DATA CENTERS

Jobs and Opportunities in Communities Nationwide

C_TEC
U.S. Chamber of Commerce
Technology Engagement Center

REPORT HIGHLIGHTS

Technological innovations are rapidly changing our lives, our businesses, and our economy. Technology, no longer an isolated business sector, is a facilitator enabling innovation, growth, and the strengthening of America's traditional business sectors. From transportation and energy to finance and medicine, businesses rely on technology to interact with their customers, improve their services, and make their operations more globally competitive. Innovative technology is deeply integrated into the economy and is the driving force behind the creation of new jobs in science, health care, education, transportation, and more. Technology has fundamentally transformed our economy—and is poised to fuel even more growth in the future.

Overall, there were 6 million jobs in the U.S. technology industry last year, and we expect this to increase by 4.1% in 2017. Technology-related jobs run the gamut—from transportation logistics and warehousing to programmers and radiologists. In 2012, economists estimated that each high-tech job in the U.S. creates five additional jobs in other local goods and services sectors across all occupations—for example, construction workers, lawyers, dentists, schoolteachers, cooks, and retail clerks.

So what is the backbone that supports the rapid growth of this sector?

Data centers are facilities that house computers that store and process data, anchor our nation's economic growth, bolster job creation, and enable globally competitive innovations.

Burgeoning technologies like drones and sensors, both of which farmers use to monitor their crops and gather key information about their soil and how to increase their yields, are powered by data centers. Lifesaving gene therapies for diseases like cancer and hemophilia are powered by these centers.

Heat sensing drones deployed after natural disasters to locate survivors and deliver lifesaving equipment can arrive at the scene faster than first responders. Wearable technologies that we sport help us lead healthier lifestyles. Distance learning courses empower children and adults to learn new skills or trades to keep up with the constantly evolving job market. Innovations in science, energy, manufacturing, health care, education, transportation and many other fields—and their jobs—are being powered by data centers.

But the benefits of data centers go beyond powering America's cutting-edge innovations. The economic impact, direct and indirect, is substantial.

While being built, a typical data center employs 1,688 local workers, provides $77.7 million in wages for those workers, produces $243.5 million in output along the local economy's supply chain, and generates $9.9 million in revenue for state and local governments. Every year thereafter, that same data center supports 157 local jobs paying $7.8 million in wages, injecting $32.5 million into the local economy, and generating $1.1 million in revenue to state and local governments. And the economic impacts don't stop here.

Opening data centers creates other real, tangible benefits for residents. Data centers directly and indirectly improve local public infrastructure—roads, power lines, water, and sewage systems. They increase the pool of skilled workers and often attract additional centers or partner businesses.

Data centers aren't passive bystanders—they contribute financial and other resources and collaborate with local organizations to support their communities.

With 6 million jobs and 2.5 million job openings, America's technology sector is driving economic growth, expanding global dominance in innovation and entrepreneurship, and putting

Americans to work. Without data centers, we can't power the innovations to keep our economy moving.

That's why the U.S. Chamber Technology Engagement Center (C_TEC) works with hundreds of technology and manufacturing companies on rational policy solutions to drive economic growth and spur innovation to create jobs. To capitalize on the environment for all Americans, our companies need accelerated investment and infrastructure deployment at all levels. Too many regulatory barriers threaten infrastructure improvements.

The tens of thousands of Americans working to build and operate data centers in our local communities are proof that with the right policies and investments, technology will continue to generate jobs and benefits for hardworking families.

Table 1. Initial Capital and Operating Expenditures of a Typical Data center

Net rentable square feet (NRSF)	165,141
Capital expenditure per NRSF	$1,305
Initial capital expenditures	$215.5 M
Land acquisition (6.2%)	$13.4 M
Construction building (20.9%)	$45.0 M
IT equipment (72.9%)	$157.1 M
Annual operating expenditures (8.6% of capital expenditures)	$18.5 M
Power (40.0%)	$7.4 M
Staffing (15.0%)	$2.8 M
Real estate taxes and insurance (5.5%)	$1.0 M
Maintenance, administration, and others (39.5%)	$7.3 M

Table 2. Economic Impacts of a Typical Large Data center to Local Communities

CONSTRUCTION PHASE 18-24 MONTHS	OPERATION PHASE ANNUALLY
1,688 Local Jobs	157 Local Jobs
$77.7 million wages	$7.8 million wages
$243.5 million local economic activities	$32.5 million local andeconomic activities
$9.9 million state & local taxes	$1.1 million state & local taxes

LANDSCAPE OF THE DATA CENTER INDUSTRY

Nam D. Pham, Ph.D.[1] | May 1, 2017

Data centers are facilities containing information technology equipment including servers and networking computers for data processing, data storage, and communications. Large data centers usually consist of shells stacked with racks of servers and IT equipment on a raised floor with power backup and temperature control systems. Many large data centers also have their own power generators for heating and cooling equipment.

