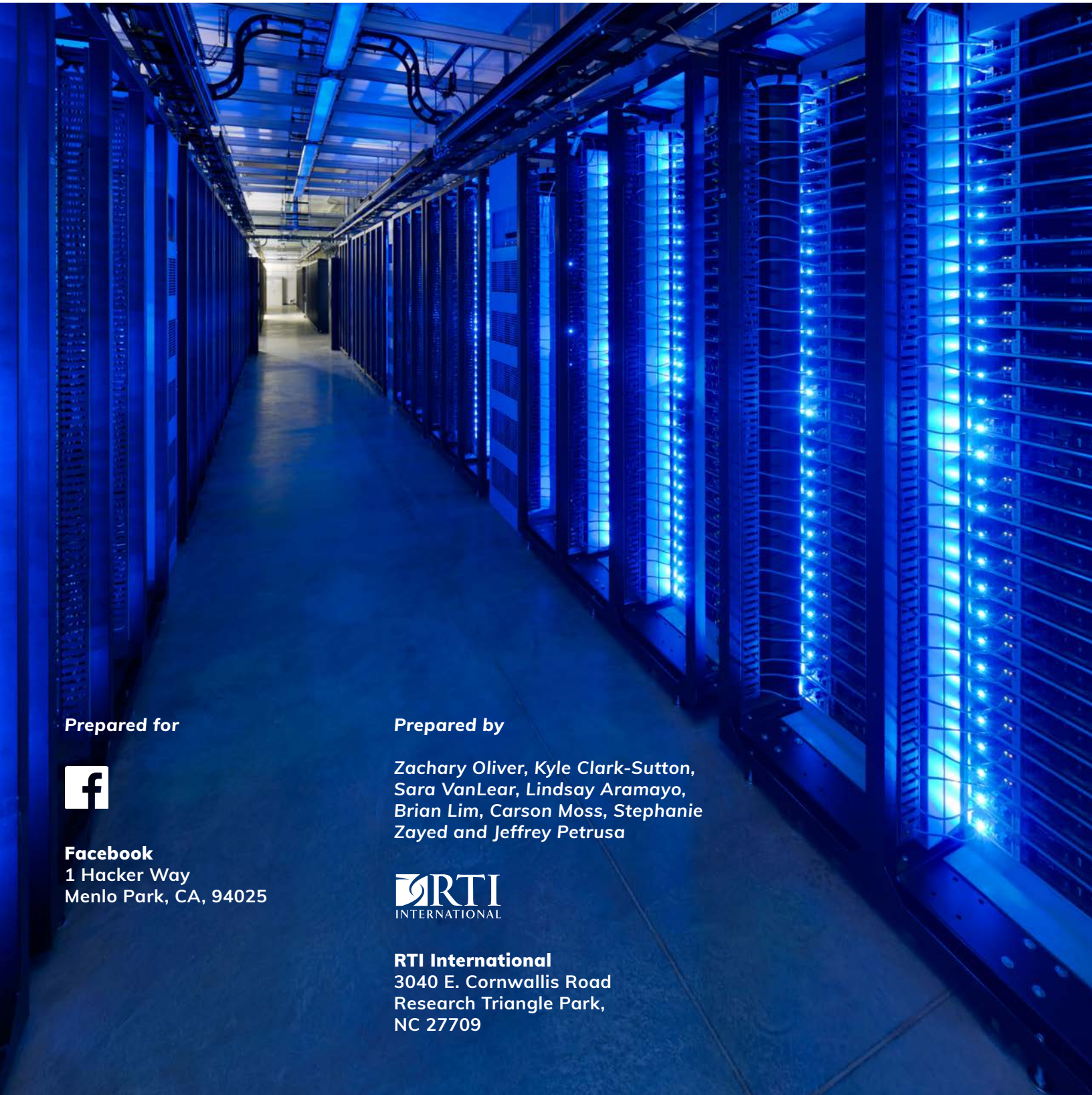
# The Impact of Facebook's U.S. Data Center Fleet

March 2018



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# Introduction

The data center infrastructure that powers Facebook for billions of users around the world is growing quickly. In the United States, four data centers are currently in operation, while another four are in various stages of development at the time of this report.[1]

RTI International analyzed Facebook's domestic data center fleet, focusing on how their construction and operation are impacting the economy, the environment, and communities.

