



THE ECONOMIC IMPACT OF GOOGLE DATA CENTERS IN EUROPE

NOVEMBER 2022



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To discuss the report further please contact:

Hamilton Galloway
Head of Consultancy, Americas

Oxford Economics
5 Hanover Square, 8th Floor
New York, NY 10004
Tel: (646) 503-3068

hgalloway@oxfordeconomics.com

EXECUTIVE SUMMARY

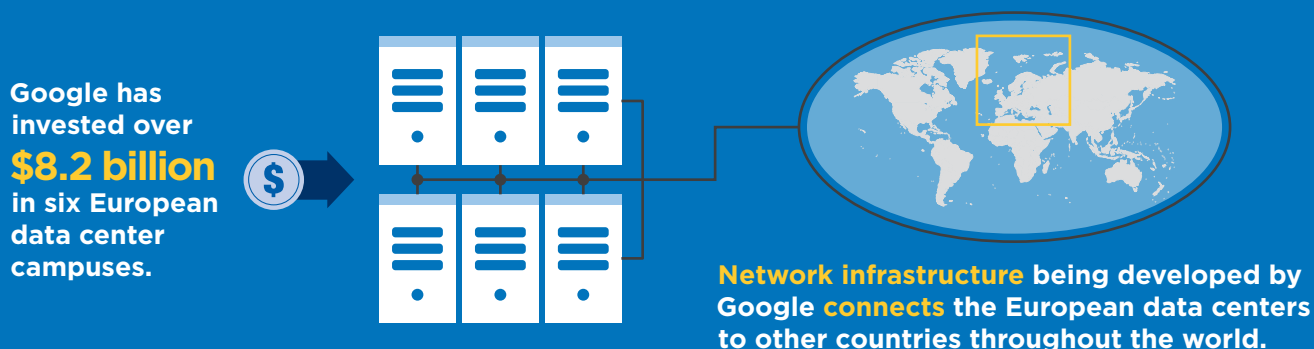
Digital transformation continues to foster significant opportunities for global economies, providing continued innovation, improving processes and services, all while maintaining reliability for businesses and people around the world. As the COVID-19 pandemic demonstrated, digital transformation is occurring at an accelerated pace. School and work shifted to remote, governments required expanded online services, and companies needed reliable and affordable products as their business models shifted. To support the digital transformation shift and acceleration, considerable infrastructure, including Google's six European data centers, was required.

In calculating the 2020 economic impact attributable to Google's hyperscale data center investments in Europe, we considered three business activities:

- Data center operations
- Construction and investment at the data centers
- Clean energy projects

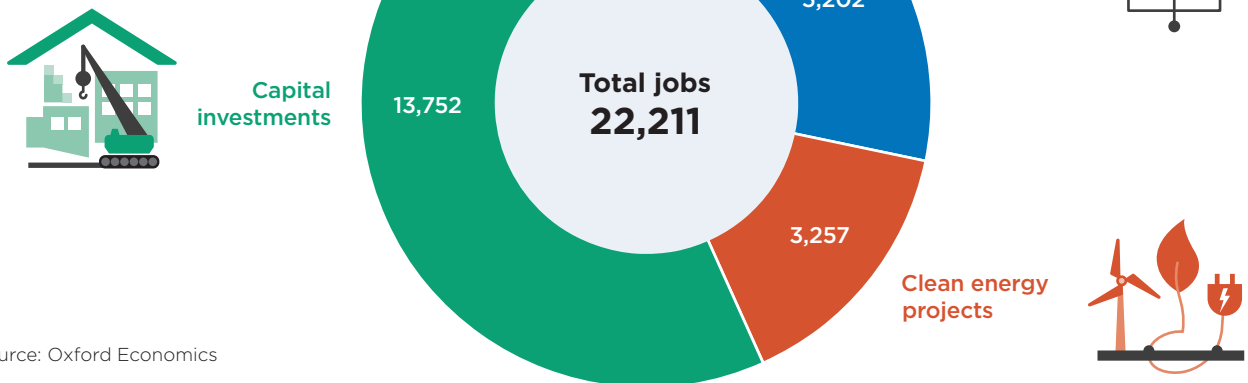
In addition, in this report are case studies that illustrate examples of Google's community contributions.

Data centers are a critical component of the digital transformation, providing the physical infrastructure of the internet. At the macro level, data centers allow Google to provide customers with search, cloud computing, education, workplace productivity, and other internet-related services on which so much economic activity depends. Locally, data centers contribute to economic development.



Google's procurement of clean energy enables investments in clean energy projects, delivering significant carbon emission savings and adding to the company's economic impact. For example, Google's long-term procurement agreements with wind and solar projects throughout the region have contributed to the growth of the clean energy industry in Europe. Google's capital investments in its data centers also significantly contribute to local economic impact. For example, in addition to the large upfront cost associated with the initial construction of a data center, Google makes ongoing capital investments in each data center campus. These investments support jobs (particularly in construction) at the local level.

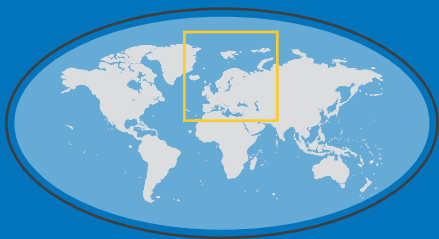
FIGURE 1: Jobs supported by Google's key activities in Europe (2020)



Source: Oxford Economics

For every job supported by data center operations, three more jobs are supported through Google's capital investments and clean energy commitments.

In 2020, over **22,211 jobs** in the region were supported by Google's operations, clean energy commitments, and capital investment in the data centers.

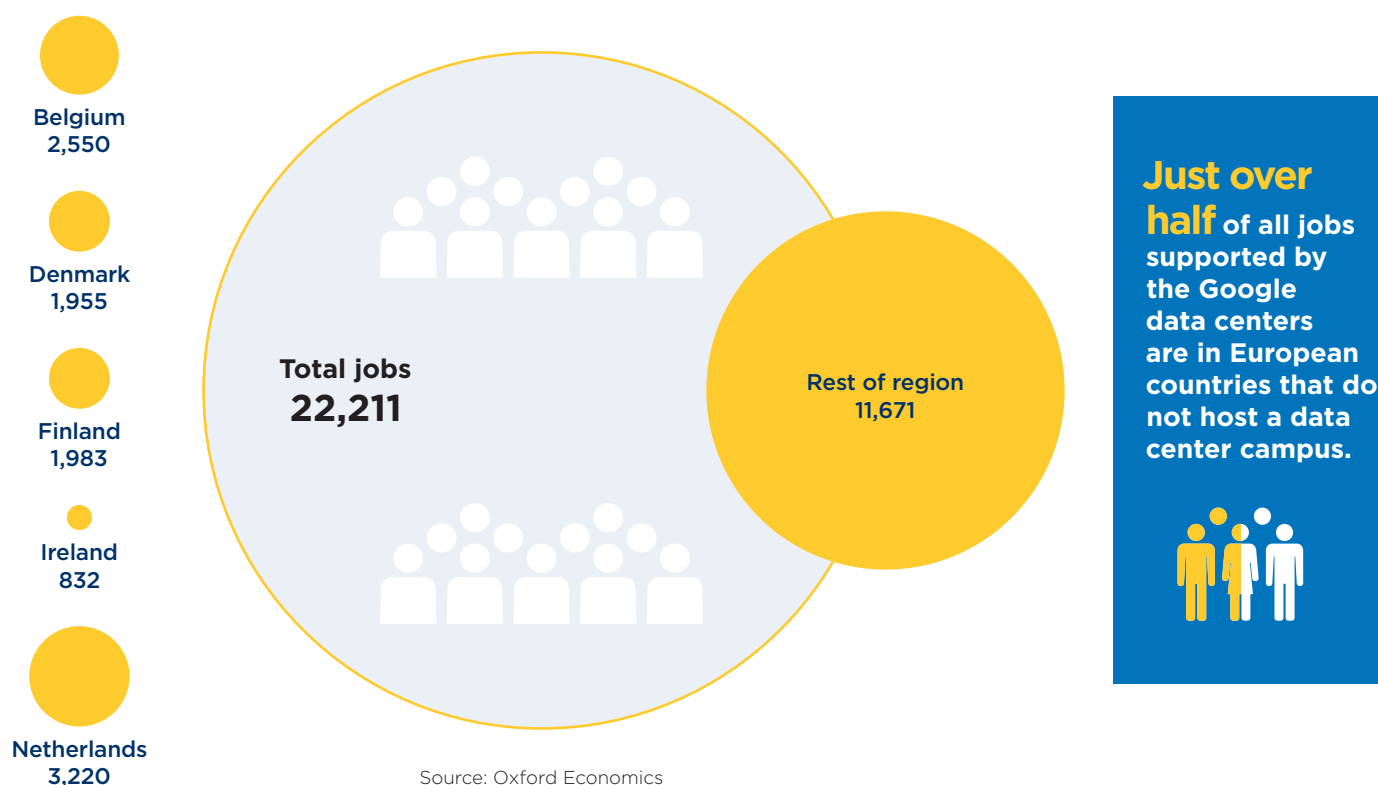


Throughout Europe, Google operations during 2020 generated **\$1.1 billion** in income for workers.



Data centers produce jobs in all three economic impact channels: direct, indirect (supply chain), and induced (spillover). When all three channels are considered, Google data centers in 2020 supported 22,211 jobs in Europe. In fact, just over 50% of these jobs are in European countries that do not even host a Google data center. We can attribute this wide distribution of jobs to the capital investments made by Google for data center development and the energy generation capacity needed to support Google's clean energy commitments. These each require large amounts of physical and human capital that is sourced throughout the continent. For example, of the 11,671 jobs located in countries throughout Europe that do not host data centers, 1,014 are in Sweden or Norway (investments enabled by Google's clean energy procurements), and another 1,920 are in Germany or the United Kingdom (supported by Google's capital commitments).

FIGURE 2: Jobs distributed by geography



At the heart of Google's economic impact are the data centers themselves. Data center operations support 5,202 total jobs in Europe (see Figure 1). The total income associated with these jobs is \$302 million.

The broad spillover effects of Google's data center operations and investments translate to economic activity for the region at large. In 2020, income supported by Google's recurring operations and related investments generated approximately \$1.1 billion in income for workers throughout Europe and added \$2.2 billion in economic activity as measured by GDP.

The jobs supported by Google's clean energy and data center operations are widely distributed, and many are in industries not normally associated with data center operations. As Figure 3 shows, the impact on jobs was spread across 11 sectors led by information, communication and telecom (1,888), trade and transportation (1,285), and mining and manufacturing (977).

In reviewing the figure below, please note that because of the COVID-19 pandemic and resulting travel restrictions, Google's normally high impact in the hotel and restaurant industries was dramatically reduced during 2020. These restrictions limited the normally high level of travel to and from the data centers by vendors, contractors, and employees. At Fredericia, Denmark, travel was down 44% from the prior year; and at St. Ghislain, Belgium, it was down 85%. As travel returns to pre-pandemic levels, Google's impact in the hospitality industries is expected to substantially increase.

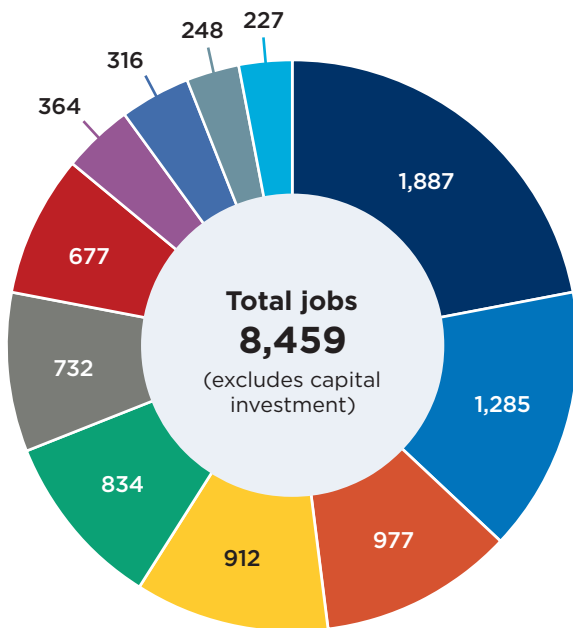


FIGURE 3: Sector analysis: data center operations and clean energy

Total jobs supported by Google

- Information, communication, telecom
- Trade and transportation
- Mining and manufacturing
- Professional services
- Utilities (clean energy)
- Health
- Agriculture
- Leisure (hotels, restaurants, arts)
- Utilities (other)
- Finance and real estate
- Other

Source: Oxford Economics

Jobs supported by Google are widely distributed, and most are in industries not normally associated with data center operations.

In the figure above, we distinguish between the more than 800 utility jobs supported by Google's clean energy commitments and the approximately 300 utility jobs supported through grid electricity consumption and infrastructure needed to support data center campuses both directly and through supply-chain impacts. This reflects the relative importance of the clean energy industry to Google data centers. In Figure 4 below, we more specifically examine how Google's data centers support jobs in the clean energy industry. Included in this figure are 718 jobs held directly by those in the industry and another 1,557 jobs in companies providing equipment and services to the clean energy industry (i.e., "supply chain"). Taken together, 2,275 jobs are supported by Google in the clean energy industry in Europe. These jobs are widely distributed and include countries that supply equipment and services needed to operate and maintain the clean energy projects but do not host a data center. For example, Sweden and Norway each host wind projects supported by Google's clean energy commitments. When full spillover effects are considered, the total jobs supported by Google's clean energy commitments in Europe total 3,257.

