Economic, Environmental, and Social Impacts of Data Centers in the United States

Including Statewide Impacts for Arizona, Ohio, and Virginia

Prepared for The Data Center Coalition

September 2023

pwc

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Economic, Environmental, and Social Impacts of Data Centers in the United States

About

The Data Center Coalition (DCC) engaged PwC to quantify the economic, environmental, and social impacts of the US data center industry. This report presents PwC's impact assessments for the 2017-2021 period at the national level and for three states: Arizona, Ohio, and Virginia. Data for select environmental and social impact metrics were available for 2022 and are included in this report.

DCC is the membership association for the data center industry and represents the industry's interests through a range of activities, including public policy advocacy, thought leadership, stakeholder outreach, and community engagement.

For more information, see www.datacentercoalition.org

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Acronyms

BEA	United States Bureau of Economic Analysis
BLS	United States Bureau of Labor Statistics
CRIT	Colorado River Indian Tribes
CSR	Corporate social responsibility
DCC	Data Center Coalition
DEI	Diversity, equity, and inclusion
ESG	Environmental, social, and governance
GDP	Gross domestic product
HVAC	Heating, ventilation, and air conditioning
IT	Information technology
LGBTQ+	Lesbian, gay, bisexual, transgender, and queer community
NAICS	North American Industry Classification System
OCP	Open Compute Project
PPA	Power purchase agreement
PUE	Power usage effectiveness
SBT/SBTi	Science-Based Target or Science-Based Targets Initiative
STEAM	Science, technology, engineering, arts, and mathematics
Tbps	Terabits per second
WUE	Water usage effectiveness

Executive Summary

Data centers are a crucial component of the modern economy, supporting digitalization, enabling data-driven decision-making, and powering a wide range of industries and services. Their role in storing, processing, and managing data is essential for organizations to thrive in the digital age.

Economic and Tax Impacts

Displayed in **Table E-1** below, the data center industry has had a significant impact on the US economy over the 2017-2021 period. The industry's growth has significantly outpaced that of the overall US economy over this period. From 2017-2021, the US data center industry's direct employment grew by over 17 percent, compared to 2 percent employment growth for the United States overall during the same period.

Between 2017 and 2021, the data center industry's total annual impact (combining its direct, indirect, and induced impacts arising from data center construction and operations) on national employment has grown from 2.9 million jobs in 2017 to 3.5 million jobs in 2021, a 20 percent increase over the period.

Based on preliminary government data for 2022, the industry is estimated to have added more jobs in 2022 than it added over the entire 2017-2021 period, resulting in 560,000 direct jobs and supporting 4.2 million total jobs across the country. This report finds that at the national level, each direct job in the data center industry supports more than six jobs elsewhere in the US economy (including both operational and capital spending impacts).

The US data center industry total* annual economic impacts between 2017-2021 included

2.9 to 3.5 million annual jobs

Each direct job in the data center industry supports more than 6 jobs elsewhere in the US economy.

$209 to $294 billion in annual labor income

Total impact on national labor income grew 40% and labor income earned directly from the data center industry grew by 74% between 2017 and 2021.

$355 to $486 billion in annual GDP contribution

Total contribution to GDP grew 37% from 2017 to 2021. The growth rate in GDP for the US economy as a whole was about half as much over the same time period.

*Total impact includes direct, indirect, and induced impacts. Direct impacts are those occurring directly within the data center industry. Indirect impacts are those occurring within other businesses as part of the supply chain to the data center industry. Induced impacts are those arising from household spending of income earned from the data center industry or its supply chain.

The industry's total annual impact on national labor income grew from $209 billion in 2017 to $294 billion in 2021, a 40 percent increase. The industry's total annual impact on US value added (i.e., contribution to Gross Domestic Product, GDP) grew from $355 billion in 2017 to $486 billion in 2021, a 37 percent increase. Over this same period, the growth rate in GDP for the entire US economy was only about half as much.

Table E-1.– The Economic Impacts of the US Data Center Industry, 2017-2021

Item	2017	2018	2019	2020	2021
Employment (jobs)[1]					
Direct Impact	400,100	420,400	421,600	443,600	468,800
Indirect and Induced Impact	2,525,290	2,628,140	2,683,520	2,883,680	3,039,490
Operational Impact	2,202,100	2,311,400	2,315,700	2,438,200	2,572,900
Capital Spending Impact	323,190	316,740	367,820	445,480	466,590
Total Impact[4]	2,925,390	3,048,540	3,105,120	3,327,280	3,508,290
Labor Income ($billions)[2]					
Direct Impact	$43	$51	$56	$60	$75
Indirect and Induced Impact	$166	$178	$184	$202	$219
Operational Impact	$144	$155	$158	$168	$180
Capital Spending Impact	$22	$23	$26	$34	$39
Total Impact[4]	$209	$229	$240	$262	$294
Value Added ($billions)[3]					
Direct Impact	$89	$103	$112	$114	$136
Indirect and Induced Impact	$267	$287	$297	$322	$350
Operational Impact	$234	$253	$259	$275	$295
Capital Spending Impact	$33	$34	$38	$47	$55
Total Impact[4]	**$355**	**$390**	**$409**	**$436**	**$486**

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

1. Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
2. Labor income is defined as wages, salaries, and benefits as well as proprietors' income.
3. Value added refers to the additional value created at a particular stage of production. It is measured as the difference between the total revenue of the industry and the total cost of its materials, supplies, and services purchased from other businesses, other than capital goods.
4. Total impact includes direct, indirect, and induced impacts. Direct impacts are those occurring directly within the data center industry. Indirect impacts are those occurring within other businesses as part of the supply chain to the data center industry. Induced impacts are those arising from household spending of income earned from the data center industry or its supply chain.

[1]Value added is a term commonly used by economists to describe how much an industry contributes to a nation's or state's GDP. It represents the additional value created at a particular stage of production. Value added is measured as the difference between the total revenue of the industry and the total cost of its materials, supplies, and services purchased from other businesses, other than capital goods. Value added can also be derived as the sum of employee compensation, proprietors' income, pretax income to capital owners from property (including depreciation), and taxes on production and imports (including excise taxes, property taxes, fees, licenses, sales taxes, and custom duties paid by businesses).

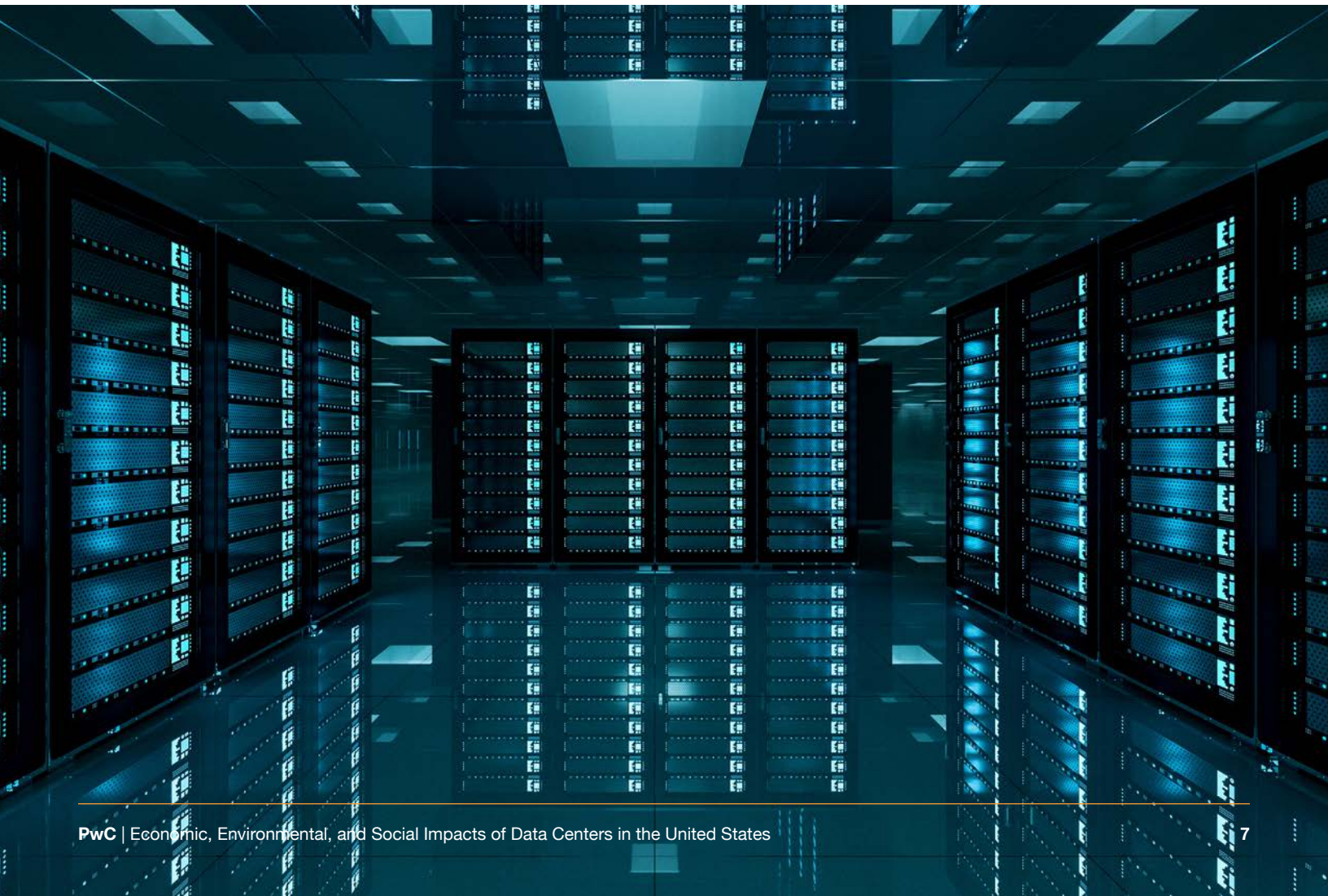
Displayed in **Table E-2** below, the data center industry's total contribution to government revenues at the federal, state, and local level, including direct, indirect, and induced impacts, increased from $66.2 billion in 2017 to $99.6 billion in 2021, a 50 percent increase.

Table E-2.– Federal, State, and Local Tax Impact of the US Data Center Industry, 2017-2021[1]

Item	2017	2018	2019	2020	2021
Total Impact ($billions)	**$66.2**	**$74.0**	**$79.0**	**$84.7**	**$99.6**
Social Insurance Contributions	$20.3	$22.7	$24.2	$26.9	$31.5
Corporate Income Taxes	$5.6	$6.3	$6.8	$7.1	$8.2
Personal Income Taxes	$20.2	$22.6	$24.2	$26.7	$31.2
Property Taxes	$8.1	$9.0	$9.6	$9.6	$11.5
Sales/Use Taxes	$9.1	$10.1	$10.8	$10.8	$12.9
Other payments	$2.9	$3.2	$3.4	$3.6	$4.3

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

1. Tax impact includes all federal, state, and local taxes directly or indirectly resulting from the US data center industry's construction and operations (including direct, indirect, and induced economic effects).

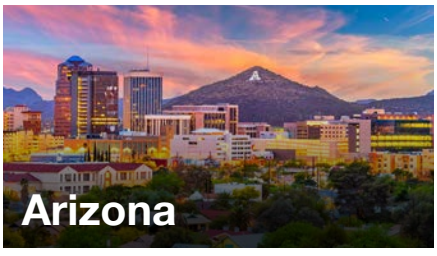


The data center industry operates in all 50 states and the District of Columbia (see Table A-1 in the appendix). In 40 states and the District of Columbia, data centers directly provided at least 1,000 jobs in each jurisdiction in 2021. We examine the total employment impact of the data center industry in three selected states: Arizona, Ohio, and Virginia. Including direct, indirect, and induced impacts, the industry's total annual employment impact in Arizona increased from 60,810 jobs in 2017 to 72,210 jobs in 2021, an 19 percent increase. The industry's total annual employment impact in Ohio increased from 50,330 jobs in 2017 to 61,740 jobs in 2021, a 23 percent increase. The industry's total annual employment impact in Virginia increased from 65,500 jobs in 2017 to 86,290 jobs in 2021, a 32 percent increase (see **Table E-3**).

Table E-3.– Total Economic Impacts of the Data Center Industry on Selected States, 2017-2021

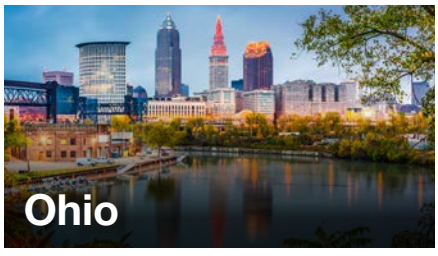
Item	2017	2018	2019	2020	2021
Employment (jobs)[1]					
Arizona	60,810	62,410	64,920	65,660	72,210
Ohio	50,330	53,050	55,140	59,760	61,740
Virginia	65,500	64,460	74,930	81,770	86,290
Labor Income ($millions)					
Arizona	$3,891	$4,147	$4,382	$4,578	$5,330
Ohio	$2,994	$3,358	$3,614	$3,960	$4,388
Virginia	$5,051	$5,041	$6,214	$6,814	$7,921
GDP ($millions)					
Arizona	$6,965	$6,850	$7,211	$7,460	$8,573
Ohio	$5,027	$5,650	$6,099	$6,462	$7,070
Virginia	$8,913	$8,979	$11,079	$11,732	$13,525

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.



72,210 jobs

The data center industry's total employment impact supported 72,210 jobs in Arizona in 2021, an increase of 19% from 2017.



61,740 jobs

The data center industry's total employment impact supported 61,740 jobs in Ohio in 2021, an increase of 23% from 2017.

86,290 jobs

The data center industry's total employment impact supported 86,290 jobs in Virginia in 2021, an increase of 32% from 2017.

Environmental and Social Impacts

DCC member companies participated in an environmental impact survey and social impact survey in conjunction with this report. Among the small number of survey participants, procurement of clean energy grew substantially over the 2017-2021 period, and participants also reduced their Scope 2[2] greenhouse gas emissions over the period. Data center owners and operators also contributed billions of dollars towards science, technology, engineering, arts, and mathematics (STEAM) education and other workforce development programs, and millions of dollars in charitable contributions.[3] Respondents to the social impact survey also increased workforce representation of women and racial and ethnic minority groups between 2019-2021.

[2] Greenhouse gases are categorized in three scopes. Scope 1 emissions are produced directly from the combustion of fuel. Scope 2 are indirect emissions from the use of purchased electricity. Scope 3 emissions are indirect emissions from a company's value chain, discussed further in Section IV.

[3] PwC Survey of DCC members.

I. Introduction

The rapid expansion of digital technologies, the proliferation of cloud computing, and the increasing demand for data-intensive applications have driven the exponential growth of data centers in the United States and worldwide. Data centers have become vital infrastructure supporting our digital-driven society. At the same time, they are driving economic activity and job opportunities across the United States.

DCC engaged PwC to quantify the economic, environmental, and social impacts of the US data center industry, including job creation, economic growth, regional development, and environmental sustainability. This report presents PwC's assessments for the 2017-2021 period at the national level and for three states: Arizona, Ohio, and Virginia.[4] We selected a set of states significant to the data center industry that reflect a range of market sizes and of varying maturity. Arizona is a rapidly growing data center market, with the Phoenix metro area ranked third in data center leasing activity in the first half of 2022.[5] Ohio is an emerging market for the data center industry. Virginia is a large and mature data center market.

The establishment and expansion of data centers have generated a wide range of employment opportunities across different skill levels, from construction and facility management to highly specialized roles in information technology (IT) and data management. The US data center industry has become a catalyst for economic growth, attracting investments and fostering innovation. Beyond the direct impact on job creation, data centers generate secondary effects by stimulating the growth of supporting industries such as construction, telecommunications, power infrastructure, and technology manufacturing.

DCC members completed an environmental impact survey and social impact survey for the purposes of this report. Of the 27 DCC member companies (24 at the time the survey was conducted), 13 submitted environmental and social impact surveys. Responses have been aggregated in some presentations to anonymize the data. The survey responses are the primary source of environmental and social impact data for this report. Additional data from member companies' environmental, social, and governance (ESG) reports, corporate social responsibility (CSR) reports, and other sources are documented throughout the report. The environmental and social impacts described in the report are representative only of the DCC members who participated in the survey and are not necessarily representative of the entire data center industry.

Data centers have rapidly innovated to drive operational efficiencies in the use of water and energy and meet their environmental sustainability goals. Data center operations often require large amounts of electricity and water to power and cool their equipment. As the industry has grown significantly over the last decade, there has been increasing attention to the environmental impacts of data centers from regulators and residents in the communities where data centers are located. This report estimates environmental impacts from 2017 to 2021 regarding energy[6] use, including both clean energy procurement and advances in energy efficiency, carbon emissions, water consumption and replenishment, and waste.

[4] Data for select environmental and social impact metrics were available for 2022 and are included in this report.
[5] CBRE Research, North America Data Center Trends H1 2022, (CBRE, 2022), https://www.cbre.com/insights/reports/north-america-data-center-trends-h1-2022#download-report.
[6] Clean energy is energy that is produced by non-polluting or greenhouse gas-emitting methods. Clean energy includes renewable energy sources such solar, wind, geothermal energy, and hydropower, as well as non-renewable sources such as nuclear energy.

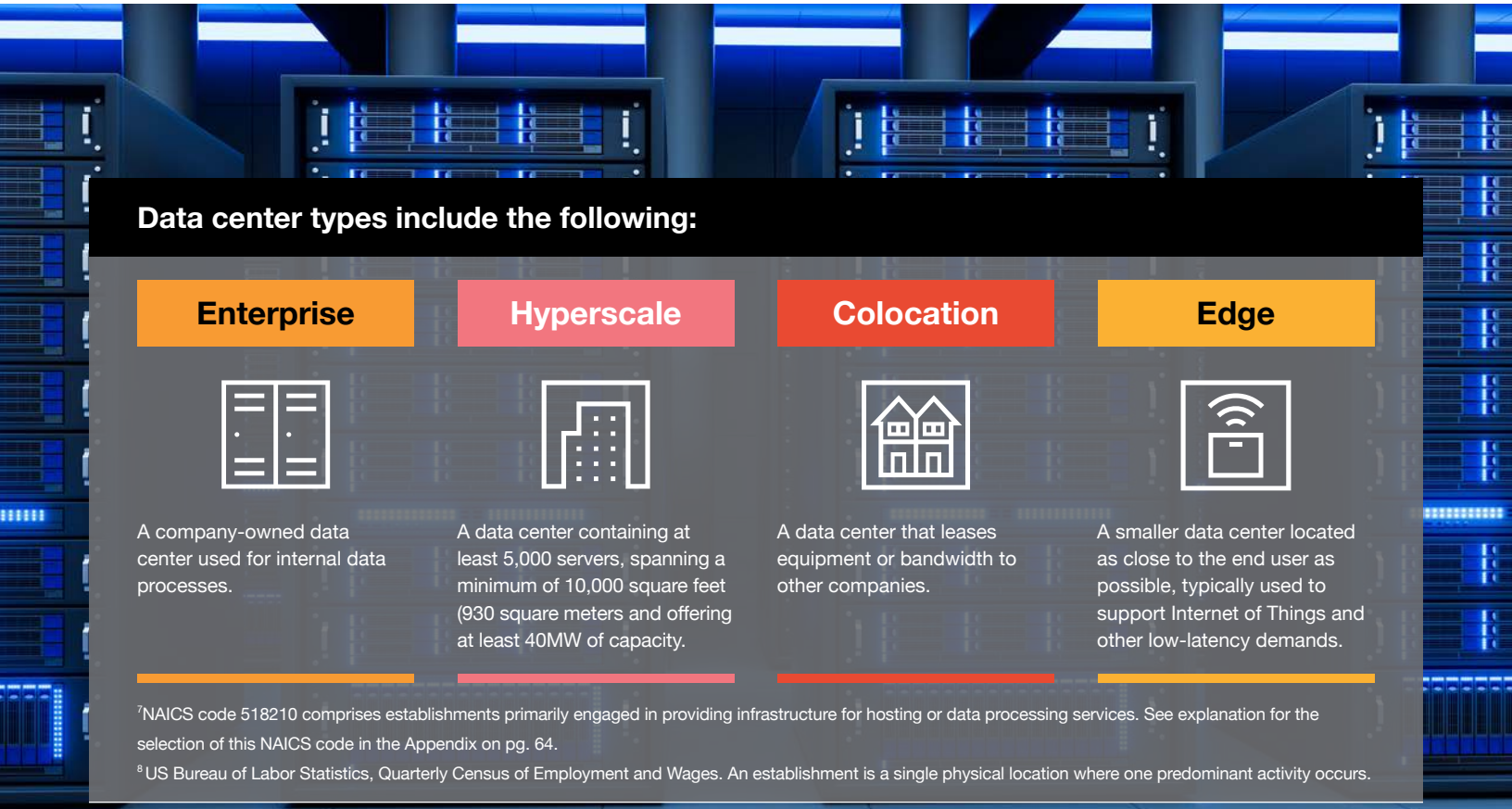
In addition to the economic benefits to local communities, the data center industry creates positive social impacts. This report presents data center contributions in science, technology, engineering, arts, and mathematics (STEAM) education and workforce development programs, community support, diversity, equity, and inclusion (DEI) initiatives, enhancing connectivity infrastructure in rural communities, and support of small and minority-owned businesses.