## THE ECONOMY

RTI analyzed Facebook's expenditures for U.S. data center construction and operations and estimated that, when accounting for multiplier effects, **Facebook data centers have contributed a cumulative $5.8 billion in gross domestic product (GDP) to the U.S. economy from 2010-2016, or $835 million per year.** This contribution estimate is primarily driven by the up-front capital investments for construction. Facebook's renewable energy goals also drive third-party investment in solar and wind farms to provide clean energy to data centers in Iowa, Texas, New Mexico, and Nebraska and eventually in Ohio and Virginia.


## THE ENVIRONMENT

Facebook has taken steps to minimize their environmental footprint by designing data centers for maximum energy and water efficiency and procuring energy from clean and renewable sources. Facebook's energy-efficient designs reduce data center energy consumption by an estimated 38% and water use by at least 50% relative to the average data center. Facebook shares their efficient design innovations publicly through the Open Compute Project (OCP), which it helped found in 2011 to accelerate the open hardware movement. In 2016, clean and renewable energy consumption approached 360,000 megawatt hours (MWh), accounting for 35% of Facebook's U.S. data center electricity consumption.[2]

Since 2013, every new data center Facebook has constructed has used 100% clean and renewable energy, a commitment that will continue with all future data centers Facebook constructs. **RTI estimates that, from 2011-2016, Facebook avoided over 2.5 million MWh of carbon-intensive electricity consumption through energy efficiency and renewable energy investments. This resulted in $CO_2$ emissions reductions of over 1.2 million metric tons.**

## COMMUNITIES

Finally, Facebook data centers have a local impact through their community engagement efforts which include direct grantmaking, volunteer, and other partnership activities. From 2011-2017, **Facebook's three operational grant programs invested in 155 organizations, funding 292 projects to support priority needs** such as technology resources and equipment in elementary, middle and high schools and targeted funding for the arts, safety, and health programs led by local nonprofits and institutions.

[1] The Los Lunas, New Mexico, data center was announced on September 14, 2016; the Papillion, Nebraska, data center was announced on April 4, 2017; the New Albany, Ohio, data center was announced on August 15, 2017 ; and the Henrico County, Virginia data center was announced October 5, 2017.

[2] Although 35% of U.S. data center electricity came from clean and renewable sources, global energy consumption (including the United States) for Facebook's operations was 43% clean and renewable in 2016.

# Economic Contribution

**Facebook's expenditures on U.S. data center construction and operation contributed $5.8 billion to U.S. GDP and 60,100 jobs from 2010-2016. This equates to $835 million in U.S. GDP per year and 8,600 jobs per year.**

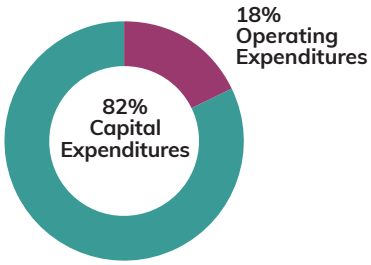
## Data Center Spending

The four U.S. data centers that are currently in operation have spent **$4.2 billion** from 2010-2016.

Dollar values in the economic contribution section are inflation-adjusted to 2016 dollars.


Capital expenditures represent **82%** of data center spending from 2010-2016.

$2.6 billion of capital expenditures are for construction-related services




## Data Center Workforce

**An average Facebook data center has a workforce of 196 people after five years of operation.**

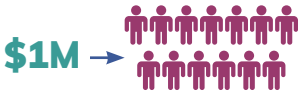

Data center workforce includes a mix of employees and full-time on-site contractors.

## Multipliers

When accounting for income spent by suppliers and people:

For every 1 Facebook data center worker, there were 5 jobs supported elsewhere in the economy by operating expenditures.

For every $1 million in Facebook spending on data center operations, there were 13 jobs supported elsewhere in the economy.




## Economic Contributions to the U.S. Economy

Including multiplier effects, Facebook data centers had a cumulative total contribution of $5.8 billion to U.S. GDP from 2010-2016, or $835 million per year.

To put this number in context, the entire "data processing, Internet publishing, and other information services" sector was responsible for an annual average of $87 billion in GDP from 2010-2016.[1]

Including multiplier effects, Facebook data centers contributed a cumulative 60,100 jobs from 2010-2016, or 8,600 jobs per year.

