



Data Center Impact Report

TAIWAN



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Executive summary

Data centers are at the core of the transformation to a digital economy. They enable a growing number of industries to make quick, information-driven decisions and provide products and services to their stakeholders securely and reliably. Google's data centers are part of this ecosystem, with an owned and operated network of [over 25 data center locations around the world](#). Each location has been strategically chosen based on considerations such as: land availability, infrastructure, talent, and the opportunity for impact to meet the requirements of the world's increasing digital needs.

As Google seeks to drive positive change in the communities where it operates, learning more about the impacts its data center has had in Changhua County, Taiwan became a priority. To do this, Google engaged Deloitte in 2023 to quantify the economic, social and environmental impacts that the Google data center has had in Changhua County. This report presents the impact across those three

dimensions for the period of 2017-2022. The objective of this report is to be as transparent as possible about the data center impacts. In cases where some data was not included, it is due to regulatory, competitive, or data quality considerations. As the ability to do so changes, future impact assessments will reflect Google's capability to share additional information.

Economic impact

From 2017-2022, annually, Google added ~\$4.9 billion to the Gross Domestic Product (GDP) of Taiwan through direct, indirect, and induced contributions and ~\$1.0 billion in direct, indirect and induced contributions to Labor Income. In the same time period, Google's operations supported ~47,000 direct, indirect and induced jobs.



Social advancement

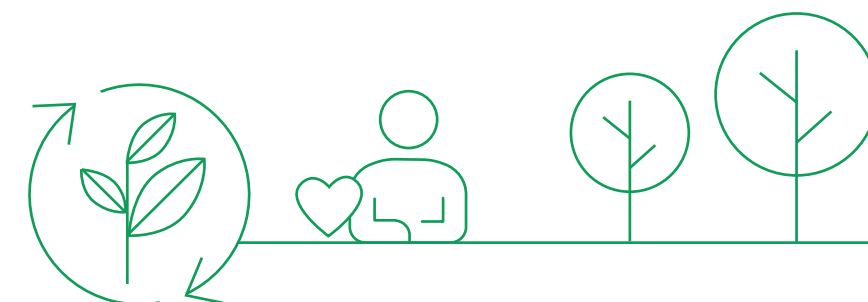
Google aims to improve the lives of as many people as possible – both for people in Google through employee wellbeing measures and for people around Google, through supporting local education and other programs. Between 2017 and 2022, Google.org awarded \$721,000 in grants to communities in Taiwan to help strengthen Science, Technology, Engineering, Mathematics (STEM) education programs, advance digital literacy across age groups, provide digital training to develop highly-skilled talent, and offer COVID-19 support to teachers and students across Taiwan.

Environmental sustainability

At its data centers, Google is working to maximize energy efficiency and reduce the use of water. Google acknowledges the potential impact it has on its surrounding environment—namely through energy usage, greenhouse gas emissions, water, waste, land, and biodiversity – and works to mitigate this impact. To this end, Google has invested in several power purchase agreements (PPAs). Google has set

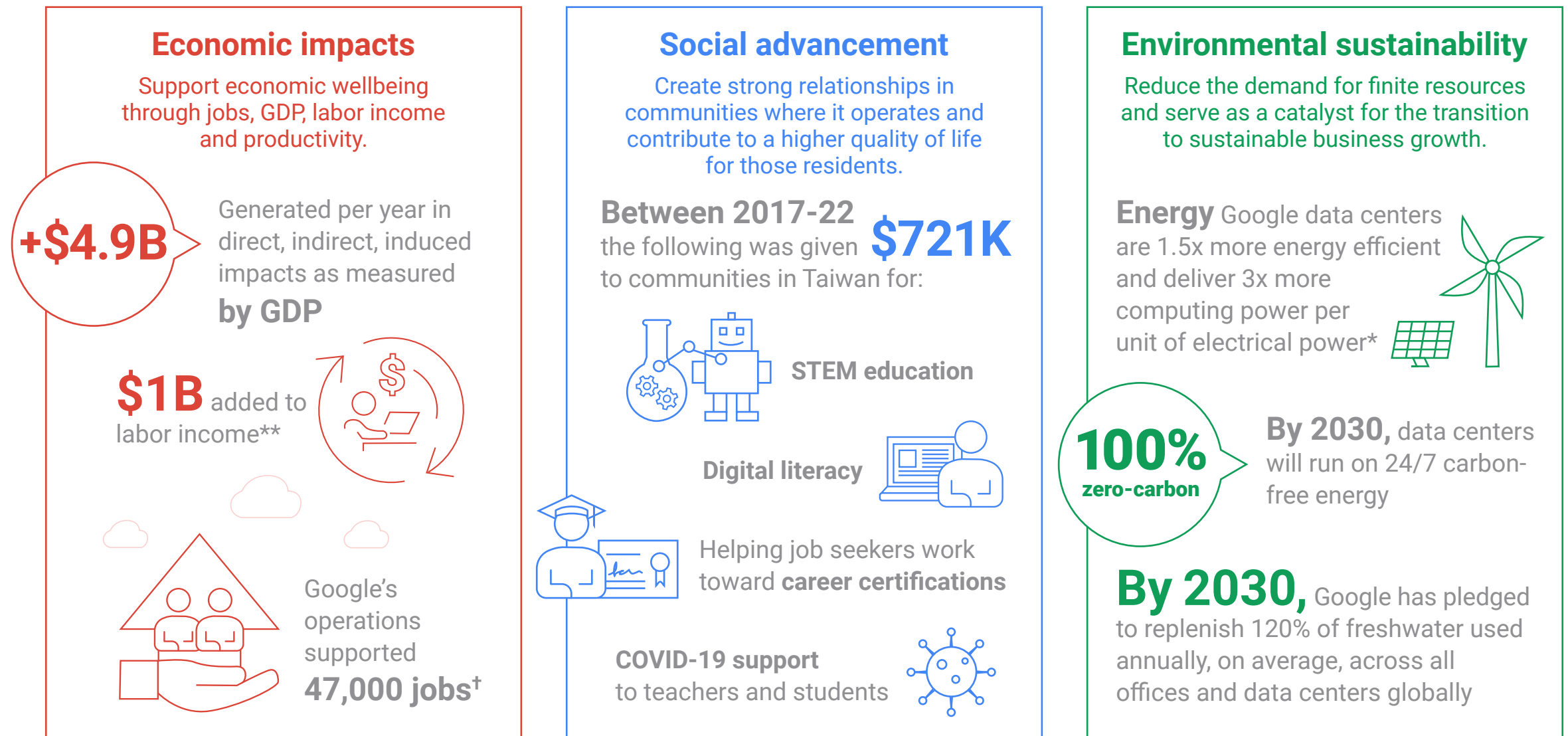
a target that by 2030, Google aims to run on 24/7 carbon-free energy on every grid where it operates, and Google aims to replenish 120% of freshwater volume it consumes, on average, across data centers and offices.

Through this report, Google has a more comprehensive understanding of the economic, social, and environmental impact it has had in Taiwan, including the issues most important to its stakeholders. Moving forward, Google will take these learnings to continue finding ways to channel its economic impact locally, minimizing its environmental impact through optimizing water and energy, and engaging with local stakeholders - all in support of continuing to make an impact on the communities in which it operates.



Google data centers: Keeping the internet secure & sustainable

By driving local economic development, fostering thriving communities, and spurring environmental stewardship. In Taiwan, from 2017-2022, Google data centers impacted the community through:

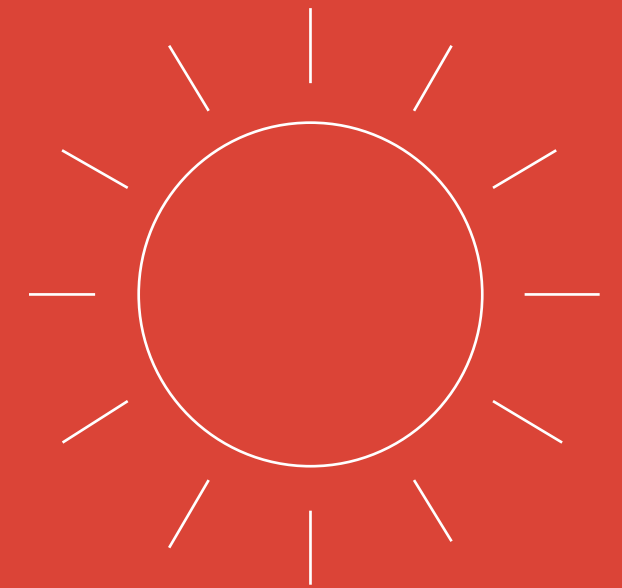


FOOTNOTE:

*As of 2022, Google's data centers globally are, on average, 1.5 times as energy efficient as a typical enterprise data center and compared to five years ago, they now deliver approximately three times as much computing power per unit of electrical power. ** Includes direct, indirect and induced labor income. † Includes, direct, indirect and induced jobs.

Introduction

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INTRODUCTION

An introduction to data centers

Where does the internet live?

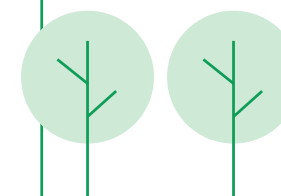
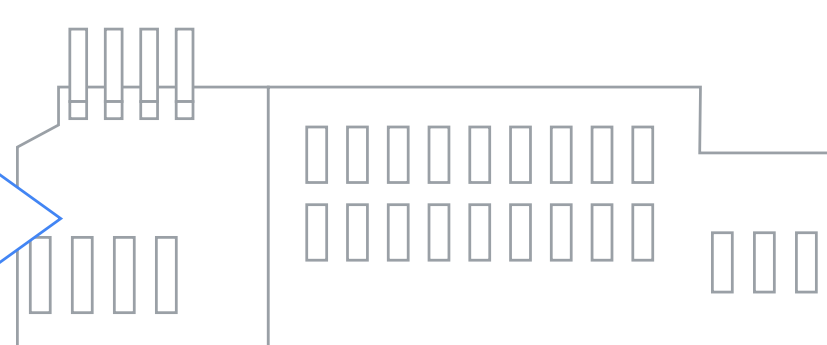
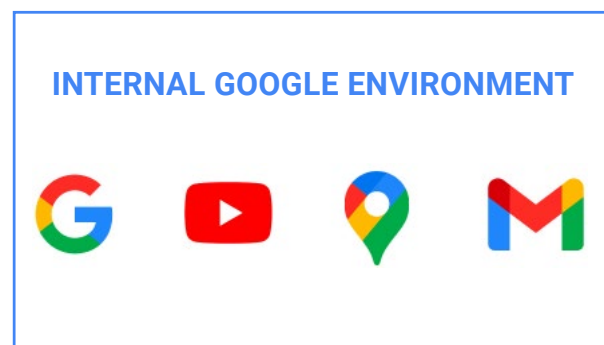
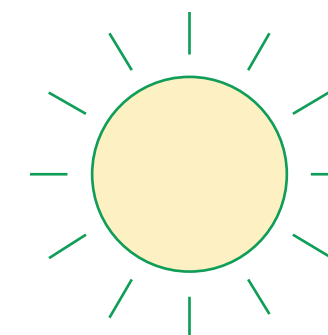
We use data every day when we do things like pull up a map to a new restaurant, attend online classes, stream favorite TV shows, or subscribe for online services. The demand for internet-based services just keeps growing – and as it grows, so does the need to store and safeguard enormous quantities of digital information.