This report is organized as follows: **Section II** defines the data center industry for this study. **Section III** presents PwC's estimates of the industry's total economic impacts at the national and state levels for Arizona, Ohio, and Virginia for the 2017-2021 period, the most recent five years for which a consistent set of national and state-level data by industry is available. **Section IV** presents PwC's estimates of data center environmental impacts in the areas of energy efficiency, clean energy, carbon emissions, water usage and replenishment, and waste. **Section V** presents PwC's estimates of data center companies' social impacts in the areas of STEAM education, workforce development, DEI, community support, connectivity impact, and small and minority-owned business support. An appendix at the conclusion of the report provides additional information on data sources and methodology for the economic impact estimates.

II. Industry Overview

Data centers power our daily lives. They are the physical facilities that house computing machines and related information technology (IT) infrastructure, such as servers and network equipment, and store the digital data demanded by users around the globe. With their roots in the large computer rooms of the 1940s, data centers and the data stored within them have been powering the technology sector and enabling business-critical functions across nearly all sectors throughout our increasingly digitally connected economy for decades. Data centers are essential digital infrastructure that support nearly all industries across all sectors.

For the purpose of this study, we define the data center industry to include all establishments under the North American Industry Classification System ("NAICS") code 518210.[7] The data center industry, as measured by NAICS code 518210, has experienced tremendous growth over the last 20 years. At the end of the third quarter of 2022 (the most recent quarter for which government data are currently available), there were 47,310 data center establishments spanning every state and the District of Columbia, more than three times the number of data center establishments that were in operation in 2001.[8] The pace of the expansion was especially strong in the last five years, with the industry recording double-digit growth in the number of data center establishments each year. This rapid growth is indicative of exponential growth of the US digital economy as government, businesses, and households embrace broader digital transformation.



Data center types include the following:

Enterprise	Hyperscale	Colocation	Edge
A company-owned data center used for internal data processes.	A data center containing at least 5,000 servers, spanning a minimum of 10,000 square feet (930 square meters and offering at least 40MW of capacity.	A data center that leases equipment or bandwidth to other companies.	A smaller data center located as close to the end user as possible, typically used to support Internet of Things and other low-latency demands.

[7] NAICS code 518210 comprises establishments primarily engaged in providing infrastructure for hosting or data processing services. See explanation for the selection of this NAICS code in the Appendix on pg. 64.

[8] US Bureau of Labor Statistics, Quarterly Census of Employment and Wages. An establishment is a single physical location where one predominant activity occurs.

Data centers provide a variety of hosting and data processing services, such as:

1. Business process management services,
2. Application service provisioning,
3. Web site hosting services,
4. Data management services,
5. Data storage services,
6. IT technical support services,
7. Other data processing or IT infrastructure provisioning services,
8. Information and document transformation services, and
9. Computer systems design services.

III. Economic Impact

This section presents the estimated economic impact of the data center industry in the United States for the 2017-2021 period, as well as at the state level for Arizona, Ohio, and Virginia.

In measuring the total economic impact, we included the **direct impact** (the jobs, labor income, value added, and tax payments from operations of companies in the data center industry), the **indirect impact** (the jobs, labor income, value added, and tax payments occurring throughout the supply chain of the data center industry), and the **induced impact** (the jobs, labor income, value added, and tax payments resulting from household spending of income earned either directly or indirectly from the data center industry).

We used the IMPLAN input-output model to quantify these linkages (a detailed description of data sources and modeling methodology used can be found in **Appendix A**).[9]

To measure the economic activity of the US data center industry, we considered four metrics: employment, labor income, value added, and tax payments, as defined below.

Employment	The number of full-time and part-time payroll and self-employed jobs averaged over the year.
Labor income	Total wages, salaries, and benefits, as well as proprietors' income.
Value added	The total output of each sector less the associated value of intermediate inputs.[10] The sum of the value added across all sectors in the economy is GDP. An industry's value added represents its contribution to GDP.
Tax payments	Fiscal support through taxes to the federal government and state and local governments.

A. US Results

As shown in **Table III-1** below, the data center industry had a significant impact on the US economy over the 2017-2021 period. During the onset of COVID-19 in 2020, the data center industry experienced growth in each economic indicator evaluated, with further growth in direct employment, labor income, and value added in 2021. This growth during a period of economic disruption further highlights the importance of the US data center industry to the US economy.

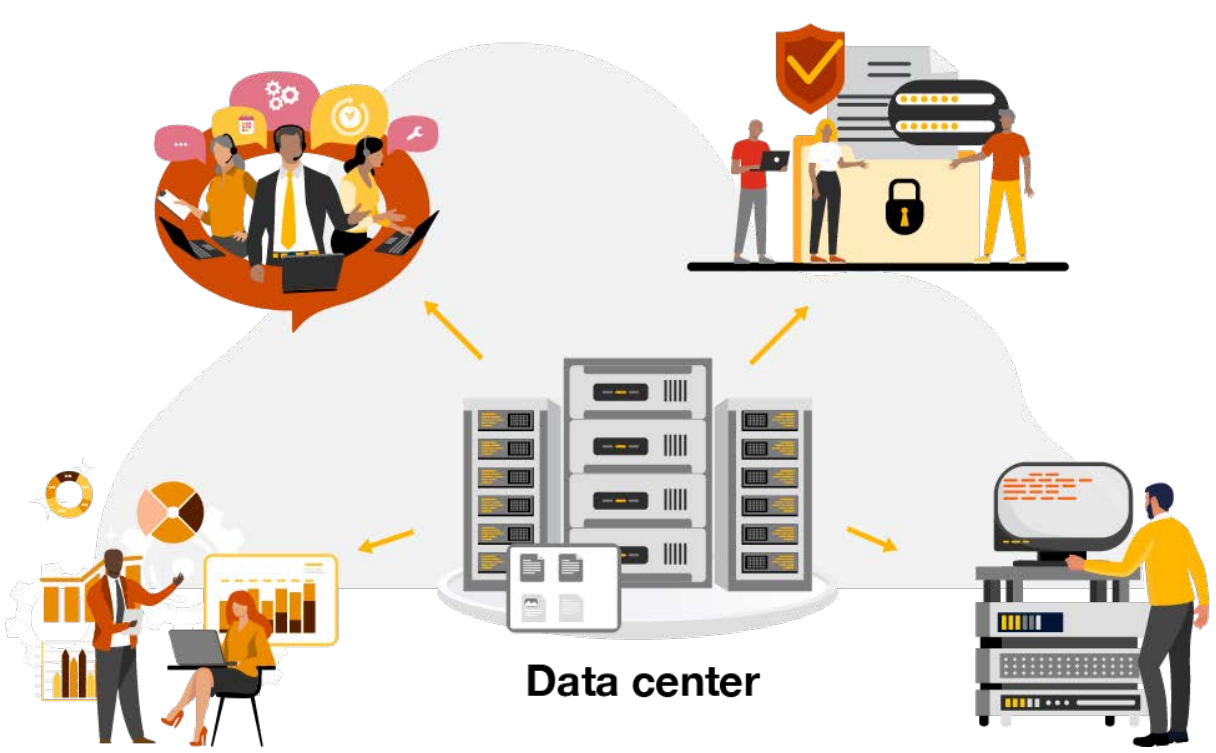
[9] The IMPLAN model, supported by the IMPLAN Group LLC., is an application that provides economic impact data and analysis using the economic modeling "input-output" (I-O) technique. Input-output analysis is a type of applied economic analysis that tracks the interdependence among various industries of an economy. IMPLAN is a regional economic analysis software that is designed to estimate the ripple effects of a given economic activity or the contribution of an existing activity within a specified geographic area of interest. "About IMPLAN", https://support.implan.com/hc/en-us/articles/360044985833-About-IMPLAN.

[10] Intermediate inputs are goods and services that are used in the production process to produce other goods or services. Bureau of Economic Analysis "What are intermediate inputs?" https://www.bea.gov/help/faq/185.

Employment. This report finds that at the national level, each direct job in the data center industry supports more than six jobs elsewhere in the US economy (including both operational and capital spending impacts). The jobs supported elsewhere in the economy are a result of the indirect impact (jobs existing to produce goods and services needed in the supply chain of the data center industry) as well as the induced impact (jobs resulting from additional household spending of income earned from the data center industry and its supply chain). Direct employment in the US data center industry grew by over 17 percent from 2017 to 2021. For comparison, the growth of employment in the United States overall was 2 percent over the same period.

Between 2017 and 2021, the data center industry's total annual impact (combining its direct, indirect, and induced impacts arising from data center construction and operations) on national employment grew from 2.9 million jobs in 2017 to 3.5 million jobs in 2021, a 20 percent increase over the period. Based on preliminary government data for 2022, the industry is estimated to have added more jobs in 2022 than it added over the entire 2017-2021 period, resulting in 560,000 direct jobs and supporting 4.2 million total jobs across the country.

Including both operational and capital spending impacts, each direct job in the US data center industry accounted for a total of 7.4 jobs throughout the US economy on average over the 2017-2021 period. This relationship is summarized as an employment multiplier of 7.4, meaning that each job in the US data center industry supported an average of 6.4 additional jobs elsewhere in the US economy through indirect and induced operational and capital spending impacts.[11]



[11] The employment multiplier based only on the operational impact averaged 6.5 over the 2017-2021 period.

Labor Income. Labor income earned directly from the data center industry grew by 74 percent between 2017 and 2021, rising from $43 billion to $75 billion. This growth is almost three times as much as the growth in labor income across all US industries over the same period. The industry's total annual impact on national labor income (from both operations and capital investments) grew from $209 billion in 2017 to $294 billion in 2021, a 40 percent increase. The labor income multiplier including both operational and capital spending impacts averaged 4.3 over the 2017-2021 period, meaning that for each dollar of labor income in the US data center industry, 3.3 dollars of labor income were generated elsewhere in the US economy.[12]

Value Added. Value added generated directly by the data center industry grew by 53 percent between 2017 and 2021, rising from $89 billion in 2017 to $136 billion in 2021. Over this same period, the growth rate in GDP for the entire US economy was only about half as much. The industry's total annual impact on US value added (i.e., contribution to GDP) from both operations and capital investments grew from $355 billion in 2017 to $486 billion in 2021, a 37 percent increase. The value added multiplier including both operational and capital spending impacts averaged 3.7 over the 2017-2021 period, meaning that for each dollar of direct value added in the US data center industry 2.7 dollars of value added were supported elsewhere in the US economy.[13]

[12] The labor income multiplier based only on the operational impact averaged 3.8 over the 2017-2021 period.

[13] The value added multiplier based only on the operational impact averaged 3.4 over the 2017-2021 period.

At the national level, each direct job in the data center industry supports **more than six jobs** elsewhere in the US economy.

Table III-1.– The Economic Impacts of the US Data Center Industry 2017-2021

Item	2017	2018	2019	2020	2021
Employment (jobs)[1]					
Direct Impact	400,100	420,400	421,600	443,600	468,800
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Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

1. Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
2. Labor income is defined as wages, salaries, and benefits as well as proprietors' income.
3. Value added refers to the additional value created at a particular stage of production. It is measured as the difference between the total revenue of the industry and the total cost of its materials, supplies, and services purchased from other businesses, other than capital goods.
4. Total impact includes direct, indirect, and induced impacts. Direct impacts are those occurring directly within the data center industry. Indirect impacts are those occurring within other businesses as part of the supply chain to the data center industry. Induced impacts are those arising from household spending of income earned from the data center industry or its supply chain.

Taxes. The data center industry is an important tax contributor to the US economy. These tax contributions at the federal, state, and local level support the financing of government and public programs and services. Notable services supported by taxes include public education, maintenance of infrastructure such as roads and public transportation, and public health. Displayed in **Table III-2** below, the data center industry's total fiscal support to the federal government and state and local governments, including direct, indirect, and induced impacts, increased from $66.2 billion in 2017 to $99.6 billion in 2021, a 50 percent increase.

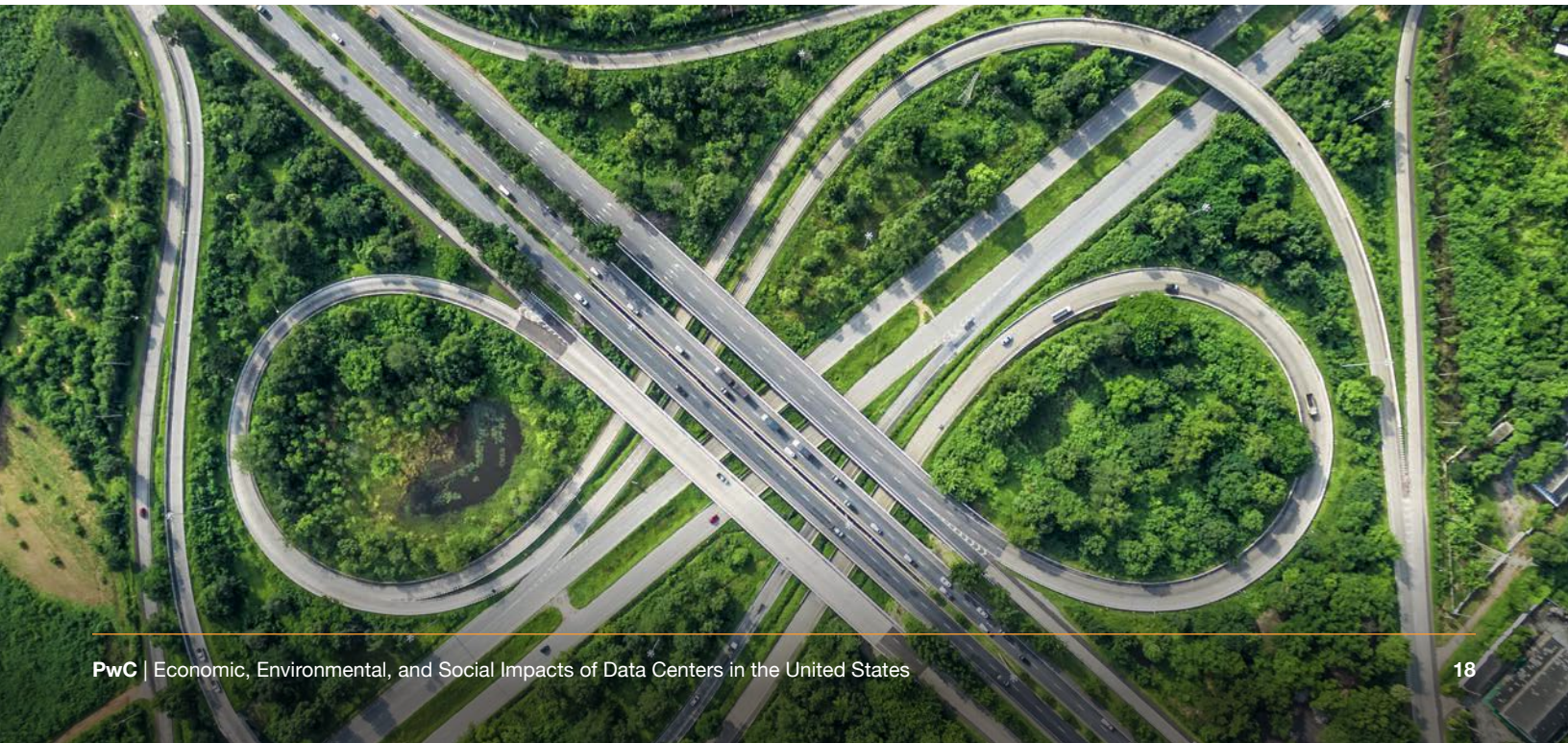
Data centers are eligible for exemptions from certain taxes in many states, as are other industries. Tax exemptions applicable to data centers in the states of Arizona, Ohio, and Virginia are discussed in **Section III B,** below.

Table III-2.– Federal, State, and Local Tax Impact of the US Data Center Industry, 2017-2021[1]

Item	2017	2018	2019	2020	2021
Total Impact ($billions)	**$66.2**	**$74.0**	**$79.0**	**$84.7**	**$99.6**
Social Insurance Contributions	$20.3	$22.7	$24.2	$26.9	$31.5
Corporate Income Taxes	$5.6	$6.3	$6.8	$7.1	$8.2
Personal Income Taxes	$20.2	$22.6	$24.2	$26.7	$31.2
Property Taxes	$8.1	$9.0	$9.6	$9.6	$11.5
Sales/Use Taxes	$9.1	$10.1	$10.8	$10.8	$12.9
Other payments	$2.9	$3.2	$3.4	$3.6	$4.3

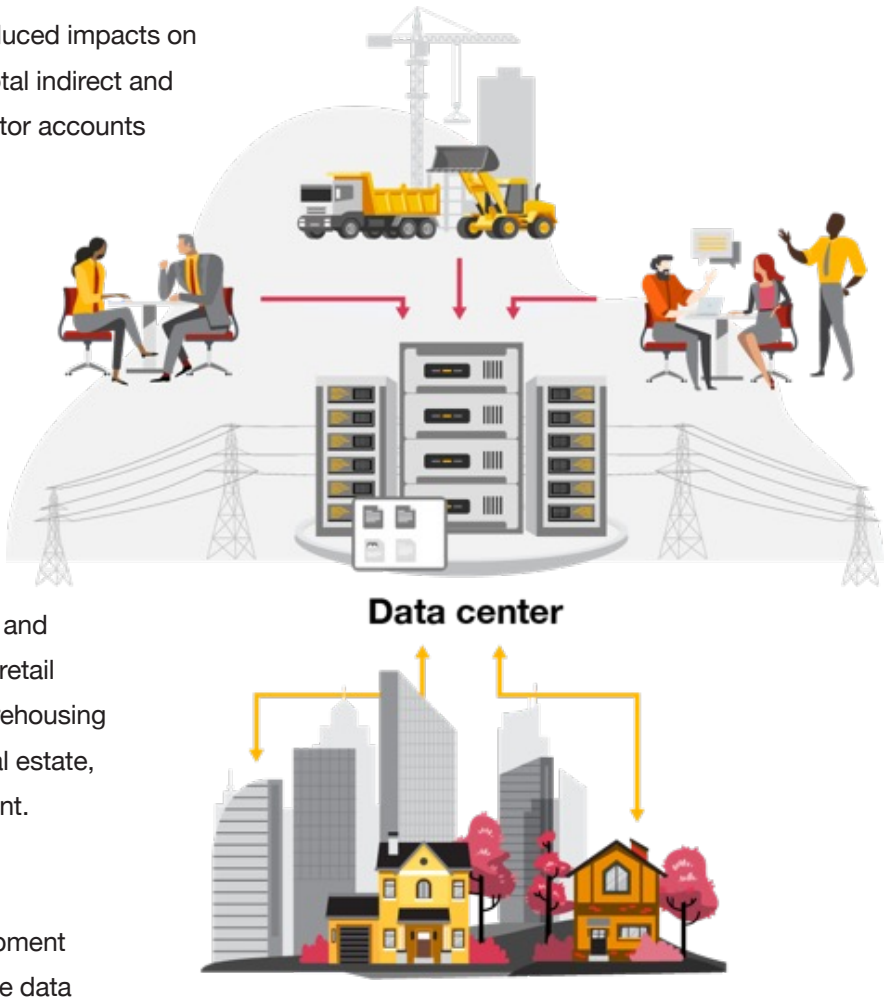
Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

1. Tax impact includes all federal, state, and local taxes directly or indirectly resulting from the US data center industry's construction and operations (including direct, indirect, and induced economic effects).



Widespread indirect and induced effects across industries. This study finds that the indirect and induced economic activity spurred by the data center industry between 2017 and 2021 occurred across a broad range of other US industries.

Table III-3 below breaks out the indirect and induced impacts on employment by sector as a percentage of the total indirect and induced employment impact.[14] The services sector accounts for over half of the indirect and induced impacts attributable to the US data center industry from 2017 to 2021. This is not surprising because the services sector, which includes professional services, administrative support services, food services, management consulting services, health care, and accommodations, among others, is the largest in the US economy.



The next three sectors with the greatest indirect and induced employment effects are wholesale and retail trade at over 10 percent, transportation and warehousing at roughly 9 percent, and finance, insurance, real estate, rental and leasing sector also at roughly 9 percent.

The manufacturing sector (including fiber cable, server, storage device, and other electrical equipment manufacturing) received close to 5 percent of the data center industry's indirect and induced employment impact. The information sector (excluding data centers) received nearly 3 percent of the data center industry's indirect and induced employment impact. The construction sector (including new structures and fiber cable installation) received nearly 2 percent of the data center industry's indirect and induced employment impact.

Industry distributions of the indirect and induced impacts for labor income and value added are similar, since the economic indicators of jobs, labor income, and value added are closely related to one another.

[14] The top supplying sectors benefiting from the data center industry's indirect economic effect are shown in Table A-2 in the appendix.