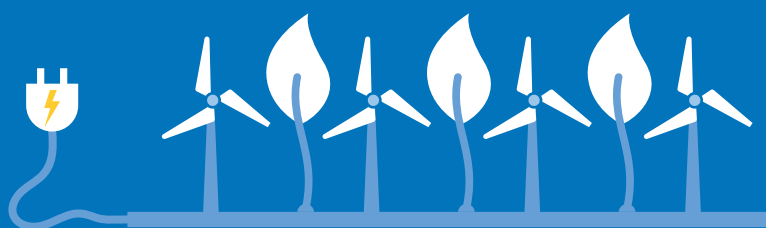
FIGURE 4: Distribution of jobs in the clean energy sector

Location	Directly employed by industry	Employed in industry's supply chain	Induced (spillover) jobs
Belgium	100	120	53
Denmark	4	16	12
Finland	142	227	115
Ireland	0	2	3
Netherlands	91	139	58
Norway	77	92	45
Sweden	304	340	156
Rest of region	0	621	540
European total	718	1,557	982

Source: Oxford Economics

Oxford Economics was provided with detailed information on 23 wind and solar projects in Europe that are the result of Google's clean energy commitments. The 2,275 jobs described above are the workers required each year to maintain and operate these clean energy projects. However, the initial building of this clean energy infrastructure generated its own economic impact. In fact, we estimate that each of these projects required 541 workers employed for an average of three years building, installing, and making these facilities operational. When all projects are aggregated, over 37,000 people-years have been spent building and installing the clean energy infrastructure needed to satisfy Google's clean energy commitments. Thus, Google's carbon-free energy commitments help Europe build and sustain its clean energy industry.

Google's investments help build and sustain Europe's clean energy infrastructure, including **more than 700 jobs** in the clean energy industry annually.



We also examined the economic impact of data center capital investments made by Google. Capital investments refer to the physical infrastructure put in place to create and improve a given data center. It includes activities such as construction of new buildings and infrastructure and in improvements made to existing structures. Capital investments also include the purchases of equipment used on-site. Each year, Google makes significant capital investments to its data centers, and when these are made, the economic impact is sizable. At each data center, however, the amount of capital investment fluctuates a great deal year by year. To address this fluctuation, we calculated the average annual amount of capital investment that Google has made at each data center since that campus opened. Using this annual average, we calculated the annual average amount of economic impact associated with the capital investment that has occurred at each data center.

Based on that methodology, we estimate that each year, capital improvements at Google data centers support (on average) nearly 14,000 jobs throughout Europe (see Figure 1). These include jobs in construction, plus those involved in the manufacturing of equipment used at the data center, as well as spillover effects as these workers spend their earnings in the broader economy. In our report, we describe the particular contribution made by construction jobs in the communities where data centers are located.

Beyond these measurable effects, Google data centers contribute to workforce, educational, and other community development initiatives that deliver consequential benefits throughout the region. For example, Google partners with local educators to help design and implement programs that explore imaginative new ways to teach about science and technology; or help workers transition from old-economy to new-economy work-skills. Additionally, during the COVID-19 pandemic, Google implemented substantial actions to help communities in Europe such as aiding local not-for-profits that provided critical assistance to folks suddenly unable to support themselves. Our report includes a series of case studies that illustrate these softer impacts on the communities in which Google data centers are located.

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1. INTRODUCTION

This study examines the economic impact of six European Google data centers in the five countries where they are located (Belgium, Denmark, Finland, Ireland, and the Netherlands) and throughout Europe. The report also examines the local economic impact in the regions where the data centers are located.

FIGURE 5: Google data centers: \$8.2 billion invested to date

Location		Year opened	Total investment (billions)
St. Ghislain	Belgium	2010	\$1.8
Fredericia	Denmark	2020	\$0.7
Hamina	Finland	2011	\$2.3
Dublin	Ireland	2012	\$0.6
Middenmeer	Netherlands	2019	\$2.8
Eemshaven	Netherlands	2016	

Source: Google, LLC

In each of these five countries, we also calculated the economic impact at sub-national levels, including regional or provincial, as well as the local or city level.¹ In addition, our model allows us to consider cross-border effects. When Google buys goods and services for its data centers, the products and services it purchases often originate in a country not hosting a data center. By considering these cross-border effects, we calculate Google's economic impact throughout Europe.



¹ More specifically, sub-national *regions* examined in this report correspond to the Nomenclature des Unités Territoriales Statistiques ("NUTs") with region generally corresponding to the relevant NUTs 2 level, and city to the relevant NUTs-level.

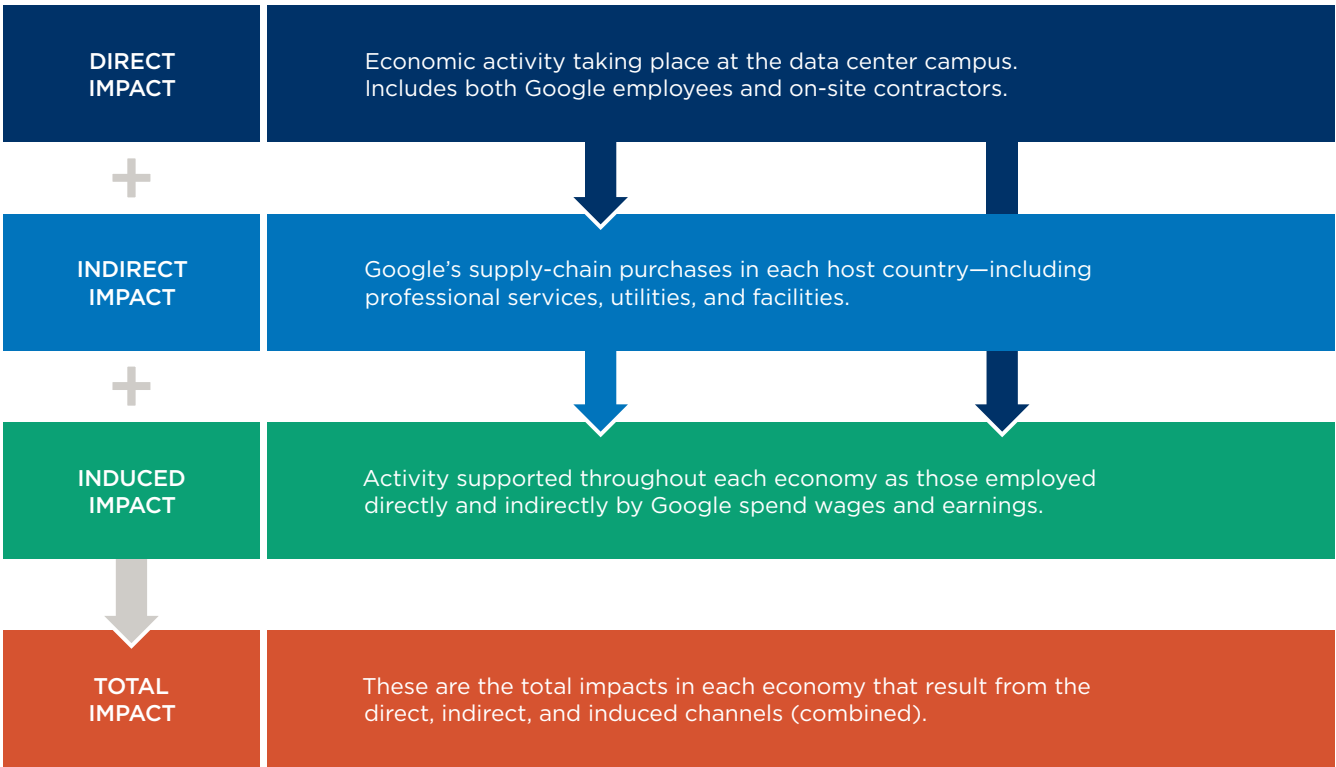
In general, our analysis is focused on the recurring economic benefit that results each year from Google's data center operations and clean energy commitments. However, there are also economic benefits that result from capital expenditures made by Google in its data centers and supporting infrastructure. These include, for example, both construction at the data center campuses themselves (discussed below) and the one-time benefit that results from new wind or solar projects made in response to Google's clean energy commitments. The one-time capital expenditure economic impacts associated with the initial construction of the clean energy investments are discussed in the next chapter on Europe.

In describing our results, we refer to three “channels” of economic activity:

- **Direct:** On-site workforce at the data center.
- **Indirect:** The economic activity associated with the supply-chain purchases made by Google to vendors who provide services that support the data center. This is the business-to-business network that supplies Google with the goods and services associated with data center operations.
- **Induced:** This channel measures the spillover effects that result as on-site workers at the data center plus those of the businesses in Google's supply chain spend their wages and earnings throughout the broader economy.

The following schematic depicts the relationship among these three channels:

FIGURE 6: An economic impact overview

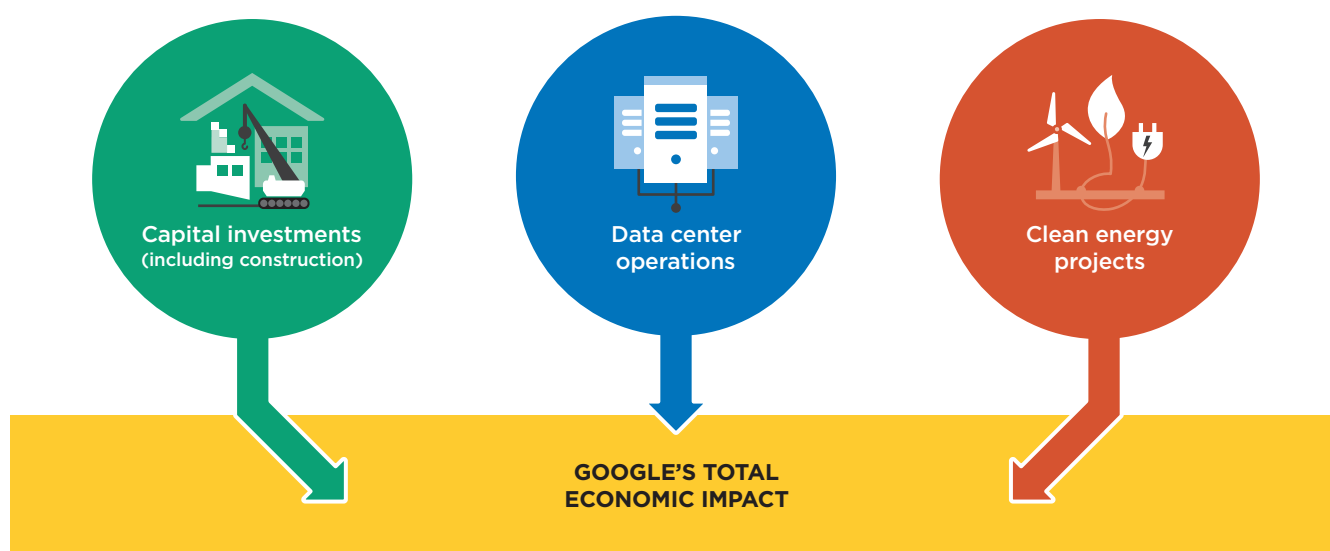


In this report, we examine how Google data centers generate economic impact from three different business activities:

- operations of the data centers;
- clean energy projects supported by Google procurement; and
- on-site capital investment including construction.

Each of these activities generates economic impact through the three channels described above. The economic impact that results from each activity is independently calculated because each requires unique modeling and assumptions. Google's total economic impact is the sum of the economic impacts calculated for each activity—as depicted in the figure below:

FIGURE 7: Total economic impact: Capital investments, operations, and clean energy projects



Most of our focus is on the recurring operational impact associated with the Google data centers. By recurring, we mean the economic impact that is expected to repeat in subsequent years.

Included in our estimates of recurring impacts are those resulting from an average amount of expected capital investment at each data center. In addition to large upfront capital investment associated with the initial construction of a data center, Google also makes ongoing capital investments in each data center campus. The amount of these ongoing investments fluctuates from year to year. To account for this fluctuation in spending, we calculated an annual average amount of capital investment at each of the European data centers. Our estimate of recurring economic impact includes the economic impact associated with the average annual amount of capital investment that has historically occurred at each data center.

Interpreting economic impact results

In general, the size of the country or regional economic impact varies based on the data center size and the amount of Google's supply chain that is located in that specific geography:

- **Size:** The larger the data center, the larger the impact the data center will have, especially when including the network of businesses in its supply chain.
- **Concentration:** The greater the concentration of the data center's supply chain that is located in the economy being examined, the greater the economic impact in that location. This specifically influences the indirect effects generated through data center spending.

Differences in either size or concentration get amplified as we consider the induced effects occurring in the broader economy. That is because the more workers located in the area (whether direct employees or those in the supply chain), the more likely it is that economic benefit will spill over to the broader (local) economy as these workers spend their wages where they live.