Data centers (DCs) are the global hubs of the internet's connectivity, digital activity, and secure storage. They are where the internet lives. Google's global network of data centers is designed to do this work. Google distributes all the data under its care – including its own – across many computers in different locations. This helps Google keep data safe, and makes it possible to deliver information to users in a fraction of a second, using fiber and internet connections.

Artificial Intelligence (AI) and Machine Learning (ML) contribute to the reliability of Google's data infrastructure and its ongoing innovation.

Google's Changhua County data centers securely store data from Cloud customers, ensuring the safety and performance of their web applications. These data centers also play a role in serving everyday user needs, like running Google searching and streaming YouTube videos.

In other words: Google's network of data centers is the heart of Google's services – services that are used every day by people all over the world.





What is a data center?

A data center is a facility with many computers that store and process large amounts of information. Whenever a person accesses Gmail, edits a document, or searches for information on Google, they are using Google's data centers and have the power of a supercomputer at their fingertips. Data centers require different types of supporting infrastructure - including power systems, backup generators, water cooling systems, security facilities, warehouse buildings and office space – that work together to achieve a common goal.

Data center buildings can be as large as dozens of football fields put together. They host servers that are stacked in racks up to the ceiling. These servers are what make the data center go, and Google employs the highest security standards (see footnote) for protecting these machines and the sensitive data they hold.

FOOTNOTE: Google Cloud continues to hold certification against internationally-recognized privacy standards including ISO 27018 and ISO 27701 ([read more](#)).

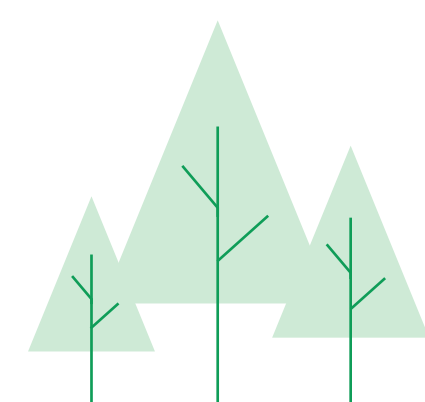
Google's network of enterprise data centers benefit from economies of scale, enabling a favorable ratio of data storage capabilities per kilowatt hour of energy and liters of water that outperforms industry averages. According to the Dutch Data Center Association, "Hyperscalers are gigantic single-tenant data centers, built by and for globally operating internet companies". Enterprise data centers also make sure that computations and data processing are evenly distributed across the data center network, which allows them to scale computing power and adapt to client needs more quickly.

Data center buildings are made up of different types of supporting infrastructure – that work together to achieve a common goal.





Google data centers have impacts beyond the efficient delivery of data security, adaptability, and connectivity. The internet lives in the physical infrastructure of data center campuses – and these campuses live within local communities. This report covers the ways Google's data center in Changhua impacts the environment and the people who live in it, and marks a step towards Google's ongoing practice of accountability and transparency.



Google data centers have impacts beyond the efficient delivery of data security, adaptability, and connectivity.





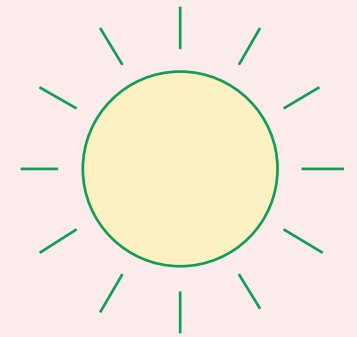
INTRODUCTION

Google in Taiwan

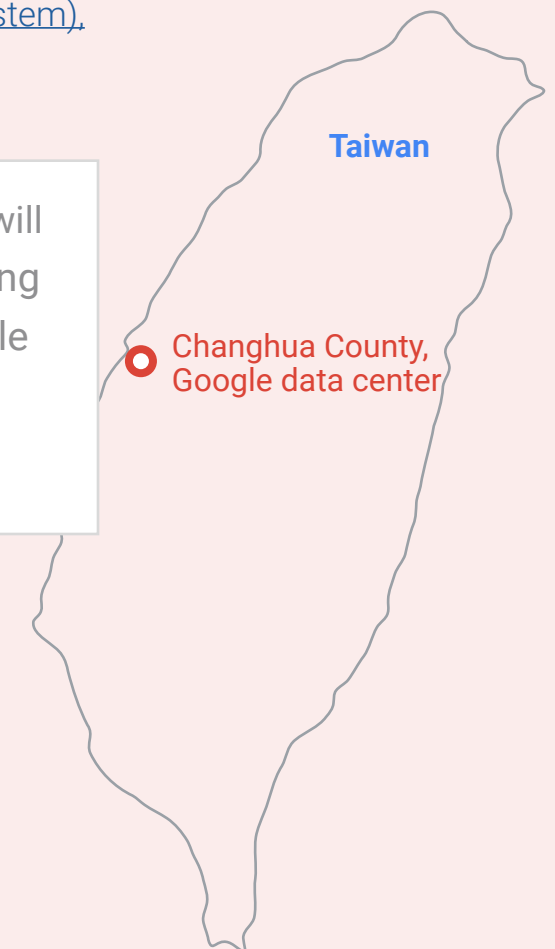
10 years ago, [Google invested \\$600 million in constructing a data center in Changhua County](#)—the first enterprise data center owned by a multinational technology company in Asia. Taiwan (TW) is a strategic investment location for Google because of its history of supporting innovation and foreign investment, reliable infrastructure, and stable regulatory environment.

In 2022, the government of TW inaugurated the [“Ministry of Digital Affairs \(MODA\)”](#) to regulate domestic data storage policy and orchestrate cutting-edge technologies like cloud computing. This ministry will play an important role in improving cybersecurity practices for people and businesses, and realize the vision of a “smart country”. Google strictly adheres to the Taiwanese government’s requirements for local resilience to ensure the stability and security of Taiwanese digital infrastructure and provides support to Taiwan’s role as a global trade leader and top player in the world’s information and communication technology industries. Google also aligns with MODA’s overarching vision for resilience and digital growth by supporting nonprofit organizations in Taiwan to educate students & teachers about digital responsibility.

Furthering the national policy directive of “Digital Nation, Smart Island,” the [DIGI+ Taiwan 2017-2025](#) program is intended to enhance digital infrastructure, re-construct a service-based digital government, and realize a fair and active internet society with equal digital rights. Historically, Google has been at the forefront in building critical digital infrastructure projects which have helped connect Taiwan to the rest of the world. For instance, multiple submarine cable networks were built, including Faster 2016 (Trans-Pacific), [PLCN 2020](#) (Connecting Taiwan to the Phillipines, Hong Kong and the US), [Apricot 2024 \(Planned Pan-Asian system\)](#), [SJC 2022 \(Planned\)](#), [TPU \(Planned\)](#).



Ministry of Digital Affairs (MODA) will play an important role in improving cybersecurity practices for people and businesses, in creating a **“smart country”**.

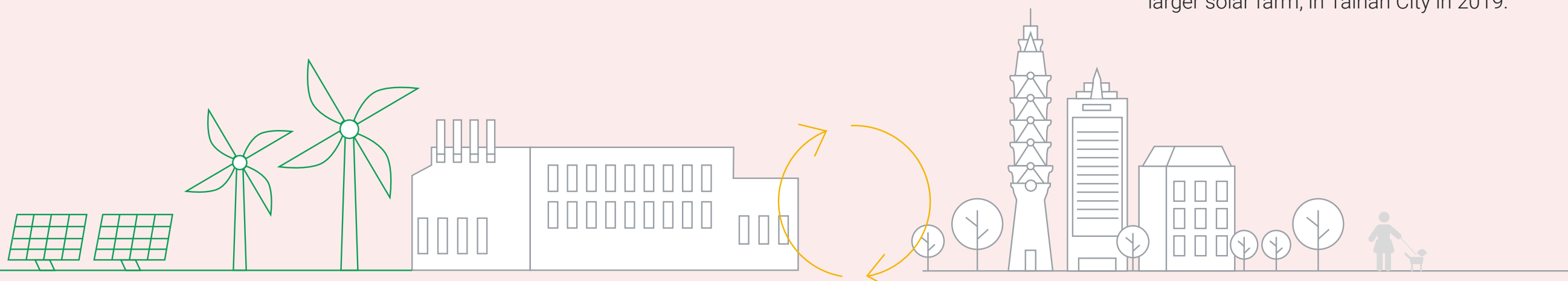


Google's data center investments in the Taiwan region for infrastructure and connectivity have had some notable direct and induced effects to the local economy and employment.

As the Taiwanese economy transitions from being a manufacturing-based to a service-based one, organizing data and information becomes even more critical. Cloud services, the security of enhanced data privacy, and a lower cost of data storage are all elements that support service businesses. These help them stay productive, focus on their day-to-day priorities, and thrive locally as well as internationally. Google's data centers provide all this, supporting strategic sectors such as information and digital technology, cybersecurity, biotech and medical technology,

and government services. These are some of the prioritized sectors that Taiwan includes in its "[New Model for Economic Development](#)."

Google's support of Taiwan's strategy goes beyond digital and economic development. [The Ministry of Economic Affairs](#) has declared plans to generate 20% energy from renewables [by 2026](#). Moreover, the Taiwanese government amended Taiwan's Electricity Act in 2017 to allow non-utility companies to directly buy renewable energy and decrease their carbon footprint. Google was not only a strong supporter of this renewables-friendly change to the law, but also the first corporate power purchaser to act in accordance with it. As a result of a deal between Google, industry stakeholders, and the Taiwanese government, Google signed a long-term agreement to purchase the output of a solar array, part of a larger solar farm, in Tainan City in 2019.