Table III-3.– Distribution of Indirect and Induced Activity Generated by the US Data Center Industry, 2017-2021: *Employment*

Total number and percent by industry

Item	2017	2018	2019	2020	2021
Total (thousands of jobs)	**2,525**	**2,628**	**2,684**	**2,884**	**3,039**
Services	59.4%	59.6%	59.5%	59.3%	59.4%
Wholesale and retail trade	10.2%	10.1%	10.1%	10.5%	10.4%
Transportation and warehousing	9.3%	9.3%	9.3%	9.2%	9.2%
Finance, insurance, real estate, rental and leasing	9.2%	9.2%	9.1%	9.1%	9.0%
Manufacturing	4.7%	4.7%	4.7%	4.7%	4.7%
Information	2.8%	2.8%	2.8%	2.7%	2.7%
Construction	1.8%	1.6%	1.8%	1.8%	1.9%
Other	1.2%	1.2%	1.1%	1.1%	1.1%
Agriculture, forestry, and fishing	1.0%	1.0%	1.0%	1.0%	1.0%
Utilities	0.4%	0.4%	0.4%	0.4%	0.4%
Mining	0.1%	0.1%	0.1%	0.1%	0.1%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

B. State Results

The economic impact of the data center industry varies from state to state, depending on each state's population, natural resources, industry mix, wage structure, spending and saving patterns, and connections to other economies. For this study, the economic impact reported for each state includes the data center industry's direct, indirect, and induced impacts in the state based only on the data center industry's operations in the state.[15]

[15] The operations of the data center industry outside of each state also generate economic benefits for the state through indirect and induced effects. These spillover benefits for each state are excluded from the analysis presented in this section.

Arizona

Arizona has the second greatest number of data center jobs among the three states evaluated. **Table III-4a** below details the data center industry's economic and tax impacts in Arizona.

Direct data center jobs in Arizona increased from 11,310 to 13,080 between 2017 and 2021, an increase of 16 percent, compared to an 8 percent increase in the state's economywide total employment over the same period. The indirect and induced employment impact in Arizona generated by Arizona's data center industry increased from 49,500 jobs to 59,130 jobs between 2017 and 2021, of which the operational employment impact increased from 44,340 jobs in 2017 to 51,630 jobs in 2021, and the capital spending employment impact increased from 5,160 jobs in 2017 to 7,500 jobs in 2021. All told, the industry's total annual employment impact in Arizona increased from 60,810 jobs in 2017 to 72,210 jobs in 2021, a 19 percent increase.

The industry's total annual labor income impact in Arizona increased from $3.9 billion in 2017 to $5.3 billion in 2021, a 37 percent increase.

The industry's total annual GDP impact in Arizona grew from $7.0 billion in 2017 to $8.6 billion in 2021, a 23 percent increase.

Arizona's data center industry directly and indirectly **generated $2.3 billion total state and local taxes** over the 2017 and 2021 period.

Arizona offers a transaction privilege and use tax exemption for data center equipment to qualifying data centers investing at least $50 million.[16] Local governments in Arizona may offer other exemptions and abatements.

To put the total tax impacts of the data center industry in perspective, we evaluated the industry's state and local tax revenue impact for Arizona relative to the state and local governments' fiscal budget and spending for 2020, the most recent year for which state-level government spending data are currently available.[17] Our analysis shows that, in 2020, the US data center industry's total state and local tax impact in Arizona was sufficient to fund all of Arizona's state and local expenditures on library education services plus over one-fourth of hospital services.

[16] The state government in Arizona reported $1.1 million in transaction privilege and use tax exemptions on sales of computer data equipment for use in a certified computer data center in fiscal year 2021 (https://www.azjlbc.gov/revenues/22taxbk.pdf).

[17] Census Bureau, "Annual Survey of State and Local Government Finances", https://www.census.gov/programs-surveys/gov-finances.html. Data for state and local government spending in 2021 are not yet available.

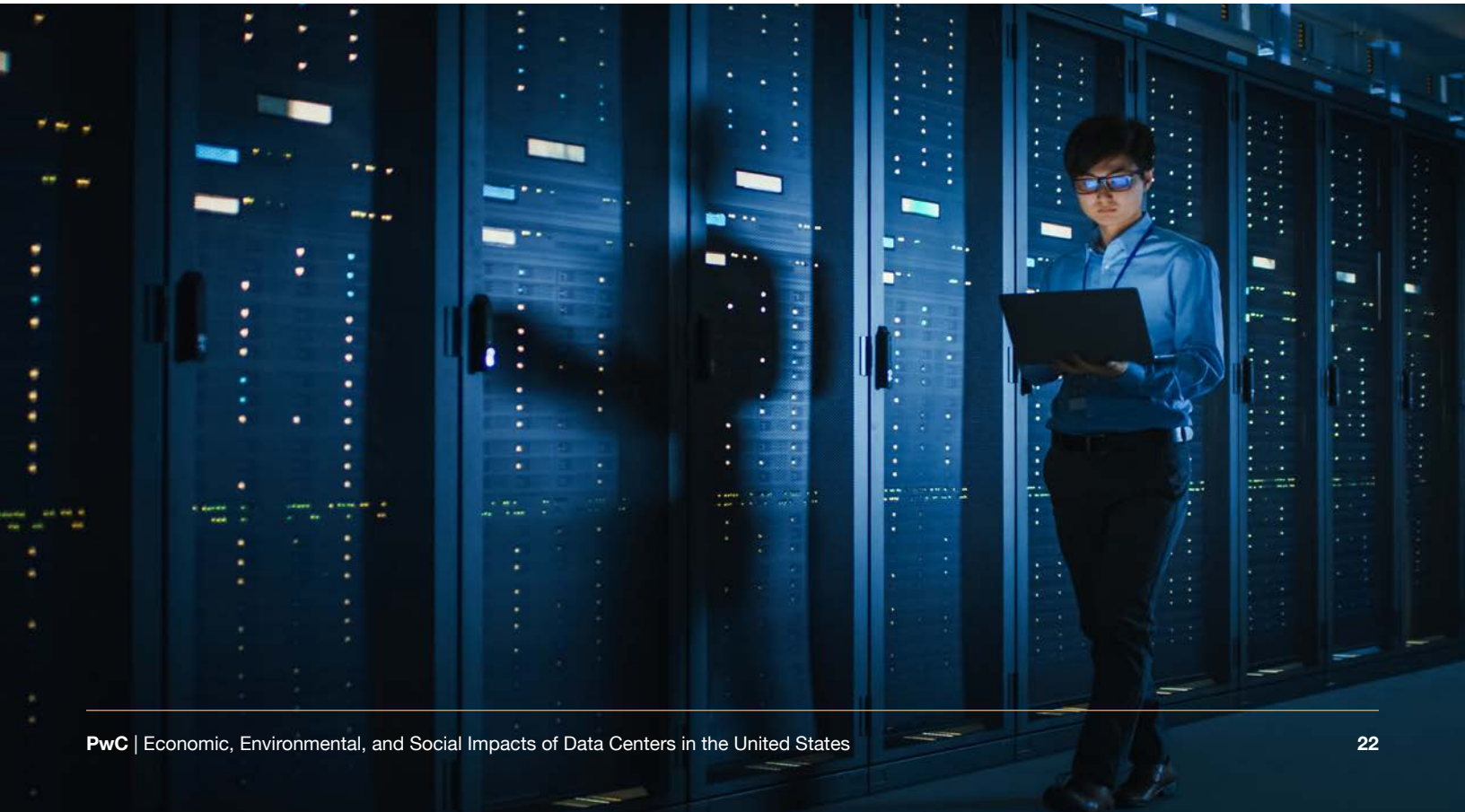


Table III-4a.– The Economic and Tax Impacts of the Data Center Industry in Arizona, 2017-2021

Item	2017	2018	2019	2020	2021
Employment (jobs)					
Direct Impact	11,310	11,640	11,980	11,890	13,080
Indirect and Induced Impact	49,500	50,770	52,940	53,770	59,130
Operational Impact	44,340	45,750	47,050	46,710	51,630
Capital Spending Impact	5,160	5,020	5,890	7,060	7,500
Total Employment Impact	**60,810**	**62,410**	**64,920**	**65,660**	**72,210**
Labor Income ($millions)					
Direct Impact	$1,051	$1,143	$1,205	$1,290	$1,623
Indirect and Induced Impact	$2,841	$3,004	$3,177	$3,288	$3,707
Operational Impact	$2,538	$2,694	$2,816	$2,828	$3,167
Capital Spending Impact	$302	$309	$361	$461	$540
Total Labor Income Impact	**$3,891**	**$4,147**	**$4,382**	**$4,578**	**$5,330**
GDP ($millions)					
Direct Impact	$2,480	$2,098	$2,188	$2,292	$2,737
Indirect and Induced Impact	$4,485	$4,751	$5,023	$5,167	$5,837
Operational Impact	$4,028	$4,290	$4,497	$4,528	$5,075
Capital Spending Impact	$456	$461	$526	$639	$762
Total GDP Impact	**$6,965**	**$6,850**	**$7,211**	**$7,460**	**$8,573**
Total State and Local Tax Impact ($millions) [1]	**$422**	**$427**	**$462**	**$442**	**$565**

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

[1] Tax impact includes all state and local taxes directly or indirectly resulting from the US data center industry's construction and operations (including direct, indirect, and induced economic effects) benefiting the state.

Ohio

Ohio has the lowest direct data center employment among the three states evaluated, largely because it is an emerging market for the data center industry. **Table III-4b** below details the data center industry's economic and tax impacts in Ohio.

Direct data center industry employment grew by a rapid 17 percent between 2017 and 2021 compared to less than a 1 percent increase in Ohio's economywide total employment over the same period. The indirect and induced employment impact in Ohio generated by Ohio's data center industry increased from 40,530 jobs to 50,240 jobs between 2017 and 2021, of which the operational employment impact increased from 33,380 jobs in 2017 to 39,410 jobs in 2021, and the capital spending employment impact increased from 7,150 jobs in 2017 to 10,830 jobs in 2021. All told, the industry's total annual employment impact in Ohio increased from 50,330 jobs in 2017 to 61,740 jobs in 2021, a 23 percent increase.

The industry's total annual labor income impact in Ohio increased from $3.0 billion in 2017 to $4.4 billion in 2021, a 47 percent increase.

The industry's total annual GDP impact in Ohio grew from $5.0 billion in 2017 to $7.1 billion in 2021, a 41 percent increase.

Ohio's data center industry directly and indirectly **generated $2.6 billion in total** state and local tax revenues in Ohio from 2017 to 2021.

Ohio offers sales tax abatement for data centers that invest at least $100 million and create annual payroll of $1.5 million or more. Local governments in Ohio may offer other exemptions and abatements.

To put the total tax impacts of the data center industry in perspective, we evaluated the industry's state and local tax revenue impact for Ohio relative to the state and local governments' fiscal budget and spending for 2020, the most recent year for which state-level government spending data are currently available.[18] Our analysis shows that in 2020, the US data center industry's total tax impact in Ohio was sufficient to fund all of Ohio's state and local government expenditures on airport-related services plus roughly 20 percent of Ohio's state and local expenditures on natural resource protection and management.

[18] Census Bureau, "Annual Survey of State and Local Government Finances", https://www.census.gov/programs-surveys/gov-finances.html. Data for state and local government spending in 2021 are not yet available.

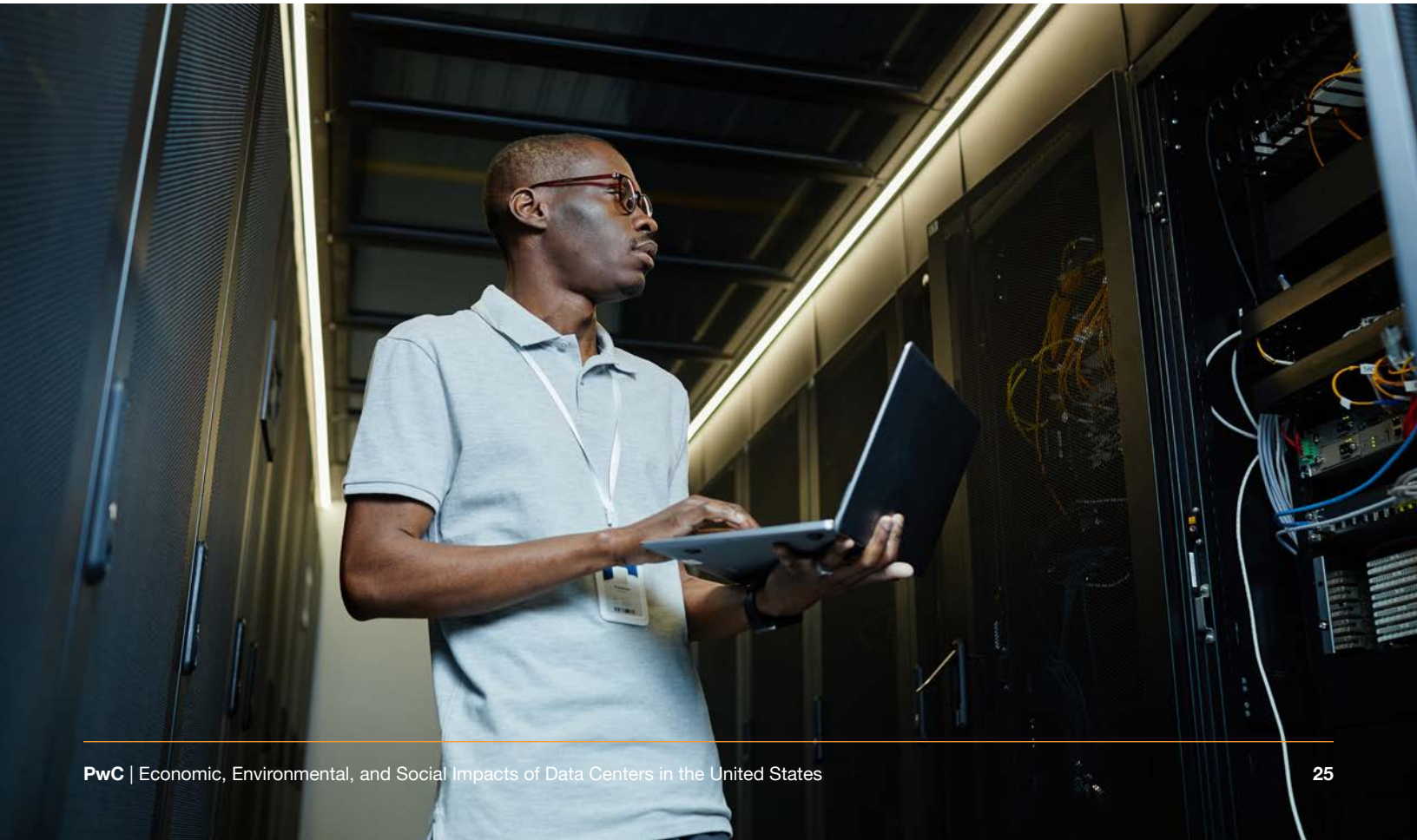


Table III-4b.– The Economic and Tax Impacts of the Data Center Industry in Ohio, 2017-2021

Item	2017	2018	2019	2020	2021
Employment (jobs)					
Direct Impact	9,800	10,490	10,670	11,290	11,500
Indirect and Induced Impact	40,530	42,560	44,470	48,470	50,240
Operational Impact	33,380	35,260	36,070	38,170	39,410
Capital Spending Impact	7,150	7,300	8,400	10,300	10,830
Total Employment Impact	**50,330**	**53,050**	**55,140**	**59,760**	**61,740**
Labor Income ($millions)					
Direct Impact	$750	$921	$1,033	$1,087	$1,299
Indirect and Induced Impact	$2,244	$2,437	$2,581	$2,873	$3,089
Operational Impact	$1,818	$2,007	$2,063	$2,203	$2,309
Capital Spending Impact	$426	$430	$518	$669	$780
Total Labor Income Impact	**$2,994**	**$3,358**	**$3,614**	**$3,960**	**$4,388**
GDP ($millions)					
Direct Impact	$1,441	$1,737	$1,956	$1,912	$2,176
Indirect and Induced Impact	$3,586	$3,913	$4,143	$4,551	$4,894
Operational Impact	$2,965	$3,270	$3,396	$3,633	$3,806
Capital Spending Impact	$621	$643	$747	$918	$1,088
Total GDP Impact	**$5,027**	**$5,650**	**$6,099**	**$6,462**	**$7,070**
Total State and Local Tax Impact ($millions) [1]	**$419**	**$481**	**$533**	**$489**	**$630**

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

[1] Tax impact includes all state and local taxes directly or indirectly resulting from the US data center industry's construction and operations (including direct, indirect, and induced economic effects) benefiting the state.

Virginia

Virginia has the highest industry direct employment of the US states evaluated due to the number and size of data centers in the state. **Table III-4c** below details the data center industry's economic and tax impacts in Virginia.

Direct data center jobs in Virginia increased by 26 percent between 2017 and 2021 compared to a 2 percent increase in the state's economywide total employment over the same period. The indirect and induced employment impact in Virginia generated by Virginia's data center industry increased from 51,730 jobs to 68,910 jobs between 2017 and 2021, of which the operational employment impact increased from 44,780 jobs in 2017 to 58,320 jobs in 2021, and the capital spending employment impact increased from 6,950 jobs in 2017 to 10,590 jobs in 2021. All told, the industry's total annual employment impact in Virginia increased from 65,500 jobs in 2017 to 86,290 jobs in 2021, a 32 percent increase.

The industry's total labor annual income impact in Virginia increased from $5.1 billion in 2017 to $7.9 billion in 2021, a 57 percent increase.

The industry's total annual GDP impact in Virginia grew from $8.9 billion in 2017 to $13.5 billion in 2021, a 52 percent increase.

Virginia's data center industry directly and indirectly **generated $3.5 billion** in state and local tax revenues over the 2017-2021 period.

Virginia offers a sales tax exemption for data center equipment to those data centers that qualify by meeting both a capital investment and employment threshold.[19] Local governments in Virginia may offer other exemptions and abatements.

To put the total tax impacts of the data center industry in perspective, we evaluated the industry's state and local tax revenue impact for Virginia relative to the state and local governments' fiscal budget and spending for 2020, the most recent year for which state-level government spending data are currently available.[20] Our analysis shows that in 2020, the US data center industry's total tax impact in Virginia was sufficient to fund Virginia's state and local expenditures on all cash assistance program payments plus almost one-third of housing and community development program expenditures.

[19] Data from Virginia Department of Accounts show that the amount of abated retail sales and use tax revenues for data centers for the fiscal year 2021 was $124.5 million, nearly twice the amount of data center tax abatements in 2017 ($65.2 million). Available at: https://www.doa.virginia.gov/reports/ACFReport/2021-ACFReport.shtml.

[20] Census Bureau, "Annual Survey of State and Local Government Finances", https://www.census.gov/programs-surveys/gov-finances.html. Data for state and local government spending in 2021 are not yet available.

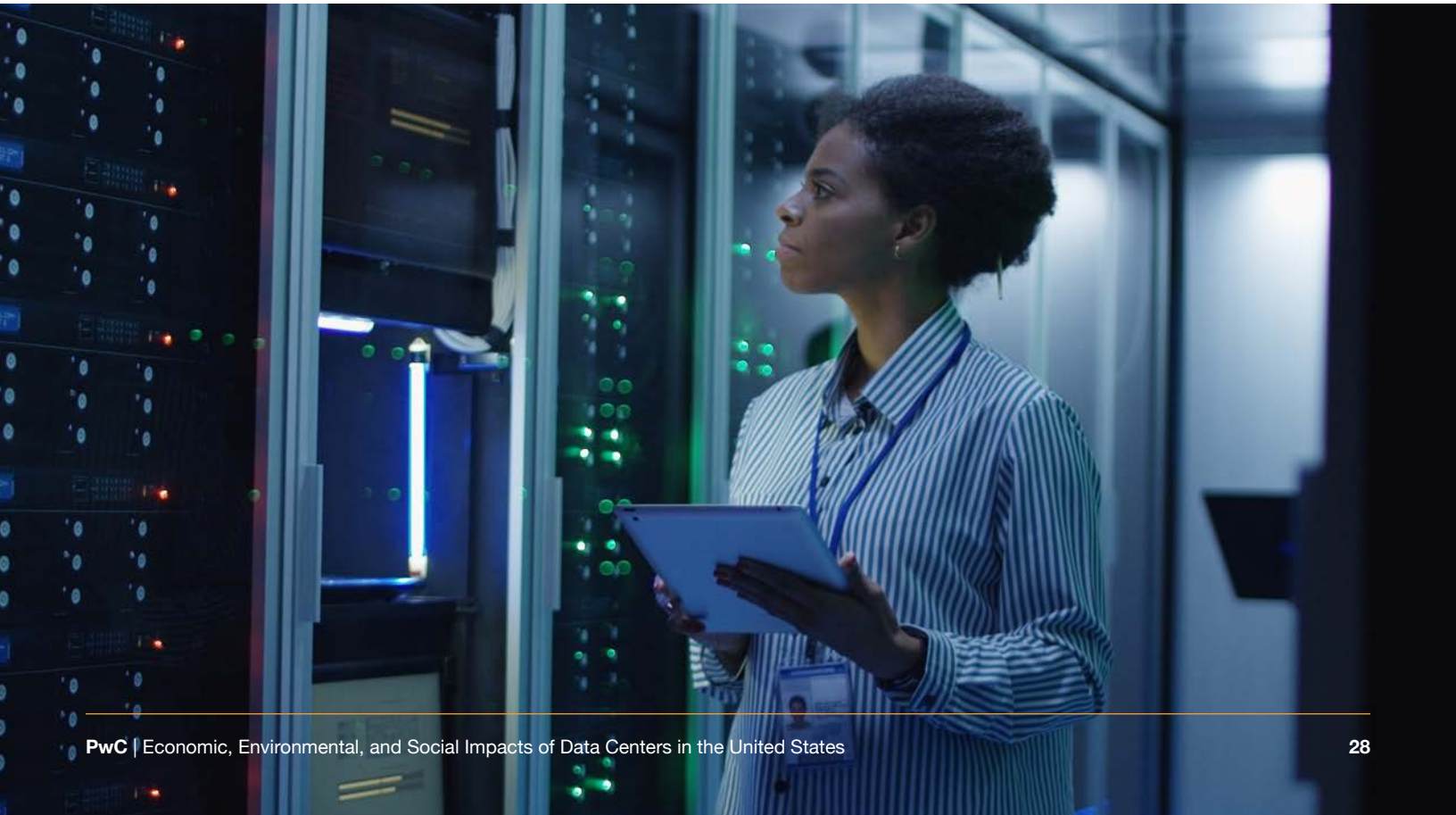


Table III-4c.– The Economic and Tax Impacts of the Data Center Industry in Virginia, 2017-2021

Item	2017	2018	2019	2020	2021
Employment (jobs)					
Direct Impact	13,770	13,590	15,730	16,880	17,380
Indirect and Induced Impact	51,730	50,870	59,200	64,890	68,910
Operational Impact	44,780	44,170	51,070	54,850	58,320
Capital Spending Impact	6,950	6,700	8,130	10,040	10,590
Total Employment Impact	**65,500**	**64,460**	**74,930**	**81,770**	**86,290**
Labor Income ($millions)					
Direct Impact	$1,706	$1,683	$2,245	$2,375	$3,008
Indirect and Induced Impact	$3,345	$3,359	$3,969	$4,440	$4,912
Operational Impact	$2,827	$2,836	$3,339	$3,614	$3,938
Capital Spending Impact	$518	$523	$631	$825	$974
Total Labor Income Impact	**$5,051**	**$5,041**	**$6,214**	**$6,814**	**$7,921**
GDP ($millions)					
Direct Impact	$3,640	$3,667	$4,804	$4,789	$5,824
Indirect and Induced Impact	$5,273	$5,312	$6,275	$6,943	$7,701
Operational Impact	$4,538	$4,569	$5,403	$5,869	$6,409
Capital Spending Impact	$735	$743	$872	$1,074	$1,292
Total GDP Impact	**$8,913**	**$8,979**	**$11,079**	**$11,732**	**$13,525**
Total State and Local Tax Impact ($millions) [1]	**$568**	**$593**	**$728**	**$725**	**$909**

Source: PwC calculations using the IMPLAN modeling system and public data sources. Details may not add up to totals due to rounding.