## Top Sectors

Facebook data center spending had the largest total economic contribution to the construction sector, wholesale trade sector, and real estate sector.

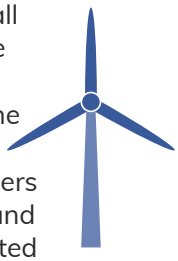
**$1.2 Billion**

**$546 Million**

**$236 Million**

## Renewable Energy Investment

Facebook has committed to sourcing all their energy from clean and renewable sources and chooses investments that result in new renewable capacity on the electricity grid. To date, Facebook has worked with local utilities and developers to bring online **573 MW** of new wind and solar capacity, representing an estimated **$807 million** in investment.



[1] RTI calculations based on Bureau of Economic Analysis "GDP-by-industry" data

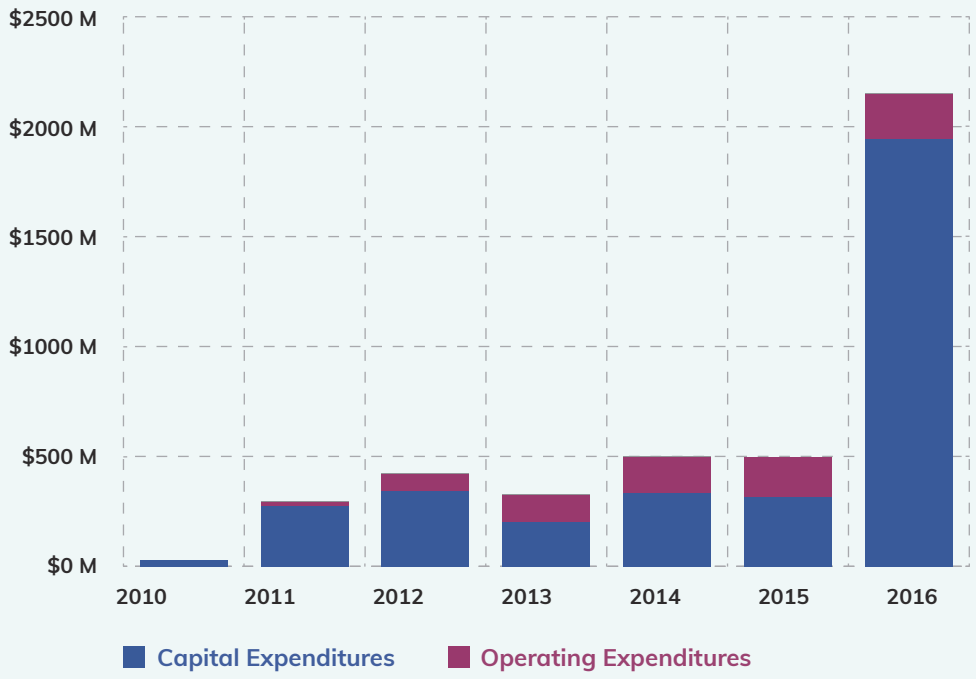
# Economic Contribution

RTI used input-output analysis to analyze the economic contribution[1] of Facebook data center spending over time. Input-output analysis, which is based on tabular representations of how industries interact in the economy, was originally developed by a Nobel Prize winning economist Wassily Leontief in the 1940s and is widely used today.[2]

RTI incorporated Facebook's financial records into the economic analysis to increase the accuracy of estimates using this method. RTI carefully categorized each Facebook vendor by industry to customize the economic model to the unique aspects of Facebook's data center business.[3] Two broad spending categories include capital expenditures and operating expenditures. RTI incorporated data centers in the model that are currently operational: Prineville, Forest City, Altoona, and Fort Worth.

Capital expenditures make up 82% of total expenditures. Spending in 2016 was substantially larger than in other years, because all four data centers in the analysis invested significantly in capital expansions in 2016 (see Figure 1).

**Figure 1. Total U.S. Expenditures, 2010–2016**




**Capital Expenditures**

- General contractors
- Building design
- Consulting services
- New building furniture
- Generators
- Networking and cabling
- Switchboards
- Transformers

(Excludes server imports)

**Operating Expenditures**

- Employee payroll
- Electricity
- Security services
- Other on-site contractors

## DATA CENTER WORKFORCE

As Facebook's data center fleet has expanded, the total workforce has increased over time. The four Facebook data centers that are serving traffic have a total workforce of more than 800 people including employees and full-time on-site contractors. After five years of operation, an average Facebook data center has an on-site workforce of 196 people.