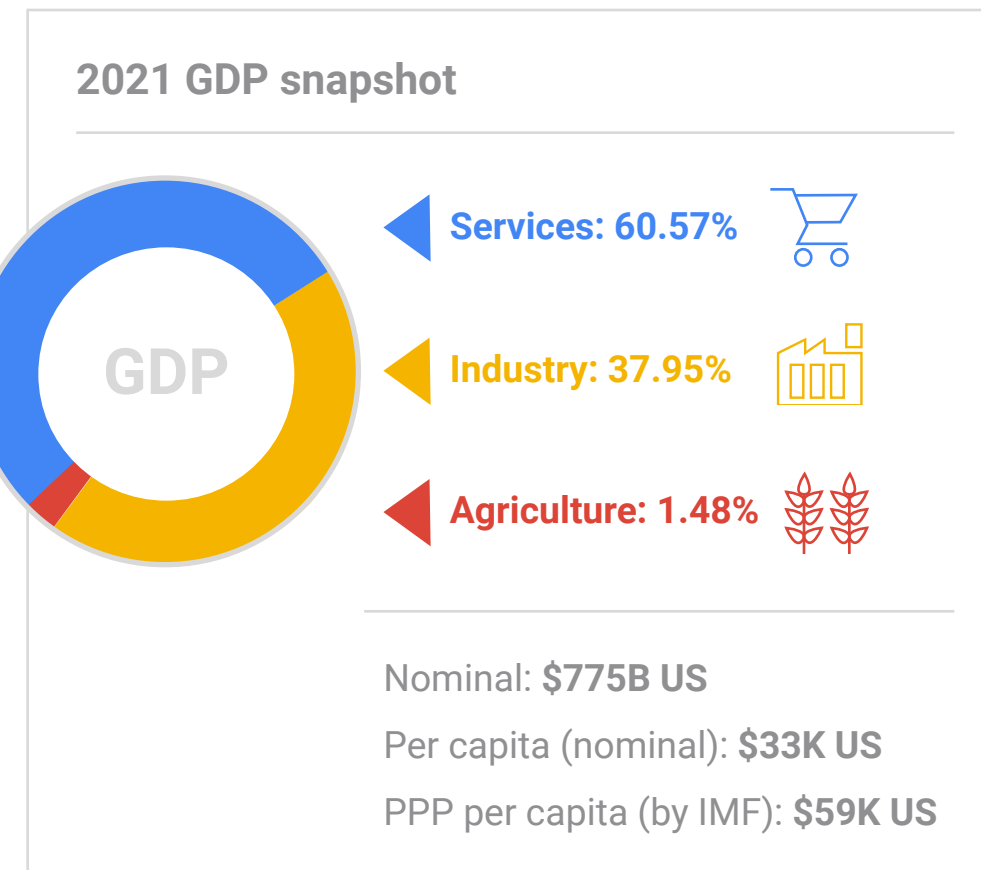
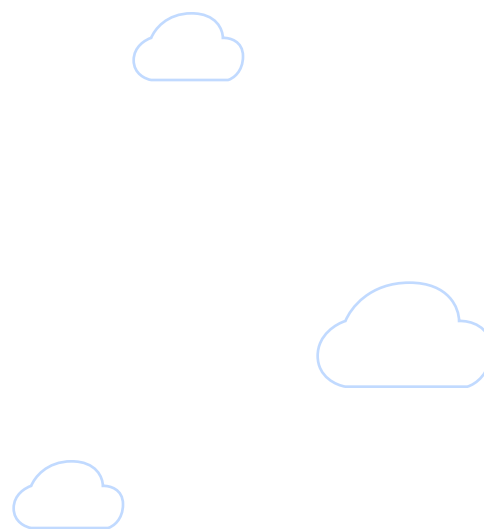
INTRODUCTION

External business environment

The Taiwanese economy has evolved significantly in the last decade, with the service sector now making up more than half of Taiwan's GDP. Since May 2016, Taiwan has adopted the "New Model for Economic Development" which prioritizes the promotion of six core strategic industries, namely information and digital technology, cybersecurity, biotech and medical technology, national defense, green and renewable energy, and strategic stockpile industries.

The government's policies which enhance digital growth and resiliency, namely MODA and DIGI+ Taiwan, further aid the development of data center infrastructure in Taiwan. By 2025, the [DIGI+ program](#) is expected to expand Taiwan's digital economy to \$213 billion.

[Taiwan is home to 20 data centers](#), some of which are enterprise. This industry continues to evolve rapidly as digital tools and technologies become more ubiquitous.



[View source](#)

Google's theory of change

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GOOGLE DATA CENTER THEORY OF CHANGE

Google's data center guiding principle

Keep the digital infrastructure secure and sustainable while driving local economic development, fostering thriving communities, and spurring environmental stewardship

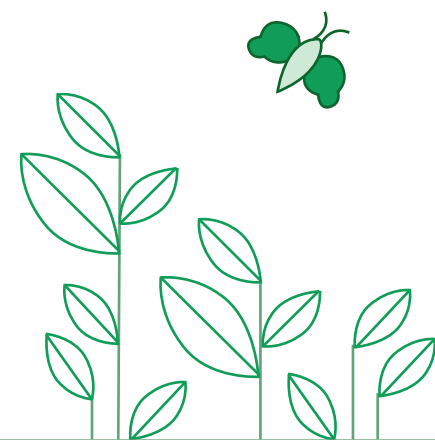
Data centers play an important role in Google's corporate mission to organize the world's information and make it universally accessible and useful. To achieve its mission, Google takes a three-part approach to driving positive change in the communities where its data centers operate.

Economic development: Google seeks to make positive contributions to the communities that host its DCs by working to improve the economic conditions of its employees and suppliers, offering grants, and making investments in local businesses and infrastructure.

Social advancement: Google aims to support higher quality of life in the communities near its DCs by providing high-paying jobs, grants, and educational programming to community members.

Environmental sustainability: Google works to maximize its energy efficiency and reduce water use by investing in energy efficient operations, clean power, and site selection.

These three areas of community development work are interconnected, and the impacts made across each towards community wellbeing must be driven by a cascaded approach from action (e.g., digital upskilling programs), to output (e.g., increased technical abilities in the workforce), to outcome (e.g., increased employability in the workforce).





GOOGLE DATA CENTER THEORY OF CHANGE

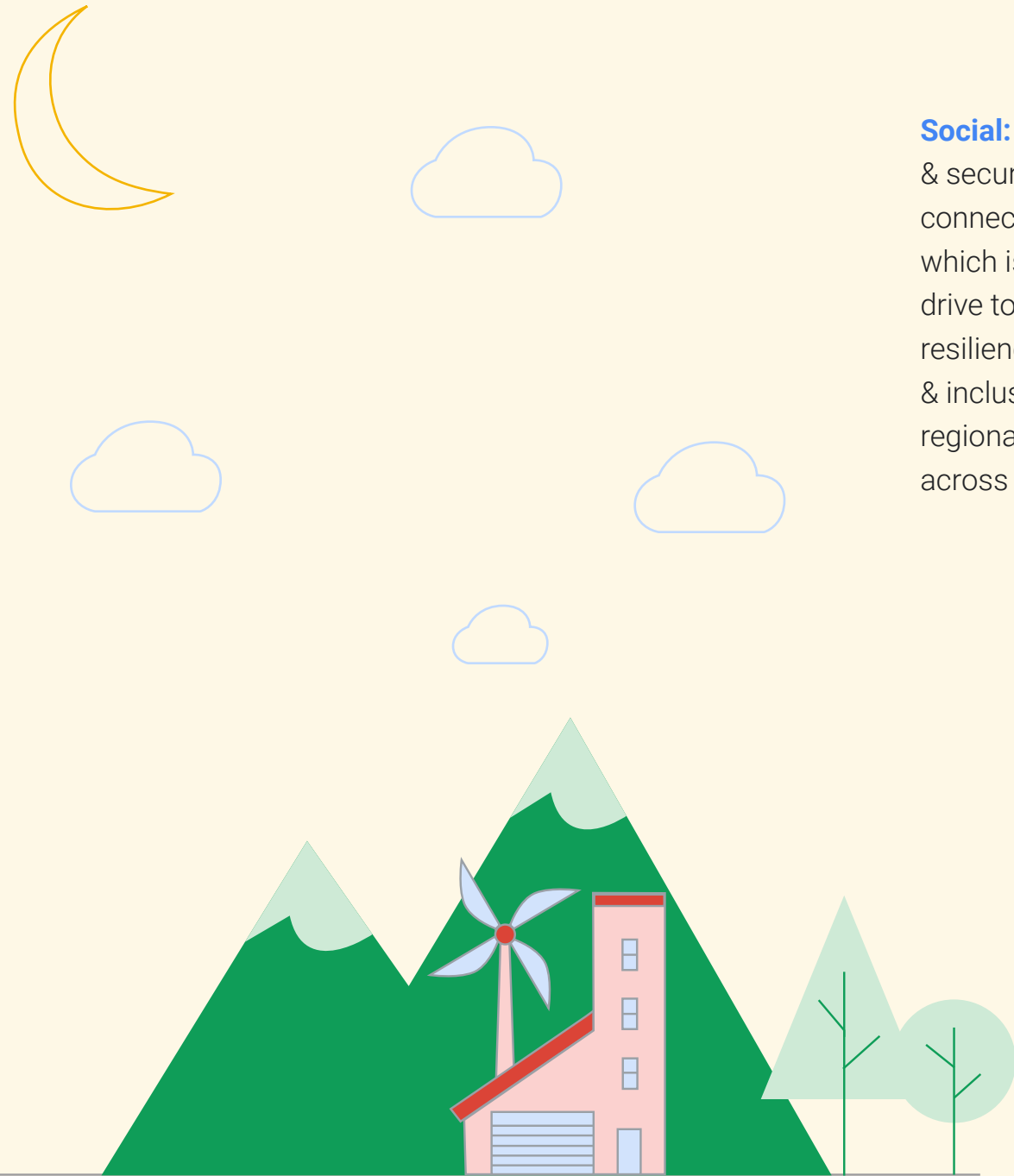
Prioritized topics from stakeholder interviews

This report delves into economic, social, and environmental topics of high importance to stakeholders in Taiwan. By identifying areas of focus according to the values expressed by stakeholders, Google will be able to identify which topics are most important to those stakeholders and reflect unique needs and concerns of individual data center communities.

During 9 semi-guided interviews, participants were asked to assess 13 topics that were deemed relevant to Google's business activities and indicate which they considered most important for Google to consider. Interviewees included trade associations, municipality and state development authorities, universities, public policy makers, educators, and NGOs. Internal stakeholders from teams within Google – such as Energy, Operations, Sustainability, Site Selection, and Public Policy – were also interviewed.