[1] Tax impact includes all state and local taxes directly or indirectly resulting from the US data center industry's construction and operations (including direct, indirect, and induced economic effects) benefiting the state.

C. Other Economic Benefits of Data Centers

C1. Diverse Job Opportunities

The data center industry provides employment opportunities for individuals across a broad range of educational backgrounds. As shown in **Table III-5a** below, nationwide over 40 percent of the data center industry's workforce are high school graduates or have some post-secondary training or associate degree, and nearly 60 percent have a four-year college degree or higher.[21] This contrasts with workers across all US jobs, where about 70 percent have less than a four-year college degree and 30 percent have a bachelor's degree or higher.

Table III-5a.– Typical Employee Education: Data Centers vs. All US Jobs, 2021

	Percent of Employees	
Education Level	**Data Centers**	**All US Jobs**
Less than a high school diploma	0.8%	9.9%
High school diploma or equivalent	16.5%	35.2%
Post-secondary certificate or some college courses	14.2%	17.4%
Associate degree (or other 2-year degree)	10.8%	8.5%
Bachelor's degree	46.7%	19.5%
Post-graduate	11.1%	9.6%
Total	**100.0%**	**100.0%**

Source: PwC calculations using the IMPLAN modeling system. Details may not add up to totals due to rounding.

[21] IMPLAN occupation database, which combines four government data sources: (1) BLS Occupational Employment and Wage Statistics (OEWS); (2) BLS Employment Projections national industry by occupation matrix; (3) Census Bureau American Community Survey (ACS) Public Use Microdata Sample (PUMS); and (4) The US Labor Department's O*NET database, which provides information on knowledge, skills, abilities, education, work experience, and on-the-job training by occupation.

Data centers support a range of occupations with growth opportunities for employees, as shown in **Table III-5b** below. Some of the most in-demand job positions in the industry include: (1) computer specialists (38.9 percent), (2) business operations specialists (10.5 percent), (3) information and record clerks (8.1 percent), and (4) operations specialties managers (6.6 percent).

Table III-5b.– US Data Center Industry: Types of Occupation, 2021

Occupation	Percent of Employees
Computer Occupations	38.9%
Business Operations Specialists	10.5%
Information and Record Clerks	8.1%
Operations Specialties Managers	6.6%
Other Office and Administrative Support Workers	5.8%
Sales Representatives, Services	5.7%
Top Executives	4.2%
Financial Specialists	2.9%
Advertising, Marketing, Promotions, Public Relations, and Sales Managers	2.7%
Financial Clerks	1.9%
Supervisors of Office and Administrative Support Workers	1.7%
Sales Representatives, Wholesale and Manufacturing	1.2%
Mathematical Science Occupations	1.2%
Engineers	1.2%
All Other Occupations	7.5%
Total	**100.0%**

Source: PwC calculations using the IMPLAN modeling system.

Data center occupations require a wide range of skills and expertise, allowing people with different educational backgrounds and professional experiences to contribute to the growing field. For example,

1. **Technical Roles:** Data centers employ professionals with technical knowledge and skills in areas such as networking, system administration, and hardware maintenance. These roles often require specialized training or degrees in computer science, information technology, or related fields.
2. **Operations and Management:** The operations and management of data centers involve personnel responsible for monitoring, troubleshooting, and maintaining critical systems and equipment. These roles may require certifications in areas such as data center operations, facilities management, or project management.

3. **Security and Compliance:** Data centers must protect sensitive information. Professionals with backgrounds in cybersecurity, risk management, compliance, and auditing can play crucial roles in implementing and maintaining robust security measures and ensuring adherence to relevant regulations.
4. **Support and Customer Service:** Data centers need to provide technical support, customer service, and account management services. These roles may require strong communication skills and a customer-oriented approach, among others, making such job opportunities available to individuals from diverse backgrounds.
5. **Project Management:** Data center construction, expansion, or migration projects require experienced project managers. Individuals with project management expertise can supervise the planning, coordination, and successful execution of these projects.
6. **Sales and Marketing:** Data centers operators need sales and marketing professionals to promote their services, attract customers, and drive business growth, thus opening the door for individuals with backgrounds in sales, marketing, or business development.

As the types of jobs described above illustrate, the data center industry provides diverse job opportunities in the local communities in which they operate. The range of job opportunities can be attractive to residents who wish to stay and work in their own community, whether they are young workers entering the job market for the first time, or experienced professionals who look to join the growing industry. This helps strengthen the talent pool in the local economy and form the foundation of a local "tech hub," providing the expertise needed to support the growth of digital businesses in the local economy.[22] A data center-led tech hub may result in spillover benefits to the local economy, particularly in terms of innovation and productivity.[23] This is because data centers help bring together technology companies, startups, researchers, and industry professionals. Their collaboration enhances the flow of ideas, sharing of best practices, and the transfer of knowledge, all of which can help stimulate new innovations. Further, data centers serve as the foundation for emerging technologies such as artificial intelligence, machine learning, Internet of Things (IoT), and big data analytics, so their presence increases the likelihood of the adoption and development of these technologies in the local economy. This in turn leads to the creation of innovative products, services, and solutions that enhance productivity, efficiency, and competitiveness across other sectors of the region.

In addition, a more diversified economy reduces the exposure of the region to a reduction in economic activity specific to a single sector. A diversified economy creates a sustainable cycle of economic activity, makes employment more stable, and reduces the volatility of local government tax revenue.

[22] A tech hub refers to a geographical location where there is a concentration of technological-related businesses and startups as well as supporting infrastructure and talent pool.

[23] The potential spillover benefits of a tech hub is a part of the agglomeration phenomenon extensively studied by economists. For a recent literature review, see Kathleen Bolter and Jim Robey, "Agglomeration Economies: A Literature Review," W.E. Upjohn Institute for Employment Research, 2020. Also see Enrico Moretti, "The Effect of High-Tech Clusters on the Productivity of Top Inventors," American Economic Review, 2021, 111(10): 3328–3375, https://doi.org/10.1257/aer.20191277.

C2. Investment and Development

Businesses throughout the data center supply chain benefit from the development of data centers. When a data center opens a new campus location, it draws additional businesses to the surrounding area. Suppliers to data centers may be drawn to the area to be geographically close. Other businesses may come due to the availability of high-speed internet connectivity and other infrastructure provided by the data center industry.

Given the interdependency between the US data center industry and the rest of the economy, the data center industry's growing demand for energy, infrastructure, technology, connectivity, security, and public services has driven investment in many other industries, supporting their development and advancement.

Clean Energy: As detailed in **Section IV: Environmental Impact,** data centers are energy intensive. The industry has increased its use of clean energy sources, such as solar and wind, to power its operations. This has led to increased industry investment in clean energy projects.

Real Estate: As data centers continue to expand, more physical space is needed to support the expansion. This has led to increased demand for commercial real estate in areas of the country across the United States, including:

- Northern Virginia, known as "Data Center Alley"

- Silicon Valley, home to many of the world's largest technology companies and a popular location for data centers
- Dallas-Fort Worth, one of the largest data center markets and high-tech employment centers in the country
- Chicago, a major telecommunications hub
- New York metro area, a popular location for data centers due to its central location and proximity to major financial markets
- Phoenix, due to the city's lower power costs relative to proximate markets, affordable real estate, and low natural disaster risk
- Atlanta, due to robust connectivity, power availability, a competitive colocation/cloud environment, and low natural disaster risk[24]

Artificial Intelligence (AI): Data centers offer high-performance servers, GPUs (Graphics Processing Units), and specialized hardware accelerators like TPUs (Tensor Processing Units) that can handle large-scale matrix operations with high throughput and parallel processing capabilities, ideal for running complex AI models, conducting large-scale data processing, and training AI algorithms. Data center equipment needs facilitate advancements in AI technology, leading to innovations and applications across sectors.

Manufacturing: Data centers have a significant impact on the manufacturing industry by driving demand for materials such as aluminum and steel during construction and hardware components and encouraging technological advancements.[25] Data centers rely on advanced hardware and equipment, such as high-performance servers, storage devices, networking components, and security systems. To meet the requirements of data centers, hardware manufacturers invest in research and development to improve the performance, efficiency, and reliability of their products. Data centers drive technological advancements in hardware and equipment, pushing for innovations that can handle the computational demands, storage capacity, and networking requirements of data-intensive operations. This has led to improved hardware technologies, including more powerful processors, higher-capacity storage devices, and faster networking solutions. For instance, semiconductor manufacturers continuously innovate to develop processors with higher

[24] "Markets," DataCenterHawk.com, accessed July 24, 2023, https://www.datacenterhawk.com/markets/

[25] Emily Freehling, "Data Centers' Job Impact is Spread Out," Virginia Business, April 27, 2023, https://www.virginiabusiness.com/article/data-centers-job-impact-is-spread-out/.

core counts, improved clock speeds, and enhanced architectures. These advancements in processor technology benefit not only data centers but also other industries that rely on computing-intensive tasks. The development of technologies like non-volatile memory express (NVMe) and 3D NAND flash has significantly enhanced storage performance and efficiency. The emergence of 40 Gigabit Ethernet (40GbE), 100 Gigabit Ethernet (100GbE), and beyond has revolutionized data center networking. These technological advancements benefit all sectors that rely on cutting-edge hardware solutions.

Telecommunications: Data centers require high-speed connectivity to function properly, and this has led to increased investment by telecommunications companies in telecommunication infrastructure. Over the 2017-2021 period, US telecommunications companies invested $450.9 billion to upgrade their infrastructure, roughly three times greater than the amount of capital investment by the US auto industry over the same period. Telecommunications companies have invested in fiber optics (the fastest way to send data), edge computing (which involves processing data closer to the end user), cloud services (which provide customers with necessary computing resources without having to manage their own data centers), and internet exchanges (which allow different networks to exchange data more efficiently by reducing the amount of data transferred to and from data centers.)

Construction: The construction of data center facilities requires specialized expertise, which has led to increased investment by construction firms that specialize in data center design and construction. For example, construction companies have invested in developing techniques to construct modular data centers that can be quickly deployed and easily expanded. They have also developed expertise in building data centers that are energy-efficient and sustainable.

Security: Data centers house sensitive information that require strict security data protection protocols. This has led to increased investment by cybersecurity firms that provide data center security services. Such services may include vulnerability assessments, penetration testing, monitoring of network traffic, real-time threat intelligence feeds, secure cloud storage, encryption, and identity management, among others. Additionally, physical security is an important component to the operation of data centers. Physical security may include: security guards on patrol around the facility perimeter and at the entrance, monitoring security camera video feeds inside and out of the data center facility, and screening inside the datacenter (upon entrance to the facility as well as

entrance to any datacenter floor), and other security and safety functions.[26] As both the cyber and physical threat landscape continues to evolve, it is reasonable to expect continued investment in cybersecurity tools and services to support the secure operation of data centers.

Public Services: Construction of data centers creates demand for the expansion and upgrade of roads, power infrastructure, network speeds, and sewer systems due to the influx in employment and business activity. Data center operators and local government organizations often work in partnership to address these infrastructure demands. The expanded infrastructure provides benefits to local communities and residents.[27]

This report highlights the social implications of broadband investments and development in **Section V: Social Impact.**

[26] Microsoft, "Datacenter physical access security," March 2, 2023, https://learn.microsoft.com/en-us/compliance/assurance/assurance-datacenter-physical-access-security.

[27] US Chamber of Commerce Technology Engagement Center. Data Centers: Jobs and Opportunities in Communities Nationwide (US Chamber of Commerce Technology Engagement Center, 2017) https://www.uschamber.com/assets/archived/images/ctec_datacenterrpt_lowres.pdf.

IV. Environmental Impact

With the growing usage of cloud-based services and data storage, data center companies face increasing regulatory, shareholder, and activist pressure to reduce their negative environmental impacts. Data center companies have innovated in energy and water management to reduce costs and build a more sustainable future, and the industry is making great strides in reducing carbon emissions and promoting water and waste management stewardship. For many of these environmental initiatives, the major hyperscale providers have set industry standards by defining commitments or funding new innovations, and smaller industry players have been fast followers. In this section, we outline data center progress in environmental sustainability through enhancing energy efficiency, procuring clean energy, reducing greenhouse gas emissions, promoting water stewardship, and responsibly managing waste.

A. Energy Efficiency

Data centers are essential digital infrastructure and support the technologies that are driving digital transformation across industries. Demand for data center processing and storage is expanding dramatically. One report projects that the global volume of data will grow from 33 zettabytes (ZB) in 2018 to 175 ZB by 2025. One zettabyte, or a billion terabytes, is equivalent to the data capacity of about 250 billion DVDs. Data centers require substantial energy to power their large data capacities. In Northern Virginia, the largest electric utility recently temporarily suspended new data center service connections to ensure transmission infrastructure will keep pace with growing demand. In response, some data center owners and operators have partnered with the utility to identify unique solutions for new data center projects. For example, one data center owner partnered with the utility to build a new 300 megawatt substation on the site of its new data center campus.[31]

[31] Hannah Denham, "Dominion Energy, PowerHouse find workaround to Loudoun's data center power supply issues," Washington Business Journal, March 28, 2023, https://www.bizjournals.com/washington/news/2023/03/28/powerhouse-data-center-loudoun.html.

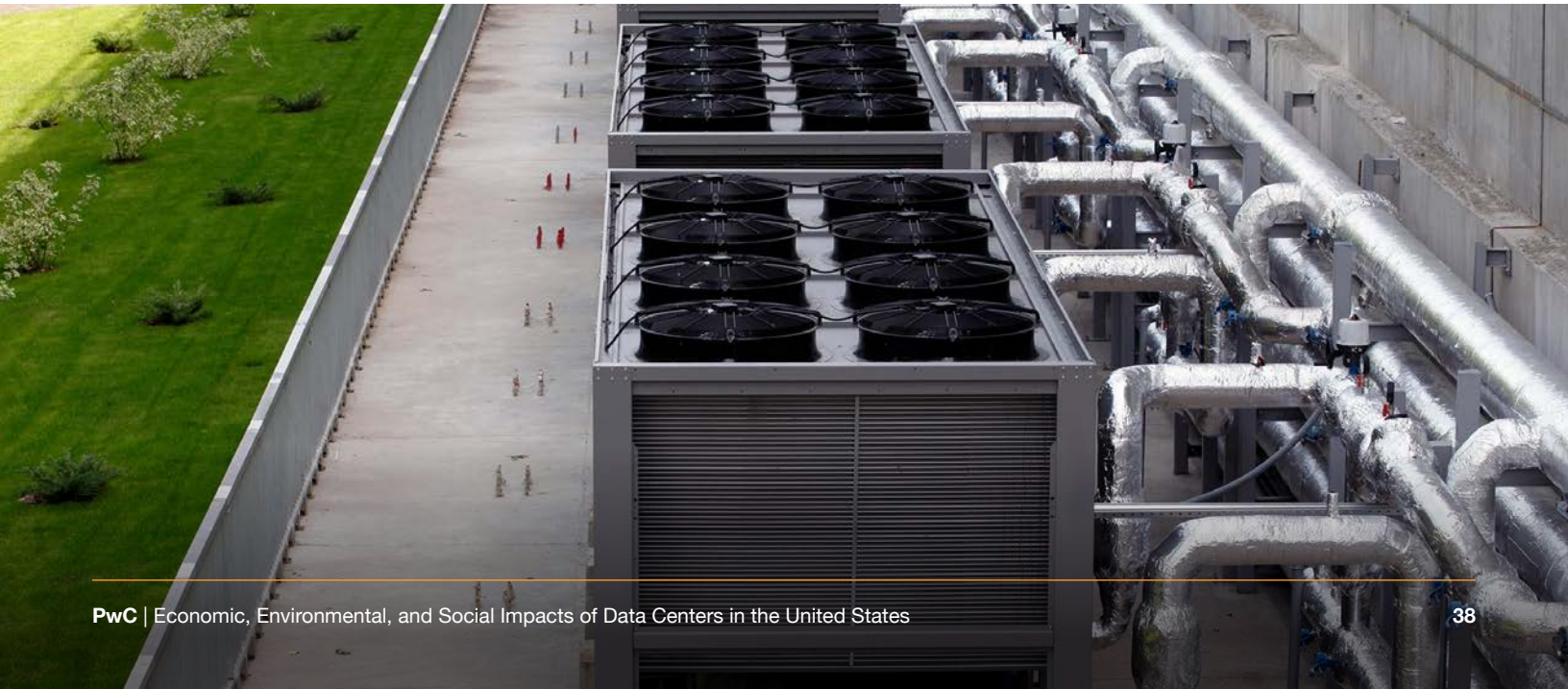
As demand has increased for data processing and storage, energy efficiency has become more of a business-critical consideration for data center providers to reduce costs and mitigate negative environmental impacts. Data center owners and operators seek to design their facilities to optimize energy efficiency from day one, while prioritizing reliability. For example, some data centers use computational fluid dynamics to optimize the design of their facilities' cooling systems before they become operational.

Leading companies have adopted a number of innovations to reduce energy consumption in data centers, such as efficient cooling technology solutions, AI-driven caching, load-balancing technologies, and energy-efficient servers.[32]

Through an innovative industry collaboration, data center providers use energy efficient design principles to reduce energy usage. The Open Compute Project Foundation (OCP) is an open-source, collaborative model founded in 2011 "to design, use, and enable mainstream delivery of the most efficient designs for scalable computing."[33] OCP members publish hardware designs that reduce complexity in components and enable flexibility, scalability, and efficiency within data centers. Today, its board includes some of the largest data center owners and operators in the United States, and their collaborative efforts have accelerated innovation in the industry and raised the bar for environmental sustainability.

[32] PwC survey of DCC members.

[33] Open Compute Project, "About," accessed April 24, 2023, https://opencompute.org/about.



Advances in energy efficiency have resulted in industry-wide power usage effectiveness (PUE, the ratio of all power used by a data center over a given time divided by the amount of power used by the IT equipment alone[34]) falling from 2.5 in 2007 to 1.6 in 2022.[35] Moreover, while data center computing workloads increased nearly 550 percent between 2010 and 2018, electricity consumption grew only six percent,[36] due to efficiencies from the cloud migration, improvements in cooling systems, and other operational and technological efficiency gains at modern data centers.[37] Data center operators must continue to balance the competing priorities of reliability and energy efficiency.