[1] Results are cumulative U.S. results over a multi-year period from 2011-2016. RTI adjusted all data to 2016 dollars using Bureau of Labor Statistics Consumer Price Index (CPI) data, unless otherwise noted.

[2] For the interested reader, more infomration about Wassily Leontief and his contributions to economic accounting can be found at https://bea.gov/scb/pdf/NATIONAL/Inputout/1999/0399leon.pdf.

[3] This approach is consistent with for the "bill-of-goods" method discussed in Bureau of Economic Analysis guidelines located at https://www.bea.gov/regional/pdf/rims/rimsii_user_guide.pdf. RTI analysis used 2013 IMPLAN data to estimate cumulative economic contributions.

# Economic Contribution

## ECONOMIC CONTRIBUTION RESULTS

RTI estimates cumulative economic contributions from 2010-2016 using two economic indicators: jobs and GDP. We report cumulative contributions alongside annual averages. We also report multipliers that account for income spent by suppliers and people. Key concepts are defined in Figure 2.

**We find that Facebook data center spending contributed $5.8 billion in cumulative U.S. GDP from 2010-2016, or $835 million per year. Expenditures by Facebook data centers also contributed a total of 60,100 jobs across the economy, or 8,600 jobs per year.**

Table 1 summarizes the total contribution by category of spending. Facebook data center capital expenditures and operating expenditures accounted for 81% and 19% of the total, respectively. Capital expenditures produce short-term economic activity and operating expenditures produce long-term activity over the life of each data center. Capital expenditures had the largest contribution to the construction, wholesale trade, and real estate sectors, while operating expenditures had the largest contribution to the electric power generation, wholesale trade, and telecommunications equipment sectors.

**Figure 2. Key Concepts Box**

**Jobs:** Job-years, defined as a year of work for one person. This includes full-time and part-time positions.

**GDP:** A measure of the overall size of the economy in terms of the value of goods produced and services provided, minus the value of intermediate inputs. GDP is also commonly referred to as "value-added," because it represents additional value created through human and machine processing.

**Total effects:** Economic contributions that account for Facebook spending and income spent by suppliers and people.

**Multipliers:**

$$\textit{Spending Multipliers} = \frac{\text{Total Contribution}}{\text{(Facebook Expenditures/}10^6\text{)}}$$

$$\textit{Jobs Multiplier} = \frac{\text{Total Jobs Contribution from Operating Expenditures}}{\text{On-Site Jobs}}$$

**Table 1. Cumulative Economic Contribution, 2010–2016** (numbers may not sum to total due to rounding)

| | Cumulative (2010–2016) | | Annual Average (per year) | |
|---|---|---|---|---|
| | Jobs | U.S. GDP | Jobs | U.S. GDP |
| Operating expenditures | 10,100 | $1.1 billion | 1,400 | $162 million |
| Capital expenditures | 50,000 | $4.7 billion | 7,100 | $673 million |
| **Total** | **60,100** | **$5.8 billion** | **8,600** | **$835 million** |

## MULTIPLIERS

Multipliers represent how the Facebook data center activities have a larger connection to the economy as a whole. The ratio of the total economic contribution to Facebook expenditures are one intuitive way of thinking about the multiplier effect. RTI finds that

- **For every $1 million in operating expenditures, there were 13.1 jobs and $1.4 million in GDP supported in the economy.**
- **For every $1 million in capital expenditures, there were 14.5 jobs and $1.4 million in GDP supported in the economy.**

Another way to represent the multiplier effect is to compare on-site jobs to jobs supported elsewhere in the economy by operating expenditures. **Because of multiplier effects in other industries — for example, electric power generation, wholesale trade, and telecommunications equipment — for every on-site Facebook data center worker, there were nearly five jobs supported elsewhere in the economy by operating expenditures.**