Two broad categories of data center ownership are enterprise and colocation. Enterprise, or corporate, data centers are built and owned by large technology companies such as Amazon, Facebook, Google, Microsoft, Yahoo, as well as government agencies, financial institutions, insurance companies, retailers, and other companies across all industries. Enterprise data centers support web-related services for their organizations, partners, and customers. Colocation data centers are typically built, owned, and managed by data center service providers such as Coresite, CyrusOne, Digital Realty Trust, DuPont Fabros, and QTS. These data center service providers do not use the services themselves but rather lease the space to one or multiple tenants. Since third-party data center solutions offer flexibility and scalability of IT needs, many large enterprises operate their own data centers and lease space from data center service providers at the same time. For example, IBM, CenturyLink, and Equinix have their own large data centers and also the largest tenants of Digital Realty Trust. In addition to their own data centers, Microsoft also leases data centers from many different data service providers including Digital Realty Trust, DuPont Fabros, Vantage Data Centers, and CyrusOne.

According to the U.S. Department of Energy, there are 3 million data centers scattered across urban and rural areas in the U.S. More than 90% of the servers are, however, housed in data centers and owned or leased by small- and medium-size businesses. Less than 10% of servers located in large data centers are owned by major cloud providers and national super computer centers.[2]

The Data Center Institute classifies data centers into six size standards, measuring by compute space or rack yield. Compute space is the area, measured in square foot (sf) or square meter (m2), within the data center facility containing server racks and related IT equipment. Rack yield is the number of racks that can fit within a compute space. A rack is normally set to be 25 sf to allow aisle and perimeter space around the server room (Table 3).

As data reliability and privacy become more vital in the digital economy, data centers require uninterruptible power supply systems to minimize the downtime for servers and security systems for their users. Data center infrastructure costs and operational complexities increase with the reliability level. Uptime Institute created a standard Tier Classification System that has four tiers to consistently evaluate the infrastructure performance or uptime of data centers (Table 4).

The number of internet users and the number of applications have been rising exponentially for decades. Commercial users increasingly rely on the internet to provide their services and to store data; noncommercial users access the internet for emailing, texting, streaming videos and music, and social networking through Google, YouTube, Facebook, and Twitter, to name a few. Consequently, more data centers are created to meet the demand of the rising amount of data that is created and stored.

Table 3. Data center Size Classifications[3]

Size Metric	Rack Yield	Compute Space (sf)
Mega	> 9,000	> 225,000
Massive	3,001 - 9,000	75,001 - 225,000
Large	801 - 3,000	20,001 - 75,000
Medium	201 - 800	5,001 - 20,000
Small	11 - 200	251 - 5,000
Mini	1 - 10	1 - 250

Table 4. Data center Infrastructure Tiers[4]

Tier	Description	Uptime	Downtime Per Year
I - Basic Capacity	Data centers provide dedicated site infrastructure to support IT beyond an office setting, including a dedicated space for IT systems, an uninterruptible power supply, dedicated cooling equipment that does not shut down at the end of normal office hours, and an engine generator to protect IT functions from extended power outages.	99.671%	28.8 Hours
II - Redundant Capacity Components	Data centers include redundant critical power and cooling components to provide select maintenance opportunities and an increased margin of safety against IT process disruptions that would result from site infrastructure equipment failures. The redundant components include power and cooling equipment.	99.749%	22 Hours
III - Concurrently Maintainable	Data centers have no shutdowns for equipment replacement and maintenance. A redundant delivery path for power and cooling is added to the redundant critical components of Tier II so that each component needed to support the IT processing environment can be shut down and maintained without impactingthe IT operation.	99.982%	1.6 Hours
IV - Fault Tolerance	Site infrastructure builds on Tier III, adding the concept of Fault Tolerance to the site infrastructure topology. Fault Tolerance means that when individual equipment failures or distribution path interruptions occur, the effects of the events are stopped short of the IT operations.	99.995%	26.3 Minutes

CAPITAL AND OPERATING EXPENDITURES OF DATA CENTERS

Large data centers are capital intensive and require significant investments in time and money to build. Depending on the size and the tier, initial capital investments for large data centers start from several hundreds of millions of dollars and can be over one billion dollars. It is very common that new and larger data centers are added to the same site or campus of the first data center over time. For example, Switch, which designs, constructs, and operates some of the most advanced data centers, has been continuously building and expanding its core Las Vegas Campus. Upon the completion of its Las Vegas 12 data centers, Switch Las Vegas Campus covers nearly 2.4 million square feet with 315 MW capacity of power.

A large up front investment for the initial construction phase includes land purchase, shell construction, and equipment installation. The annual operating costs to run data centers consist of power, staff, taxes, maintenance, and other administration costs. Many cost components such as land prices and taxes vary substantially across states and cities.