B. Clean Energy

While data centers continue to improve their energy efficiency, they nevertheless require substantial energy to run. Data centers require a great deal of electricity to power a large amount of equipment which stores the data needed for streaming services, social media platforms, email, real-time applications, and other integral digital tools.[38] Many data center providers partially utilize clean energy to reduce the carbon footprint of their electricity consumption. Furthermore, many data center companies have committed to sourcing 100 percent of their energy from clean sources, and two respondents to the environmental impact survey already operate with 100 percent clean energy.[39]

Hyperscale providers, referred to as hyperscalers, have been among the leading US companies in clean energy procurement through power purchase agreements (PPAs), virtual power purchase agreements, green bonds, carbon offsets, and large-scale investments in solar and wind farms. According to a recent report, the top four buyers of clean energy globally are data center operators,[40] and the US Environmental Protection Agency lists eight DCC members among its Green Power Partnership National Top 100.[41]

[34] Uptime Institute Intelligence, Glossary of Digital Infrastructure Sustainability, (New York: Uptime Institute, 2022), https://uptimeinstitute.com/resources/research-and-reports/glossary-of-digital-infrastructure-sustainability.

[35] Jacqueline Davis, Daniel Bizo, Andy Lawrence, Owen Rogers, Max Smolaks, Lenny Simon, and Douglas Donnellan, Uptime Institute Global Data Center Survey 2022, (New York: Uptime Institute, 2022), https://uptimeinstitute.com/resources/research-and-reports/uptime-institute-global-data-center-survey-results-2022.

[36] Md Abu Bakar Siddik, Arman Shehabi, and Landon Marston, "The environmental footprint of data centers in the United States," Environmental Research Letters 16, 6 (May 2021), https://doi.org/10.1088/1748-9326/abfba1.

[37] Eric Masanet, Arman Shehabi, Nuoa Lei, Sarah Smith, and Jonathan Koomey, "Recalibrating Global Data Center Energy-use Estimates," Science Vol 367, 984-986 (February 2020), https://www.science.org/doi/abs/10.1126/science.aba3758.

[38] Arman Shehabi, Sarah J Smith, Eric Masanet, and Jonathan Koomey, "Data Center Growth in the United States: Decoupling the Demand for Services from Electricity Use," Environmental Research Letters 13, 12 (December 2018), https://iopscience.iop.org/article/10.1088/1748-9326/aaec9c.

[39] PwC survey of DCC members.

[40] Michelle Lewis, "These big tech firms bought the most clean energy in 2022," Electrek, February 9, 2023, https://electrek.co/2023/02/09/big-tech-clean-energy-2022/.

[41] "Green Power Partnership National Top 100," EPA, last updated April 24, 2023, https://www.epa.gov/greenpower/green-power-partnership-national-top-100.

To meet the needs of data centers, clean energy supply must increase, particularly in key data center markets. In 2019, a coalition of data center owners and operators signed a joint letter to the largest electricity utility in Virginia to request that the utility expand its clean energy supply.[42] In June 2022, DCC submitted comments to Virginia's State Corporation Commission requesting that the Commission require the electric utility to evaluate whether it would be cost-effective to accelerate the decarbonization of its electrical generation fleet. The Virginia Clean Economy Act requires utilities in Virginia to transition to 100 percent clean energy sources by 2045, and DCC requested that the largest electric utility consider beginning this transition sooner.[43] Similarly, DCC submitted comments to the Ohio Power Siting Board recommending that the Board consider all relevant public benefit factors, not only economic benefits, when making a public interest determination for new clean energy projects.[44] The data center industry has initiated conversations about the procurement and transmission of clean energy in the United States and created demand for more clean energy in the regions in which they operate.

In addition to procuring clean energy, leading data center companies have also invested large sums to develop new clean energy projects to meet the demands of their operations. For example, in Ohio, leading hyperscalers have invested in several solar and wind farms capable of generating millions of megawatt-hours of clean energy each year.[45, 46] In Virginia, a leading hyperscaler plans to fund 15 new utility-scale solar farms with a total capacity of 1,430 megawatts, which represents a 56 percent increase in state-wide solar generation capacity.[47] By investing in new grid-scale clean energy projects, the data center industry strengthens clean energy infrastructure and demonstrates that clean energy is a reliable power source, even for power-intensive industries.[48]

In Ohio, leading hyperscalers have invested in several solar and wind farms capable of generating millions of megawatt-hours of clean energy each year.

[42] Rich Miller, "Dominion Energy Plans More Green Power for Virginia's Data Centers," Data Center Frontier, January 27, 2021, https://www.datacenterfrontier.com/cloud/article/11428441/dominion-energy-plans-more-green-power-for-virginia8217s-data-centers.

[43] William T. Reisinger, "Comments and Recommendations of the Data Center Coalition," SCC Docket Search, June 30, 2022, https://www.scc.virginia.gov/docketsearch/DOCS/7fsh01!.PDF.

[44] Josh Levi, "Data Center Coalition Comments," Ohio Public Utilities Commission Docketing Information System, August 4, 2022, https://dis.puc.state.oh.us/ViewImage.aspx?CMID=A1001001A22H05B04059A01138.

[45] PwC survey of DCC members.

[46] Sara VanLear, Facebook's U.S. Renewable Energy Impact Study, (Research Triangle Park, NC: RTI International, 2021), https://www.rti.org/publication/facebooks-us-renewable-energy/fulltext.pdf.

[47] "Economic Impact of Amazon Solar Investment Impact in Virginia," AWS, https://d1.awsstatic.com/WWPS/pdf/aws-renewable-investments-virginia.pdf.

[48] Ciaran Flanagan, "How Data Centers Are Driving The Renewable Energy Transition," Forbes, March 13, 2023, https://www.forbes.com/sites/siemens-smart-infrastructure/2023/03/13/how-data-centers-are-driving-the-renewable-energy-transition/?sh=187c5a274214.

Among the data center companies that participated in the environmental impact survey, 13 have committed to procure 100 percent clean energy, with target dates ranging from 2024-2040. Survey results for several data center companies show a large aggregate growth in megawatts of clean energy procured from 2017-2021.

Some providers have committed to powering their data centers with clean energy 24 hours a day, seven days a week within the next seven to 10 years. To achieve 24/7 clean energy, these companies must develop and procure significantly more clean energy production capacity than they will actually use to accommodate hourly fluctuations in supply (e.g., solar energy is not available at night) and current technical limitations of storage. A data center operator must develop its clean energy portfolio to generate sufficient energy to meet expected demand every hour in the day, especially in the critical evening hours when clean energy is limited. An energy portfolio designed to meet the 24/7 clean energy goal will then produce much more energy than the data center actually needs, and the excess energy can be sold back to local power grids at market rates. Excess clean energy production will therefore create greener power grids and will further accelerate clean energy growth and availability to local communities, mitigating power generation constraints and reducing blackouts in some regions. Data centers accelerate the clean energy transition in the United States with commitments to purchase clean energy and by funding the development of new sources of clean energy.

C. Carbon Emissions

To meet the decarbonization goals set forth in the Paris Agreement intended to limit global warming to 1.5°C, society will need to reduce global emissions by 50 percent by 2030. Regulatory, activist, and investor pressure to reduce greenhouse gas emissions is increasing across industries, and data center providers are rising to meet the challenge.

Data center providers are setting increasingly ambitious targets to reduce carbon emissions. Among respondents to the environmental impact survey, operators committed to the following.

Table IV-1.– Data Center Carbon Emissions Reduction Commitments by Type

Carbon neutral commitment	Net zero commitment	SBT validated or committed	Other carbon reduction goal
3	6	8	4

Sources: PwC survey of DCC members, company ESG reports, and sciencebasedtargets.org

Carbon neutral operations: Commitment to achieve carbon neutrality in operations by purchasing carbon offsets equivalent to the company's operating emissions.

Net zero emissions: Commitment to reduce emissions to zero or to a residual level that is consistent with reaching net-zero emissions and neutralizing any residual emissions through carbon removals.

Science-Based Targets (SBT): A target validated by the Science-Based Targets Initiative (SBTi) as aligning with climate science to limit warming to 1.5°C. SBTs are rigorous climate targets due to third-party review, and a net zero target validated by SBTi is the most rigorous.

Other carbon reduction goals: All other commitments related to reducing greenhouse gas emissions.

Data center emissions of greenhouse gases are attributable to two key sources. Emissions from purchased electricity, or Scope 2 emissions, are typically the largest source of emissions attributable to data centers because data center operations require a great deal of electricity. However, the increasing use of clean energy sources discussed above is leading to a reduction in Scope 2 emissions among data center providers. Our survey results show an aggregate decrease in Scope 2 emissions from 2018-2021 across the small number of respondents that provided data.[49]

The other key source of emissions attributable to data centers are the Scope 3 emissions from a company's value chain. Scope 3 emissions are indirect emissions not created by the data center provider but created upstream and downstream of their operations, including emissions from purchased goods and services. For example, the materials used to build the data center, primarily concrete and steel, are a large source of Scope 3 emissions. Data center providers are taking steps to reduce embodied emissions from construction by employing algorithms to optimize concrete add-ins to reduce concrete usage and investing in innovative, low-carbon building materials.[50]

Addressing Scope 3 emissions can be challenging, regardless of industry. To achieve net zero emissions, however, companies must reduce their emissions to zero or to a residual level in line with a 1.5°C scenario. Data center providers use a variety of options to reduce their Scope 3 emissions. For example, one major hyperscaler recently updated its Supplier Code of Conduct to require suppliers to disclose and reduce their greenhouse gas emissions on an absolute basis at least 55 percent by 2030.[51] Another hyperscaler is engaging suppliers to set carbon reduction commitments, and addressing other sources of Scope 3 emissions, such as employee commuting.[52] One survey respondent is engaging two-thirds of its suppliers with the greatest emissions to set their own science-based greenhouse gas targets.[53]

As data centers continue to decarbonize their operations, companies using data center services will have lower Scope 3 emissions. Data centers can have a catalytic effect in the net zero transition because they play a role across many sectors.

[50] PwC survey of DCC members.

[51] Microsoft, "Supplier Code of Conduct," accessed May 22, 2023, https://www.microsoft.com/en-us/procurement/supplier-conduct.aspx?activetab=pivot:primaryr11.

[52] PwC survey of DCC members.

[53] PwC survey of DCC members.

D. Water

Water stewardship is a critical sustainability concern for the data center industry.[54] When water is used in data centers, it is predominantly used in cooling systems[55], ensuring controlled heat production, improved energy efficiency, and 24/7 runtime for internal servers. Especially in communities experiencing record-breaking droughts and accelerating climate change impacts, local communities are asking data center operators to improve water use efficiency and to withdraw less water from local sources. In Arizona, a state that experienced drought conditions in 99 percent of the state in 2021, the driest conditions on record for the state, expectations for data centers entering the market are understandably high.[56] In response to community concerns over the anticipated water consumption for a new data center in Mesa, Arizona, a leading hyperscaler developed three water restoration projects[57] that restore more than 200 million gallons per year.[58] Within their operations, data center owners and operators seek to reduce their water use effectiveness (WUE), the ratio of water used divided by the IT equipment's energy use. Data centers can reduce WUE by implementing innovative cooling systems for servers to decrease water usage and by considering water availability as a major factor for location selection.

Reducing water requirements for data centers is highly complex, as water consumption mostly depends on the climate in the region in which the data center is located. The hot, dry climate of the southwestern United States has historically required more water for cooling in data centers than in other regions, but the water stress of the region necessitates reduced water withdrawals. Leading hyperscalers are addressing regional water stress for data center sites and have pledged to become water positive by 2030.[59] "Water positive" is defined as replenishing more water in the natural environment than is consumed in operations. Water positive initiatives include reducing water use, using sustainable water sources like recycled water or harvested rainwater, and supporting water replenishment projects.

[54] Jay M. Dietrich and Andy Lawrence, Three Key Elements: Water, Circularity, and Citing, (New York: Uptime Institute, 2022), https://uptimeinstitute.com/resources/research-and-reports/three-key-sustainability-elements-water-circularity-and-siting.

[55] Water cooling is also used in other industries, such as utilities, chemicals, and some heavy manufacturing.

[56] Tom Di Liberto, "Western drought 2021 spotlight: Arizona," NOAA, accessed April 28, 2023, https://www.climate.gov/news-features/event-tracker/western-drought-2021-spotlight-arizona.

[57] Water restoration projects create, re-create, or enhance water habitats.

[58] Rich Miller, "Facebook Unveils Water Projects to Support $800 Million Mesa Data Center," Data Center Frontier, August 12, 2021, https://www.datacenterfrontier.com/featured/article/11428015/facebook-unveils-water-projects-to-support-800-million-mesa-data-center.

[59] Amanda Schupak, "Corporations are pledging to be 'water positive'. What does that mean?", The Guardian, October 14 2021, https://www.theguardian.com/environment/2021/oct/14/water-positive-pledge-corporations.

To reduce water withdrawals, data centers use an array of efficient cooling strategies tailored to the local climate. Direct evaporative cooling uses water evaporation to reduce air temperature and can eliminate the need to use water for many months of the year. Free air cooling uses outdoor air rather than water to cool data centers. Immersion cooling systems involve submerging hardware in a liquid coolant to reduce temperatures. Data center owners and operators minimize water usage by deploying the appropriate cooling system for the local environmental conditions of each data center. One survey respondent eliminated direct evaporative cooling in their operations and achieved a WUE of zero for all new data centers.[60, 61] Another DCC member plans to use a closed-loop cooling system for its new data center campus in Phoenix, Arizona, which will operate with a WUE near zero.[62]

Data center operators committed to being water positive use sustainable water sources when water use is unavoidable. Leading data center owners and operators use recycled water in their operations when possible, which frees up drinking water for local communities. In Virginia, a major hyperscaler worked with the local water utility to be the first data center operator in the state approved to use recycled water in direct evaporative cooling systems, and the company now uses recycled water for cooling in 20 data centers worldwide.[63] Other data centers in Virginia also make use of recycled water in closed loop water systems.[64]

[60] PwC survey of DCC members.

[61] Rich Miller, "Prime Will Enter Phoenix Market with 210 Megawatt Campus," Data Center Frontier, May 4, 2023, https://www.datacenterfrontier.com/hyperscale/article/33004536/prime-will-enter-phoenix-market-with-210-megawatt-campus.

[62] Rich Miller, "Prime Will Enter Phoenix Market with 210 Megawatt Campus," Data Center Frontier, May 4, 2023, https://www.datacenterfrontier.com/hyperscale/article/33004536/prime-will-enter-phoenix-market-with-210-megawatt-campus.

[63] Nat Sahlstrom, "Here's how AWS is working together with communities to lower water footprint," Fairfax County Times, March 24, 2023, https://www.fairfaxtimes.com/articles/opinions/here-s-how-aws-is-working-together-with-communities-to-lower-water-footprint/article_019719a4-c9aa-11ed-963c-a7cf3b8f9c4f.html.

[64] Rich Miller, "AWS Plans to Slash Water Use in its Cloud Data Centers," Data Center Frontier, November 28, 2022, https://www.datacenterfrontier.com/sustainability/article/21438279/aws-targets-water-use-in-its-cloud-data-centers.

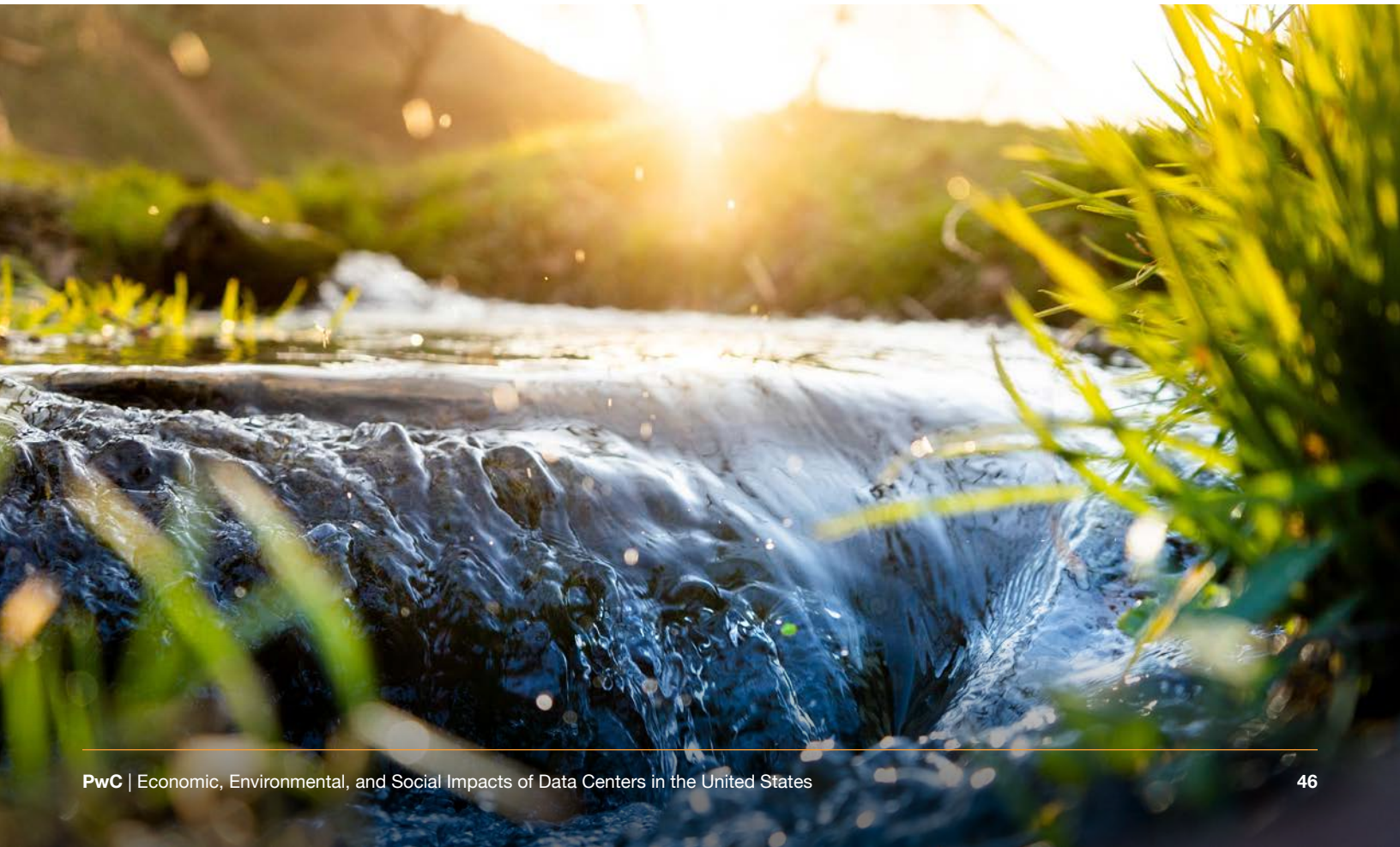
Increasingly, data center owners and operators fund water replenishment projects to restore drinking water in regions of high water stress. One of the major hyperscaler survey respondents set a target to replenish 850 million gallons of water per year. The company partners with local nonprofits to identify water restoration projects with the greatest impacts and currently has water restoration work underway in New Mexico, Arizona, Texas, Utah, Oregon, and California.[65]

In Arizona, leading hyperscalers have worked with the State of Arizona and the Colorado River Indian Tribes (CRIT) in an innovative public-private partnership to reduce risks from ongoing drought. The goal is to stabilize water levels in Lake Mead under Arizona's Drought Contingency Plan. The companies provided funding to CRIT by leasing water rights from the tribes in exchange for CRIT adopting practices that reduce water withdrawals from Lake Mead, for example by forgoing irrigation water deliveries to some of their least profitable and least efficiently irrigated areas. The project will benefit CRIT, enabling them to modernize their irrigation infrastructure. The project is also projected to create volumetric water benefits through 2030 for Colorado River water users.[66, 67]

[65] "Restoring More Water Than We Consume by 2030," Meta, August 19, 2021, https://about.fb.com/news/2021/08/restoring-water/.

[66] Noelle Walsh, "Expanding cloud services: Microsoft launches its sustainable datacenter region in Arizona," Microsoft Azure (blog), June 15, 2021. https://azure.microsoft.com/en-us/blog/expanding-cloud-services-microsoft-launches-its-sustainable-datacenter-region-in-arizona/#:~:text=We%20chose%20Arizona%20as%20the,in%20the%20regions%20we%20operate.

[67] LimnoTech. Meta: Volumetric Water Benefits Report 2021, LimnoTech, 2022. https://sustainability.fb.com/wp-content/uploads/2022/08/Meta_2021_Volumetric_Water_Benefit_Report.pdf.



E. Waste

Waste reduction (the elimination of waste) and circularity (increased reuse of materials) are emerging as key environmental issues. Data center owners and operators seek to reduce waste across their operations, including electronic waste (e-waste), construction waste, and other operational waste. To reduce waste, companies can increase reusability of components and materials or divert waste from landfills. Leading data center owners pursue zero waste certification for their facilities by avoiding waste where possible and diverting at least 90 percent of unavoidable waste from landfills.[68]

Data centers produce e-waste in the normal course of their operations. The most common sources of data center e-waste include decommissioned racks, computing equipment, monitors, circuits and other electrical components, and obsolete devices within the infrastructure. The industry has been proactive in addressing e-waste, with several data center companies outlining initiatives to reduce and divert waste by promoting reuse and recycling of e-waste. Increasing lifetime usage of microchips and other potential sources of e-waste can also moderate supply chain shortages. Major data center companies partnered to form the Circular Electronics Partnership (CEP), which aims to drive circular practices and reduce e-waste. In 2020, a major hyperscaler performed server upgrades using 23 percent refurbished inventory.[69] Another hyperscaler announced circular centers dedicated to reusing and recycling servers and other hardware in its data centers and the company expects the centers to increase reuse of components to 90 percent by 2025.[70] Most data centers have partnered with third-party firms to recycle their e-waste, and one DCC member offers onsite e-waste recycling service to their customers.[71] Recycling of e-waste reduces landfill waste and spurs economic activity. The e-waste management market is expected to grow significantly through 2030.[72]

As the footprint of data centers grows across the United States, construction and operational waste management increases in importance. Effective waste management practices like recycling, reducing waste generation at the source, reusing, and repurposing can help reduce construction waste.