COMMONLY USED TERMS

Capital investments (data centers): The expenditures made by Google in property, plant, and equipment at its data center campuses. Most significant is the construction or renovation of infrastructure put in place at each data center campus, including the construction of the data center building itself.

Capital investments (clean energy projects): The capital expenditures allocated to wind and solar projects as a result of Google's clean energy commitments. Each wind or solar project constructed is a one-time occurrence, and hence the economic impact associated with the manufacture and installation of each wind or solar project is also treated as a one-time, non-recurring occurrence.

Clean energy commitments: Google enters into agreements to purchase clean energy. As noted above, these commitments result in the construction of wind and solar projects.

Gross Domestic Product (GDP): GDP is defined as the total market value of all final goods and services produced within a region during a given time period (usually annually). As a broad measure of overall domestic production, it functions as a comprehensive scorecard of a region's economic health.

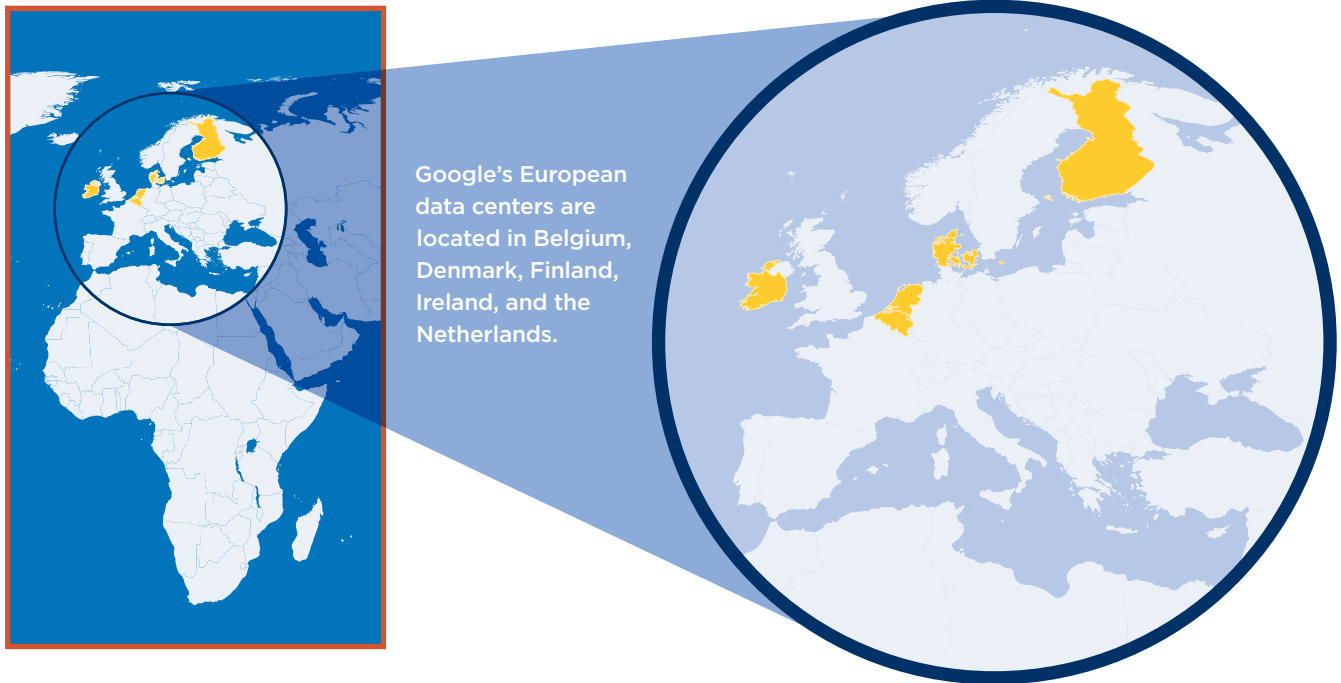
Income: Includes all forms of employment income, including employee compensation (wages, salaries, and benefits) and proprietor (or self-employment) income.

People-years: Throughout our report, a job supported by Google is generally understood to be one that will be supported year after year given Google's current operations. We treat jobs attributable to the capital investment of clean energy projects differently because once the project is completed the job is no longer supported by the investment (i.e., it does not recur year after year). To account for this finite duration, we count each job supported during the construction period as one person-year for each year that the project is being constructed. For example, one person employed for two years of construction employment would be counted as two people-years.

Rest of region: Google's economic impact spills over to countries not hosting a data center. This is largely attributable to Google's supply chain. Countries not hosting a data center but benefiting from Google's European economic impact are often grouped together in a cohort labeled rest of region. Most of the economic impact for this cohort is in other European countries. Some, however, is attributable to African or Middle Eastern countries which were also considered in our modeling for this region. Because the non-European impacts were small, they are not broken out separately in our report.

For readers interested in our technical modeling assumptions we have included a separate chapter on methodology found at the end of this report. To complete our calculations, Google provided us with data regarding its operations, clean energy commitments, and capital investment. However, all analytic findings and conclusions presented herein are the result of independent research conducted by Oxford Economics. Please note that in addition to the data centers included in this report, Google has other operations in Europe that were not part of our analysis.

2. EUROPE



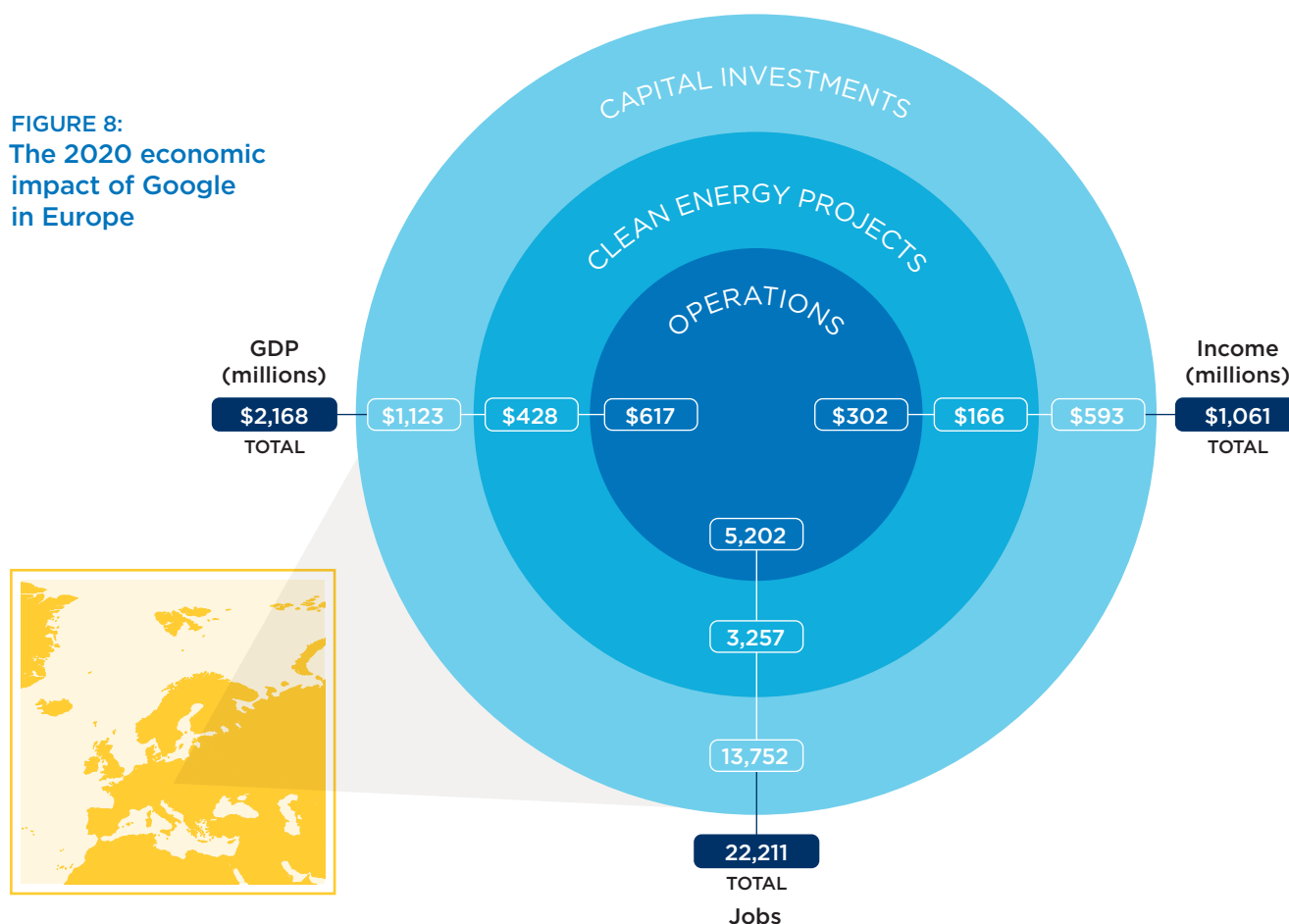
Google opened its first European data center in Belgium in 2008 and has since opened new data center campuses in Finland (2011), Ireland (2012), Denmark (2020), and two in the Netherlands (2016 and 2019). In addition to its investments in the data centers, Google continually strengthens and expands network infrastructure that consists of fiber links spanning Europe. This infrastructure connects these data centers to countries throughout the world.

The data centers generate significant economic impact in the countries and localities where they are located through both data center operations and capital investment, especially construction. In this chapter we will explore how the economic impact also reaches other countries throughout the region. Much of the region-wide economic impact is the result of the region-wide supply chain that supports Google's data center operations. These are the businesses throughout Europe that supply the data centers with equipment or provide services that support data center operations. For example, when Google invests in the physical infrastructure of its data center campuses portions of the materials used in making that investment are sourced throughout Europe. In the methodology section at the end of this report is a detailed discussion on how supply-chain impacts are calculated.

Another example of a region-wide supply chain is found in the jobs supported by Google's clean energy commitments. Because the resulting economic impact is widely dispersed throughout Europe, we give it particular attention in this chapter.

In total, Google's data center operations, clean energy commitments, and capital investments supported over 22,000 jobs, generated \$1.1 billion in income for workers, and added \$2.2 billion to GDP in the region.

FIGURE 8:
The 2020 economic
impact of Google
in Europe



Source: Oxford Economics

At the heart of Google's economic impact are the data centers themselves. These are captured in what we label the "operations" impact and support 5,202 jobs. Reflecting on the nature of the data centers themselves, over one-third (1,822) of the jobs are in the Information, Communication and Telecom sector. The remainder of these 3,380 jobs are distributed among a variety of industries, including Trade and Transportation (692), Professional Services (530), and Mining and Manufacturing (521).

In examining Figure 8 (above) one striking feature to note is that the enormous investments that Google makes in supporting infrastructure generate even more economic impact than do data centers' operations themselves. In Europe, for every job supported by operations at the data centers, three additional jobs are supported through the company's clean energy and capital investments.



**For each job supported by
data center operations,**



3 additional jobs are supported by Google's
clean energy and capital investments.

One quick note on the impact of COVID-19. In other economic studies that Oxford Economics has completed for Google,² we found that data center operations typically generate a great deal of travel-related economic impact as vendors, contractors, and employees travel to and from the data center campuses. During 2020, however, travel-related economic impact was quite small due to widespread pandemic-related travel restrictions and supported only 224 jobs in the hotel and restaurant industry. As a result, our estimate of 5,202 jobs supported by data center operations is likely a conservative estimate that is expected to increase as travel restrictions are lifted.

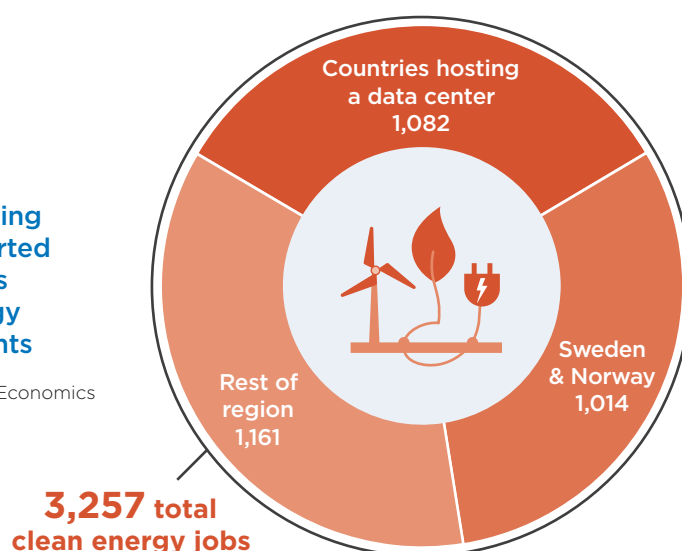
2.1 CLEAN ENERGY

Google's purchases of wind and solar power have resulted in the company being one of the largest corporate purchasers of clean energy.³ The company's clean energy commitments generate substantial economic impact and in 2020 supported over 3,000 jobs throughout the broader economy. Of these, more than 700 are in the clean energy industry itself, while many more are in fields that support clean energy investment and production such as trade and transportation (593), mining and manufacturing (455), or professional services (382).

