_steam/CT	gas	0.043499	0.000229
gas_subpeak_CC	gas	0.043104	0.000679
gas_subpeak_steam/CT	gas	0.036975	0.000984
nuc_base_Gen II	nuclear	0.123057	0.020439
refined liquids_base_ steam/CT	refined liquids	0.028088	0.092326
rooftop_pv	rooftop_pv	0.184634	0
wind_base	wind	0.039287	0
wind_base_storage	wind	0.039287	0
hydro_base	hydro	0.028689	NA

To determine which EF to use for each facility, we establish the load segment of each based on its capacity factor, calculated from total annual net generation and nameplate capacity found in EIA Form 923 and Form 860,[4,5] respectively. We take base load to be a capacity factor of greater than 60%, intermediate load to be between 20-60%, and peak load to be less than 20%.[14]

Additionally, GCAM technologies, fuel, and load did not always match up with the actual generator technology, fuel, and load; therefore, we made additional assumptions to make employment estimates:

- The gas steam/combustion peak load EF value was used for plants with gas steam/combustion, intermediate load, because there are no EF values for gas steam/combustion intermediate load.
- The gas peak load EF value was used for plants with oil peak load, because there are no EF values for oil peak load.

- The oil combustion base load EF value was used for plants with gas combustion base load, because there are no EF values for gas combustion base load.
- The gas combustion peak load EF value was used for plants with gas combustion intermediate load, because there are no EF values for gas combustion intermediate load.
- The coal intermediate load EF value was used for plants with coal peak loads, because there are no EF values for coal peak load.
- The biomass intermediate load EF values were used for plants with biomass peak loads, because there are no EF values for biomass peak load.

The results of these estimates are provided in Table T4.

Table T4. Estimated O&M employment numbers for thermal generation facilities in Maryland based on 2023 load segment.

Plant Name	Fixed O&M Estimated Employment	Variable O&M Estimated Employment	Total O&M Estimated Employment
Calvert Cliffs Nuclear Power Plant	228	38	266
Brandon Shores	144	18	162
Chalk Point	79	0	80
Wildcat Point Generation Facility	34	7	41
Herbert A Wagner	40	0	40
CPV St. Charles Energy Center	13	25	39
Rock Springs Generating Facility	34	0	34
Keys Energy Center	25	6	31
AES Warrior Run	24	3	27
Perryman	22	0	22
Dickerson	14	0	14
Morgantown	11	0	11
Brandywine Power Facility	9	2	11
Montgomery County Resource Recovery	10	0	10
Wheelabrator Baltimore Refuse	9	1	10
Vienna	8	0	8
NRG Chalk Point CT	4	0	4
Philadelphia	4	0	4
NIH Cogeneration Facility	1	3	3
Central Utility Plant at White Oak	2	0	2
Easton 2	2	0	2
Easton	1	0	1
UMCP CHP Plant	1	0	1
APG Combined Heat and Power Plant	0	1	1
Wicomico	1	0	1
American Sugar Refining, Inc.	1	0	1
Eastern Landfill Gas LLC	0	0	1
Brown Station Road Plant II	1	0	1
Eastern Correctional Institute	1	0	1
Millersville LFG	0	0	1
Crisfield	1	0	1
Berlin	0	0	0
Alpha Ridge LFG	0	0	0
Brookville Smart Bus Depot Microgrid	0	0	0
Smith Island	0	0	0
Maryland Bioenergy Center (Jessup)	0	0	0

References

(1) United States Census Bureau. 2021 SUSB Annual Datasets by Establishment Industry, 2023. https://www.census.gov/data/datasets/2021/econ/susb/2021-susb.html (accessed 2024-06-30).

(2) U.S. Bureau of Economic Analysis (BEA). Input-Output Accounts Data. https://www.bea.gov/industry/input-output-accounts-data (accessed 2024-09-11).

(3) Horowitz, K.; Planting, M. Concepts and Methods of the Input-Output Accounts; Bureau of Economic Analysis, U.S. Department of Commerce, 2009. https://www.bea.gov/sites/default/files/methodologies/IOmanual_092906.pdf (accessed 2024-08-28).

(4) U.S. Energy Information Administration. Form EIA-860 (2023), 2024. https://www.eia.gov/electricity/data/eia860/ (accessed 2024-09-30).

(5) U.S. Energy Information Administration. Form EIA-923 (2023), 2024. https://www.eia.gov/electricity/data/eia923/ (accessed 2024-11-07).

(6) U.S. Department of Energy's Office of Energy Jobs. *United States Energy & Employment Report 2024*; U.S. Department of Energy, 2024. https://www.energy.gov/policy/us-energy-employment-jobs-report-useer (accessed 2024-08-29).

(7) Department of Energy. *Appendix A: State Level Clean Energy Jobs*. https://www.energy.gov/sites/default/files/2024-10/USEER%202024%20Appendices_1002_0.pdf (accessed 2024-11-11).

(8) Sheng, D.; O'Neill, B.; Waldhoff, S.; Binsted, M. GCAMUSAJobs: An R Package for Employment Projections Based on GCAM-USA Power Sector Outcomes, 2024. https://doi.org/10.5281/ZENODO.13947803.

(9) Funderburg, R. The Disparate Local Impacts of Closing Fossil-Fuel Power Plants – Working Paper. 2024.

(10) Constellation. Calvert Cliffs Clean Energy Center. https://www.constellationenergy.com/our-company/locations/location-sites/calvert-cliffs.html.

(11) Kane, S. I7 ODEC Wildcat Point Generation Facility, 2024.

(12) *CPV St. Charles Energy Center - Competitive Power Ventures*. https://www.cpv.com/our-projects/cpv-st-charles-energy-center/ (accessed 2024-10-29).

(13) National Renewable Energy Laboratory. Jobs and Economic Development Impact (JEDI). https://www.nrel.gov/analysis/jedi/about.html (accessed 2024-10-27).

(14) Ridley & Associates, Inc. *Nebraska's Electric Utility Industry: Glossary*; L.R. 455 Phase II Study; 1999. https://neo.ne.gov/info/pubs/reports/LR455Final/glossary.htm (accessed 2024-10-25).