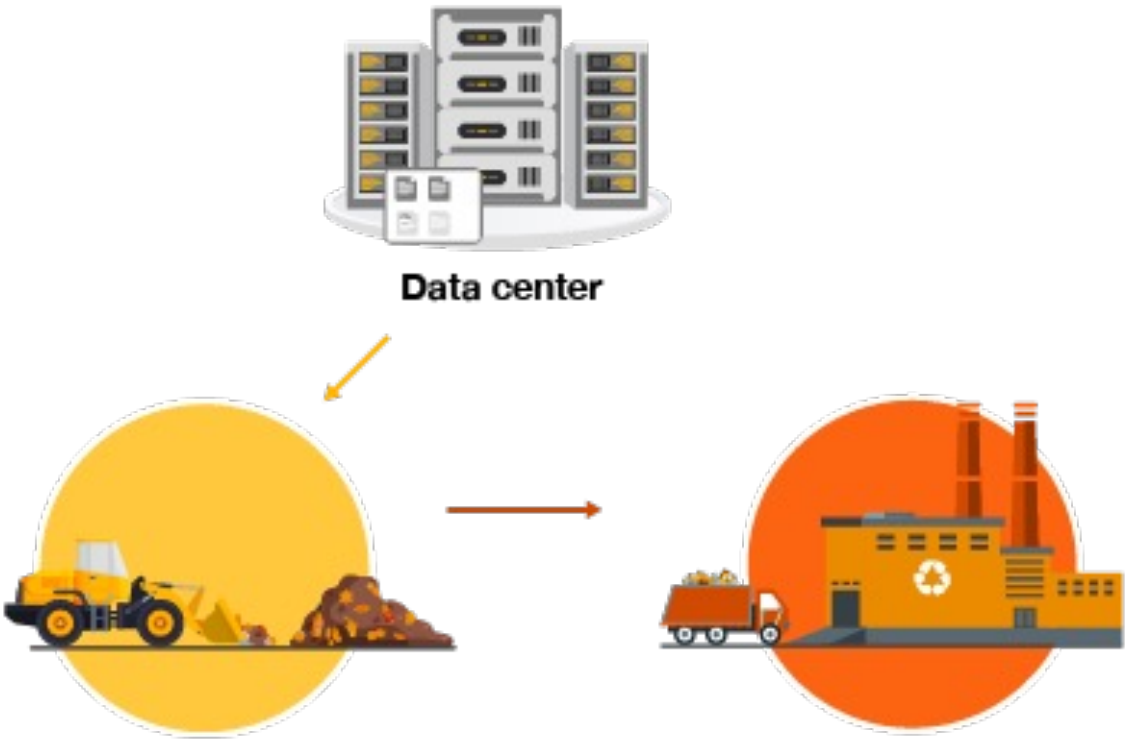
[68] GBCI, TRUE Rating System, (GBCI, 2022), https://true.gbci.org/sites/default/files/resources/TRUE-Rating-System-2022.pdf.

[69] Dan Swinhoe, "Re-use, refurb, recycle: Circular economy thinking and data center IT assets," Data Center Dynamics, March 8, 2022, https://www.datacenterdynamics.com/en/analysis/re-use-refurb-recycle-circular-economy-thinking-and-data-center-it-assets/#:~:text=Google%20is%20also%20a%20major,resold%20into%20the%20secondary%20marke.

[70] "Microsoft Circular Centers program achieves 83% reuse, increasing supply chain efficiency and resiliency with Dynamics 365 and Power Platform," Microsoft, November 2, 2021, https://customers.microsoft.com/en-us/story/1431789627332547010-microsoft-circular-centers.

[71] PwC survey of DCC members.

[72] "Global E-Waste Management Market to Reach $158.9 Billion by 2030," PRNewswire, January 31, 2023, https://www.prnewswire.com/news-releases/global-e-waste-management-market-to-reach-158-9-billion-by-2030--301734485.html.



A leading hyperscaler is partnering with a zero-waste technology company on a pilot seeking to reduce construction waste from drywall. If successful, the program will use mushrooms to convert drywall debris into a fully renewable byproduct for use in manufacturing.[73, 74] This closed-loop solution could avoid tons of drywall debris from being placed in landfills for each new data center.[75] Recycling of construction waste is not available in all US markets, so identifying new ways of preventing construction waste is key to reducing volumes sent to landfill.

[73] Meta, "Building with Mushrooms to Reduce Drywall Waste—or Cooking Up a New Future for Data Center Construction," Sustainability (blog), April 10, 2023, https://sustainability.fb.com/blog/2023/04/10/building-with-mushrooms-to-reduce-drywall-waste-or-cooking-up-a-new-future-for-data-center-construction/.

[74] Mycocycle, accessed May 3, 2023, https://mycocycle.com/.

[75] Meta, "Building with Mushrooms to Reduce Drywall Waste—or Cooking Up a New Future for Data Center Construction," Sustainability (blog), April 10, 2023, https://sustainability.fb.com/blog/2023/04/10/building-with-mushrooms-to-reduce-drywall-waste-or-cooking-up-a-new-future-for-data-center-construction/.

V. Social Impact

Leading data center companies make donations and form partnerships that aim to strengthen communities and improve the lives of local residents. Many data center companies have programs in place to expand STEAM education in their communities, collectively investing billions of dollars. These programs aim to provide technical skills to community members and serve as an investment in the next generation of data center employees. Data center owners and operators also contribute time and funds to charitable causes and encourage their employees to volunteer for organizations addressing food insecurity, education, women's empowerment, and other social issues. This report finds that data center companies have collectively donated millions of dollars and thousands of hours of volunteer time to community support. Data centers have set goals and commitments to expand workforce diversity by increasing representation of women, ethnic and racial minorities, veterans, disabled people, and/or members of the LGBTQ+ community.

In this section, we focus on the impacts that data centers have both nationwide and in the selected markets of Arizona, Ohio, and Virginia in the areas of STEAM education and workforce development, DEI, community support, connectivity impact, and small and minority-owned business support. The initiatives outlined below are drawn largely from the survey of DCC members undertaken for this report as well as company ESG reports.

A. STEAM Education and Workforce Development

The rapid expansion of the data center industry in much of the United States made it challenging for data center operators to attract and retain talent.[76] Data centers often require employees with highly technical skills. Communities and data center operators both benefit from expanding the talent pool of skilled employees by upskilling workers today and by building a talent pipeline for the next generation. Data center companies create and fund STEAM education programs and other workforce development initiatives.[77] These initiatives aim to spark interest in STEAM for participants of all ages and empower diverse populations to pursue careers in IT and other technological fields. Data center companies collectively contributed billions of dollars and thousands of hours to STEAM education and workforce development initiatives since 2011.

Data center operators support STEAM education from the grade school level to community college and beyond.[78] Programs focus on coding, cloud computing, and computer science, building subject knowledge in areas critical for technology careers.[79] Major hyperscalers have designed curricula for use in schools and created innovative learning environments where students can learn in a hands-on setting.[80] Some data center operators encourage their employees to share their unique career experiences in mentorship programs with local schools and community groups.[81] Often, educational programs are designed to reach underrepresented groups in the technology sector, including women and girls and racial and ethnic minority groups.[82] For example, a leading hyperscaler created a program to build sustainable computer science programs in high schools. The program supports educators in teaching computer science by providing proven curricula and pairing technology industry volunteers with teachers. The program serves underrepresented groups, including students from rural communities who historically lack access to STEAM education.[83] One major hyperscaler developed a program in Arizona to introduce graduating high school seniors from historically underrepresented groups to the field of computer science. The program helps to prepare students for success in college while sparking a passion for technology.[84] In another example, two DCC members contributed funds through the Loudoun Education Foundation for a mathematics summer program for middle schoolers from underrepresented groups interested in STEAM careers. Many of the students who participated in the math program improved enough to move upwards into advanced math classes the following school year.[85]

[76] Jacqueline Davis, Daniel Bizo, Andy Lawrence, Owen Rogers, Max Smolaks, Lenny Simon, and Douglas Donnellan, Uptime Institute Global Data Center Survey 2022, (New York: Uptime Institute, 2022), https://uptimeinstitute.com/resources/research-and-reports/uptime-institute-global-data-center-survey-results-2022.

[77] PwC survey of DCC members.

[78] PwC survey of DCC members.

[79] PwC survey of DCC members.

[80] AWS and Community Outreach," AWS, Amazon, https://aws.amazon.com/about-aws/global-infrastructure/aws-incommunities/.

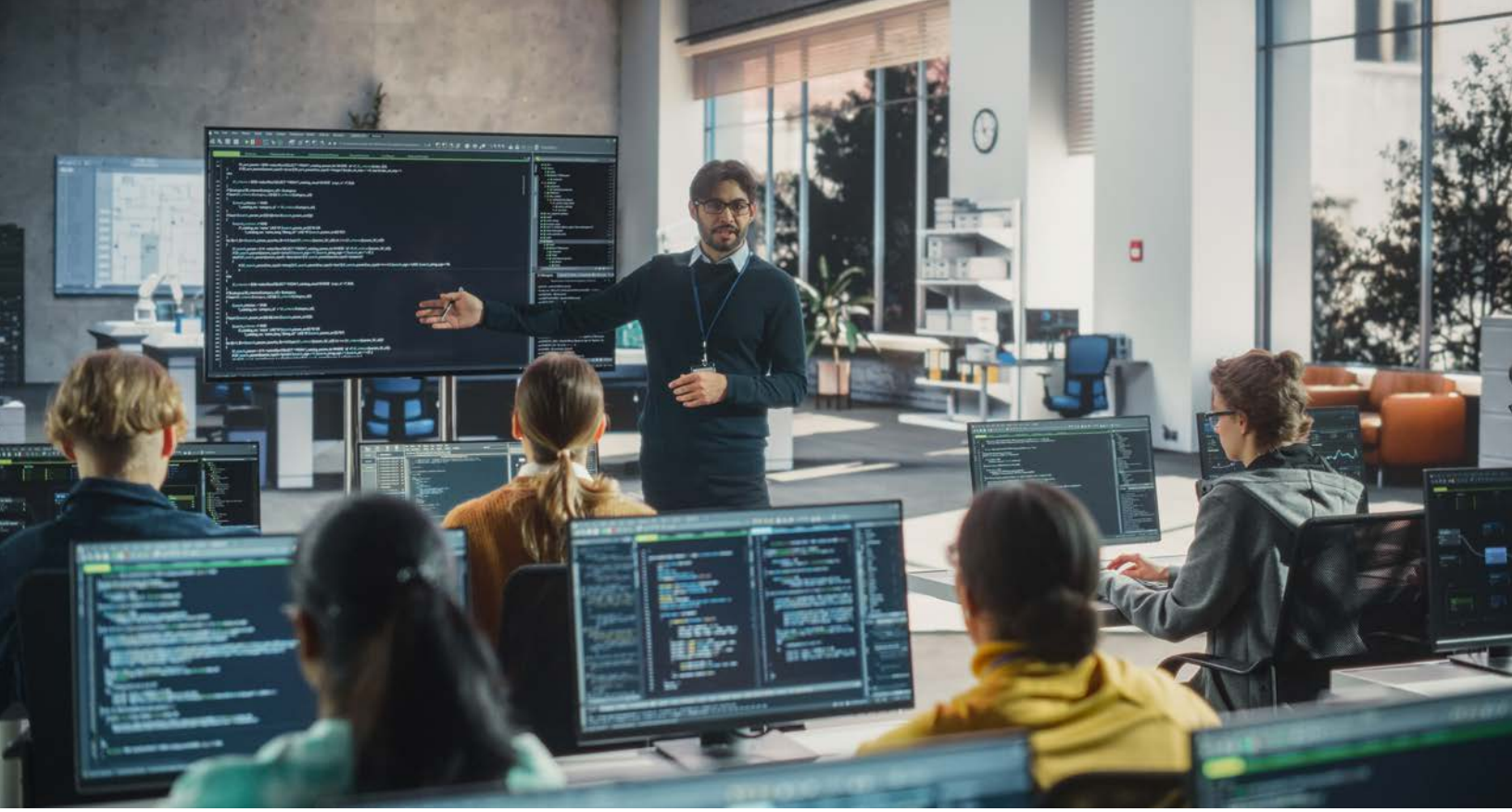
[81] PwC survey of DCC members.

[82] PwC survey of DCC members.

[83] "TEALS Program," Microsoft, accessed May 23, 2023, https://www.microsoft.com/en-us/teals.

[84] PwC survey of DCC members.

[85] Danielle Nadler, "Nadler: Data Center Partner with Educators to Blaze New 'Classroom-to-Career' Pathways," LoudounNow, March 2, 2023, https://www.loudounnow.com/opinion/nadler-data-centers-partner-with-educators-to-blaze-new-classroom-to-career-pathways/article_12780ea0-b847-11ed-a790-67ef6ad86820.html.



Data center operators also invest in educational programs that help pave the way for students entering the workforce. DCC members have cultivated partnerships with high schools, community colleges, and universities throughout the United States to offer training and certification courses.[86] In Ohio, one company partnered with Columbus State Community College to develop a new associate degree of applied science in software development. The program was designed to coordinate with certification exams and other credentials in the IT industry, with the goal of teaching students the skills necessary to enter the data center industry.[87]

High school graduates who earn an associate degree are more likely to be employed, earn higher wages, and own a home, compared to students whose highest level of education achieved is a high school diploma.[88] A recent study found that on average, an individual who graduates with an associate degree from a US community college will earn $9,600 more per year compared to an individual with only a high school diploma.[89] Because individuals earn more, they create additional tax revenue throughout their working lives. Their increased disposable income also allows them to spend more, stimulating economic activity throughout the region. Data center companies' investments in high school and postsecondary education benefit students and create benefits for the broader economy.

[86] PwC survey of DCC members.

[87] Jennifer Smola, "New Path to IT Jobs", The Columbus Dispatch, March 5, 2019, https://www.dispatch.com/story/news/education/campus/2019/03/05/new-path-to-it-jobs/53189807007/

[88] American Council on Education, Center for Policy Research and Strategy and Hobsons, "A Look at Five Key Outcomes in Early Adulthood for Associate Degree Earners", Jonathan M. Turk, Ph.D.

[89] American Association of Community Colleges, "The Economic Value of America's Community Colleges," https://www.aacc.nche.edu/wp-content/uploads/2022/11/AACC_ExecSum_1920_Formatted-Finalv2.pdf

Data center operators also offer technical workforce development such as certification programs in fiber optic installation and repair, internship and apprenticeship programs, and scholarships and grants for training programs.[90] A major data center operator partnered with colleges in Arizona to develop workforce courses that will prepare students for IT sector and data center jobs.[91] One hyperscaler has more than 30 active training and educational programs designed to upskill workers to transition into careers related to data centers in Virginia.[92] Another hyperscaler founded a trade school on the campus of a homeless youth support organization in Virginia to provide training programs for young adults pursuing careers in trades such as plumbing, automotive, or HVAC.[93]

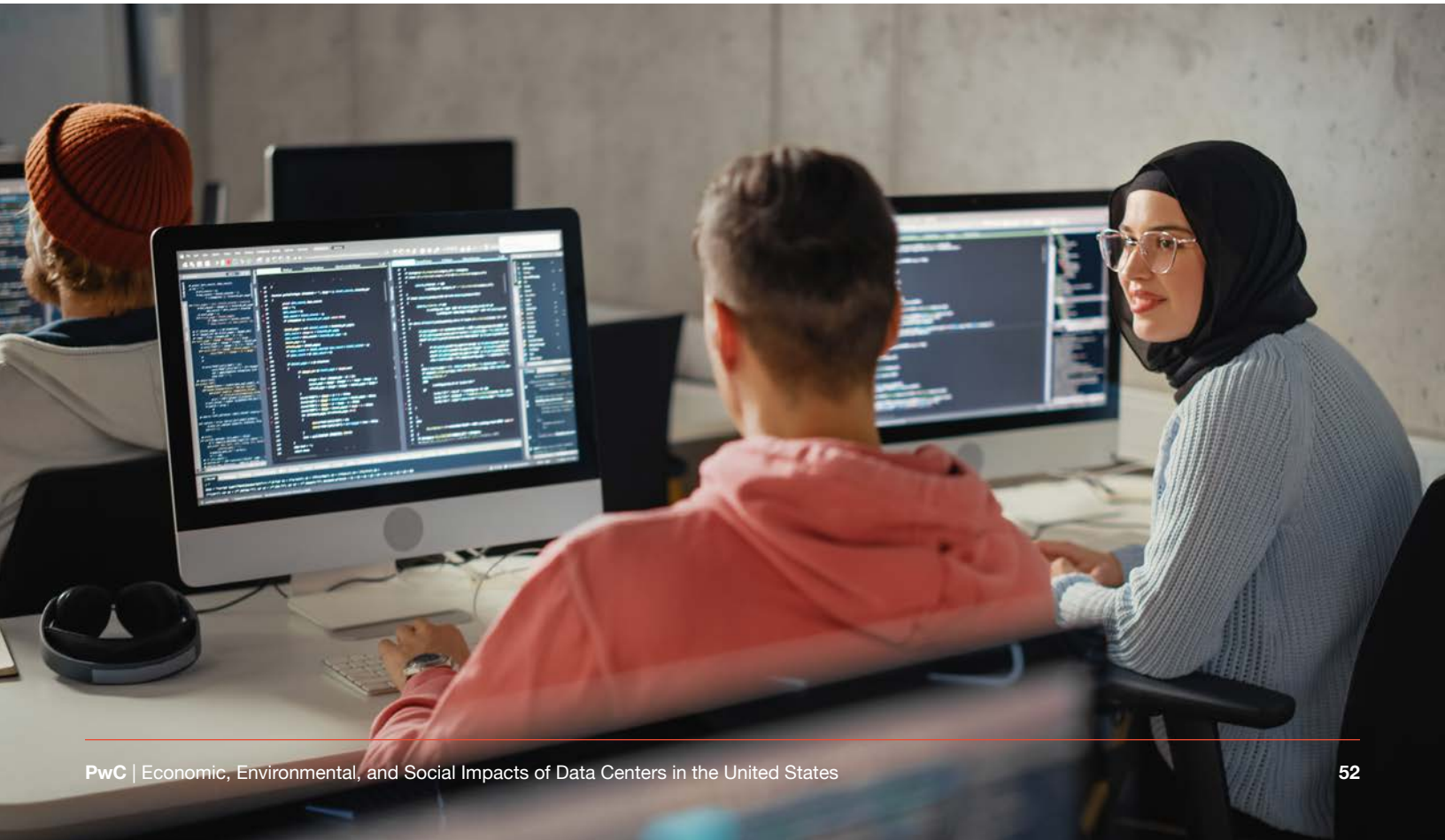
Data center companies collectively contributed billions of dollars and thousands of hours to STEAM education and workforce development initiatives since 2011.

[90] PwC survey of DCC members.

[91] Noelle Walsh, "Expanding cloud services: Microsoft launches its sustainable datacenter region in Arizona," Microsoft Azure (blog), June 15, 2021. https://azure.microsoft.com/en-us/blog/expanding-cloud-services-microsoft-launches-its-sustainable-datacenter-region-in-arizona/#:~:text=We%20chose%20Arizona%20as%20the,in%20the%20regions%20we%20operate.

[92] PwC survey of DCC members.

[93] PwC survey of DCC members.



One hyperscaler is investing $1.2 billion toward their commitment to upskill more than 300,000 employees by 2025.

One hyperscaler is investing $1.2 billion toward their commitment to upskill more than 300,000 employees by 2025,[94] including funding $50,000 in scholarship and internship opportunities in Ohio.[95]

Another hyperscaler regularly hosts job fairs, employee-led classroom training, data center site tours, and conducts mock interviews to engage with students and job seekers.[96] One of the survey participants invested more than $75,000 in digital education scholarship programs.[97]

A company with data centers around the country provided a $10 million grant to a nonprofit organization to help 25,000 lower-income older adults improve their technology skills.[98]

Another survey respondent provided $24 million in funding since 2011 across the United States to organizations that promote STEAM education.[99]

[94] Amazon, 2021 Sustainability Report, accessed April 10, 2023, https://sustainability.aboutamazon.com/2021-sustainability-report.pdf

[95] PwC survey of DCC members.

[96] PwC survey of DCC members.

[97] PwC survey of DCC members.

[98] "AARP Foundation Gets Grant to Help Older Adults Build Digital Skills," AARP, January 26, 2022, https://www.aarp.org/work/careers/aarp-foundation-grant-google/.

[99] PwC survey of DCC members.

B. Diversity, Equity, and Inclusion

The data center industry, like many technical industries, is generally male-dominated. According to a recent survey of data center operators more than three-quarters report that women make up only 10 percent of their workforce or less.[100] Among the broader technology sector, some have charged that recent layoffs have disproportionately impacted Black and brown employees despite company commitments to embed DEI in their organizations.[101] It is difficult to identify whether and how broader technology sector layoffs and DEI initiatives impact the data center industry specifically. However, data center companies are taking action to improve DEI in their workplaces.