In the course of these stakeholder interviews, the following topics emerged as areas of interest for this report:

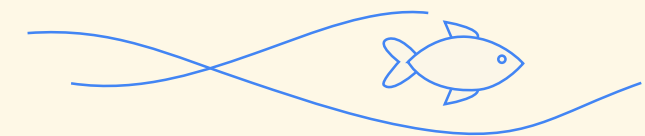
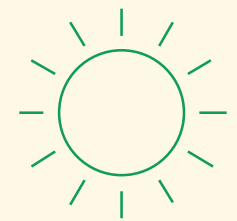
Economic: Stakeholders prioritized impact of data centers on local business as the most important topic, followed by impact on employment. However, tax contribution was a lower priority. This could be driven by the fact that while communities are able to observe impact on jobs and business first-hand, benefits from tax contributions take a while to trickle down to the community and are not immediately visible.



Social: Stakeholders prioritized data privacy & security and digital infrastructure & connectivity as the most top-of-mind topics, which is in line with the government's policy drive towards digital development and resiliency. Stakeholders also prioritize diversity & inclusion, however DEI in Taiwan has had regional nuances as the industry employs across various ethnicities and groups.

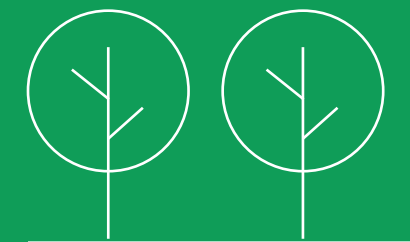
Environmental: Stakeholders prioritized energy use as the most important environmental topic for DCs, followed closely by the impact of their greenhouse gas emissions and water use.

Due to the anonymized nature of these interviews, the directional information about which topics are important to stakeholders reflect broad views on data centers and the data center industry in general, while some are specific to Google as a data center owner and operator.



Keep digital infrastructure secure and sustainable

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KEEP DIGITAL INFRASTRUCTURE SECURE AND SUSTAINABLE

Google's economic, social, and environmental data center impacts in Taiwan

This report provides an overview of how Google's actions are aligned with its work addressing the economic, social, and environmental concerns and priorities for DCs. The first section offers an overview of Google's contributions to the economy in Taiwan. The second section outlines how Google is prioritizing its people, both internally and externally. The third section examines Google's relationship to the environment, including energy use, emissions and water.

Google's contributions to the local economy

Google creates economic opportunities throughout Taiwan both via its contributions to the technology sector and the indirect ripple effects on the local economy. Google's business in Taiwan helps create jobs, develop infrastructure, and generate revenue. However, Google's definition of economic development extends even further. Google also supports technology advancements by housing them in its data centers and by patronizing businesses in other sectors such as construction, manufacturing, or IT equipment resale. Overall, Google's data center in Changhua County positively impacts the economic wellbeing of the area.

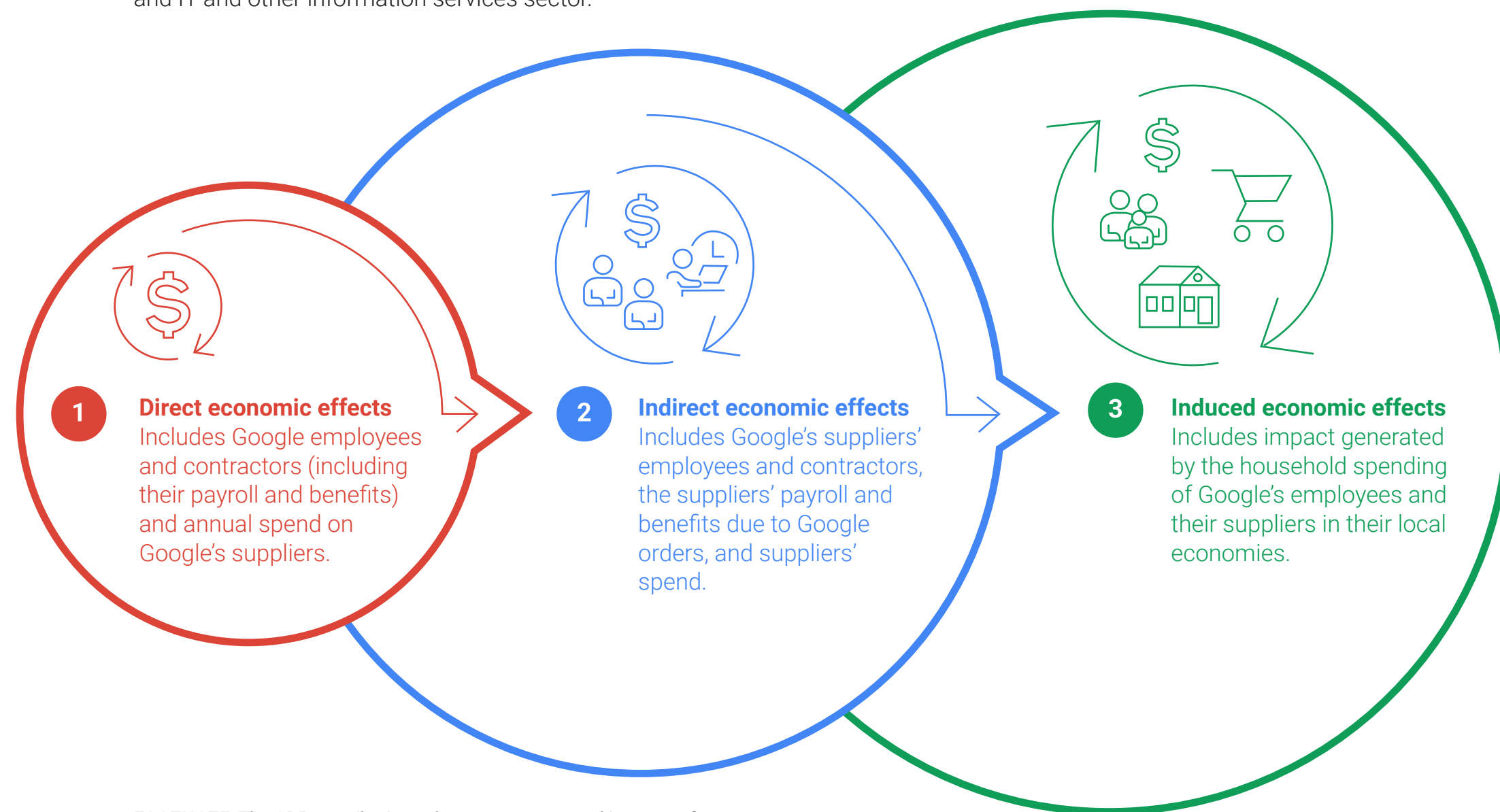
Contribution to Taiwan's GDP: direct, indirect, and induced impact

Data centers necessitate the use of land, highly specialized equipment, servers, and buildings; not to mention the ongoing expenditures that must be made on maintenance and repair, staffing, equipment upgrades, energy, and retaining highly qualified employees.

Between 2017 and 2022, Google's data center investments in Changhua County generated an average of ~\$2.6 billion per year in direct, ~\$1.5 billion in indirect, and ~\$810 million in induced economic impacts, as measured by GDP— ~\$4.9 billion on average, in total, per year and ~\$6.7 billion in total in the most recent year of study, 2022. The direct economic impacts



of these investments include the headcount of Google employees and contractors (including their payroll and benefits) and annual spend on Google's suppliers. Indirect effects include the headcount of Google's suppliers' employees and contractors, the suppliers' payroll and benefits due to Google orders, and suppliers' spend. Induced effects are generated by the household spending of Google's employees and their suppliers in their local economies. Overall, Google's DC construction and operations have had a significant impact on the computer, electronic and optical equipment sector and IT and other information services sector.



FOOTNOTE: The GDP contributions above are represented in terms of nominal values, and no adjustments for inflation have been made.



Direct and indirect impact on employment

Between 2017 and 2022, Google's initial investment and ongoing operations in Changhua County have supported the creation of an average of ~330 direct, ~37,000 indirect and ~9,400 induced jobs per year and \$1.0 billion in direct, indirect and induced impact on labor income. The yearly values vary based on specific investments in the construction of data centers and other large capital projects, and the most recent year of study, 2022, saw ~470 direct jobs supported. The direct jobs created in this time include full-time and part-time positions Google needs to run its data center, such as a Plant Engineer or Operations Manager. The indirect jobs include Google's suppliers' employees and contractors, suppliers' payroll and benefits, and supplier spend. Indirect jobs include, among many others, construction workers, engineers and IT specialists. Lastly, the induced jobs come from Google employees and suppliers' employees spending within their local communities – such as the owner of a restaurant or retailer.

Google's business impact isn't restricted to staying within Taiwan—it has also supported Taiwanese companies in expanding beyond

Taiwan. An example is a Taiwanese computer and server contract manufacturer, one of Google's partners for the Changhua data center. During the multi-year collaboration with Google, the Taiwanese electronic hardware manufacturer expanded internationally to support the global data center industry in general, opening new manufacturing plants in the US and Mexico.

“Google was one of the first multinational companies to invest in setting up ultra-large-scale data centers in Taiwan. It has not only long-term supported Taiwan's innovative R&D environment and technology industry, but also helped Taiwan improve digital resilience, implement energy transformation, and activate the Internet economy in the investment and operation process.”

- Wang Meihua, *Minister of Economic Affairs*

Google

Launched the Google for Startups Cloud Program in 2018 to increase access to its services and benefits.

For each startup Google partnered with, **Google designated up to \$200,000** to cover costs over the course of two years.

Impact on taxes and public budget

Income from taxes provides the government in Changhua County with funds to provide essential services – such as education, healthcare, capital improvements, public safety, parks, and recreation and culture – to its citizens.

Small business spotlight

Small businesses have benefited both from the increased business activity around Google's site and infrastructure development and from Google's online resources. Google launched the Google for Startups Cloud Program in 2018 to increase access to its services and benefits. For each startup Google partnered with, Google designated up to \$200,000 to cover costs over the course of two years. Over 100 Taiwanese startups enrolled in the program between 2020-2022, receiving technical training and business support from Google.

One of the companies supported as part of the Google for Startups Cloud program back in 2018 was [KKday](#), an e-commerce travel

platform. Google helped them to scale by providing cloud credits, technical support and data analytics tools to gain deeper insights into their customer behavior to personalize their offerings.

To continue fostering Taiwan's digital competitiveness, Google places special emphasis on supporting AI startups and offers an extra \$150,000 in cost coverage under the Startup's Cloud Program.

70% of generative AI startups rely on Google's AI capabilities and platforms, including pre-trained machine learning models and tensor processing unit (TPU) chips provided by Google. [\(read article\)](#).