# Energy Efficiency and Renewable Energy

## Facebook data centers use:

**38% Less**

**an estimated 38% less electricity than an average data center[1]**

**Less Than 50%**

**less than half the water used by an average data center[2]**

## From 2011-2016, Facebook data centers avoided 2.5 million MWh of electricity consumption from carbon-intense sources:

- Equivalent to the annual electricity use of 229,000 U.S. homes

- 1.9 million MWh (77%) of avoided carbon-intense consumption is attributable to energy efficiency innovation
- Over 562,000 MWh (23%) of avoided carbon-intense consumption is attributable to clean and renewable energy procurement

## From 2011-2016, Facebook data centers avoided nearly 1.1 billion gallons of water use:

**192 million gallons (18%) of avoided water use comes from reductions in on-site water use[3]**

**876 million gallons (82%) of avoided water use comes from indirect water use[4]**

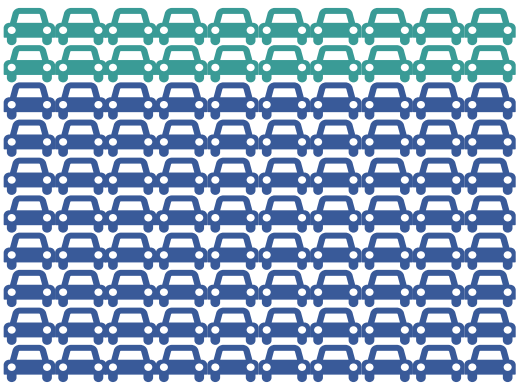
1 Estimate based on Facebook calculations (https://www.facebook.com/notes/facebook-engineering/building-efficient-data-centers-with-the-open-compute-project/10150144039563920/).

2 A 50% reduction in water use is a conservative estimate of Facebook's avoided water ***withdrawal*** due to their use of evaporative cooling instead of the more traditional chiller cooling technology.

3 On-site avoided water use refers to reductions in water ***withdrawal***.

4 Indirect water use refers to water ***consumption*** by non-renewable power plants to generate electricity using fossil fuels or hydropower.

## Energy efficiency and renewable energy has helped Facebook avoid over 1.2 million metric tons of $CO_2$ emissions from 2011-2016, the equivalent of taking over 266,000 passenger vehicles off the road for a year.



- **20%** of emissions reductions are attributable to renewable energy purchases; **80%** to energy efficiency investments

**In 2016, 35% of Facebook's U.S. data center energy consumption came from clean and renewable energy sources. Globally, Facebook's operations ran on 43% clean and renewable energy in 2016, and they are on track to reach 50% by the end of 2018.**

# Energy Efficiency and Renewable Energy

A key focus of Facebook's investment their own fleet of data centers has been to maximize their energy and water efficiency through innovations in data center infrastructure and server hardware design. Implementing efficiency innovations in the design of the electrical system, cooling system, racks, and server hardware allows Facebook to reduce energy consumption by an estimated 38% and water consumption by over 50%.