Moreover, when we examine where the over 3,257 jobs attributable to Google's clean energy commitments from all channels (direct, indirect, and induced) are geographically located, we find that roughly two-thirds are located in countries that do not host a Google data center. One reason for this widespread distribution is that several wind projects associated with Google's clean energy commitments are located in Sweden; and another is that much equipment for the clean energy projects is manufactured throughout Europe.⁴

FIGURE 9:
Total recurring jobs supported by Google's clean energy commitments

Source: Oxford Economics



Each year, Google's clean energy commitments support **3,257 jobs** throughout Europe.

² [Google Data Centers: Economic Impact and Community Benefit](#). Oxford Economics, April 2018.

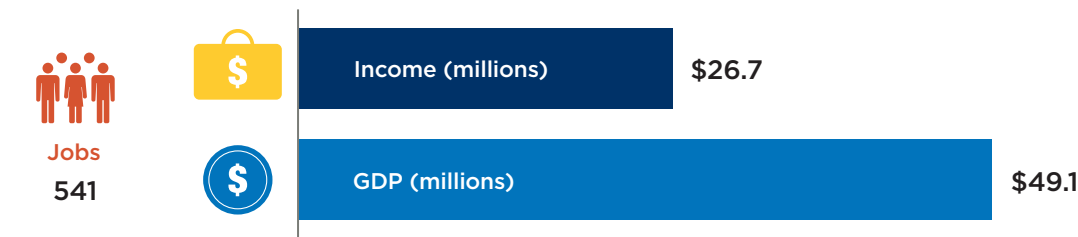
³ Schechner, Sam. "Amazon and other tech giants race to buy up renewable energy." *The Wall Street Journal*, June 23, 2021.

⁴ Google has a stated goal to operate on 24/7 carbon-free energy, everywhere and at all times by 2030. It is expected that Google will increasingly be sourcing clean and carbon-free energy in the same countries where it has data center operations to enable the company to meet its commitment to source carbon-free energy on the same grids where it operates its data centers.

Google’s clean energy commitments have resulted in the investment of new wind and solar projects across Europe. Google provided Oxford Economics with data on 23 wind and solar projects in the region that are supported by its clean energy commitments. Each year, these projects require people to operate and maintain the infrastructure and keep the electricity produced by these projects connected to the electrical grid. The 3,257 workers described in Figure 9 are those workers throughout Europe who are directly involved in this effort, or who benefit as economic activity spills over to the broader economy. This is an ongoing effort and hence these are recurring jobs.

In addition to the recurring jobs described above, the construction and installation of each clean energy project also generates significant one-time economic impact. To analyze that economic impact, we examined the capital investment made in each one of the 23 projects and calculated an average investment cost for each project. We estimated that on average a project took three years to complete from the time construction began on its components until it was fully operational and connected to the grid. Based on that methodology we found that each project generated the following economic impact during each of the three years that it was being developed:

FIGURE 10: Building clean energy infrastructure: Per-project annual impact



Source: Oxford Economics

Over 37,000 people-years were spent building and installing **wind and solar projects** supported by Google clean energy investments in Europe.



We found that on average, each new wind or solar project supported by Google generated 541 jobs, nearly \$27 million in income, and contributed \$49 million to GDP during each of the three years that the project was in development. When all these projects are considered, we calculate that Google’s clean energy commitments have supported the equivalent of 37,299 people working for one year building and installing clean energy projects in Europe. In a concrete way, Google investments are helping to build the clean energy industry in Europe.

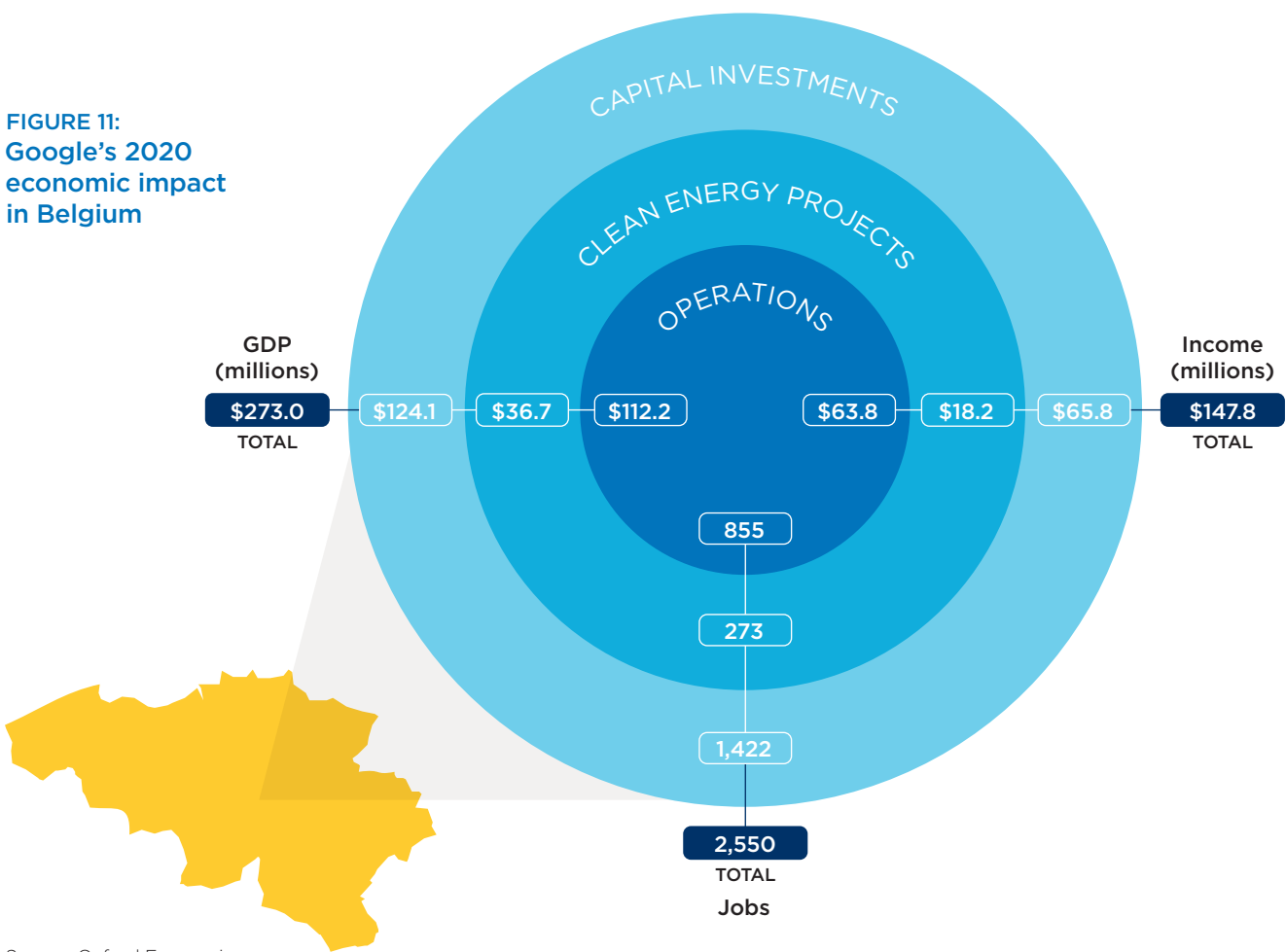
3. BELGIUM

3.1 BELGIUM NATIONAL

Google's first data center in Europe became fully operational in 2010 near the city of St. Ghislain in Belgium. Since initial construction activities began, the company has invested a total of \$1.8 billion at the data center site. As part of that investment, the data center uses an advanced evaporative cooling system rather than older refrigeration methods. The new water purification system draws grey water from a nearby industrial canal, rather than relying on the community's water supply.

In 2018, St. Ghislain became Google's first data center to have a fully operational solar plant on site. As a result, the Belgium data center has moved a bit closer to the goal of round-the-clock carbon-free energy sourcing in all locations. In addition, Google supports Belgium's network infrastructure development goals through its investments in fiber that connect Europe to other regions throughout the globe.

FIGURE 11:
Google's 2020
economic impact
in Belgium



Source: Oxford Economics

As a result of these efforts in 2020, Google's data center operations supported 855 total jobs in Belgium and another 273 in the clean energy sector. In addition, since the data center opened, Google's ongoing capital investments in the facility have each year supported an average of 1,422 additional jobs.

Figure 11 above includes the total economic impact from all channels (direct, indirect, and induced).



3.2 THE WALLONNE REGION AND HAINAUT PROVINCE

In examining the economic impact of the St. Ghislain data center in the Wallonne Region and Hainaut Province, we focus more on understanding the three channels of economic impact. This gives perspective on how the data center's economic impact spreads throughout the local economy. At these sub-national levels, we examine only the operational and capital investment impacts since our data were not granular enough to examine clean energy at these levels.

At the regional level, the St. Ghislain data center supports 627 jobs and generates \$51 million in annual income for workers.

FIGURE 12: Google's operational impact in the Wallonne Region

Channel	Direct ⁵	Indirect	Induced	Total
Jobs	350	176	101	627
Income (millions)	\$32.5	\$13.3	\$5.2	\$51.0
GDP (millions)	\$49.7	\$25.6	\$9.9	\$85.2

Source: Oxford Economics

⁵ The figures for direct impacts have been adjusted to accommodate public disclosure concerns, but this does not affect any of the total amounts presented in this or any other table (see the methodology chapter for more detail).

Almost all of Google’s regional economic impact in the Wallonne Region is locally concentrated near the data center in Hainaut Province as seen in the following chart:

FIGURE 13: Local impact in Hainaut Province



Source: Oxford Economics

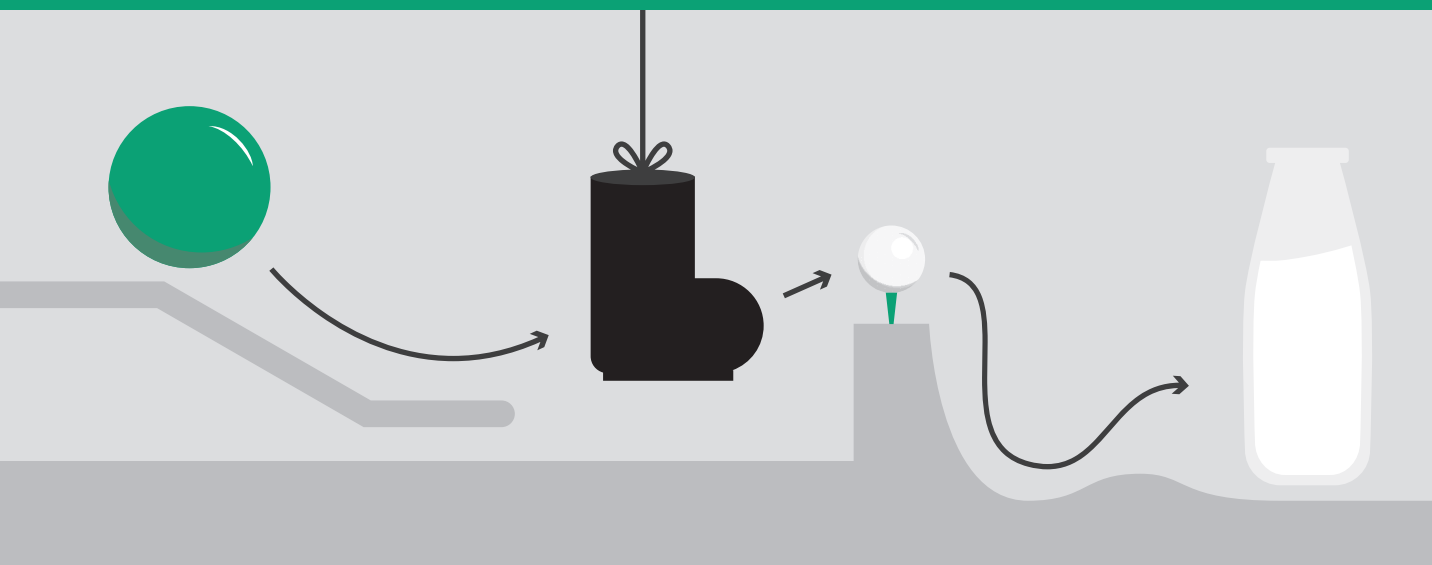
Capital investment is especially important at the local level because it results in construction jobs that are not normally associated with data centers, and these generate significant local economic impact. Based on the amount of total capital investment made by Google in the St. Ghislain data center since it opened, we estimate that during an average year, 541 construction jobs are supported in the Province, with another 305 jobs resulting from spillover effects in the broader local economy.

FIGURE 14: Construction impacts in Hainaut Province

Channel	Direct	Indirect	Induced	Total
Jobs	541	234	71	846
Income (millions)	\$20.5	\$13.1	\$3.7	\$37.3
GDP (millions)	\$39.2	\$23.7	\$6.9	\$69.8

Source: Oxford Economics

The Crazy Machine Challenge



Maxime Dumenil's job is to make science and engineering interesting and accessible to a diverse group of people. A department head for MUMONS, the museum at Belgium's University of Mons, Mr. Dumenil is building on the university's rich tradition of teaching applied science by focusing on STEM disciplines (science, technology, engineering, and math)—a priority even for well-educated countries like Belgium as they seek to develop a next-generation workforce.