Google has partnered with Diandian Global to create innovative technology, information services, and commercial network solutions to help local businesses. This partnership created a "faster, smart catering retail platform" that has helped 12,000 catering companies increase revenue by an average of 15%.



KEEP DIGITAL INFRASTRUCTURE SECURE AND SUSTAINABLE

Google's commitment to people

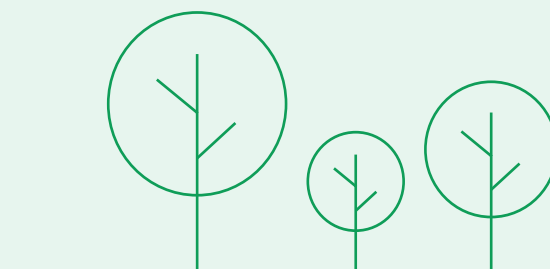
Google is committed to improving the lives of as many people as possible – both internally, for their employees and contractors, and externally, through initiatives like supporting nonprofits. Its goal is to create strong relationships with stakeholders in the communities in which it operates and contribute positively to a higher quality of life for residents.

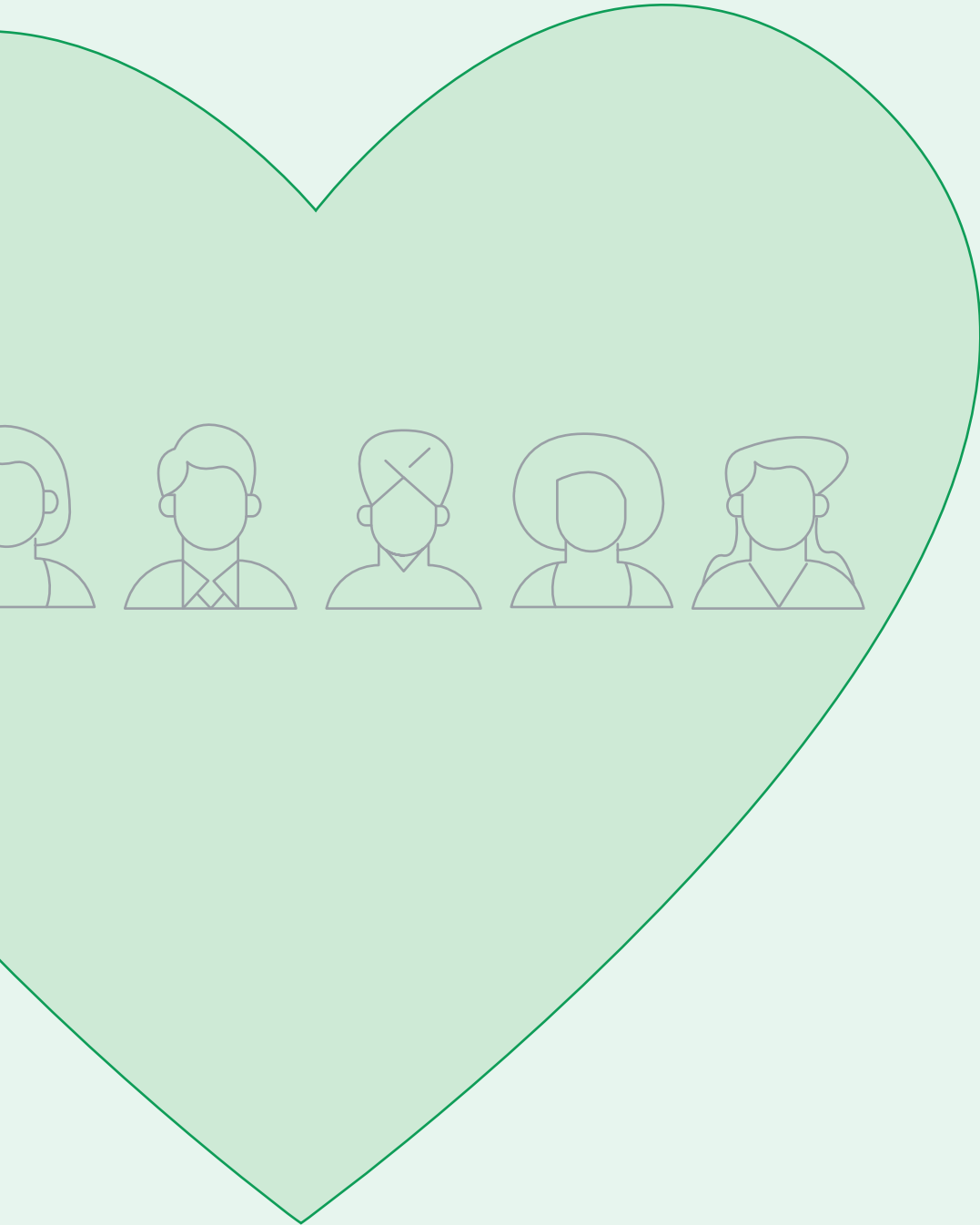
Investing in people at Google

Talented employees from a variety of skill sets and backgrounds are proud to call Google's data centers their place of work. They cite team diversity, culture, and career development opportunities (such as the IT Support Professional Certificate, etc.) as a few reasons for their job satisfaction.

In terms of safety, Google's EHS (environment, health, and safety) requirements are higher than Taiwan's local regulations. Google's requirements include providing protective training and process monitoring to achieve the goal of zero harm to employees and contractors. To date, there have been no permanent injuries on site.

The Changhua County data center provides safety and skills training each year to employees across the APAC region. Training includes courses on facility management, hardware operations, electrical safety, usage





of personal protective equipment (PPE), first aid, and safety procedures to help data center employees familiarize themselves with handling the equipment safely. The trainings also expose employees to systems knowledge such as Python programming and 3D printing. These exercises are continually refined to offer hands-on experiences to data center trainees with machine operations as they begin their full-time roles. This training remains open to current employees seeking to refresh themselves on newer technologies introduced to the data center.

Supporting digital literacy

Taiwan is in the midst of a digital transformation but may be facing a talent gap. 90% of Taiwan employers report they have difficulty in filling open roles, compared to [77% as the global average](#). Where some see obstacles, Google sees potential to usher in a new generation of students to fill professional roles as part of the digital economy. The internet has revolutionized the way Taiwan operates, educates, and acquires knowledge. However, harnessing its complete potential requires the development of digital competencies that can facilitate expansion and

continued innovation. To help Taiwan achieve this, Google's Changhua County data center has awarded more than \$721,000 in grants to educational projects and training programs from 2017-2022.

Google is dedicated to fueling this progress. It is providing the necessary educational support and resources to cultivate a workforce prepared for the future and for businesses to compete on a global scale. The broader theme of Google for Taiwan was building a strong digital economy through investments in education, with partnerships focused on three key areas – Digital Literacy, Digital Learning, and Advancing Knowledge.





Google is raising the quality of education in Taiwan by dedicating an educational team to upskill teachers in under-resourced, rural schools on how to administer these resources. The Changhua County data center sponsored a partnership with the Ministry of Education and Central Taiwan Education Bureau to offer a series of lecture-based trainings for publicly employed teachers in Taiwan. Participating teachers received Chromebooks on loan to provide hands-on opportunities for learning about Google tools. The program offers Educator [Level 1](#) and [Level 2](#) certifications so that teachers can clearly demonstrate their proficiency with Google's classroom tools by the end of the program. The program benefited

over 18,700 educators and Information Communications Technology (ICT) Managers employed in Taiwanese schools.

When the pandemic hit, Taiwanese schools and students were asked to quickly adjust to remote learning. We now know the impact of this change, as [The Asian Development Bank](#) estimated that students in developing Asia lost more than a half year of learning on average. Google recognized the importance of digital access and supported this rapid adaptation. To enable continuous and equitable education,



Google

Between 2019 and 2022 awarded **\$721K** in grants to communities in Taiwan



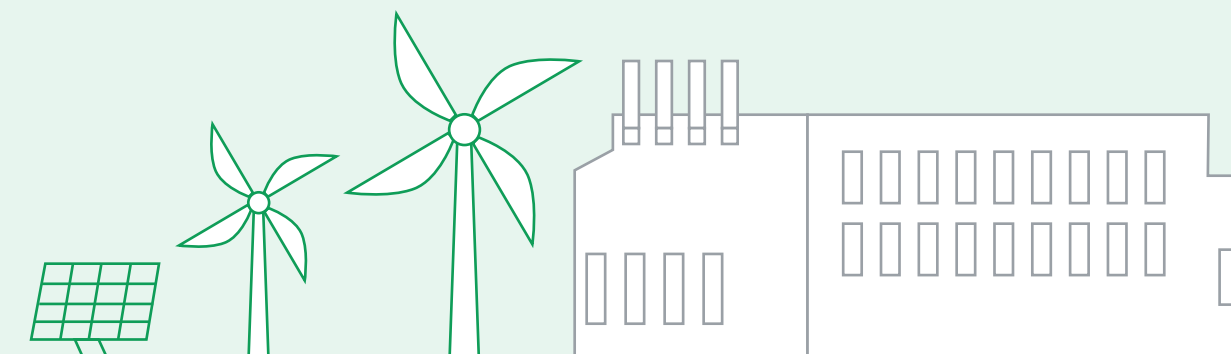
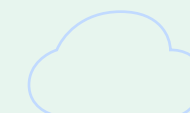


they provided over 80,000 Workspace Education Licenses to 3.5 million Taiwanese students ([85% of all students in Taiwan](#)) and their respective teachers at an 80% discount. Students were able to use Google's suite of online tools to continue learning assignments and attend class virtually through Google Meet.

Students are now back in the classroom, but the Taiwanese government wants to help its teachers continue to improve their ability to use digital tools through programs like the [Cloud Innovation Teacher Training Program](#), an initiative with [Junyi Academy](#) and Taipei City to train 600 teachers from 300 schools. Junyi is also working to incorporate [Google's CS First](#) computer science curriculum in Taiwanese primary schools, so kids can grasp the fundamental technology as part of their education. To cultivate local talent and potential college-level future Google recruits, Google has developed a [Cloud Talent Cradle](#) program

([read article](#)). This program plans to assist 1,500 students across three colleges in obtaining a Google Cloud Foundation certification over the course of three years. Thus far, [more than 100 students](#) have received the certification.

Google understands that educating young students in cutting-edge technology like AI/ML is not just about preparing them for the job market. It's also about fostering innovation, digital literacy, ethics, and problem-solving. It's an investment in Taiwan's competitiveness, technological advancement, and the wellbeing of its citizens.