In addition to improving equity in the local community, DEI efforts can also help data centers improve employee retention and overcome staffing shortfalls.[102] Lack of representation can deter potential candidates and impact retention of existing employees, so improving DEI can help data center providers address their staffing needs while supporting historically underrepresented groups.

[100] PwC survey of DCC members.

[101] Rich Miller, "Prime Will Enter Phoenix Market with 210 Megawatt Campus," Data Center Frontier, May 4, 2023, https://www.datacenterfrontier.com/hyperscale/article/33004536/prime-will-enter-phoenix-market-with-210-megawatt-campus.

[102] Rich Miller, "Prime Will Enter Phoenix Market with 210 Megawatt Campus," Data Center Frontier, May 4, 2023, https://www.datacenterfrontier.com/hyperscale/article/33004536/prime-will-enter-phoenix-market-with-210-megawatt-campus.

Many companies have set targets to increase representation of various demographic groups across the workforce, including in leadership roles, and to include a more diverse pool of candidates in all interview processes.[103] Of the participants in the social impact survey, the majority have set time-bound targets for improving representation of women and/or racial and ethnic minorities.[104] To support these targets, data center operators hold DEI trainings for staff, create employee resource groups to build employees' sense of inclusion, and appoint internal DEI champions to ensure organizational efforts reach staff across regions.[105] These initiatives help to create a more inclusive and equitable culture within the organizations, improving employee retention while also addressing the needs of historically marginalized groups.

While DEI initiatives have mostly addressed representation of women and racial and ethnic minorities in the past, data center companies are increasingly addressing the needs of other underrepresented communities, including veterans, the LGBTQ+ community, and people with disabilities.[106] For example, one major hyperscaler runs an autism career program, with a goal of increasing hiring of autistic individuals. Only 29 percent of people diagnosed with autism have any sort of paid work, suggesting the community is in need of greater support in hiring and employment. The autism career program trains managers and recruiters to ensure equitable hiring processes and accommodations for candidates with autism.[107] These initiatives aim to increase hiring and retention of underrepresented groups in the future.

Respondents to the social impact survey increased workforce representation of women and racial and ethnic minority groups between 2019-2021, the years for which the most complete data were available.[108]

[103] PwC survey of DCC members.

[104] PwC survey of DCC members.

[105] PwC survey of DCC members.

[106] PwC survey of DCC members.

[107] AWS and Community Outreach," AWS, Amazon, https://aws.amazon.com/about-aws/global-infrastructure/aws-incommunities/.

[108] PwC survey of DCC members.

C. Community Support

Many data center operators have made concerted efforts to give back to the communities in which they are located. Supporting local communities through charitable donations and volunteer work is a core component of many data center operators' social impact programs. Data centers have contributed volunteer hours and made donations to a variety of causes, ranging from food security and disaster relief to environmental stewardship and community revitalization.[109]

Data center employees volunteer for a myriad of causes, including food banks, tree planting campaigns, and even the DCC-hosted "#DataCenterSleevesUp" Red Cross blood drive campaign, which witnessed strong participation from its member companies.[110] One major hyperscaler appoints employees as "community ambassadors" who nominate local causes and organizations for volunteer work or donations. The ambassador program empowers employees to make a difference for causes they find personally significant and address local needs.[111] Another DCC member granted its employees paid leave to do community service and created a portal to track progress toward their 2025 goal of completing 100,000 hours of volunteer work.[112]

[109] PwC survey of DCC members and company ESG Reports.

[110] PwC survey of DCC members.

[111] PwC survey of DCC members.

[112] PwC survey of DCC members and Iron Mountain ESG report, https://www.ironmountain.com/about-us/sustainability/strengthening-our-communities.

At the start of the COVID-19 pandemic, data center operators took steps to meet the increased need for community support. Many donated funds to local nonprofit organizations. One data center supported local restaurants in delivering over 10,000 free meals for first responders and funded delivery services to provide more than 50,000 meals to local seniors.[113]

Among other examples with respect to service time, one of the leading data center providers holds an annual "Impact Month," during which employees are encouraged to volunteer or donate to their favorite causes. In 2021, the company provided more than 7,300 service hours from 1,700 volunteers and raised more than $300,000 in charitable donations.[114]

In other examples, a hyperscaler partnered with organizations that combat human trafficking and forced labor, making donations and running volunteering campaigns.[115] Similarly, another data center operator supports philanthropic efforts to rescue girls from exploitation and provides them with vocational training.[116] Another leading hyperscaler donated more than $80 million worldwide to organizations that work towards creating equitable job opportunities for women.[117] Yet another data center made a $750 million commitment in housing grants and investments to create affordable housing. Of this, approximately $580 million was granted to preserve about 9,000 housing units in Washington state.[118] The company also launched a technology acceleration program and enrolled more than 1,500 organizations that support Black and African American communities to provide technology training and support.[119]

In Virginia, five data center companies contributed more than $4.6 million in charitable contributions in the period from 2020-2022, the years for which most complete data were available.[120] Multiple data center operators have made donations to local schools, libraries, food banks, underserved communities, veterans, and art labs.[121] In Loudoun County, Virginia a leading hyperscaler partnered with a youth shelter to build raised beds at a community farm, which improved access to high quality produce for 200,000 local residents.[122]

Since 2018, a leading data center operator has provided more than $2 million in grants to nonprofit organizations based in Ohio. The company supported more than 8,000 nonprofit organizations in Ohio since 2011 and provided over $17 million in free digital advertising.[123, 124]

[113] PwC survey of DCC members.

[114] PwC survey of DCC members.

[115] PwC survey of DCC members.

[116] PwC survey of DCC members.

[117] "Google.org Impact Challenge for Women and Girls 2021", Google.org, accessed May 5, 2023, https://impactchallenge.withgoogle.com/womenandgirls2021/organizations.

[118] Jane Broom, "An update on our $750 million commitment to affordable housing," Microsoft On the Issues (blog), January 20, 2022, https://blogs.microsoft.com/on-the-issues/2022/01/20/affordable-housing-initiative-washington-state-2022/.

[119] "Supporting Black community nonprofits," Microsoft, https://www.microsoft.com/en-us/nonprofits/technology-resources-black-nonprofits

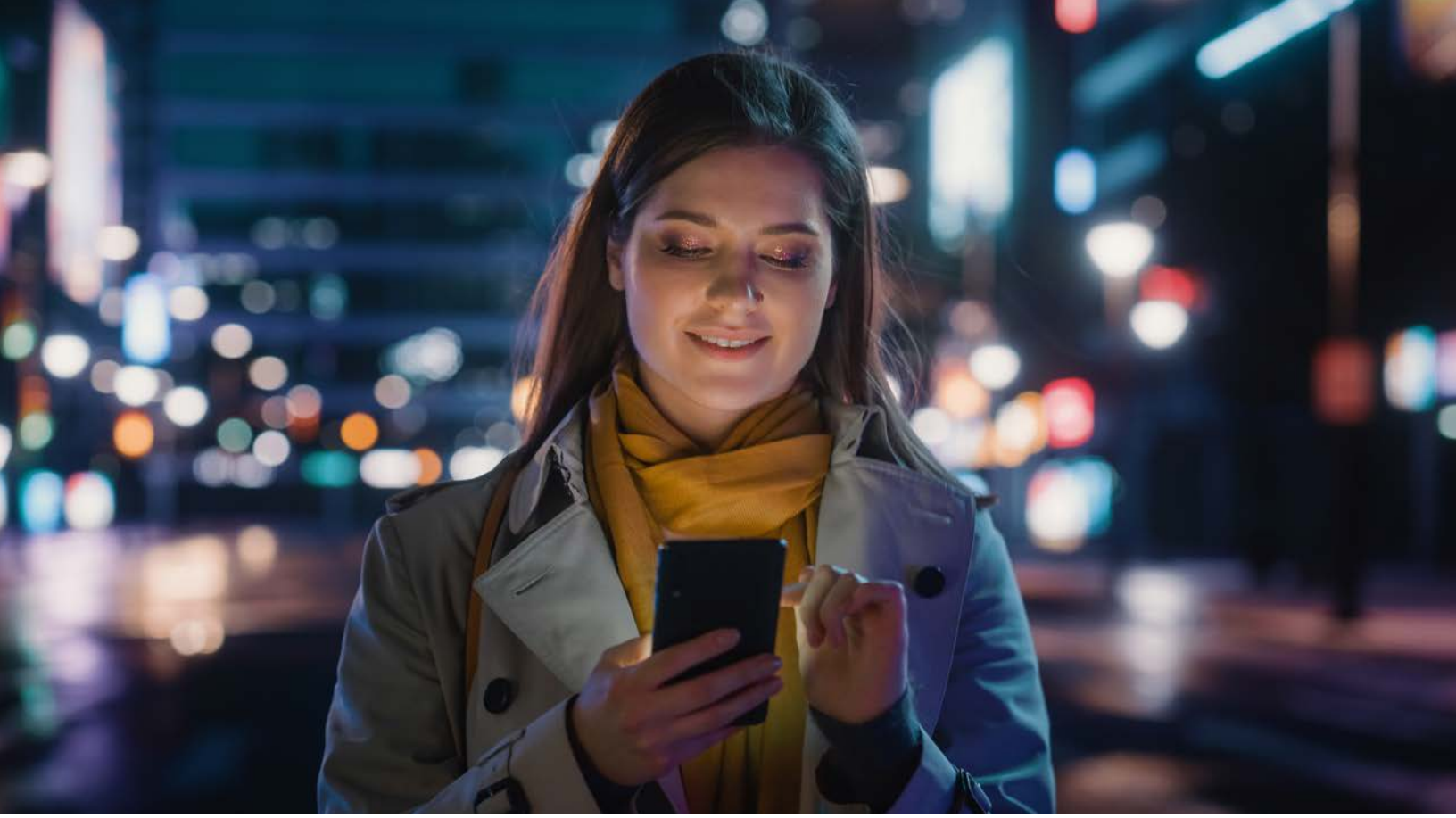
[120] PwC survey of DCC members.

[121] PwC survey of DCC members.

[122] PwC survey of DCC members.

[123] Google, Google is proud to call Ohio home, (Mountain View, CA: Google, 2021), https://kstatic.googleusercontent.com/files/dc1d93cfc71c0402fdbc14e4a252e8005fa01712bcf8525ebe22bea31647d986af8bf5ad327b0e84a2cdc03b11e4e11b8d7e58048140ab5646de6c85570f601e.

[124] "Ohio," Google Economic Impact, accessed April 17, 2023, https://economicimpact.google/state/oh/.



D. Connectivity Impact

The data center market has grown rapidly in recent years, and this trend continues today. Some of the key factors driving this growth include 5G adoption and deployment, evolution of cutting-edge technologies, and increased automation. Rapid development requires enhanced connectivity, particularly in rural communities, where data centers are often located.

Hyperscalers have invested heavily to improve connectivity in the communities in which they operate by improving internet speeds, developing new fiber routes, and improving access to internet services. Among the survey respondents, there were several examples of investment in constructing new long-haul fiber routes to link their data centers.[125] New fiber routes create robust connectivity for data centers and increase internet access for residents and businesses of the surrounding regions. For example, one data center provider extended a fiber connection to connect local schools in rural Nevada school districts, increasing bandwidth by 2,000 percent and reducing internet costs by 14 percent for local schools. The fiber routes act as a backbone for local internet service providers in the region, allowing them to provide high-speed internet to residents.[126]

[125] PwC survey of DCC members and company ESG Reports.

[126] PwC survey of DCC members.

Data center companies helped several areas with little or no broadband access gain access to affordable broadband connections. Hyperscalers partner with local communities and equipment suppliers to deploy high-speed, low-cost internet in underserved rural communities.[127] One leading data center provider developed and published a detailed dashboard that visually represents the state-by-state digital divide in the United States. The dashboard can help governments and lawmakers identify which areas need digital infrastructure urgently and allows the data center company to partner with local governments to expand internet accessibility.[128]

In response to the COVID-19 pandemic, data center companies deployed technology tools including contact tracing applications, enhanced video conferencing capabilities, health information tools, and other IoT-enabled tools. These tools mitigated the health and economic impacts of the crisis.[129]

One DCC member participated in the planning and funding of a pilot initiative to bring broadband access to one of Virginia's least connected counties, Grayson County. The company participated in the project due to its presence in Virginia and nearby states.[130] The initiative to connect Grayson County with high-speed internet began in 2017 with a collaboration between a regional internet service provider and a power company. The data center joining this partnership provided engineering, construction, and technical resources. The regional providers did not have capacity on their own, so the data center's involvement filled a crucial gap. This mutually beneficial partnership spurred by the investments and location of the data center industry is an example of positive social and economic impacts to the surrounding regions. In another example, a leading data center owner partnered with the internet service provider in Boydton, Virginia to bring free public Wi-Fi service to the community. The data center owner provided funds to construct the infrastructure needed for the Wi-Fi system, enabling internet access for the community.[131]

[127] "Microsoft Airband Initiative," Microsoft, accessed April 10, 2023, https://www.microsoft.com/en-us/corporate-responsibility/airband-initiative.

[128] Vickie Robinson, "A street-by-street view of digital inequity in the United States," Microsoft (blog), 2022. https://blogs.microsoft.com/on-the-issues/2022/07/14/digital-inequity-dashboard-broadband-access/.

[129] Sanjoy Mondal and Priyanjana Mitra, The Role of Emerging Technologies to Fight Against COVID-19 Pandemic: An Exploratory Review, (Transactions of the Indian National Academy of Engineering 7(1), 2022), https://doi.org/10.1007%2Fs41403-022-00322-6.

[130] Brian Funk, "No more going to the cemetery to get wi-fi," Cardinal News, September 28, 2021, https://cardinalnews.org/2021/09/28/facebook-joins-grayson-countys-broadband-roll-out/.

[131] "Microsoft and Lake Country Satellite roll out free Wi-Fi in Boydton, Virginia," Microsoft News Center, October 10, 2018, https://news.microsoft.com/2018/10/10/microsoft-and-lake-country-satellite-roll-out-free-wi-fi-in-boydton-virginia/.

Data center owners and operators also built new fiber routes in Northern Virginia. Leading data center providers invested to bring the Marea subsea cable to Virginia, connecting Spain and Virginia. With an estimated theoretical total capacity of 160 terabits per second (Tbps), the Marea cable increases data transfer speed by about 20 percent compared to other existing cables.[132] Another data center invested in bringing the Dunant submarine cable to Virginia, which has a capacity of 250 Tbps.[133] The cable landing station in Virginia has attracted newer data centers to the state, which has in turn allowed higher speed internet connectivity for local communities. Data center companies also improved connectivity in Virginia by donating cash and equipment to local schools.[134] Expanded broadband access in Virginia and donations of headsets enabled remote learning during the COVID-19 pandemic.[135]

Similarly, data center expansion in Ohio is driving connectivity improvements in the state. One major hyperscale provider invested in a new long-haul fiber route to connect its data centers in Ohio and Virginia. This fiber route created enough additional bandwidth to enable the hyperscaler to extend excess capacity to Ohio's internet service providers, which in turn can provide better network connectivity in adjoining rural areas by building new local networks from the provider's fiber.[136] Rural communities in Ohio benefit from this strategy with improved digital infrastructure.

[132] AChuong Nguyen, "Microsoft and Facebook's undersea Marea cable breaks data transfer speed record," DigitalTrends, February 28, 2019, https://www.digitaltrends.com/computing/marea-undersea-cable-faster-data-transfer-speed/.

[133] Chris Ciauri, "The Dunant subsea cable, connecting the US and mainland Europe, is ready for service," Google Cloud (blog), February 3, 2021, https://cloud.google.com/blog/products/infrastructure/googles-dunant-subsea-cable-is-now-ready-for-service.

[134] PwC survey of DCC members.

[135] ARLnow.com, "Amazon Donating $1 Million to Arlington and Alexandria Schools," ARLnow, October 7, 2020, https://www.arlnow.com/2020/10/07/amazon-donating-1-million-to-arlington-and-alexandria-schools/.

[136] Yevgeniy Sverdlik. "Facebook to Sell Bandwidth on Its New Inter-Data Center Fiber Routes," Data Center Knowledge, March 6, 2019, https://www.datacenterknowledge.com/facebook/facebook-sell-bandwidth-its-new-inter-data-center-fiber-routes.

E. Small & Minority-Owned Business Support

Data center companies are interconnected to the communities in which they operate, and have great impacts on local economies, as discussed in **Section III**. Many data center owners and operators set targets to increase their spend with small and minority-owned enterprises, fueling small business growth.[137] A leading company with data centers around the world recently launched a $150 million initiative to promote Black-owned businesses.[138] The company also launched a program where small and/or minority-owned businesses, nonprofits, and public sector organizations can access business, technical, and marketing support. The program grants a variety of financial incentives, including discounted prices for digital and marketing services, as well as access to the company's partner benefits and resources.[139]

A leading company with data centers around the world recently launched a $150 million initiative to promote Black-owned businesses.

[137] PwC survey of DCC members.

[138] "AWS Impact Accelerator: Black Founders," AWS, accessed April 17, 2023, https://aws-startup-lofts.com/amer/program/accelerators/black-founders. https://aws-startup-lofts.com/amer/program/accelerators/black-founders.

[139] "AWS Think Big for Small Business Program," AWS, accessed April 17, 2023, https://aws.amazon.com/partners/programs/small-business/.

A leading hyperscaler launched a program to support and train small businesses in communities where they operate with the aim of improving economic success for Black-, Latinx-, and Hispanic-owned businesses.[140] They also launched a platform to provide small businesses with training, consultative support, digital marketing guidance, and certifications for digital marketing, advertising, liquidity management, and performance measurement.[141] This hyperscaler introduced a digital marketing resource hub and a community platform for small business owners to collaborate and learn from each other.[142]

A major data center operator launched a training program to improve the digital skills of women entrepreneurs, training more than 10,000 people with digital skills that can help them start or improve their businesses.[143]

A leading hyperscaler trained 1,870 small business owners in Ohio through more than 75 digital skills workshops.[144]

As data centers expand and face increased scrutiny, operators seek to make positive impacts through workforce development, philanthropy, DEI initiatives, enhanced connectivity, and support of small businesses.

[140] "Meta Elevate," Meta, accessed April 17, 2023, https://www.facebook.com/fbelevate.

[141] "Meta Blueprint," Meta, accessed April 17, 2023, https://www.facebookblueprint.com/student/catalog.

[142] "Introducing Meta Boost Small Business Studios, a new digital marketing resource hub and event series," Meta, July 20, 2022. https://www.facebook.com/business/news/small-business-studios.

[143] PwC survey of DCC members.

[144] Google, *Google is proud to call Ohio home,* (Mountain View, CA: Google, 2021), https://kstatic.googleusercontent.com/files/

VI. Conclusion

Data centers are critical to the digital economy. Data centers store and process the data that enables our digital lives, from social media and entertainment streaming to mission critical business services. The data center industry made a significant impact on the US economy over the 2017-2021 period, and the industry is growing rapidly. Between 2017 and 2021, the data center industry's total impact (combining its direct, indirect, and induced impacts arising from data center construction and operations) on national employment has grown from 2.9 million jobs in 2017 to 3.5 million jobs in 2021, a 20 percent increase over the period. This report finds that at the national level, each direct job in the data center industry supports more than six jobs elsewhere in the US economy. The data center industry's total contribution to government finances at the federal, state, and local level, including direct, indirect, and induced impacts, increased from $66.2 billion in 2017 to $99.6 billion in 2021, a 50 percent increase.

Data center owners and operators seek to reduce negative environmental impacts from their operations. Energy efficiency is a business-critical consideration in this energy-intensive industry, and data center providers adopt an array of innovations to reduce energy consumption, including efficient cooling technology solutions, energy-efficient servers, and AI-driven caching. Many data center owners and operators are committed to using clean energy to reduce the greenhouse gas emissions from energy consumption. Leading industry players have contributed to the clean energy transition by procuring large amounts of clean energy, funding new clean energy projects such as solar farms to increase the supply of clean energy, and advocating for improved clean energy policies. Data center providers are setting increasingly ambitious targets to reduce carbon emissions, which will lead to reduced Scope 3 emissions for data center customers. Reduction of water use in data centers and replenishment of water in the natural environment are also critical environmental priorities for many data centers, particularly in regions of high water stress. Data center owners and operators also seek to responsibly manage waste in their operations, particularly e-waste and construction waste, with some committed to zero waste targets.

Data center providers also make positive social impacts on the communities in which their data centers are located. Many data center companies have programs in place to expand STEAM education in their communities. These programs aim to provide technical skills to community members and serve as an investment in the next generation of data center employees. Data center owners and operators also contribute time and funds to charitable causes and encourage their employees to volunteer for organizations addressing food insecurity, education, women's empowerment, and other issues. Data centers have set goals and commitments to expand workforce diversity by increasing representation of women, ethnic and racial minorities, veterans, disabled people, and/or members of the LGBTQ+ community. Leading data center companies also make investments to improve connectivity in rural areas, enhancing digital infrastructure and enabling internet access for rural communities. Many data center owners and operators are also committed to supporting small and minority-owned businesses.