CONSTRUCTION PHASE: Three main components of capital expenditures during the initial phase of large data centers are land acquisition, shell construction, and mechanical and electronic equipment purchasing and installation. The construction phase is typically between 18 months and 24 months (Table 5).

Land acquisition: The cost of land includes the property purchase, consultant fees, and brokerage fees. Although the smallest component of a data center's capital expenditures, the cost of land varies substantially across states, counties, and cities. In 2015, CBRE estimated an average cost of land to be 2.5% of total construction and operating costs over 10 years of a typical 5 MW enterprise project across 30 U.S. cities. The CBRE research shows the cost variation from 0.1% of total costs over 10 years in Kansas City, Missouri to 9.9% in Southern California.[5] Other estimates conducted by Uptime Institute and Microsoft range from 0.5% and 2.0% of the initial capital investment.[6]

Base building construction: The base building construction costs include architectural planning and design, building permits, local taxes, land excavation and grading, roadways, tie-ins to utilities, and the building shell. Although less than land prices, construction costs also vary across areas. For example, CBRE estimated that the construction costs of a Tier III 5 MW enterprise project in expensive areas such as Boston and Silicon Valley could be 45% higher than the cost of construction in less expensive areas such as Tulsa and Charlotte. Microsoft Corporation and Forrester Research estimated the cost of a base building shell is approximately 16% of initial capital investment and $200 per sf.[7] The construction costs also increase with the redundancy level of Tier III and Tier IV facilities compared with Tier I and Tier II facilities.[8] Architectural planning and design range between 7.0% (Microsoft) and 25% of the total construction costs (Forrester). The costs of building permits and taxes paid to local governments vary substantially by location. Forrester Research estimated $70 per sf in building permits and taxes paid to local governments.

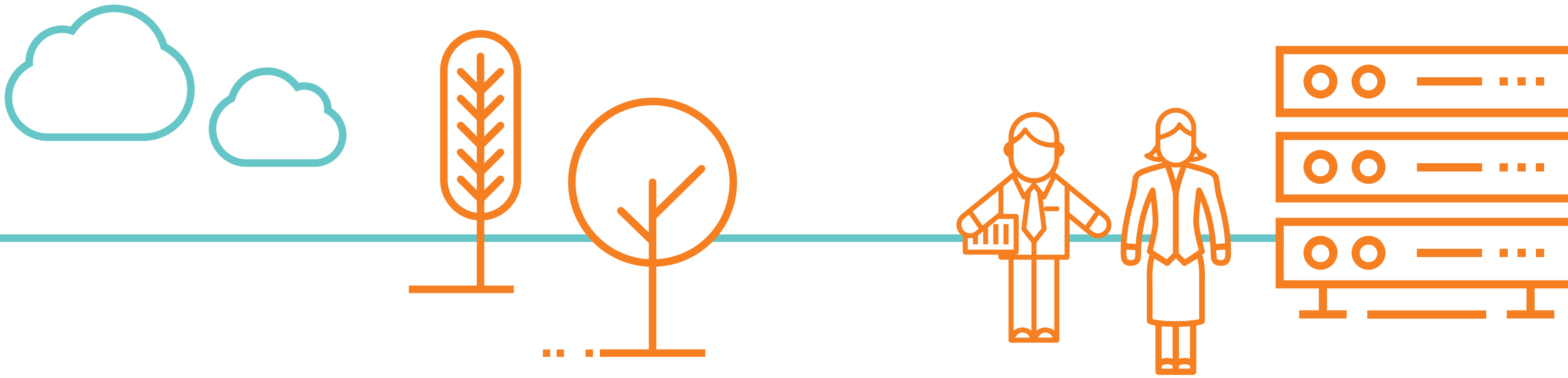
Mechanical and electrical equipment: The costs of data center infrastructure include mechanical and electronic equipment purchases and installation. Mechanical equipment includes computer room air-conditioning units, refrigerant loops, condenser plants or chillers, and water tanks. Electrical equipment includes power distribution units, transformers, patch panels, UPS systems, auto transfer switches, and generators. These costs exclude servers, data storage equipment, and networking devices that are not attached to the building shell. Mechanical and electrical costs range between 82% and 85% of initial capital investment (Microsoft and Uptime Institute).[9] The American Society of Professional Estimators found that electrical equipment costs are approximately 25%, and labor installation costs account for 75% for data centers.[10]

Table 5. Capital Expenditures During the Initial Construction Phase

Land Acquisition	Base Building Construction	Mechanical & Electrical Equipment
Costs include transaction, consultant fees, and brokerage fees. The cost of land acquisition is the smallest cost item but varies substantially across areas. Cost estimates are 2.5% of total project costs over 10 years (CBRE), 2.0% of total cost of data centers (Microsoft), and 0.5% of initial CAPEX (Uptime Institute).	Costs include architectural planning and design, building permits, local taxes, land excavation and grading, roadways, tie-ins to utilities, and base building shell. The cost of the building shell is less varied across regions. Cost estimates are around 16% of initial capital investment and $200 per sf. Costs are rising with higher tier of data centers	Costs include mechanical and electronic equipment and exclude servers, data storage equipment, and networking devices that are not attached to the building shell. Cost estimates are between 82% (Microsoft) and 85% (Uptime Institute) of initial capital investment; the American Society of Professional Estimators estimated electrical equipment accounts for 25% and labor installation accounts for 75% for data centers.