Strengthening the local community

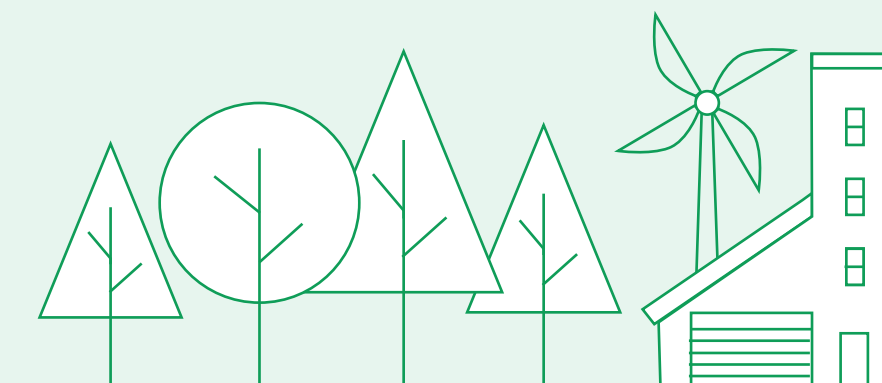
Google's commitment to supporting citizens, local businesses, and nonprofit organizations in Taiwan goes beyond corporate responsibility; it reflects a strategic investment in the region's prosperity and digital advancement. By empowering local businesses, addressing critical societal challenges, and fostering innovation, Google not only strengthens the Taiwanese community, but also solidifies its own presence as a responsible global tech leader. Through these efforts, Google demonstrates the power of corporate citizenship in building sustainable, thriving communities.

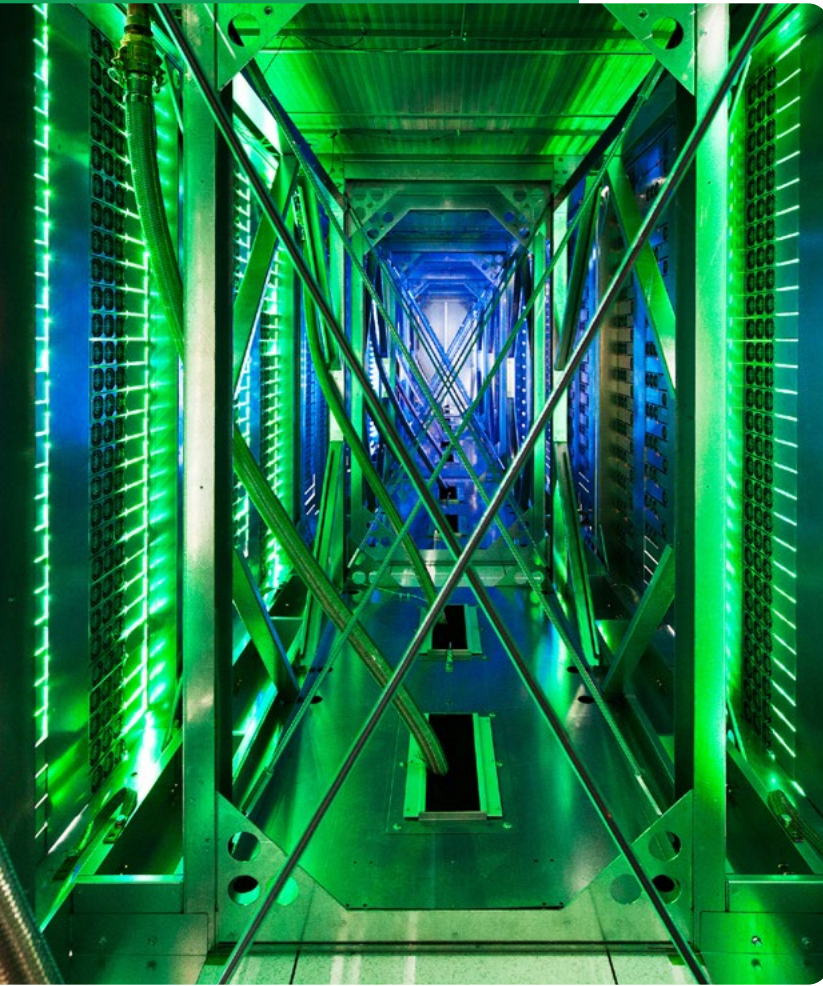
Educating small and medium-sized business (SMB) owners on technical skills can have a range of benefits that contribute to their business growth, efficiency, and overall success. Google's 2021 investments in local

Taiwanese businesses enabled over 150 employees to maintain their current level of employment as the result of their technical training.

Other Taiwan NGO support: Google is supporting the Taiwan Green Charity Energy Association with funding for an energy equity project with a local non-profit, Wang Gong Oyster Cultural Association.

Google is supporting the Association in two major ways. First, it is supporting climate change education for the migrant women employed by the Association to create art from oyster shells. Second, Google is also helping fund the Association's installation of solar panels to assist in Changhua's renewable energy transition and fulfill Google's obligation to data privacy, resiliency, and digital infrastructure.





KEEP DIGITAL INFRASTRUCTURE SECURE AND SUSTAINABLE

Google's data privacy, resiliency, and digital infrastructure

Google specializes in cybersecurity capabilities and services. As such, it takes serious measures to protect the private data its clients trust it to safeguard. Just as Google follows its mission to advance equity by increasing public access to the internet, it must honor its clients' trust by striving to keep their private information safe.

The organizations that trust Google's data centers to protect their private information include small businesses, public organizations, and large corporations. Google works hard to honor this trust with strong security measures, such as requiring Google employees who are not directly employed at a data center to complete a series of security checks before they enter the building. Measures like these might earn data centers a reputation for being secretive, but they are in place for user security and to safeguard the information Google houses for its clients.

Improving digital infrastructure

The speed at which Google is able to transport data across great distances to enable business operations to run without interruption is made possible by its digital infrastructure. The Google Cloud network consists of fiber optic cables under land and sea, and cloud regions around the world.

Google has made investments in improving local and subsea connectivity in Taiwan through submarine cable systems like Faster, PLCN, Apricot, and Taiwan-Philippines-U.S. (TPU).





Supporting local resiliency

Google fulfills the requirements of the Taiwanese government for local resiliency to ensure the stability and security of its contributions to digital infrastructure. The Changhua cloud region supports highly regulated sectors by providing local backups or data residency in Taiwan, ensuring that they meet local compliance requirements. Customers can still connect to Google Cloud's globally distributed cloud regions where permitted by regulations, enabling them to build redundancy for their data.

Google also recognizes that customers' data is theirs alone, and they have a responsibility to guarantee the privacy of their data. The protection of data is a primary design consideration for all infrastructure, products, and personnel operations run by Google. Workloads using Google Cloud services and Google Workspace align with the requirements of the [Personal Data Protection Act \(PDPA\)](#), and fully adhere to data protection obligations covering the collection, use, and disclosure of personal data.

Because protecting data is core to Google's business, Google makes extensive investments in security, resources, and expertise every year. This also frees regulators and customers to focus on their business and innovation. Data protection and privacy is more than just security. Google's strong contractual mechanisms help ensure customers maintain control over their data and how it is processed. This includes the assurance that their data is not used for advertising or any purpose other than to deliver Google Cloud services.

For these and additional reasons, over 5 million organizations across the globe, including 64% of Fortune 500 companies, trust Google with their most valuable asset: their information. Google will continue to invest in its platform to allow Taiwan to benefit from its services in a secure and transparent manner that allows global business operations to run without interruption.

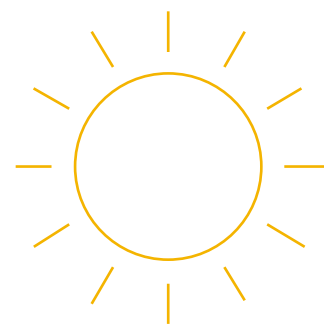




KEEP DIGITAL INFRASTRUCTURE SECURE AND SUSTAINABLE

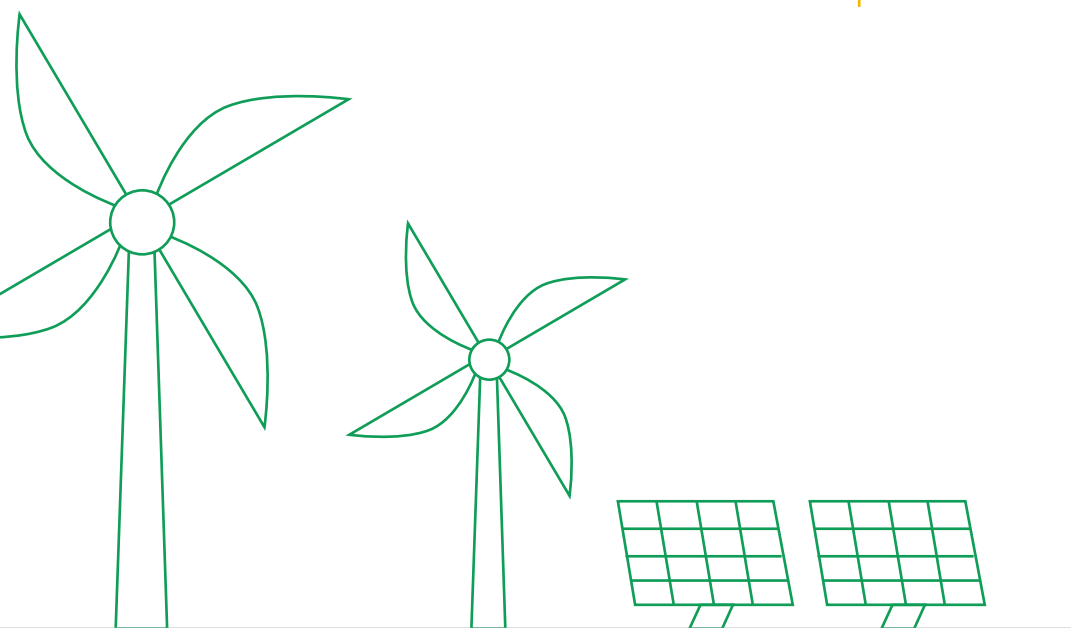
Google's impact on the environment

The following section includes the impact of Google data centers on energy use, greenhouse gas emissions and water use. In cases where some data was not included, it is due to regulatory, competitive, or data quality considerations. As the ability to do so changes, future impact assessments will reflect Google's capability to share additional information.



Google is undertaking efforts to minimize the necessary impacts its Changhua County data center presence has on the environment. One such effort is that Google is aiming to run [24/7 carbon-free energy at all data centers on every grid where it operates](#). Additionally, Google has pledged to [replenish 120% of freshwater volume consumed, on average, by 2030](#).