One successful way of engaging the public across the city of Mons has been the Crazy Machine Challenge, an annual competition run by the university with financial support from Google's data center in nearby St. Ghislain. Contestants design and build Rube Goldberg machines—contraptions intentionally created to perform a simple task in an indirect and overly complicated manner.

Picture, for example, a rubber ball gliding down a metal ramp and striking a boot, which hits a golf ball that proceeds down a wooden track to tip over a milk bottle. The result is entertaining to watch, but bringing it to life requires some study of physics, mechanics, and engineering. Ideally, students sign up for the fun part and stick around to study the underlying disciplines.

"We've always wanted to encourage learning in STEM and thought the idea of building Goldberg machines was a good way to do STEM in a very fun way," says Mr. Dumenil. The public agrees: before the pandemic, some 5,000 visitors jammed a large exhibition hall in Mons each year to see about 340 participants, ranging from eight years old to adulthood, compete in the Challenge, where a wide array of mechanical contraptions were put through their paces.

Winners are judged by a list of criteria relevant to their machines. "How many objects connect to one another, the originality of the way the pieces connect to one another—we even evaluate the beauty of the machine, so the participants have to decorate their machines around a theme," says Mr. Dumenil.

Many of the projects demand a working knowledge of scientific and engineering subjects, and designing these fanciful machines offers students a hands-on opportunity to experiment with a variety of approaches.

The competition also represents a meaningful partnership between Google and an educational institution to promote their common interests in creating a tech-savvy workforce. "The University of Mons was already trying to promote science

THE CRAZY MACHINE CHALLENGE, continued

and technology training for young people, so they seemed like an ideal partner,” says Xavier Thirionet, administrative business partner for Google’s data center office in Belgium.

The two organizations brainstormed together on ways to boost student interest in STEM activities and landed on the Crazy Machine Challenge to capture the imagination of young people. “We thought if we created a competition around Rube Goldberg machines, it could take the students in a variety of different directions,” says Mr. Dumenil. Google contributed about US\$30,000 to help kickstart the program.

Competition boosts social interaction

Organizers view the competition as a way to encourage participants to develop teamwork and communication skills, and as a means of inspiring educators with imaginative new ways to teach about science and technology. “The most interesting feedback we received is that

some pupils who have been somewhat socially withdrawn in the classroom got more interested and found a role within a team,” says Mr. Dumenil. “We also heard from the teachers that it gives them new ways to explain how things in the physical world connect to one another.”

As one student said when interviewed by a Belgian television station during the contest two years ago, “Not all students are at the same level, not all students have the same ideas, so in terms of socialization it’s something quite remarkable.”

The COVID pandemic, which put in-school learning on hiatus across Belgium, sidelined the Crazy Machine Challenge for the last two springs. A virtual version of the event that required participants to develop projects on their own, at home, did not attract a great deal of support, Mr. Dumenil says. But the series will resume when conditions improve—perhaps in a compressed version where teams are given identical sets of parts and tools and asked to build a working machine in one day.



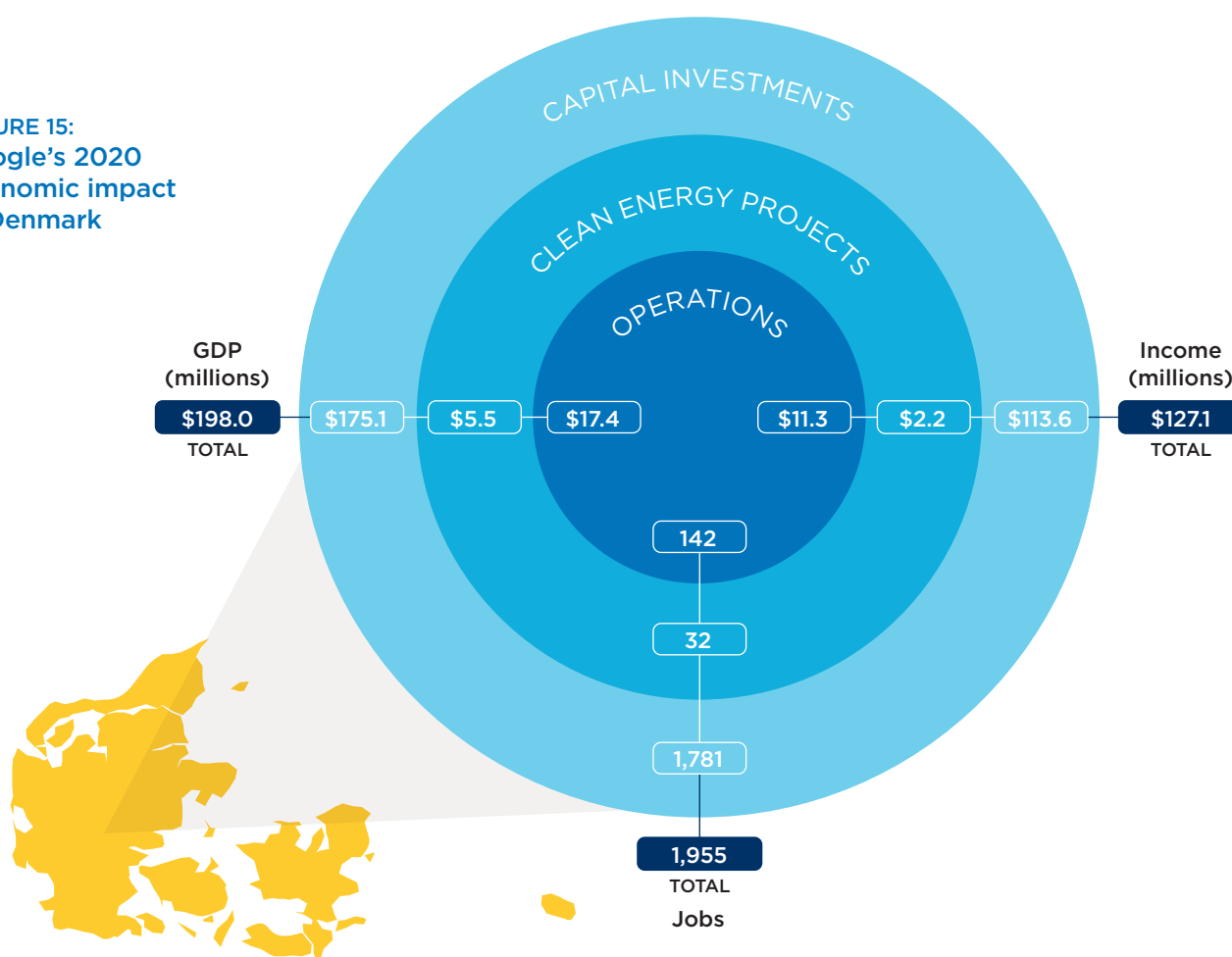
4. DENMARK

4.1 DENMARK NATIONAL

Google selected Fredericia, Denmark for its fifth European data center due to the high-quality digital infrastructure at the location and its ability to support the company's commitment to clean energy. With this infrastructure in place, Google was able to build an energy-efficient data center that is now Google's highest-scoring European data center on an hourly carbon-free-energy basis. In addition, Google also supports the development of network infrastructure in Denmark through its investments in fiber that connect Europe to other regions throughout the world.

Google broke ground on this site in 2018, and the data center opened in 2020. As such, the site was not fully operational during the period being analyzed in this report. To date, Google has invested \$684 million in the facility. Employment at the

FIGURE 15:
Google's 2020
economic impact
in Denmark

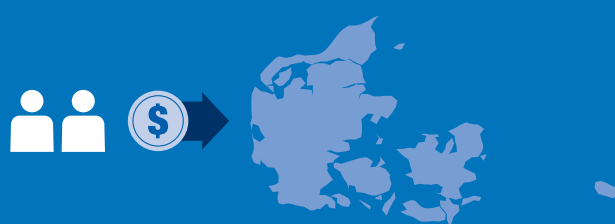


Source: Oxford Economics

site has grown in size since the 2020 figures included in this report and is currently supporting 142 direct workers on site. Reflecting on the relatively low employment at the data center itself in 2020 and the very high average annual capital investment that is the result of the data center being newly opened, construction impacts at the site are considerably large in comparison to those resulting directly from the data center's operations.

In 2020, operations and construction investments at the data center plus Google's clean energy commitments in Denmark supported 1,955 jobs, generated \$127 million in income for workers, and added \$198 million to economic activity (GDP).

Figure 15 above includes the total economic impact from all channels (direct, indirect, and induced).



Google data centers in Denmark support **1,955 total jobs** and generate **\$127 million** in income.

4.2 SYDDANMARK REGION AND SYDJYLAND (SOUTH JUTLAND)

In examining the economic impact of the Fredericia data center in the Syddanmark Region and more locally in Sydjylland, we focus more on the three channels of economic impact. This gives perspective on how the data centers' economic impact spreads throughout the local economy. At these sub-national levels, we examine only the operational and construction impacts since our data were not granular enough to examine clean energy at these levels.

At the regional level, the Fredericia data center supports 111 jobs and generates nearly \$9 million in annual income for workers.

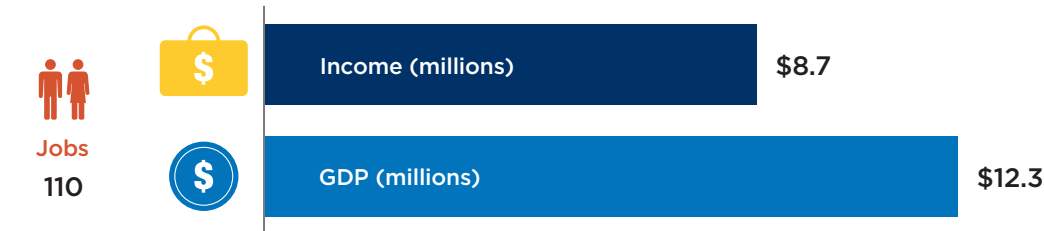
FIGURE 16: Google's operational impact in the Syddanmark Region

Channel	Direct	Indirect	Induced	Total
Jobs	77	18	16	111
Income (millions)	\$6.5	\$1.3	\$1.0	\$8.8
GDP (millions)	\$8.6	\$2.0	\$1.8	\$12.4

Source: Oxford Economics

Almost all of Google’s regional economic impact in the Syddanmark Region is locally concentrated nearer the data center in Sydjylland as seen in the following chart:

FIGURE 17: Local impact in Sydjylland



Source: Oxford Economics

Capital investment is especially important at the local level because it results in construction jobs that are not normally associated with data centers and generate significant local economic impact. Based on the average annual amount of capital investment made by Google in the Fredericia data center since it opened, we calculate that during an average year, construction directly supports 784 jobs in Sydjylland, with another 376 jobs resulting from spillover effects in the broader local economy.

FIGURE 18: Construction impacts in Sydjylland

Channel	Direct	Indirect	Induced	Total
Jobs	784	241	134	1,159
Income (millions)	\$47.3	\$16.8	\$8.6	\$72.7
GDP (millions)	\$63.1	\$27.7	\$15.3	\$106.1

Source: Oxford Economics

Sailing into the data economy



Rector Jens Færgemand Mikkelsen never imagined that his role preparing students for careers in Denmark's venerable shipping industry would translate so easily to training them for jobs in the digital economy.

"We heard that data centers would be coming to Denmark," says Mr. Mikkelsen, rector of the Fredericia College of Marine and Technical Engineering (FMS) on Denmark's Jutland peninsula. "But we didn't know that our education and training programs would fit in so well with their needs."

FMS has been training students for a professional bachelor's degree for more than a century to operate boilers, maintain engine rooms, and troubleshoot dozens of critical components aboard the ships that power the nation's vital maritime industry. Even today, ocean transport, along with offshore oil exploration, is among Denmark's leading employers.

The construction of a Google data center in Fredericia represents a fresh opportunity for the school to prepare students for the future. After

Google invited Mr. Mikkelsen to tour a similar facility in Finland, the need to create a pipeline of students with the skills to operate data centers seemed obvious—and it was a need FMS found itself surprisingly well positioned to meet.

It turns out that many of the conceptual, operational, and technical skills required to keep a big ship running around the clock are similar to those needed to maintain a data center. "When you are a marine engineer on a ship you have to take care of all the equipment, and you have to be able to manage complex problems," says Mr. Mikkelsen. "A data center has similar needs."

Google also actively collaborated with the school on the creation of its data center management curriculum. "We started discussing FMS' needs and their strategy, and we helped them to understand the industry and the business case and what they need to do to get their customers, the students, interested in a program like this," says Arni Jonsson, the site lead for Google's data center in Denmark. Yet the company was careful to respect FMS' ownership of the process. "They needed to drive it," says Mr. Jonsson.

SAILING INTO THE DATA ECONOMY, continued

With \$100,000 of direct financial support from Google, FMS installed a small data center in a classroom on its campus to offer hands-on training in maintenance and operations. It includes a solar power supply configuration and a raised floor to allow ventilation of the servers, just as larger commercial data centers do. This is the first such learning lab in the country, and Mr. Mikkelsen expects its graduates to find jobs without delay.