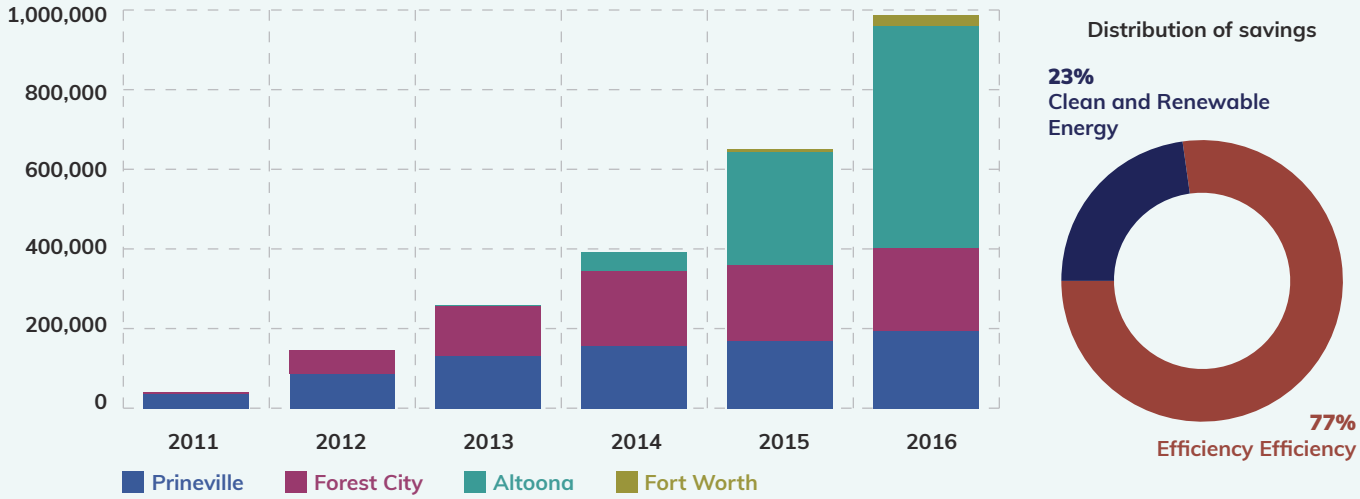
## ENERGY BENEFITS

Energy benefits, measured as avoided carbon-intense electricity consumption, were categorized in two ways for this analysis:

1. Energy savings through investments in energy efficiency
2. Clean and renewable energy procurement

RTI estimates that, from 2011-2016, Facebook avoided 2.5 million MWh of carbon-intense electricity consumption, which resulted in $CO_2$ emissions reductions of over 1.2 million metric tons.

**Figure 3. Avoided Carbon-Intense Electricity Consumption, 2011-2016 (MWh)**




## FACEBOOK CLEAN AND RENEWABLE ENERGY INVESTMENTS

Since 2013, every new Facebook data center is powered with 100% clean and renewable energy, a commitment that will continue with future data centers as well. One mechanism Facebook uses to secure renewable energy is to work with state regulators and utilities to design new renewable energy tariffs and ensure they are not just accessible to Facebook, but other companies as well.

Facebook's purchases of renewable energy result in net new renewable capacity being added to the electricity grid. In some cases, Facebook secures more energy capacity than a data center will require in the foreseeable future; excess renewable energy capacity is added to the electricity grid for purchase on the wholesale market. To date, Facebook has helped make possible 573 MW of new wind and solar capacity.

As part of Facebook's commitment to a cleaner energy future, Facebook is a founding member of the Renewable Energy Buyers Alliance (REBA), a collaboration of more than 100 companies working together to scale corporate procurement of clean energy. Through REBA, members work together to advance sustainable renewable energy procurement practices globally.

# Energy Efficiency and Renewable Energy

## AVOIDED WATER USE

Avoided water use is categorized in two ways for this analysis:

1. On-site water use (withdrawal) avoided through investments in energy and water efficiency
2. Indirect water use (consumption) avoided through reductions in the use of non-renewable electricity, which requires water for cooling, steam generation, and hydropower

From 2011-2016, RTI estimates conservatively that Facebook avoided nearly 1.1 billion gallons of water use. Approximately 18% of the avoided use was on-site, while 82% of avoided use occurred through reductions in use of non-renewable electricity.

**Table 2. Summary of Savings and Benefits, 2011–2016** (numbers may not sum to total due to rounding)

| Benefit | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|---|---|
| **Energy efficiency savings (MWh)** | 45,000 | 152,000 | 258,000 | 365,000 | 469,000 | 623,000 | 1,913,000 |
| **Clean and Renewable Energy Procurement (MWh)** | — | — | 360 | 30,000 | 174,000 | 358,000 | 563,000 |
| **Emissions reductions (MT $CO_2$)** | 30,000 | 87,000 | 142,000 | 203,000 | 314,000 | 468,000 | 1,243,000 |
| **On-site water use avoided* (millions of gallons)** | — | — | — | 47 | 64 | 82 | 192 |
| **Indirect water use avoided (millions of gallons)** | 22 | 63 | 102 | 144 | 212 | 334 | 876 |

*On-site data was unavailable for 2011-2013 for this study.

## OPEN COMPUTE PROJECT

Facebook co-founded the Open Compute Project (OCP) in 2011 to publicly share their designs for a high-efficiency data center. Through interviews with experts and stakeholders, RTI identified contributions of OCP to the hyperscale server market.

**OCP accelerated a shift in the market.** OCP was the first major catalyst that accelerated a reorientation of the server hardware market to better serve the unique needs of the growing number of hyperscale data centers in operation.