As a collective, these actions aim to reduce the demand on finite resources, improve the health and wellbeing of local community members and can serve as a catalyst for the transition to sustainable business growth.



Why do data centers need energy?

The process of storing data, processing data, and networking can be highly energy intensive. At present, data centers account for about [1–1.5% of global electricity use](#). A majority of this energy demand comes from a need to source power for data servers. As data servers run they produce heat and need to be cooled, which generates additional energy demand.

In 2022, Google [matched 100% of its annual electricity consumption with renewable energy](#) purchases globally for the sixth consecutive year. Google has also made the goal to [run on 24/7 carbon-free energy \(CFE\) on every grid where it operates by 2030](#). In pursuit of this goal, Google is investing in wind, solar, and next generation clean energy technologies to reduce fossil-based energy use in the areas where data centers operate.

The energy market in Taiwan

Taiwan's energy market has evolved significantly in recent years. Due to the country's growth, energy demand has been met primarily by fossil fuels like coal and gas. In 2020, Taiwan was listed as one of the [top 10 most challenging markets](#) to source renewable





electricity. There is a strong dependency on imports, as [~97% of Taiwan's energy is imported](#), and in 2022 consisted mainly ([~80%](#)) of oil, gas and coal.

Considering this imbalance, the Ministry of Economic Affairs has declared plans for grid resilience and sustainability, targeting to generate 20% from renewables by 2026 (Currently Google's [CFE% in Taiwan is 18%](#)).

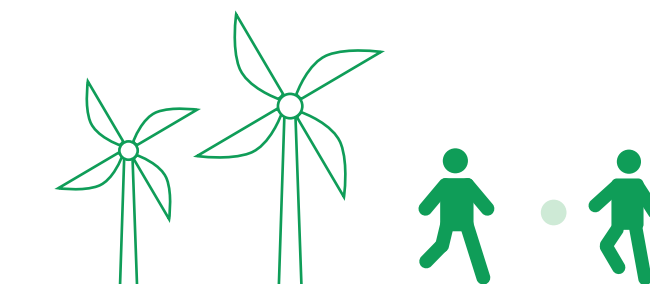
Google's efforts to reduce its energy impact

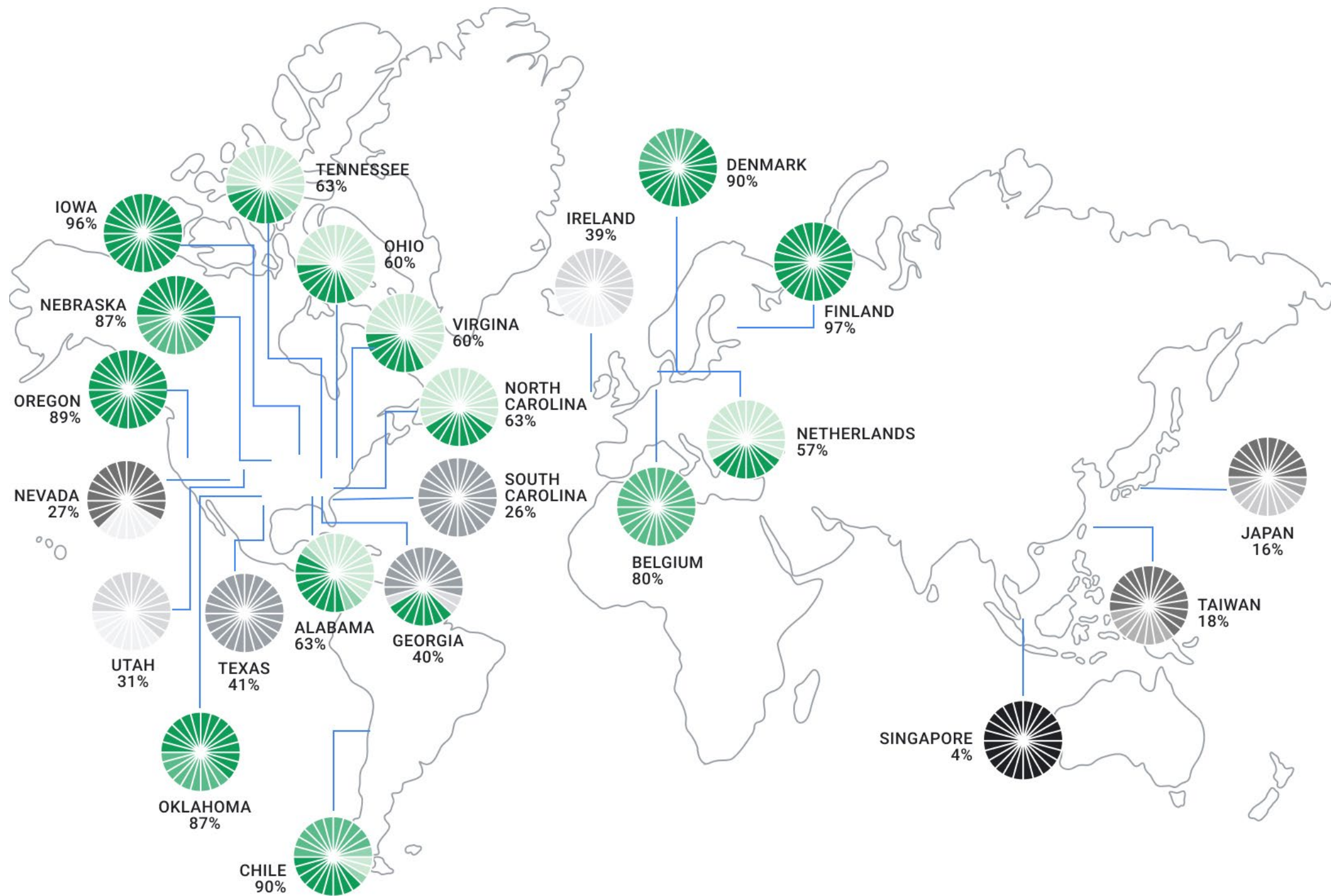
Google uses energy-efficient design, smart management operations, and carbon-free energy sourcing to support the growth of renewable energy and reduce energy consumption.

In 2019, Google signed a long-term agreement to purchase the output of a solar array (part of a larger solar farm) in Tainan City. This deal was a result of collaboration between Google, industry stakeholders, and the Taiwanese government—which amended Taiwan's Electricity Act to allow non-utility companies to directly buy renewable energy and decrease its carbon footprint. Google was the first corporate power purchaser to act on this change.

To cut greenhouse gas emissions from its electricity use and purchases, Google followed up on this act in 2020 by setting a global goal to run on [24/7 carbon-free energy](#) on every grid where it operates, by 2030. While Power Purchase Agreements (PPAs) and Renewable Energy Certificates (RECs) are tools that contribute towards developing a greener electricity grid, they do not ensure that the total energy consumed by an organization comes from low-carbon sources. New types of energy contracts and advanced clean energy technologies will also be needed.

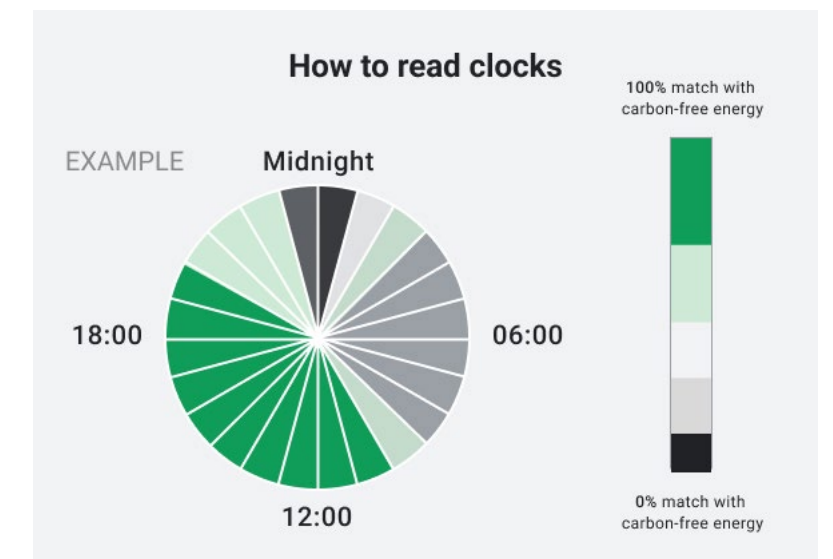
FOOTNOTE: Google defines [carbon-free energy](#) as any type of electricity generation that doesn't directly emit carbon dioxide, including (but not limited to) solar, wind, geothermal, hydropower, and nuclear. Sustainable biomass and carbon capture and storage (CCS) are special cases considered on a case-by-case basis, but are often also considered carbon-free energy sources.





Energy efficient design

As of 2022, Google's owned-and-operated data centers globally are, on average, more than [1.5 times as energy efficient](#) as a typical enterprise data center and compared with five years ago, they now deliver approximately three times as much computing power per unit of electrical power. In 2022, data center Power Usage Effectiveness (PUE) at Google's [Changhua County location](#) was [1.12](#), a 0.43 improvement over the global industry average of 1.55.



FOOTNOTE: PUE is determined by dividing the total amount of power that enters a data center by the portion of that power used to run the data center's IT equipment. PUE is expressed as a ratio, with overall efficiency improving as the quotient decreases toward 1.0. Google calculates PUE in line with ISO/IEC 30134-2 Standard for Power Usage Effectiveness.



Google uses a [carbon-intelligent computing platform](#), first announced in 2020, to shift certain computing tasks and their associated energy consumption – such as processing a video uploaded to YouTube – to times and places in which carbon-free energy is available on the grid. Google also utilizes a [task-shifting capability for demand response](#) to reduce data center electricity consumption during periods of high stress on the local or regional energy grid, temporarily reducing power consumption to provide valuable flexibility when it is needed, so that local grids continue operating reliably and efficiently.