Creating a vocational pipeline

Creating the new curriculum required the staff at FMS to educate itself first. Mr. Mikkelsen says the school did not have a full understanding of the basic functions of a data center when conversations about collaborating with Google first started in 2019. “Honestly, we had never heard much about the data center industry,” he says. “We had no conception of what it was.”

Yet similarities between traditional coursework and next-generation training surfaced quickly. For example, maintaining power under all

circumstances is a priority for both shipboard and data center engineers. And both disciplines focus on fire suppression, since data centers also need to properly maintain the vast cooling systems required to remove heat.

Google has also helped connect FMS to other schools in the Nordic region and Holland, which are themselves creating curricula to produce a growing cohort of data center workers. “It was really an eye-opener and made us more internationally minded in a very positive way,” says Mr. Mikkelsen. While the school teaches its courses in Danish, the new data center training program is taught in English—an advantage, he says, for students preparing for a global economy.

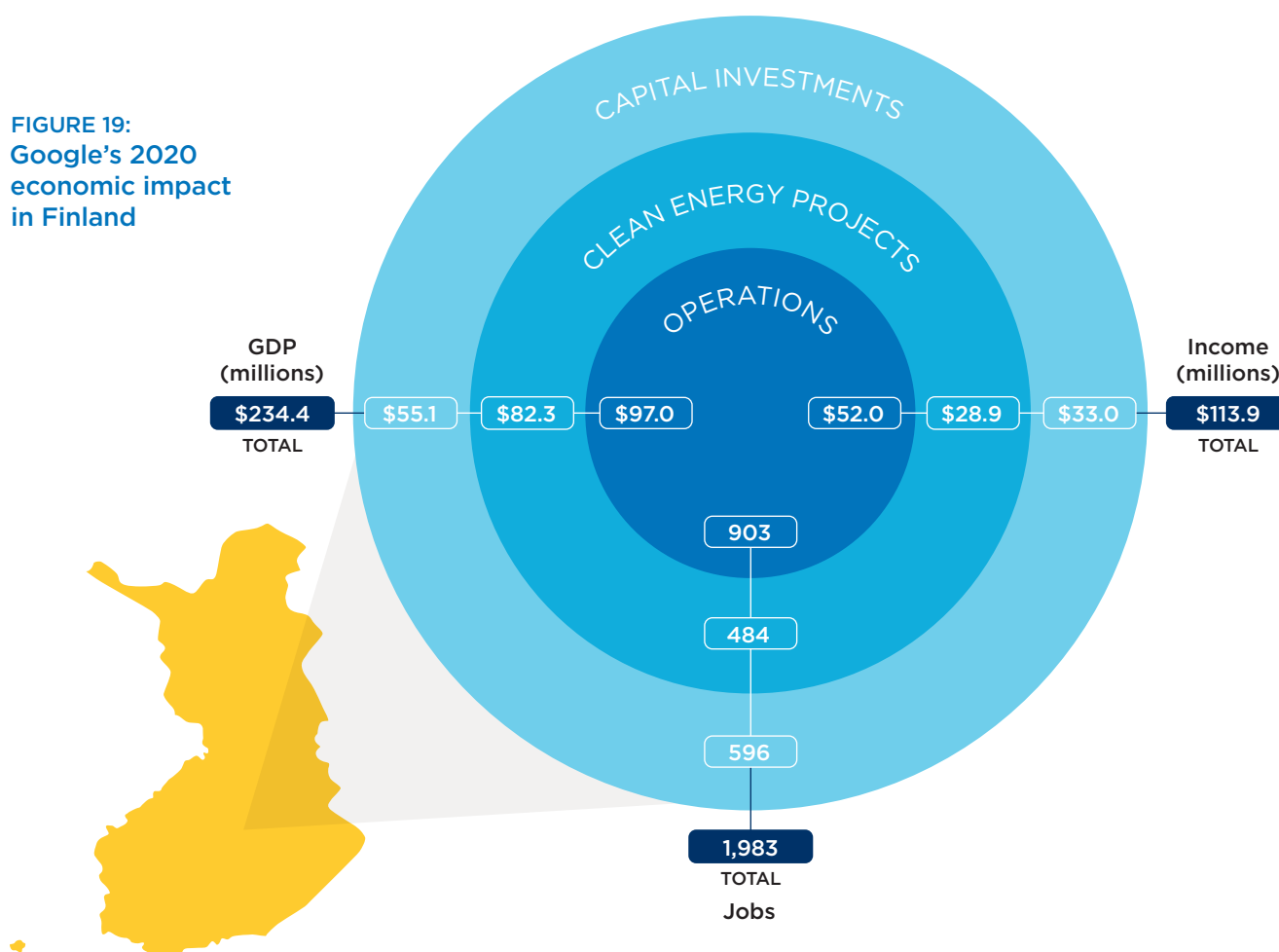
As his first wave of data center students begin to seek internships and, upon graduation, move on to full-time employment in the field, Mr. Mikkelsen’s own focus has broadened to include aiding with job placement in a new industry. It is a long way from launching shipboard engineers on their careers, but at the same time a familiar role.

5. FINLAND

5.1 FINLAND NATIONAL

Google purchased a previously closed paper mill in Hamina, Finland and converted the building into a data center that opened in 2011. As detailed in the following case study, this not only refurbished vacant real estate, but also presented significant employment opportunities to the community that had previously been lost by the mill's closure. Google has invested over \$2.3 billion in this data center, which is one of the company's most energy efficient locations. The data center uses a technologically advanced cooling system that draws seawater from the Baltic Sea, which reduces energy use, and was the first of its kind anywhere in the world. The result is that the data center is successfully running on or above 90% carbon-free energy. In addition, Google investments in fiber support the development of network infrastructure in Finland that connect Europe to points throughout the world.

FIGURE 19:
Google's 2020
economic impact
in Finland



Source: Oxford Economics

In 2020, Google's data center operations supported 903 total jobs in Finland and another 484 jobs are supported through Google's clean energy commitments. Of note, Finland has provided multiple opportunities for Google to invest in clean energy through the development of wind projects. In addition, since the data center opened, Google's ongoing investments in the facility have each year supported 596 additional jobs based on an estimated average level of capital investment at the site.

Figure 19 above includes the total economic impact from all channels (direct, indirect, and induced).



Google data centers in Finland support **1,983 total jobs** and generate **\$114 million** in income.

5.2 ETELÄ-SUOMI (SOUTHERN FINLAND) AND KYMENLAAKSO

In examining the economic impact of the Hamina data center in the Etelä-Suomi region and more locally in Kymenlaakso, we focus more on the three channels of economic impact. This gives perspective on how the data centers' economic impact spreads throughout the local economy. At these sub-national levels, we examine only the operational and construction impacts since our data were not granular enough to examine clean energy at these levels.

At the regional level, the Hamina data center supports 693 jobs and generates \$41 million in annual income for workers.

FIGURE 20: Google's operational impact in Etelä-Suomi

Channel	Direct ⁶	Indirect	Induced	Total
Jobs	450	155	88	693
Income (millions)	\$27.6	\$9.0	\$4.4	\$41.0
GDP (millions)	\$44.1	\$19.6	\$8.4	\$72.1

Source: Oxford Economics

⁶ The figures for direct impacts have been adjusted to accommodate public disclosure concerns, but this does not affect any of the total amounts presented in this or any other table (see the methodology chapter for more detail).

Almost all of Google’s regional economic impact in Etelä-Suomi is locally concentrated near the data center in Kymenlaakso as seen in the following chart:

FIGURE 21: Local impacts in Kymenlaakso



Source: Oxford Economics

Capital investment is especially important at the local level because it results in construction jobs that are not normally associated with data centers and generate significant local economic impact. Based on the average annual amount of capital investment made by Google in the Hamina data center since it opened, we calculate that during an average year, construction directly supports 214 jobs in Kymenlaakso, with another 93 jobs resulting from spillover effects in the broader local economy.

FIGURE 22: Construction impacts in Kymenlaakso

Channel	Direct	Indirect	Induced	Total
Jobs	214	55	38	307
Income (millions)	\$12.8	\$3.2	\$1.9	\$17.9
GDP (millions)	\$18.1	\$5.2	\$3.6	\$26.9

Source: Oxford Economics

Building beyond construction jobs



Harri Eela, a project manager for Cursor Oy, the non-profit economic development agency in the Kotka-Hamina subregion of Finland, was uncertain about the impact of a large data center project when Google announced plans to build in the area 10 years ago. “We didn’t know anything about data centers, we didn’t understand what this kind of business was like,” he says. “It’s been an eye-opening process.”

At that time, Hamina, an industrial town in the southeastern part of the country, was at an economic crossroads. Its largest paper mill had closed, and the community—where employment had long centered around manufacturing chemicals and turning raw timber into pulp and paper—was searching for the right mix of industries to enable a prosperous future.

Since then, Google’s local presence has proven to be a robust economic engine in ways far beyond its initial large outlay for data center construction. The company has helped create jobs, while supporting educational partnerships and other industries, including clean energy and healthcare. “People here are very proud and

happy to see the creation of new opportunities,” says Mr. Eela. “Google wants to be a good partner in this community, and the results have been widely appreciated.”

That is not to underplay the initial investment in construction, which was substantial and created numerous jobs. This impact on the building trades has included ongoing work from expansions to the original facility. “It’s been a really big boost for local construction companies,” says Mr. Eela. These local businesses have also benefited from other work sparked by Google’s presence. “They are changing old facilities to support the region’s new activities.”

In addition to construction-based employment opportunities, the data center has created a myriad of permanent jobs, including positions operating and maintaining the facility. This has gone a long way to offset the loss of the old mill, which had 460 employees. “Now, after the expansions, there are more than 400 people working directly for Google’s data center in different roles,” says Mr. Eela. With each expansion, Cursor Oy organizes events for

BUILDING BEYOND CONSTRUCTION JOBS, continued

the local companies to meet with Google and offer their operational and construction services for the data center.

Additional new opportunities beyond employment with Google reach across various sectors of the economy, helping Hamina create jobs in areas that do not touch directly on the data center business.

Benefiting supporting industries

One way in which Google actively participates in the local community is through engaging in education partnerships. Several programs that the company supports at the Ekami education consortium in Finland's Kotka-Hamina region relate to local data center operations. "We have seen a large impact of Google's presence in terms of jobs being created around service providers and vendors," says Sami Tikkanen, Ekami's CEO and Rector. "Google has given us the opportunity to provide on-the-job data center training for students."

Ekami organizes events on its campus to explain the purpose of the data center and the types of on-site employment opportunities, while also offering professional vocational training for Google's data center. Additionally, the college provides apprenticeship opportunities to students who are interested in working with Google's service providers.

Google also supports programs at Ekami that are less related to the data center but serve to

increase awareness of advanced technology while providing wider community benefits. For example, students learning practical nursing skills for home healthcare are working with robots that provide remote monitoring capabilities. Google provided financial support for the purchase of these smart machines, with which about 200 students will train each year.

The Kotka-Hamina area has seen the influence on local businesses of Google's commitment to clean energy, which includes the goal of running its entire business, including data centers, on carbon-free energy at all times by 2030. This has inspired local entrepreneurial firms to focus on sustainability and explore opportunities to capitalize on Google's local clean energy efforts. These include companies working in green energy, battery technology, and the use of seawater recovery in the cooling of the data center. Additional companies are investigating whether the heat generated by the data center can be reused effectively as an energy source.

One additional benefit to the region has been increased recognition across other industries looking to locate business units. The Google data center has put Hamina on the map with potential large employers, allowing Mr. Eela to effectively promote the region to attract new industries. "Today we are known as an area where Google is located and has built a huge data center in Finland," Mr. Eela says. "The ability to use Google as a reference and show that a big international company has already invested such a large amount of money in the area shows these companies they can safely come here."