Table 6. Annual Operating Expenditures

Power	Staffing	Taxes	Other
The largest operating item, ranging between 40% and 80% of total annual expenditures.	The second largest operating item, including 24x7x365 security, operations, and IT staff. Staffing expenditures account for 15% of annual operating expenditures.	Property taxes are estimated to be between 8.7% of total cost over 10 years and about 12% of annual operating spending. State and local governments are increasingly providing tax incentives to attract data centers.	Other costs include administrative, maintenance, security, and landscaping. Repairs, replacement, and upgrade of IT equipment and infrastructure begin in year three of operation.



OPERATION PHASE: Annual operating expenditures of a data center are grouped into four main categories: power, staffing, taxes, and other maintenance and administration (Table 6). Estimates of annual operating costs are between 6.0% and 10% of initial capital investment and data centers are typically depreciated over the course of 15 years.[11]

Power: The largest expenditure to operate a data center is power. Typically, half of the power consumption is for running IT equipment (computers and servers) and the other half is for cooling and power infrastructure at data centers.[12] Depending on the data center tier (level of uptime), energy source (traditional versus renewable energy), and region, power expenditures can range from 40% (Uptime Institute) to 80% (Forrester Research) of the overall cost of operating a data center.[13]

Staffing: The second largest expenditure to operate a data center is staffing. Data centers employ security staff, operations staff, and on-site IT engineering and management staff. Most of the positions are 24x7x365 to maintain and operate data centers nonstop. Staffing costs are about 15% of annual expenditures (Uptime Institute) and 4.9% of total costs, including construction, over 10 years (CBRE).[14] DCD Intelligence estimated the data center industry employed 108,500 people in the U.S. in 2015, accounting for 17.5% of global data center employment. It also estimated the proportion of people working on the IT/networks side of the data center industry have increased while those on the facility side have remained steady.[15]

Taxes: A large data center invests hundreds of millions of dollars in capital expenditures in the first couple of years for construction and then continues to spend millions of dollars each year for operations. Data centers generate significant property, sales, and income tax revenues for state and local governments. Uptime Institute estimated that property taxes account for 12.2% of annual operating expenditures of data centers. Similarly, CBRE estimated net taxes of data centers in 30 cities account for 8.7% of the total project cost over 10 years.[16]

Other: Other operating expenditures include maintenance, insurance, security, landscaping, and administration. In addition to ongoing activities, data centers replace, repair, and upgrade to newer and more efficient IT equipment and infrastructure after about three years–and then on an ongoing basis into the future.

INITIAL CAPITAL AND ANNUAL OPERATING EXPENDITURES OF A TYPICAL LARGE DATA CENTER

We use financial data of the most recent development projects and 2016 annual income statements of data center service providers and enterprises to estimate the initial capital and annual operating expenditures of a typical data center. Financial data of data centers are obtained mainly from a company's annual reports filings with the U.S. Securities and Exchange Commission and other publicly available information. The initial capital expenditures include the cost to purchase the land, construct the building shell, and purchase and install mechanical and electrical equipment (IT infrastructure). The annual operating expenditures include power, staffing, taxes, maintenance, and other administrative costs of a data center.

Our data sample includes 244 large colocation and enterprise data centers of the 10 largest data center service providers and enterprises, covering over 40 million net rentable square feet, located across 16 states.[17] The 10 enterprises and service providers in our sample, in alphabetical order, are Apple, CoreSite, CyrusOne, Digital Realty Trust, DuPont Fabros, Facebook, Google, Microsoft, QTS, and Yahoo.

Recent initial capital expenditures on data centers in our sample totaled $8.2 billion and created more than 6.2 million net rentable square feet (NRSF), averaging $1,305 per square foot. The breakdown of initial capital expenditures are 6.2% to acquire the land, 20.9% to build the base building (including planning and design, building permits, local taxes, land excavation and grading, roadways, tie-ins to utilities, and the building shell), and 72.9% to purchase and install mechanical and electrical equipment (including computer room air-conditioning units, refrigerant loop, condenser plant or chiller, and water tank, power distribution units, transformers, patch panels, UPS systems, auto transfer switches, and generators) (Table 7).