Appendix

Data sources and methodology for economic impacts

This appendix describes the methodology used to derive the results for the study. It first discusses the data sources PwC utilized to develop estimates of the data center industry's direct employment, labor income, and value added. It then describes the development of the indirect and induced impact estimates.

Direct Jobs, Labor Income and Value Added

PwC's employment estimates for the data center industry include both full-time and part-time workers as well as self-employed business owners. The State Annual Personal Income and Employment data set published by the BEA is the only government source on historical total employment including self-employed individuals by industry. These data are currently available through 2021. Because the NAICS sector for the data center industry is directly available from the BEA, we use the BEA data on the industry's employment, labor income, and GDP without any further adjustment. Table A-1 below shows the industry's direct employment at the state level in 2021.

NAICS code 518210 is selected to represent the data center industry in this study because it encompasses a broad range of services and activities in the industry, such as data storage, cloud computing, and data management. It should be noted that this NAICS code may not capture every aspect of the industry, and some businesses within the industry may also operate under different NAICS codes based on their specific activities.

Table A-1: – US Data Center Industry: Types of Occupation, 2021

State	Direct Employment
Alabama	3,180
Alaska	230
Arizona	13,080
Arkansas	4,290
California	66,610

State	Direct Employment
Colorado	17,180
Connecticut	4,210
Delaware	740
District of Columbia	1,870
Florida	30,200
Georgia	22,760
Hawaii	680
Idaho	1,180
Illinois	15,660
Indiana	4,130
Iowa	3,940
Kansas	2,790
Kentucky	5,130
Louisiana	3,650
Maine	980
Maryland	5,750
Massachusetts	10,790
Michigan	10,370
Minnesota	7,290
Mississippi	1,380
Missouri	13,630
Montana	730
Nebraska	2,730
Nevada	3,600
New Hampshire	1,660
New Jersey	14,420
New Mexico	1,070
New York	26,060
North Carolina	12,720
North Dakota	570
Ohio	11,500
Oklahoma	2,310
Oregon	7,990

State	Direct Employment
Pennsylvania	14,840
Rhode Island	790
South Carolina	4,890
South Dakota	400
Tennessee	8,410
Texas	49,290
Utah	7,420
Vermont	510
Virginia	17,380
Washington	16,730
West Virginia	1,360
Wisconsin	9,430
Wyoming	330
Total US	**468,800**

Source: US Bureau of Economic Analysis.

Indirect and Induced Economic Impacts

The initial round of output, income, and employment generated by the construction and operations of the data center industry leads to successive rounds of re-spending in the chain of production and through the personal consumption spending of industry and supplier employees. Such indirect and induced economic impacts can be measured using various approaches. The most common is multiplier analysis. In broad terms, a multiplier is an index that indicates the overall change in the level of economic activity that results from a given initial change. It effectively adds up all the successive rounds of re-spending, based on a number of assumptions that are embedded in the method of estimation.

There are different methods available for calculating multipliers. The method used in this report is input-output analysis. It is the most commonly used approach in regional economic impact studies. The input-output model developed by IMPLAN is built around an "input-output" table that relates the purchases that each industry has made from other industries to the value of the output of each industry. To meet the demand for goods and services from one industry, purchases are made in other industries according to the patterns recorded in the input-output table. These purchases in turn spark still more purchases by the industry's suppliers, and so on. Additionally, employees and business owners make personal purchases out of the additional income that is generated by this process, sending new demands rippling through the economy. Multipliers describe these iterations. The Type I multiplier measures the direct and indirect effects of a change in economic activity. It captures the inter-industry effects only, i.e., industries buying from local industries. The Type II (Social Accounting Matrix or SAM) multiplier captures the direct and indirect effects, and, in addition, it also reflects induced effects (i.e., changes in spending from households

as income increases or decreases due to the changes in production). The indirect and induced impacts by the data center industry on other sectors of the economy in terms of employment, labor income (including wages and salaries and benefits as well as proprietors' income), value added, and tax payments were calculated through the multiplier process built into the model.

For this study, PwC built customized IMPLAN input-output models for the United States as a whole and each of the three selected states to calculate the data center industry's indirect and induced economic impacts on each study area in terms of employment, labor income, value added, and tax payments.

Capital Investment Impact

PwC translated the data center industry's capital expenditures (as reported by the Census Bureau) into purchases of capital assets by type through the use of the so-called "capital flow matrix" prepared by the BEA. The IMPLAN model was then used to quantify the full economic impact of this spending. The capital spending impact is classified as an indirect and induced economic impact and is included in the overall economic impact of the data center industry.

Tax Impact

Due to data limitations, tax abatements are indirectly estimated in the data center industry's tax impact and are subtracted from estimated gross tax payments of the industry. We estimate that the data center industry's total tax impact is unlikely to vary by more than 5 percent (plus or minus) from the amounts shown in this report.

Top Suppliers

Table A-2 below shows the US data center industry's top supplying sectors in 2021. Nationwide the industry spent $14.5 billion on new data center construction and another $26.0 billion on new equipment, such as servers, storage devices, networking equipment, security systems, software, and automation (e.g., server provisioning, network monitoring, and workload management).[145] For its ongoing operations, the data center industry spent approximately $210 billion in 2021 to acquire goods and services from a large number of supplying sectors.[146] The top 20 supplying sectors shown below accounted for over 60 percent of the data center industry's total supplier expenditures (including both capital and noncapital expenditures) in 2021.

[145] US Census Bureau, Annual Capital Expenditures Survey (ACES). Available at: https://www.census.gov/programs-surveys/aces.html.

[146] IMPLAN economic modeling system.

Table A-2: – US Data Center Industry: Top Supplying Sectors, 2021

Supplying Sector	Percent of Total Industry Spend
Employment Services	10.2%
Construction of New Data Centers	5.7%
Management Consulting Services	5.7%
Advertising, Public Relations, and Related Services	5.0%
Custom Computer Programming Services	4.5%
Real Estate Services	4.2%
Software Publishers	3.5%
Leasing of Nonfinancial Intangible Assets	3.4%
Computer Related Services, including Facilities Management Services	3.4%
Radio and Television Broadcasts	3.0%
Data Processing, Hosting, and Related Services	2.6%
Computer Systems Design Services	2.3%
Legal Services	1.7%
Wireless Telecommunications (except Satellite)	1.6%
Air Transportation Services	1.4%
Electronics and Appliance Stores	1.4%
Wired Telecommunications	1.3%
Environmental and Other Technical Consulting Services	1.2%
Electronic Computer Manufacturing	0.4%
Computer Storage Device Manufacturing	0.2%
All Other Suppliers	37.1%
Total	100.0%

Source: PwC calculations using the IMPLAN modeling system.

Works Cited

AARP. "AARP Foundation Gets Grant to Help Older Adults Build Digital Skills." January 26, 2022. https://www.aarp.org/work/careers/aarp-foundation-grant-google/.

ARLnow.com. "Amazon Donating $1 Million to Arlington and Alexandria Schools." ARLnow, October 7, 2020. https://www.arlnow.com/2020/10/07/amazon-donating-1-million-to-arlington-and-alexandria-schools/.

Arthur, Charles. "What's a Zettabyte? By 2015, the Internet Will Know, Says Cisco." The Guardian, June 29, 2011. https://www.theguardian.com/technology/blog/2011/jun/29/zettabyte-data-internet-cisco

AWS. "AWS and Community Outreach." Accessed April 17, 2023. https://aws.amazon.com/about-aws/global-infrastructure/aws-incommunities/.

AWS. "AWS Impact Accelerator: Black Founders." Accessed April 17, 2023. https://aws-startup-lofts.com/amer/program/accelerators/black-founders.

AWS. "AWS Think Big for Small Business Program." Accessed April 17, 2023. https://aws.amazon.com/partners/programs/small-business/.

AWS. "Economic Impact of Amazon Solar Investment Impact in Virginia." Accessed May 8, 2023. https://d1.awsstatic.com/WWPS/pdf/aws-renewable-investments-virginia.pdf.

Broom, Jane. "An update on our $750 million commitment to affordable housing." Microsoft On the Issues (blog), January 20, 2022. https://blogs.microsoft.com/on-the-issues/2022/01/20/affordable-housing-initiative-washington-state-2022/.

Carton, Paul. "Data center staffing—an ongoing struggle." Uptime Institute Journal (blog), March 1, 2023. https://journal.uptimeinstitute.com/data-center-staffing-an-ongoing-struggle/.

CBRE Research. North America Data Center Trends H1 2022. CBRE, 2022. https://www.cbre.com/insights/reports/north-america-data-center-trends-h1-2022#download-report.

Ciauri, Chris. "The Dunant subsea cable, connecting the US and mainland Europe, is ready for service." Google Cloud (blog), February 3, 2021. https://cloud.google.com/blog/products/infrastructure/googles-dunant-subsea-cable-is-now-ready-for-service.

Data Center Hawk. "Markets." Accessed July 24, 2023. https://www.datacenterhawk.com/markets/

Davis, Jacqueline, Daniel Bizo, Andy Lawrence, Owen Rogers, Max Smolaks, Lenny Simon, and Douglas Donnellan. Uptime Institute Global Data Center Survey 2022. New York: Uptime Institute, 2022. https://uptimeinstitute.com/resources/research-and-reports/uptime-institute-global-data-center-survey-results-2022.

Denham, Hannah. "Dominion Energy, PowerHouse find workaround to Loudoun's data center power supply issues." Washington Business Journal, March 28, 2023. https://www.bizjournals.com/washington/news/2023/03/28/powerhouse-data-center-loudoun.html.

Di Liberto, Tom. "Western drought 2021 spotlight: Arizona," NOAA. Accessed April 28, 2023. https://www.climate.gov/news-features/event-tracker/western-drought-2021-spotlight-arizona.

Dietrich, Jay M. and Andy Lawrence. Three Key Elements: Water, Circularity, and Citing. New York: Uptime Institute, 2022. https://uptimeinstitute.com/resources/research-and-reports/three-key-sustainability-elements-water-circularity-and-siting.

Enslin, Rob. "Strengthening our workplace with neurodiverse talent." Google Cloud (blog), July 26, 2021. https://cloud.google.com/blog/topics/inside-google-cloud/google-cloud-launches-a-career-program-for-people-with-autism.

Flake, Ebony. "Tech Companies are Quietly Defunding Diversity Pledges and Industry Layoffs are Hitting Black and Brown Workers Hardest—Experts Say the Message is Clear." Essence, December 8, 2022. https://www.essence.com/news/money-career/tech-companies-quietly-defunding-diversity-pledges/.

Flanagan, Ciaran. "How Data Centers Are Driving The Renewable Energy Transition." Forbes, March 13, 2023. https://www.forbes.com/sites/siemens-smart-infrastructure/2023/03/13/how-data-centers-are-driving-the-renewable-energy-transition/?sh=187c5a274214.

Freehling, Emily. "Data Centers' Job Impact is Spread Out." Virginia Business, April 27, 2023. https://www.virginiabusiness.com/article/data-centers-job-impact-is-spread-out/.

Freehling, Emily. “On cloud nine.” Virginia Business, April 27, 2023.
https://www.virginiabusiness.com/article/on-cloud-nine/.

Funk, Brian. “No more going to the cemetery to get wi-fi.” Cardinal News, September 28, 2021.
https://cardinalnews.org/2021/09/28/facebook-joins-grayson-countys-broadband-roll-out/.

GBCI. TRUE Rating System. GBCI, 2022.
https://true.gbci.org/sites/default/files/resources/TRUE-Rating-System-2022.pdf.

Google. Google is proud to call Ohio home. Mountain View, CA: Google, 2021.
https://kstatic.googleusercontent.com/files/ dc1d93cfc71c0402fdbc14e4a252e8005fa01712bcf8525ebe 22bea31647d986af8bf5ad327b0e84a2cdc0 3b11e4e11b8d7e58048140ab5646de6c85570f601e.

Google Economic Impact. “Ohio.” Accessed April 17, 2023,
https://economicimpact.google/state/oh/.

Google.org. “Google.org Impact Challenge for Women and Girls 2021.” Accessed May 5, 2023.
https://impactchallenge.withgoogle.com/womenandgirls2021.

“Global E-Waste Management Market to Reach $158.9 Billion by 2030.” PRNewswire, January 31, 2023.
https://www.prnewswire.com/news-releases/global-e-waste-management-market-to-reach-158-9-billion-by-2030--301734485.html.

Lewis, Michelle. “These big tech firms bought the most clean energy in 2022.” Electrek, February 9, 2023,
https://electrek.co/2023/02/09/big-tech-clean-energy-2022/.

Lightcast. The Economic Value of America’s Community Colleges. American Association of Community Colleges, 2022.
https://www.aacc.nche.edu/wp-content/uploads/2022/11/AACC_ExecSum_1920_Formatted-Finalv2.pdf.

LimnoTech. Meta: Volumetric Water Benefits Report 2021. LimnoTech, 2022.
https://sustainability.fb.com/wp-content/uploads/2022/08/Meta_2021_Volumetric_Water_Benefit_Report.pdf.

Masanet, Eric, Arman Shehabi, Nuoa Lei, Sarah Smith, and Jonathan Koomey. “Recalibrating Global Data Center Energy-use Estimates,” Science 367, 984-986 (February 2020).
https://www.science.org/doi/abs/10.1126/science.aba3758.

Meta. “Meta Blueprint.” Accessed April 17, 2023.
https://www.facebookblueprint.com/student/catalog.

Meta. “Building with Mushrooms to Reduce Drywall Waste—or Cooking Up a New Future for Data Center Construction.” Sustainability (blog), April 10, 2023.
https://sustainability.fb.com/blog/2023/04/10/building-with-mushrooms-to-reduce-drywall-waste-or-cooking-up-a-new-future-for-data-center-construction/.

Meta. “Introducing Meta Boost Small Business Studios, a new digital marketing resource hub and event series.” July 20, 2022.
https://www.facebook.com/business/news/small-business-studios.

Meta. “Meta Elevate.” Accessed April 17, 2023.
https://www.facebook.com/fbelevate.

Meta. “Restoring More Water Than We Consume by 2030.” August 19, 2021.
https://about.fb.com/news/2021/08/restoring-water/.

Microsoft. “Datacenter physical access security.” March 2, 2023.
https://learn.microsoft.com/en-us/compliance/assurance/assurance-datacenter-physical-access-security.

Microsoft. “Microsoft Airband Initiative.” Accessed April 10, 2023.
https://www.microsoft.com/en-us/corporate-responsibility/airband-initiative.

Microsoft. “Microsoft and Lake Country Satellite roll out free Wi-Fi in Boydton, Virginia.” Microsoft News Center. October 10, 2018.
https://news.microsoft.com/2018/10/10/microsoft-and-lake-country-satellite-roll-out-free-wi-fi-in-boydton-virginia/.

Microsoft. “Microsoft Circular Centers program achieves 83% reuse, increasing supply chain efficiency and resiliency with Dynamics 365 and Power Platform.” November 2, 2021.
https://customers.microsoft.com/en-us/story/1431789627332547010-microsoft-circular-centers.

Microsoft. “Supplier Code of Conduct.” Accessed May 22, 2023.
https://www.microsoft.com/en-us/procurement/supplier-conduct.aspx?activetab=pivot:primaryr11.

Microsoft. “TEALS Program.” Accessed May 23, 2023,
https://www.microsoft.com/en-us/teals.

Miller, Rich. “AWS Plans to Slash Water Use in its Cloud Data Centers.” Data Center Frontier, November 28, 2022.
https://www.datacenterfrontier.com/sustainability/article/21438279/aws-targets-water-use-in-its-cloud-data-centers.

Miller, Rich. “Dominion Energy Plans More Green Power for Virginia’s Data Centers.” Data Center Frontier, January 27, 2021.
https://www.datacenterfrontier.com/cloud/article/11428441/dominion-energy-plans-more-green-power-for-virginia8217s-data-centers.

Miller, Rich. “Facebook Unveils Water Projects to Support $800 Million Mesa Data Center.” Data Center Frontier, August 12, 2021.
https://www.datacenterfrontier.com/featured/article/11428015/facebook-unveils-water-projects-to-support-800-million-mesa-data-center.

Miller, Rich. “Prime Will Enter Phoenix Market with 210 Megawatt Campus.” Data Center Frontier, May 4, 2023.
https://www.datacenterfrontier.com/hyperscale/article/33004536/prime-will-enter-phoenix-market-with-210-megawatt-campus.

Mondal, Sanjoy and Priyanjana Mitra. The Role of Emerging Technologies to Fight Against COVID-19 Pandemic: An Exploratory Review. Transactions of the Indian National Academy of Engineering 7(1), 2022.
https://doi.org/10.1007%2Fs41403-022-00322-6.

Mycocycle. Accessed May 3, 2023.
https://mycocycle.com/.

Nadler, Danielle. “Nadler: Data Center Partner with Educators to Blaze New ‘Classroom-to-Career’ Pathways.” LoudounNow, March 2, 2023.
https://www.loudounnow.com/opinion/nadler-data-centers-partner-with-educators-to-blaze-new-classroom-to-career-pathways/article_12780ea0-b847-11ed-a790-67ef6ad86820.html.

Nguyen, Chuong. “Microsoft and Facebook’s undersea Marea cable breaks data transfer speed record.” DigitalTrends, February 28, 2019.
https://www.digitaltrends.com/computing/marea-undersea-cable-faster-data-transfer-speed/.

Open Compute Project. “About.” Accessed April 24, 2023.
https://www.opencompute.org/about.

Patrizio, Andy. “IDC: Expect 175 Zettabytes of Data Worldwide by 2025.” Network World, December 3, 2018.
https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html.

Robinson, Vickie. “A street-by-street view of digital inequity in the United States.” Microsoft (blog), July 14, 2022.
https://blogs.microsoft.com/on-the-issues/2022/07/14/digital-inequity-dashboard-broadband-access/.

Sahlstrom, Nat. “Here’s how AWS is working together with communities to lower water footprint.” Fairfax County Times, March 24, 2023.
https://www.fairfaxtimes.com/articles/opinions/here-s-how-aws-is-working-together-with-communities-to-lower-water-footprint/article_019719a4-c9aa-11ed-963c-a7cf3b8f9c4f.html#:~:text=In%20Northern%20Virginia%2C%20AWS%20worked,separate%20from%20regular%20fresh%20water.

Schupak, Amanda. “Corporations are pledging to be ‘water positive’. What does that mean?” The Guardian, October 14, 2021.
https://www.theguardian.com/environment/2021/oct/14/water-positive-pledge-corporations.

Shehabi, Arman, Sarah J Smith, Eric Masanet, and Jonathan Koomey. “Data Center Growth in the United States: Decoupling the Demand for Services from Electricity Use,” Environmental Research Letters 13, 12 (December 2018)
https://iopscience.iop.org/article/10.1088/1748-9326/aaec9c.

Siddik, Md Abu Bakar, Arman Shehabi, and Landon Marston. “The Environmental Footprint of Data Centers in the United States,” Environmental Research Letters 16, 6 (May 2021)
https://doi.org/10.1088/1748-9326/abfba1.

Smola, Jennifer. “New Path to IT Jobs.” The Columbus Dispatch, March 5, 2019.
https://www.dispatch.com/story/news/education/campus/2019/03/05/new-path-to-it-jobs/53189807007/.

Sverdlik, Yevgeniy. “Facebook to Sell Bandwidth on Its New Inter-Data Center Fiber Routes.” Data Center Knowledge, March 6, 2019.
https://www.datacenterknowledge.com/facebook/facebook-sell-bandwidth-its-new-inter-data-center-fiber-routes.

Swinhoe, Dan. “Re-use, refurb, recycle: Circular economy thinking and data center IT assets.” Data Center Dynamics, March 8, 2022.
https://www.datacenterdynamics.com/en/analysis/re-use-refurb-recycle-circular-economy-thinking-and-data-center-it-assets/#:~:text=Google%20is%20also%20a%20major,resold%20into%20the%20secondary%20market

United States Census Bureau. Annual Survey of State and Local Government Finances.
https://www.census.gov/programs-surveys/gov-finances.html.

United States Environmental Protection Agency. “Green Power Partnership National Top 100.” Last updated April 24, 2023.
https://www.epa.gov/greenpower/green-power-partnership-national-top-100.

Uptime Institute Intelligence. Glossary of Digital Infrastructure Sustainability. New York: Uptime Institute, 2022.
https://uptimeinstitute.com/resources/research-and-reports/glossary-of-digital-infrastructure-sustainability.

US Chamber of Commerce Technology Engagement Center. Data Centers: Jobs and Opportunities in Communities Nationwide. Washington, DC: US Chamber of Commerce Technology Engagement Center, 2017.
https://www.uschamber.com/assets/archived/images/ctec_datacenterrpt_lowres.pdf.

VanLear, Sara. Facebook’s U.S. Renewable Energy Impact Study. Research Triangle Park, NC: RTI International, 2021.
https://www.rti.org/publication/facebooks-us-renewable-energy/fulltext.pdf.

Walsh, Noelle. “Expanding cloud services: Microsoft launches its sustainable datacenter region in Arizona.” Microsoft Azure (blog). June 15, 2021.
https://azure.microsoft.com/en-us/blog/expanding-cloud-services-microsoft-launches-its-sustainable-datacenter-region-in-arizona/#:~:text=We%20chose%20Arizona%20as%20the,in%20the%20regions%20we%20operate.