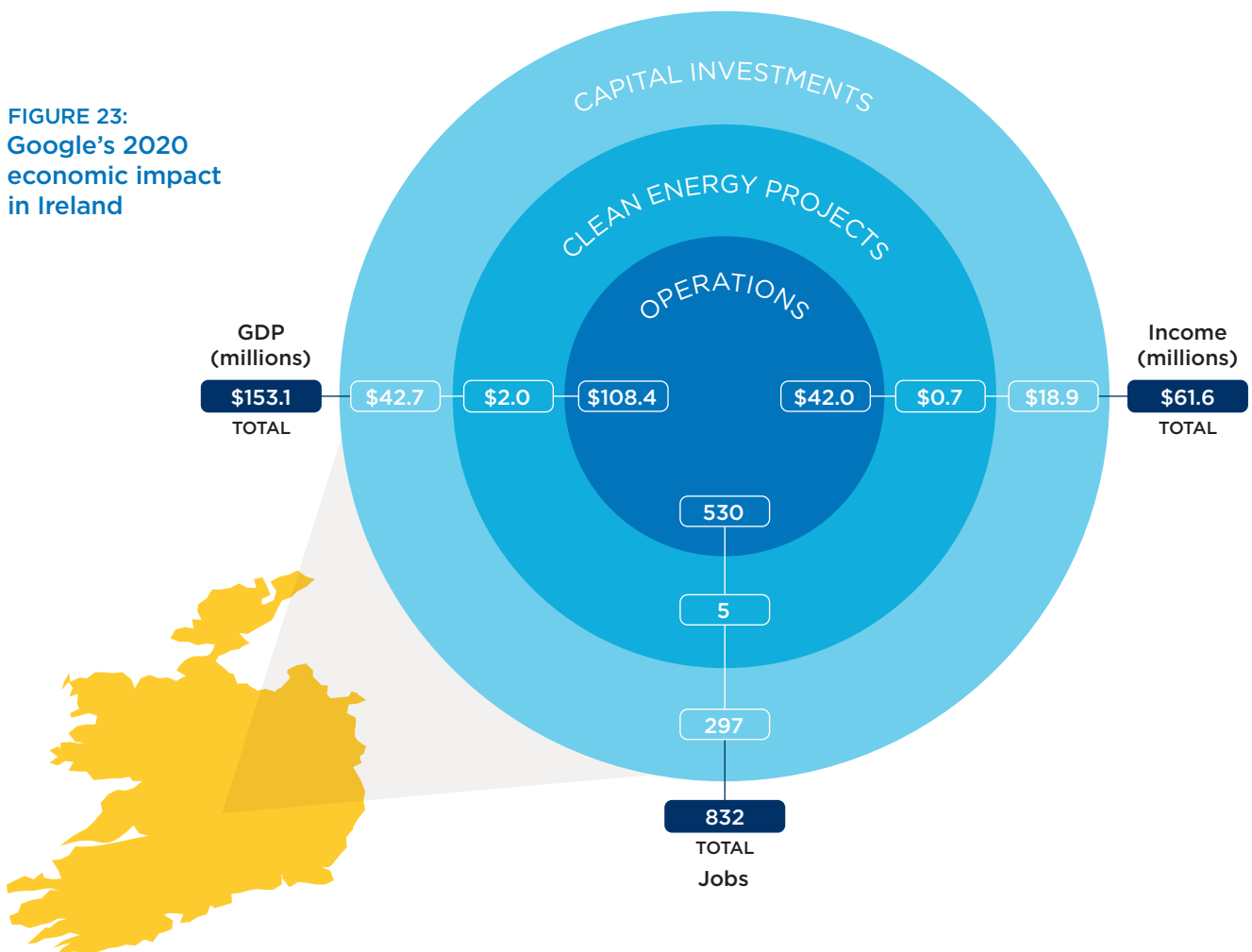
6. IRELAND

6.1 IRELAND NATIONAL

The Dublin data center became operational in 2012 and is located in what was previously a warehouse. Google was able to transform the industrial site into an energy-efficient data center and to date has invested \$570 million in the facility. In addition to the Dublin data center, which is included in this report, Ireland is also home to Google's European headquarters.

Google has been able to utilize Ireland's weather conditions to implement an advanced cooling system that omits the need for air conditioning units. This system has not only proven to be economical in cutting costs, but it also is an environmentally friendly way to cool the servers.

FIGURE 23:
Google's 2020
economic impact
in Ireland



Source: Oxford Economics

In 2020, Google's data center operations supported 530 total jobs in Ireland, and another five jobs in Ireland are supported through Google's clean energy commitments. In addition, since the data center opened, Google's investments in the facility have each year supported 297 additional jobs based on an estimated annual average level of capital investment at the site.

Figure 23 above includes the total economic impact from all channels (direct, indirect, and induced).



Google data centers in Ireland support **832 total jobs** and generate **\$62 million** in income.

6.2 THE EASTERN AND MIDLAND REGION AND DUBLIN

In examining the economic impact of the Dublin data center in the Eastern and Midland region and more locally in Dublin itself, we focus more on the three channels of economic impact. This gives perspective on how the data centers' economic impact spreads throughout the local economy. At these sub-national levels, we examine the operational and construction impacts only since our data were not granular enough to examine clean energy at these levels.

At the regional level, the Dublin data center supports 480 jobs and generates over \$39 million in annual income for workers.

FIGURE 24: Google's operational impact in the Eastern and Midland Region

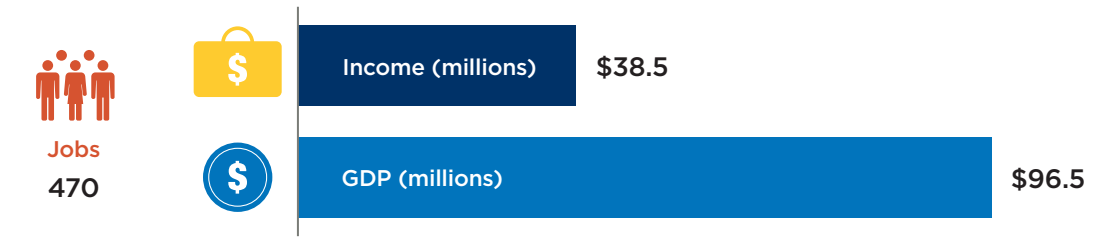
Channel	Direct ⁷	Indirect	Induced	Total
Jobs	300	107	73	480
Income (millions)	\$26.1	\$8.5	\$4.7	\$39.3
GDP (millions)	\$64.8	\$23.2	\$11.0	\$99.0

Source: Oxford Economics

⁷ The figures for direct impacts have been adjusted to accommodate public disclosure concerns, but this does not affect any of the total amounts presented in this or any other table (see the methodology chapter for more detail).

Almost all of Google’s regional economic impact in the Eastern and Midland Region is locally concentrated near the data center in Dublin as seen in the following chart:

FIGURE 25: Local impact in Dublin



Source: Oxford Economics

Capital investment is especially important at the local level because it results in construction jobs that are not normally associated with data centers and generate significant local economic impact. Based on the average annual amount of capital investment made by Google in the Dublin data center since it opened, we calculate that during an average year, construction directly supports 141 jobs in Dublin, with another 59 jobs resulting from spillover effects in the broader local economy.

FIGURE 26: Construction impacts in Dublin

Channel	Direct	Indirect	Induced	Total
Jobs	141	40	19	200
Income (millions)	\$7.1	\$3.1	\$1.2	\$11.4
GDP (millions)	\$11.3	\$8.2	\$2.8	\$22.3

Source: Oxford Economics

The South Dublin County Partnership

The impact of the COVID-19 pandemic on South County, located just outside of Dublin City, was swift, hard, and multifaceted. “We were in an emergency, and the place was cracking up,” says Larry O’Neill, CEO of the South County Dublin Partnership (SCDP), a non-governmental organization dedicated to economic and social development.

The organization was already fully engaged serving an area of a quarter million residents, with relatively high unemployment, poverty, drug use, and crime. Then the situation got even more challenging.

“We had people literally on the margins of society, or maybe working in the gray economy who suddenly were no longer able to earn the money they needed to support themselves,” says Mr. O’Neill. “They were locked down, and there was nowhere to turn for people in our community who needed relief.”

The SCDP rapidly established three food banks, an effort that was made possible with assistance from Google, which has operated a data center in the area since 2016.

“So many in the community were struggling,” says Andrew Hyland, Google’s head of data center public affairs for Europe and the Middle East. “We just felt it was important to create a fund to let the community do what it needed to do.” The company’s contribution of 100,000 euros allowed the SCDP to respond rapidly to the unfolding crisis.

The collaboration also established a help line that assisted people not only with food delivery and housing problems but with counseling services for those confronting psychological issues and social isolation. “We weren’t just taking calls, we

were solving problems,” Mr. O’Neill says, noting that virtually every issue brought to the volunteer phone bank was resolved within 48 hours.

“People are stressed to the nth degree,” Mr. O’Neill says. Even now, he adds, “We are seeing a level of mental health issues we’ve never seen before.”

Leveraging support

Dealing with a crisis of this magnitude demanded a large and ongoing flow of resources, and the early grant from Google helped the SCDP attract matching funds from other organizations to expand its food and counseling outreach. “Getting 100,000 euros from Google created quite a lot of leverage,” says Mr. O’Neill. “I could go to the local authority and say, ‘Hey, I’ve got a little bit of money to open a food bank. Will you match that?’”

The grant provided the community with hope. “When you can tell the local authorities, we’re getting this support from Google, it’s a bit like a wildfire in the wind,” says Mr. O’Neill. “It keeps fanning the flames, and that fanning of flames gives people a lot of heart and boosts morale.”

The speed of Google’s response was helped by a pre-existing relationship between the company’s local operation and the community-based SCDP. This included a collaborative program called “Inspiring the Future” that put Google employees in front of students at area schools to explain how even those without a background in data science or related fields could find employment at technology companies.

“These young people can be anything they want to be,” says Triona Reid, who supervises the program for the SCPD. Hearing speakers in their

THE SOUTH DUBLIN COUNTY PARTNERSHIP, continued

community describe their own journeys from the neighborhood and how they were able to begin their own careers is inspirational, she says.

Ultimately, working together during tough times has strengthened the relationship between the South County Dublin Partnership and Google. Beyond the food bank, funding from Google allowed SDCP volunteers to deliver prescription medicines or food to elderly residents who found themselves restricted to their homes. The organization also published a “Booklet of Hope”

that was distributed around the county, offering mindfulness tips and a guide to resources available to those needing assistance.

Even when the pandemic recedes, much work will remain to be done. Mr. O'Neill hopes the SCDP will be able to expand face-to-face counseling across the community. “When you're doing mental health intervention, people need privacy, and you don't always have that at home,” Mr. O'Neill notes. “We hope to establish safe spaces.”



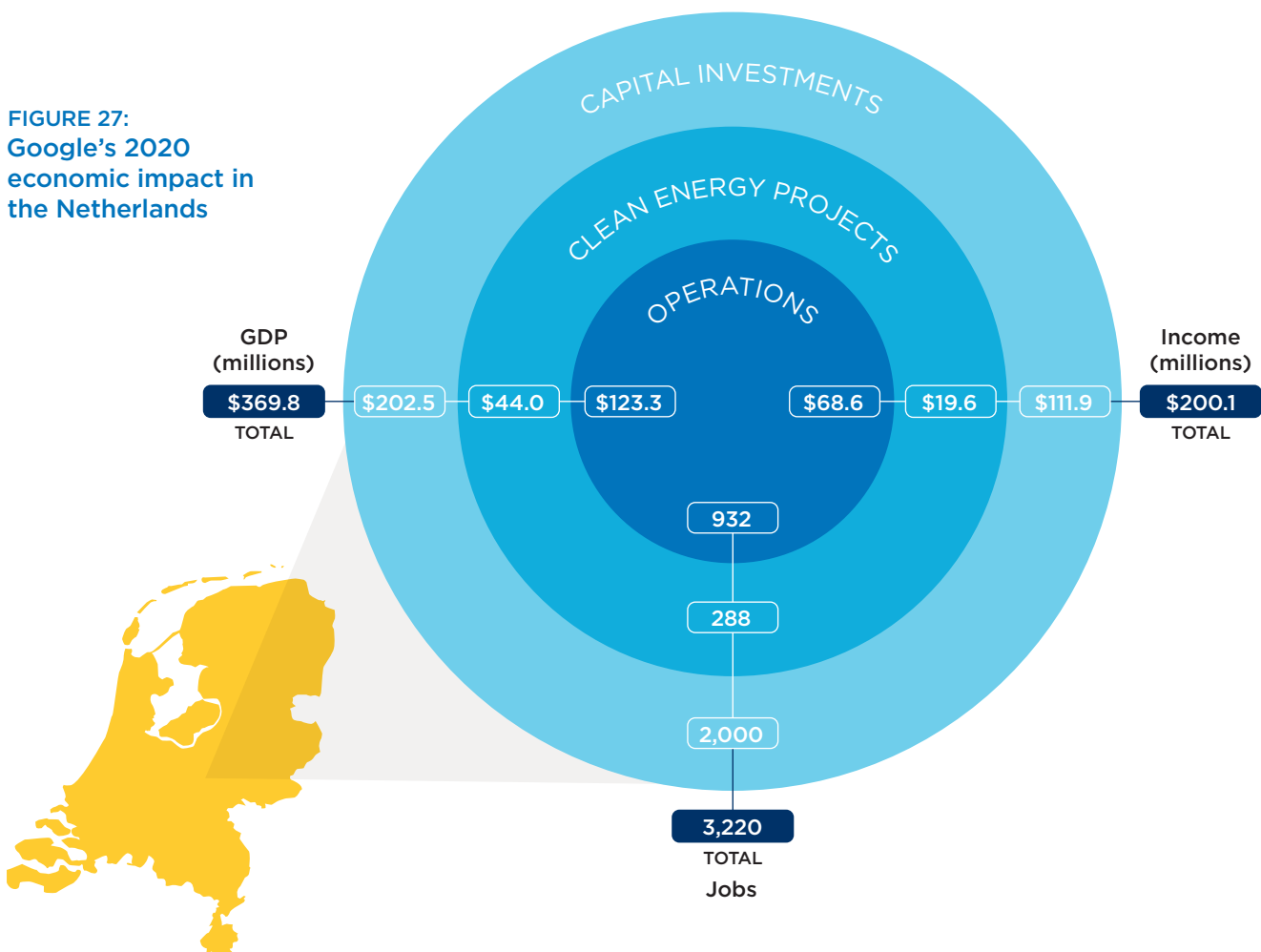
7. THE NETHERLANDS

7.1 THE NETHERLANDS NATIONAL

Google opened its first data center in the Netherlands in 2016 in Groningen and then a second data center campus in Middenmeer in 2020. Taken together, the company has invested \$2.8 billion in these facilities. One reason these locations were attractive to Google is the dedication of the Netherlands to developing its digital transformation presence. Google further supports this effort through its development of network infrastructure in the Netherlands, which helps to connect Europe to other regions throughout the globe. In addition, the Netherlands shares Google’s commitment to carbon-free energy.