Table 7. Initial Capital Expenditure and Operating Expenditure of a Typical Data Center

Net rentable square feet (NRSF)	165,141
Capital Expenditure per NRSF	$1,305
INITIAL CAPITAL EXPENDITURES	**$215.5 M**
Land acquisition (6.2%)	$13.4 M
Construction building (20.9%)	$45.0 M
IT equipment (72.9%)	$157.1 M
ANNUAL OPERATING EXPENDITURES (8.6% OF CAPEX)	**$18.5 M**
Power (40.0%)	$7.4 M
Staffing (15.0%)	$2.8 M
Real estate taxes and insurance (5.5%)	$1.0 M
Maintenance, administration, and others (39.5%)	$7.3 M

Annual operating expenditures accounted for 8.6% of the initial capital expenditures of data centers in our sample. The largest component of annual operating expenditures is power, followed by staffing, taxes, and maintenance. Annual power spending and staffing expenditures are 40.0% and 15.0% of annual spending, respectively. Real estate taxes and insurance expenses are 5.5% and maintenance and all other administrative expenses are 39.5% (Table 7).

ECONOMIC IMPACTS OF A TYPICAL DATA CENTER

Large data centers bring in millions of dollars in initial investment directly to local communities that create ripple effects throughout the surrounding areas. The initial investment directly creates construction jobs to build the data center itself and public infrastructure, including roads, water, sewer, network/fiber, and electrical infrastructure. After being built, data centers operate around the clock, directly creating 24 x 7 x 365 security, operations, and IT jobs. During the construction and operation phases, data centers purchase goods and services from local suppliers and pay wages to their employees, contractors, and vendors. With their earnings, workers spend on housing, food, clothes, education, entertainment, and other daily goods and services. State and local governments generate tax revenues from workers' personal incomes, sales taxes from business activities, and property taxes from individuals and data centers.

We apply regional economic multipliers (RIMS II) constructed and published by the Department of Commerce's Bureau of Economic Analysis (BEA) to calculate the direct, indirect, and induced economic impacts of a data center on local communities. The economic impacts include direct, indirect, and induced effects of the construction and operation of data centers. Direct impacts are changes in economic activity arising from the first round of spending resulting from the initial demand (constructing and operating a data center). Indirect impacts are changes in economic activity resulting from the subsequent rounds of spending by industries along the supply chain affected by the initial demand. Induced impacts are changes in economic activity resulting from the changes in spending by workers whose earnings are affected by the direct and indirect changes.[18]

The economic impact calculations in this study include two phases—the construction phase and the operation phase of data centers. The economic impacts of the construction phase include direct construction jobs and indirect and induced jobs supported by the construction, wages paid to construction workers and indirect and induced workers in the communities, and indirect and induced economic activities supported by the construction. The economic impacts of the operation phase include direct, indirect, and induced jobs supported by the operation of data centers, wages paid to all workers, and all economic activities. We then use average state and local income tax and sales tax rates to estimate tax revenues collected by state and local governments on direct, indirect, and induced jobs and economic activities within the state. Social impacts are real-life monetary and nonmonetary contributions of enterprises to local communities.

Overall, a $215.5 million initial capital investment on building a typical large data center of 165,141 sf supports 1,688 jobs during the 18-24 month construction phase and $77.7 million in wages. After excluding all mechanical and electrical equipment assumed to be produced outside the state, capital investment of the typical data center creates $243.5 million in economic activity for local communities where the data center is located. In addition to property and sales taxes paid directly by the data center, state and local governments generate nearly $9.9 million in income taxes paid by direct, indirect, and induced workers and sales taxes by indirect and induced economic activities (Table 8).

During its yearly operation, a typical large data center supports another 157 local jobs and $7.8 million in wages at the data center and along the supply chain. The data center each year added $32.5 million in additional economic activity to local communities. In addition to property and sales taxes paid directly by the data center, local governments receive an additional $1.1 million per year in individual income and sales taxes (Table 8).

$7.8 MILLION

in annual wages generated by a typical large data center

CONSTRUCTION PHASE: A typical data center, based on our sample of colocation and enterprise data centers, is 165,141 net rentable square feet (NRSF) and requires an initial capital investment of $1,305 per sf, totaling $215.5 million for the initial capital investment. The construction cost breakdowns of our data sample are: 6.2% for land acquisition, 20.9% for the building shell, and 72.9% for mechanical and electrical equipment purchases and installation.

We calculate the construction cost of the shell to be $45.0 million (20.9% of $215.5 million) and the cost of purchasing and installing mechanical and electrical equipment to be $157.1 million (72.9% of $215.5 million). Since mechanical and electrical equipment is most likely purchased from out-of-state vendors and does not produce significant economic impacts within the state where the data center is located, we apply only half of mechanical and electrical equipment spending (i.e., $78.5 million) to represent the installation costs that are spent on local workers. Also, we do not calculate the economic impacts of the land purchase on local economies. Thus, the construction phase of a typical data center creates a $123.5 million construction demand ($45 million for building the shell and $78.5 million for the installation of mechanical and electrical equipment) that affects local economies.