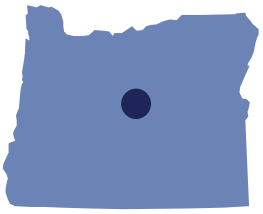
**OCP is an efficient communication channel.** The OCP community facilitates better communication between data center operators and equipment manufacturers, which reduces uncertainty in terms of what data center operators are looking for from vendors.

**OCP has produced innovations in efficiency.**

- ***Energy and water***: OCP data centers and hardware deliver energy and water efficiency improvements through several levers, including power distribution and the use of outside air evaporative cooling.
- ***Serviceability***: Bare-bones design allows for faster maintenance and easier repairs.
- ***Materials***: OCP designs reduced materials that went into server production, achieving efficiencies through cheaper production; lower shipping costs; easier installation, maintenance and decommissioning; and higher energy efficiency.
- ***End-to-end design***: By designing server hardware and data centers in tandem, Facebook could achieve higher efficiency than when facilities are designed to accommodate many types of hardware, and hardware is designed to work in many environments.

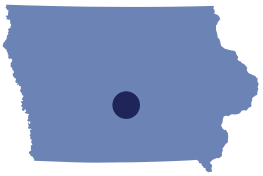
# Community Impact

Facebook's physical footprint has expanded alongside their commitment as a corporate citizen within each community. Data centers, upon becoming operational, engage in direct grantmaking as well as ongoing volunteer opportunities. Stakeholders describe tangible results: targeted resources for high priority needs, strengthened local partnerships, and organizations' heightened ability to leverage additional capital. These operational data centers include:



**Prineville**
Oregon

Forest City
North Carolina



Altoona
Iowa

Fort Worth, Texas just became operational and is currently taking grant applications.

## The foundation of Facebook's local commitment is the Community Action Grants program.

**Mission**

Invest in the long-term vitality of the region and its residents by supporting groups that meet the community's needs.

## 2011–2017: 292 Grants Awarded

### Organization types:

**112** K-12 Academic Institutions

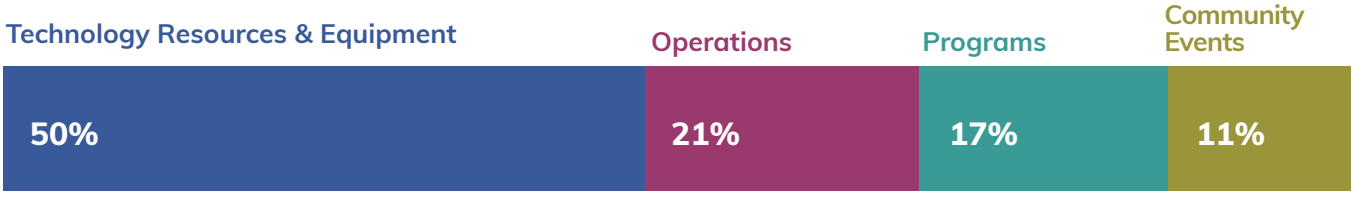
**113** Nonprofits

**37** Municipal Projects

**18** Health and Medicine

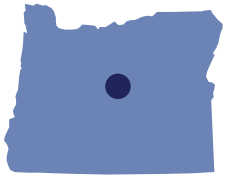
**12** Higher Education

## Types of Projects



# Community Impact

**Total Grantmaking in Prineville, 2011-2017: 150 Grants Awarded**

## PRINEVILLE GRANTEE SPOTLIGHTS

**Central Oregon Council on Aging: Teen Elder Computer Help Program.** The Central Oregon Council on Aging received $2,000 in 2016 to support the Teen Elder Computer Help (TECH) program. TECH is an intergenerational training program that pairs senior residents with teenagers. Each teen teaches an elder partner how to use modern technology. The program's aim is to help seniors navigate the Internet and learn new means of communication, such as email and social media. The program also teaches local youth about the importance of intergenerational relationships and ongoing responsibility. TECH is implemented in the local schools to reduce the need for transportation for engaged kids. Each student receives school credit for their participation.

**Central Oregon Trail Alliance: Prineville Bike Park and Trails.** The Central Oregon Trail Alliance (COTA) received two grants, in 2015 and 2017, for $7,500 and $15,000, respectively. In 2015, COTA built a bike park; Facebook's grant was instrumental in leveraging additional grants and donations. The bike park is now open to the public, and has become an important community space where people of all ages and biking levels come together. In 2017, COTA was awarded a second grant to build a network of more than 18 miles of trails. Facebook supported COTA's mission to increase the number of outdoor options for people in the region. The park and trails are free, require no special equipment, and are available from sunrise to sunset.