In 2020, Google’s data center operations supported 932 jobs in the Netherlands, and another 288 jobs are supported through Google’s clean energy commitments. In addition, since the data centers have opened, Google’s investments in its facilities have supported 2,000 additional jobs based on an estimated average level of capital investment at the site.

FIGURE 27:
Google’s 2020
economic impact in
the Netherlands



Source: Oxford Economics

Figure 27 above includes the total economic impact from all channels (direct, indirect, and induced).



Google data centers in the Netherlands support **3,220 total jobs** and generate **\$200 million** in income.



7.2 NOORD NEDERLAND AND GRONINGEN

In examining the economic impact of the Groningen data center in the Noord Nederland region and more locally in Groningen itself, we focus more on the three channels of economic impact. This gives perspective on how the data centers' economic impact spreads throughout the broader economy. At these sub-national levels, we examine the operational and construction impacts only since our data were not granular enough to examine clean energy at these levels.

At the regional level, the Groningen data center supports 636 jobs and generates nearly \$44 million in annual income for workers.

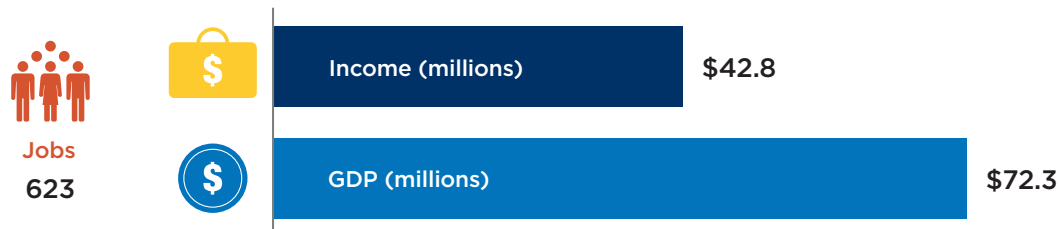
FIGURE 28: Google's operational impact in Noord Nederland

Channel	Direct ⁸	Indirect	Induced	Total
Jobs	250	302	84	636
Income (millions)	\$17.6	\$21.7	\$4.6	\$43.9
GDP (millions)	\$28.5	\$38.1	\$8.5	\$75.1

Source: Oxford Economics

Almost all of Google's regional economic impact in the Noord Nederland Region is locally concentrated near the data center in Groningen as seen in the following chart:

FIGURE 29: Local impact in Groningen



Source: Oxford Economics

Capital investment is especially important at the local level because it results in construction jobs that are not normally associated with data centers and generate significant local economic impact. Based on the average annual amount of capital investment made by Google in the Groningen data center since it opened, we calculate that during an average year, construction directly supports 728 jobs in Groningen, with another 319 jobs resulting from spillover effects in the broader local economy.

⁸ The figures for direct impacts have been adjusted to accommodate public disclosure concerns, but this does not affect any of the total amounts presented in this or any other table (see the methodology chapter for more detail).

FIGURE 30: Construction impacts in Groningen

Channel	Direct	Indirect	Induced	Total
Jobs	728	210	109	1,047
Income (millions)	\$38.3	\$13.2	\$5.9	\$57.4
GDP (millions)	\$65.9	\$24.2	\$11.0	\$101.1

Source: Oxford Economics

7.3 WEST NEDERLAND AND NOORD HOLLAND

The Google data center in Middenmeer opened in 2020 and hence only limited construction detail was available for that year. Still even at these start-up levels, an examination of the three channels of economic impact gives an indication of how the data center's local and regional impact will spill over throughout the broader economy as on-site employment increases.

FIGURE 31: Construction impacts in Middenmeer

Channel	Direct	Indirect	Induced	Total
Jobs	10	18	23	51
Income (millions)	\$7.8	\$1.4	\$1.2	\$10.4
GDP (millions)	\$12.6	\$3.3	\$2.3	\$18.2

Source: Oxford Economics





8. CONCLUSION

In 2020, Google's European data centers and related infrastructure investments supported 22,211 jobs and generated \$1.1 billion in combined income throughout Europe. Nearly half of these positions are in the countries that host a data center.

The jobs in countries without a Google data center are largely attributable to people working in businesses that supply equipment and provide services that support the Google data centers, including those in the clean energy industry.

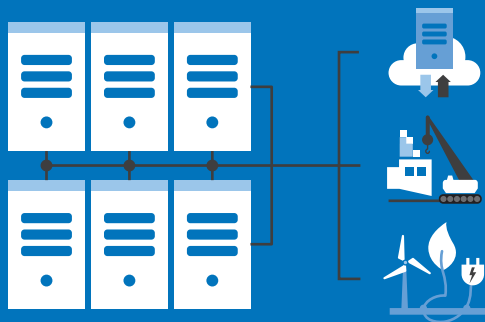
The result of this integrated supply chain is that Google's economic impact cascades throughout Europe.

Google data centers are at the heart of an economic ecosystem that connects users and customers with the digitalization that they rely on and supports job growth in a variety of key industries. During 2020, these jobs included nearly 1,900 in the Information, Communication and Telecom sector. Many of these positions are locally concentrated at the data centers themselves. Also, at the local level, we found that Google's capital investments annually support an average of 2,400 construction workers who are employed building, upgrading, or expanding the data center campuses.

Beyond the environmental benefit, Google's commitment to round-the-clock carbon-free energy has spurred economic gains that include more than 700 workers in the clean energy industry itself and nearly another 1,600 working in the supply chain that supports clean energy in Europe. In addition, over 37,000 people-years of work were spent building, constructing, and installing the wind and solar projects that power Google's clean energy commitments.

Throughout Europe, Google's data center generates an economic impact that is broadly distributed among industries, benefits countries, and has helped construct and sustain the continent's clean energy infrastructure.

In a softer but no less important way, and as illustrated in the case studies presented in this report, Google's active engagement in the communities where its data centers are located helps residents, schools, and businesses in those communities better meet today's challenges and prepare for the opportunities of today and tomorrow.



Google data centers support jobs throughout Europe and in a wide range of industries: nearly **1,900 jobs** are in the ICT sector, **2,400 jobs** in local construction, and **700** in the clean energy industry.



9. APPENDIX: METHODOLOGY

9.1 INPUT-OUTPUT MODELS AND ASSUMPTIONS

Google provided Oxford Economics with a great deal of actual (2020) expenditure information specific to each data center campus and its investments in its clean energy commitments. This information was not explicitly included in this report because of proprietary and trade secret concerns (see section 9.2) but was used to keep calculations robust. These and other inputs were analyzed using two different input-output (IO) models—first a global model, used to develop national-level impacts; and second, a set of sub-national models to calculate local and regional impacts.

National impacts were calculated using Oxford Economics' proprietary Global Economic Impact Model (GEIM). The GEIM is constructed using IO tables made available at the country level by the Organization for Economic Co-operation and Development (OECD) and related national-level data sources. The GEIM allows us to consider the cross-border economic impacts associated with supply-chain and wage-consumption expenditures. **Importantly, this means that impacts reported at the national level include cross-border supply-chain spillovers from Google's global data centers.** For example, if a data center in Ireland purchases equipment or professional services from Germany, these purchases will be included as part of the "Rest of region" impact in Europe. Subnational impacts, by contrast, do not include spillovers from outside the region. Continental-level impacts were calculated straightforwardly by summing national-level impacts, and so also include global spillovers.

For certain spend categories, (e.g., computer equipment), Google was not able to provide a breakdown of the location from which the purchased goods or services were sold, only the location of the data center for which it was purchased. For these spend categories, we built assumptions based on national- and industry-specific data within the GEIM IO tables themselves. Purchase locations therefore reflect industry spending patterns that may differ from Google's actual sourcing pattern.

Sub-national impacts were calculated differently in the United States and the rest of the world. For the United States, impacts were calculated using an input-output model developed by IMPLAN. IMPLAN provides data for assumptions regarding what share of total national expenditures were spent within the county and state in which each data center is located. This is most important for the data centers' largest spend category: electricity. Certain other expenditures, like catering, were assumed to be 100% spent locally.

For the sub-national modeling outside the United States, we constructed new IO tables for the locality based on the national IO tables from GEIM using a methodology developed by Flegg and Webber.⁹ Where necessary (again, electricity being the prime example), assumptions about the share of national

⁹ Flegg, A. T., Webber, C. D. and Elliott, M. V., On the appropriate use of location quotients in generating regional input-output tables, 1995, *Regional Studies* 29, 547-561.

spending occurring within the smaller regions are based on average values for the data centers within the US based on IMPLAN data.

Included in our direct employment calculations are all workers located on-site at each data center campus, which include both Google employees and third-party contractors. In previous work with Google, we developed profiles for the types of functions and costs associated with the third-party contractor workforce at some of the company's US data centers. We relied on those earlier profiles to estimate the costs associated with third-party contractors at each of the data centers included in this study.

9.2 TREATMENT OF PROPRIETARY INFORMATION

As noted previously, Google provided us with detailed operational and investment data that was used in producing all economic impact calculations presented throughout this report. However, operational information regarding Google data centers is largely confidential and not routinely disclosed by the company. To accommodate this concern, we made one important modification in how we presented our results: specifically, with respect to direct employment on-campus. Our calculations were made using actual on-campus data. In our report, however, we present as direct employment only figures that are consistent with what the company has previously disclosed publicly about employment at the location. This adjustment in presentation did not affect any calculation that we made, nor did it alter any key conclusion presented but does result in small adjustments to the mix of direct and indirect channels that we present at some locations. Note that total economic impact results and presentation are unaffected by this accommodation.

9.3 CLEAN ENERGY CALCULATIONS

To sustain its commitment to clean energy, Google enters into financial arrangements that result in the construction of new wind or solar projects in many of the countries where it operates its data centers. The nature of these financial commitments is not routinely disclosed publicly. Google provided us with detailed information regarding the amount, timing, and location of wind and solar projects established in response to Google's financial commitments. To calculate the economic impact associated with these investments, we relied upon various statistics published by the International Renewable Energy Agency (see IRENA (2020) "Renewable Power Generation Costs in 2019"). These included IRENA estimates for both solar and wind total installed costs by country, and IRENA estimates for the levelized cost of electricity (LCOE) by country or region for both wind and solar projects. Through these published data, we estimated the amount of electrical output produced by these investments and the operating and maintenance costs associated with annual operations. Once annual operational costs were estimated, they were further refined using cost breakouts published by windpowermonthly.com (see "Big Turbines Push down O&M costs," Milborrow, David, May 2020). Clean energy calculations were modeled using the European NACE codes corresponding to utilities, including those for electric power generation and distribution.

The data provided by Google was also used to calculate the economic impact of the capital expenditures associated with its clean energy commitments. In making these calculations, we calculated the average construction expenditure per year over the construction period, which we assumed to be three years.

9.4 DATA CENTER CAPITAL INVESTMENT

Google regularly invests in expansions and improvements to its data center campuses, in addition to the initial investment to construct the data center in the first place. We were provided with data on these capital investments. This data described the amount of construction investment that occurred at each of the European data centers each year from 2010 to 2020. We annualized the construction data specific to each data center by dividing the total amount of investment at each campus by the number of years that campus has been operational. Capital investment data was broken into spending on constructing the data center itself, purchases of computer and electronic equipment for the data center, and professional services in designing the data center. The construction expenditure was assumed to be 100% local. At the national level, the equipment and professional services expenditures were allocated geographically for each data center based on national and industry-specific data in the GEIM IO tables. At the local level, we relied on a uniform set of regional and local shares that were based on US shares as derived from shares reported in IMPLAN.



OXFORD
ECONOMICS

Global headquarters

Oxford Economics Ltd
Abbey House
121 St Aldates
Oxford, OX1 1HB
UK

Tel: +44 (0)1865 268 900

London

4 Millbank
Westminster
London, SW1P 3JA
UK

Tel: +44 (0)20 3910 8000

Frankfurt

Marienstr. 15
60329 Frankfurt am Main
Germany

Tel: +49 69 96 758 658

New York

5 Hanover Square, 8th Floor
New York, NY 10004
USA

Tel: +1 (646) 503 3050

Singapore

6 Battery Road
#38-05
Singapore 049909

Tel: +65 6850 0110

**Europe, Middle East
and Africa**

Oxford
London
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Dublin
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Milan
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Dubai

Americas

New York
Philadelphia
Boston
Chicago
Los Angeles
Toronto
Mexico City

Asia Pacific

Singapore
Hong Kong
Tokyo
Sydney
Melbourne

Email:

mailbox@oxfordeconomics.com

Website:

www.oxfordeconomics.com

Further contact details:

[www.oxfordeconomics.com/
about-us/worldwide-offices](http://www.oxfordeconomics.com/about-us/worldwide-offices)