We apply the Bureau of Economic Analysis' (BEA's) regional economic multipliers to calculate the economic impacts of the construction on local economies. The magnitude of economic multipliers varies across regions, depending on the structure of the economy of each individual state. For each additional $1 million spent on a construction project, BEA estimates that between 9 (Delaware) and 17 (Georgia) direct, indirect, and induced jobs are created within a state across all industries along the supply chain. BEA also estimates that an additional $1 million in construction demand creates an additional $0.6 million wages for all direct, indirect, and induced jobs within a state, ranging from $0.5 million in Delaware to $0.8 million in Texas. Last, an additional $1 million in construction demand creates $2.0 million in direct, indirect, and induced output within the state, ranging between $1.6 million in Wyoming and $2.4 million in Texas.

We calculate that $123.5 million investment on construction within the state where the data center is located supports 1,688 direct construction jobs and indirect and induced jobs along the supply chain within the state. These direct, indirect, and induced jobs generate $77.7 million in wages and produce $243.5 million in output within the state. Assuming an average of 5.0% for income state and local tax rates, state and local governments generate $3.9 million income tax revenues from $77.7 million in wages. Since many states offer tax incentive programs, we exclude all direct economic activities of the data center to calculate sales tax generated by state and local governments. Assuming a 5.0% sales tax, state and local governments generate another $6 million from the indirect and induced output within the state. Altogether, state and local governments generate $9.9 million in income and sales taxes during the 18–24 months of the construction period (Table 9).

Table 8. Economic Impacts of a Typical Large Data center to Local Communities

Construction Phase 18-24 months	Operation Phase Annually
1,688 local jobs	157 local jobs
$77.7 million in wages	$7.8 million in wages
$243.5 million in local economic activities	$32.5 million in local economic activities
$9.9 million in state and local taxes	$1.1 million in state and local taxes

Table 9. Economic Impacts of a Typical Data Center | Construction Phase

Data Center Outputs	Economic Multipliers	Impact
Direct construction jobs and indirect and induced jobs within the state	13.666	1,688
Wages of direct construction jobs and indirect and induced jobs	0.629	$77.7 M
Direct construction outputs and indirect and induced output	1.97	$243.5 M
State and local taxes		$9.9 M
Income taxes of direct, indirect, and induced jobs	5%	$3.9 M
Sales taxes from indirect and induced outputs	5%	$6.0 M

Table 10. Annual Economic Impacts of a Typical Data Center | Operation Phase

Description	Economic Multipliers		Total Impact
Direct, indirect and induced jobs within the state	Power	5.342	157
	Data center	10.659	
Wages of direct, indirect, and induced jobs	Power	0.311	$7.8 M
	Data center	0.503	
Direct, indirect, and induced output	Power	1.574	$32.5 M
	Data center	1.890	
State and local taxes			$1.1 M
Income taxes of direct, indirect, and induced jobs	5%		$0.4 M
Sales taxes from indirect and induced outputs	5%		$0.7 M

CONSTRUCTION PHASE DATA CENTER OUTPUTS

$77.7 Million
Wages of direct construction jobs and indirect and induced jobs

1,688
Direct construction jobs and indirect and induced jobs within the state

OPERATION PHASE: After being built, data centers have annual expenditures on power, staffing, taxes, maintenance, administive costs, and others. Using our data center sample, we estimate that annual operation expenditure accounts for 8.6% of initial capital expenditures. The annual operation expenditures breakdown are 40.0% on power, 15.0% on staffing, 5.5% on real estate tax and insurance, and 39.5% on maintenance, administration, and others.

We calculate annual operating expenditures of a typical large data center to be $18.5 million (8.6% x $215.5 million), of which $7.4 million is spent on power, $2.8 million on staffing, $1.0 million on real estate tax and insurance, and $7.3 million on other maintenance and administration. For the purpose of calculating the annual economic impacts of the data center during the operation phase, we calculate the economic impacts of $7.4 million spending each year on power separately from the rest of the $11.1 million spending on all other maintenance and administration on the data center to account for the increased demand of local utilities.

Similarly, we apply the BEA's regional economic multipliers of the utility industry to calculate the economic impacts of power consumption within a state. For each additional $1 million of spending on power consumption, BEA estimates approximately 5 direct, indirect, and induced jobs are created within a state along the supply chain. BEA also estimates that an additional $1 million in power demand creates $0.3 million wages for all direct, indirect, and induced jobs. Last, an additional $1 million in power demand creates $1.6 million in direct, indirect, and induced output within the state. We then apply the BEA's regional economic multipliers indata processing industry to calculate the economic impacts of the data center spending within a state. For each additional $1 million of spending on data processing, BEA estimates that approximately 10 direct, indirect, and induced jobs are created within a state along the supply chain. BEA also estimates an additional $1 million in data processing demand creates $0.5 million in wages for all direct, indirect, and induced jobs. Finally, an additional $1 million in data processing demand creates $1.9 million in direct, indirect, and induced output within the state.