**Total Grantmaking in Forest City 2012-2016: 90 Grants Awarded**

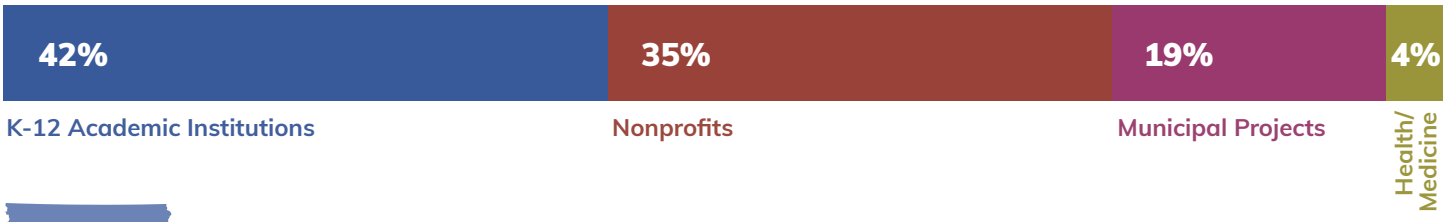

## FOREST CITY GRANTEE SPOTLIGHTS

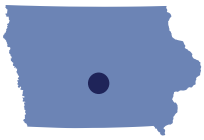
**Forrest W. Hunt Elementary School: STEM/STEAM Technology for School's Makerspace.** Forrest W. Hunt Elementary School received a $1,500 grant in 2012 to support the school's makerspace: a space where students can explore, use their hands, and create new things based on their unique interests using a variety of technology-based tools. The grant was used to purchase new resources, such as circuits and motors. Because of this hands-on space, teachers are incorporating more technological concepts within their curricula. In addition, teachers paired a female-led Ted-Talk about technology with their lessons and noticed an immediate increase the number of girls utilizing the makerspace tools. Close to 400 students have access to this makerspace daily.

# Community Impact

**Rutherford Opportunity Center: STEM/STEAM Technology.** The Rutherford Opportunity Center received two grants, in 2013 and 2016, for $5,000 and $4,700, respectively. Both grants were used to buy technological resources for the center, including tablets, document cameras, digital cameras, labquest equipment for science classes, and Lego robotics kits. These resources allow the Center to incorporate hands-on activities in the classroom, giving students an opportunity to diversify their experience using a variety of technologies. The Opportunity Center is a middle school and high school for students who need extra academic support, and each grant inspires a feeling of "being invested in" for these youth. These resources also enable project-based learning and increase students' teamwork skills and confidence.

**Total grantmaking in Altoona 2015-2017: 52 Grants Awarded**



## ALTOONA GRANTEE SPOTLIGHTS

**Polk County Master Gardeners: The Enabling Garden.** The Polk County Master Gardeners received a grant in 2015 for $4,500 to support the Enabling Garden: a children's garden that combines music, nature, exploration, and child development. The grant was used to purchase high-quality outdoor instruments. Facebook employees also volunteered during the construction of the garden. The Enabling Garden is located on a greenway and is visited frequently by families, childcare groups, and schools. The space is designed specifically for individuals with disabilities, and therefore is easily accessible by all visitors. The Master Gardeners' mission is to encourage regular outdoor activity regardless of age or special needs.

**Pursuit of Innovation: STEM/STEAM Technology for Afterschool Program.** Pursuit of Innovation is an afterschool program that has received two grants, in 2016 and 2017, for $6,100 and $10,000, respectively. The program's mission is to inspire and teach immigrant and refugee students about technology and related career opportunities. Both grants were used to purchase technological resources for the afterschool program, including laptops, software, robotics kits, a 3D printer, and other supplies and equipment. These new resources have expanded the program's offerings and allowed more students to have frequent, hands-on experiences with technology. Facebook's support has also represented a source of credibility for the nonprofit as their mission grows, as well as for the kids who participate. Many of the children describe Facebook's involvement as "real and important" for their projects at Pursuit of Innovation.