We calculate that $18.5 million spending on annual operating expenses ($7.4 million on power and $11.1 million on operations) supports 157 direct, indirect, and induced local jobs. These direct, indirect, and induced jobs earn $7.8 million in wages and produce $32.5 million in output. Again, assuming an average of 5.0% for income state and local tax rates, state and local governments generate $0.4 million income tax revenue per year from $7.8 million wages. Since many states offer tax incentive programs, we exclude all direct spending of the data center in our calculations of sales tax generated by state and local governments. Assuming 5.0% sales tax, state and local governments generate another $0.7 million per year from indirect and induced output within the state. Altogether, state and local governments generate $1.1 million income and sales taxes per year during the life of the data center (Table 10).

SPILLOVER BENEFITS TO LOCAL COMMUNITIES

Data centers create positive long-lasting effects on local communities. Building new data centers creates more demand for expanding and upgrading local roads, power, water, and sewage systems. Data centers also spend their own resources to train local workers. These assets remain in the community and benefit other local businesses and residents. With these improvements, data centers attract other data centers and businesses to communities. Like other industries, data centers tend to group together geographically and follow others as seen in Colorado Springs, Raleigh, Des Moines, and other places across the country. In 2017 alone, both Apple and Google have purchased land to build or expand data centers in Nevada. Furthermore, data centers make charitable contributions, partner with local educational institutions, and support local organizations to build stronger communities.

CONTINUOUS ECONOMIC DEVELOPMENT: The development of large data centers tends to happen in stages with ongoing investment in construction to increase capacity. As a result, local economies have additional inflow investments and pipeline projects that promote economic growth. For example, Google in 2016 acquired another 74 acres in Dalles, Oregon, to expand its first corporate data center that was built a decade earlier. The new expansion is estimated to be approximately $600 million, bringing its total investment on data centers in the area to $1.8 billion. Similarly, the Apple and Facebook data centers in Prineville, Oregon, have brought over $1 billion in new investments, which helped the county's economy transition from its dependence on the wood products industry. These projects have created thousands of construction jobs that helped Prineville to reduce unemployment from 20% during the Great Recession to 8%. The diversification of businesses helps lessen local economies' dependence on a particular sector.

ADDING POOL OF TALENTED AND SKILLED WORKERS TO ATTRACT ADDITIONAL BUSINESSES: The availability of related skilled labor such as engineers and construction workers is crucial for high-end and large-scale data centers. The pool of skilled workers in the data center industry, such as building architects and engineers, IT engineers and technicians, and computer system designers, creates advantages for local communities to attract other data centers and other industries as seen in Ohio, Central Washington, and Virginia. Workers trained by Apple and Facebook in Prineville, Oregon, by Google in Dalles, and Dell, Intuit, Microsoft, and Yahoo in Central Washington are valuable assets for these regions.

IMPROVING AND UPGRADING INFRASTRUCTURE: Many data center developments are located in rural areas where public infrastructure is limited. The building of data centers in underdeveloped areas creates a high demand for expansion and the upgrade of public roads, power, water, and sewer systems. In some cases, data centers directly collaborate with local companies to find innovative solutions. These public infrastructure improvements are long lasting and benefit all local businesses and residents.

COMMUNITY IMPACT: Data centers contribute to local communities in different ways, including cash donations, local sponsorships, community grants, STEM education, computer donations, and community assistance. In addition to monetary donations, corporate employees are active volunteers who provide assistance to communities. For example, Google each year works with local organizations to sponsor community events such as Storm the Citadel to promote STEM education, Googlefest to help local teachers, nonprofit leaders, and small business owners use the Internet more effectively, and other seminars to help business owners set up and run successful websites. Google has awarded $1.9 million in grants to South Carolina nonprofits and schools.[19] Similarly, Facebook awarded more than $2 million to schools and qualified nonprofits to support STEM education and technological and economic development in communities in which operate data centers,[20] entered into a partnership with Isothermal Community College in North Carolina to develop the curriculum for its Datacenter Institute,[21] and launched a pilot program with the Town of Forest City, North Carolina and Rutherford County Schools to provide free Wi-Fi access to 75–100 students' homes.[22]

INNOVATION: Power is the largest component of data center operating expenditures. Companies are constantly evaluating the source and the cost of power for data centers. Over the past decades, data center owners have been actively involved in clean and renewable energy development by working with local utility and renewable energy companies to develop and purchase power from local wind, solar, and micro-hydro resources. For example, Apple employs an innovative cooling system that reuses water 35 times, resulting in a 20% reduction in overall water consumption in its data center. The data center also uses a rainwater-supplied system for on-site landscape irrigation, further reducing overall water consumption.[23] The Apple campus in Maiden, North Carolina, is supported by renewable energy from two separate 100-acre solar arrays that each produce 42 million kilowatt-hours (kWh) of energy annually.[24] Google contracted many agreements to purchase renewable energy, including the agreement to purchase 407 megawatts of wind-sourced power from MidAmerican Energy Company to supply its data center in Council Bluffs, Iowa. Google sets its goal of powering all its operations with 100% renewable energy. In addition to powering its last seven data centers with renewable energy, Facebook has also begun working with local energy utilities to help create renewable energy tariffs to cover 100% of the anticipated energy consumption for new data centers in Los Lunas, New Mexico, and Papillion, Nebraska. These tariffs are accessible to all companies and Yahoo recently announced the tariff would enable its Nebraska facility to go 100% renewable, as well. Inspired by the model of open source software, the Open Compute Project was launched in 2011 with a mission to share the innovations of IT hardware designs. Since then, the Open Compute Project has become a collaborative community of hundreds of IT and non-IT companies to share specifications and best practices for creating the most energy efficient and economical data centers.

OPPORTUNITIES FOR CITIES

The demand for large data centers is growing because of the demands of increased internet usage and from the migration of smaller to larger data centers. Large businesses are increasingly moving to bigger data centers to achieve cost savings since large data centers experience economies of scale. In its 2016 Cisco Global Cloud Index, Cisco projects that global data center storage capacity will grow nearly 5 times and the number of hyperscale data centers will grow more than 87% from 2015 to 2020.[25]

Enterprises and service providers are constantly searching for reliable, dependable, and cost effective solutions for data center site selection. Factors that affect data center decision makers include the capacity and availability of power, labor, geography, real estate, and costs. Since hundreds of millions of dollars are needed to build and to operate a data center per year, the cost element is crucial.

CONCLUSIONS

Recognizing the short and long-term benefits of data centers to communities, many state and local governments have devoted resources to attract these centers to their areas. Local policymakers have introduced business-friendly policy measures such as sales tax exemption for computing equipment and software, machinery equipment, and computers; infrastructure grants; and property tax abatements or exemptions. These incentives drive companies to build data centers and invest in the surrounding areas, creating significant economic and social benefit to local communities.

The Date Center Institute Board has endorsed the following terms and definitions.[26]

Standard Term	Definition
Average Measured Peak kW Load	Reported as kW or MW. The average of the measured Peak kW Loads relative to multiple racks and REU or multiple Compute Spaces.
Average Peak kW Load	Reported as kW or MW. New site design: The design target Peak kW Load a Compute Space is designed, or required to support in terms of power and cooling. Existing operational facility: Use the Average Measured Peak kW Load definition.
Compute Space	Reported in Area (sqft or sqm). The area within the data center facility containing racks, REU and associated IT and/or networking equipment. Located within a single facility that shares critical (power and cooling) infrastructure. A campus environment may have more than one Compute Space. Also known as computer area, computer room, data center room, data hall, raised floor area, technical area, and white space.
Data Center	Also spelt data centre and data center. One or more physical rooms or containers accommodating systems and infrastructure that support the operation of IT systems located in one or more IT racks or Rack Equivalent Units.
Design kW Load	Reported as kW or MW. Applies to the maximum kW load the Compute Space is designed to support in terms of power and cooling.
Enterprise Data Centers	Data centers house critical operations of individual companies.
Load	Reported as kW or MW. The actual measured Peak kW Load as reported by an acceptable measurement device or system relative to the REU or Compute Space. The measurement period must exceed 1 calendar month. Partial results and decimal points are to be rounded up to the nearest whole number.
Peak kW Load	Reported as kW or MW. New site design: The design target Peak kW load a Compute Space is designed, or required to support in terms of power and cooling. Existing operational facility: Use the Measured Peak kW Load definition.
Rack Area	Reported in sqft (ft2) or sqm (m2). Sets a common understanding for rack footprint, allowing for aisle space and perimeter and other space within the room area.
Rack Equivalent Unit (REU)	Converts a heterogeneous environment into a standard unit of measure. Also converts non-traditional rack equipment, including free-standing items into an equivalent Rack as used in Rack Area and Rack Yield. A large piece of equipment may use multiple REUs. 1 x REU in spatial terms equals 1 x [Rack Area]
Rack Yield	Reported as quantity of Racks or REUs. Number of Racks (by Rack Area) that can fit within a Compute Space. Rack Yield = [Compute Space] divided by [Rack Area]
Retail Colocation	Building shell and infrastructure in shared environment, space generally divided by racks or cages. May include IT hardware as well as menu of services.
Wholesale Colocation	Building shell and infrastructure to the power distribution unit providing space, power and cooling. Generally in demised suites above 250 kW.

ENDNOTES

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ABOUT US

C_TEC (U.S. Chamber Technology Engagement Center) promotes the role of technology in our economy and advocates for rational policy solutions that drive economic growth, spur innovation, and create jobs.

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