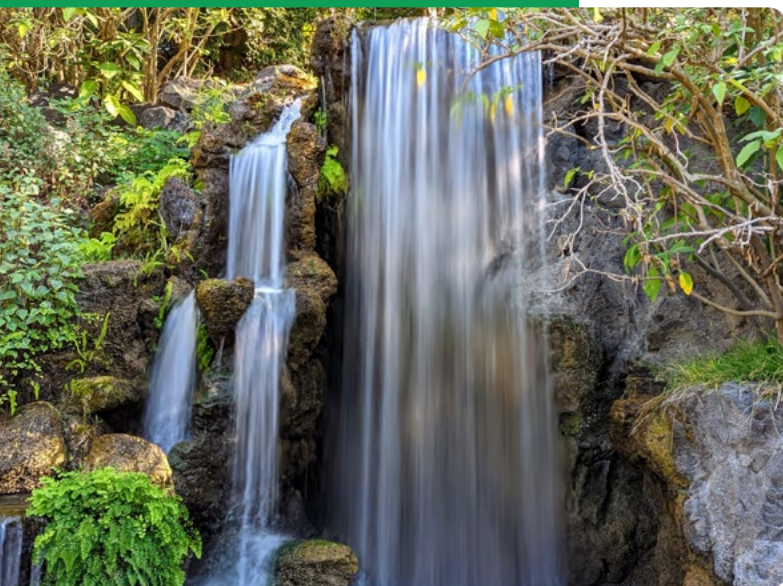
As Google developed this compute-based demand response capability, they have continuously tested it alongside partners across different regional contexts, including Taiwan. In the region, geographic constraints of an islanded grid can lead to grid reliability issues, especially in the summer months.

In both summers of 2022 and 2023, Google supported a grid reliability program run by the [Taiwan Power Company](#) by reducing data center power consumption daily during peak hours, when energy supply margins were typically lower in order to increase power availability and reduce the potential for blackouts.

Moreover, Google has designed and implemented highly efficient Tensor Processing Units and has outfitted its facilities with high-performance servers – including smart temperature, lighting, and cooling controls. These measures have promoted even [more efficient energy use at Google's data centers](#).

Greenhouse gas emissions reduction

In 2021, Google [set a goal to achieve net-zero emissions](#) across the entirety of its operations and value chain globally by 2030. To accomplish this, Google aims to reduce its combined Scope 1, Scope 2 (market-based),



and Scope 3 absolute emissions by 50% against a 2019 baseline before 2030. It also plans to invest in nature- and technology-based carbon removal solutions that will neutralize its remaining emissions. Google has formally committed to seek out the Science Based Targets initiative's (SBTi) validation of its absolute emissions reduction target.

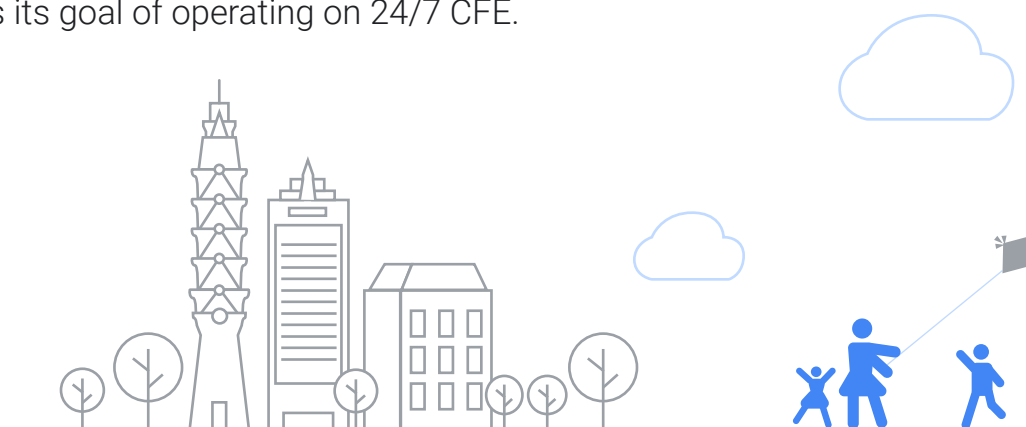
In 2022, Google's total global Scope 1, Scope 2 (market-based), and Scope 3 greenhouse gas emissions were [10.2 million metric tons](#), and the 24% of that total (2.5 million metric tons) that are Scope 2 emissions are mainly due to the electricity demands of data centers.

FOOTNOTE: Scope 1 emissions are direct emissions from company-owned and controlled resources. Scope 2 emissions are indirect emissions from the generation of purchased energy and cooling, such as from a utility provider. The market-based method of calculating Scope 2 emissions incorporates Google's renewable energy purchases via contractual mechanisms like power purchase agreements (PPAs). Scope 3 emissions are all indirect emissions – not included in Scope 2 – that occur in the value chain of the reporting company.

Water stewardship

Data centers are similar to personal devices like laptops in that as they run, they generate heat – though they do so on a much larger scale. In order to keep the servers and chips from overheating, large industrial cooling systems are used to remove heat from the data center. At present, the cooling solutions for data centers include air-cooling, water-cooling, or a combination of these technologies. There is no one-size-fits-all approach to cooling a data center. The best solution for a specific DC depends on local factors like climate as well as availability of carbon free energy and water.

Water-based cooling enables Google to lower its electricity demand, accelerating progress towards its goal of operating on 24/7 CFE.





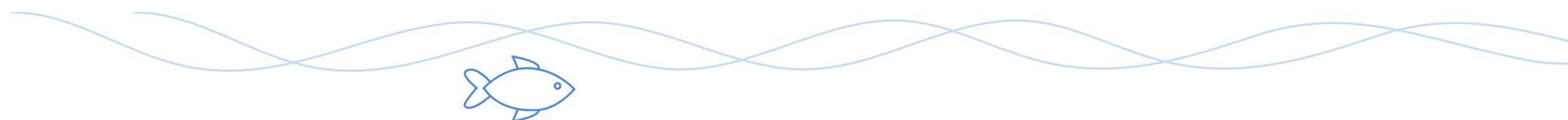
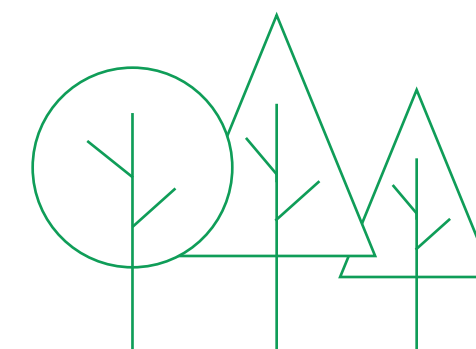
It also lowers its impact on the local energy grid and allows Google to maintain industry-leading Power Usage Effectiveness. However, water-based cooling must be deployed responsibly.

Before selecting a site for a new data center and identifying the optimal cooling solution, Google assesses the local watershed's depletion and water scarcity risk, incorporating the site's potential impact. Water-cooling is determined to be responsible and resilient at sites that return favorable assessments for both metrics, underscoring the importance of water stewardship and resilience during site selection and facility design. Once operational, Google continues to monitor these metrics to manage future risks and proactively develop strategies to mitigate them.

To advance responsible use, Google also proactively looks for alternate sources of water in regions facing water stress or higher water

risk. In 2022, Google transitioned to [the use of industrial water for cooling](#) at its data center in Changhua County, reducing demand on the potable water system used to serve the general public. Since completing this transition in April 2023, over 95% of the water typically withdrawn by Google's data center is from a non-potable source. The facility also treats the cooling system's wastewater discharge before returning it to the local watershed, complying with local discharge limitations to minimize the impact on local water quality.

In 2021, Google set a [goal to replenish more freshwater than it consumes globally by 2030](#) and to take action toward further supporting water security in the communities where it operates. Achieving these goals would mean that Google replenishes 120% of the freshwater volume it consumes annually, on average, across all of its offices and data centers globally.



Conclusion

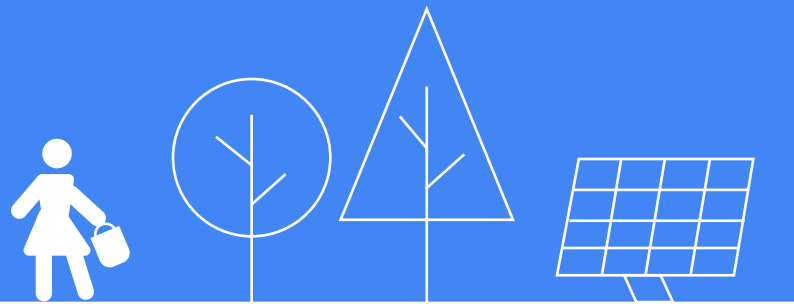
This report provided an overview of the economic, environmental and social impact of Google's data center in Taiwan from 2017-2022, and some of the actions it is taking to scale the positive impacts and minimize the negative impacts.


Data centers are essential for the transition to a more digitized economy. From 2017-2022, Google's data centers have had an economic impact of ~\$4.9 billion in contributions to GDP annually. Google.org has awarded \$721,000 in grants to help strengthen STEM education programs, advance digital literacy, provide digital training to develop talent, and offer COVID-19 support to teachers and students. Google has made investments in environmental sustainability, which can be seen in its [renewable energy purchasing](#) and [Power Usage Effectiveness \(PUE\)](#).

In alignment with the Theory of Change, Google aims to keep digital infrastructure secure and sustainable while driving local economic development, fostering thriving communities, and spurring environmental stewardship. These three areas (economic, social, and environmental) are interconnected, and collectively impact community wellbeing.

One generally accepted way to measure community-wellbeing is through the Organization for Economic Co-operation and Development (OECD) Better Life Index. This index assesses wellbeing across a range of topics and indicators that the OECD has identified as essential in the areas of material living conditions and overall quality of life. The OECD Better Life Index is a way to frame the overall impact that Google data centers may have on the communities in which they operate.

Of the eleven topics measured and weighted equally by the OECD Better Life Index, Google data centers might influence four. It is important for Google to recognize that over one-third of the wellbeing measure in a community could be driven by its actions.






With deliberate action going forward, Google data centers can positively influence the following topics: Income (measured by Household net adjusted disposable income and Household net wealth), Jobs (measured by Labor market insecurity, Employment rate, Long-term unemployment rate and Personal earnings), Education (measured by Educational attainment, Student skills, Years in education) and Environment (measured by Air pollution and Water quality).

Although Google has made investments in environmental sustainability, there are still emissions from its data center operations. Google aims to achieve [net-zero emissions across its operations and value chain by 2030](#). Google is working towards this in Taiwan by investing in local renewable energy capacity and optimizing the balance between water usage and energy usage.

As the capacity required to meet the needs of a more digital future grows, so will the digital infrastructure needed to enable it. While any expansion will increase GDP and add jobs,

Google can channel its impact by using local contractors where possible, formalizing relationships with employment agencies to shape programs that address digital skill talent gaps and continuing to use Grow with Google for career certification and for small businesses.

Google is passionate about being a good neighbor. As such, it is critical for Google to continue addressing local opportunities and challenges, which is dependent on engagement from local stakeholders, investment in collecting and sharing reliable data when possible, and a continued, proactive strategy. Google will also continue to monitor its economic, social, and environmental impacts at the local level through robust data and consistent adherence to its Theory of Change. Filtering decisions related to data center investments and operations through this lens will create a secure and sustainable internet.



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APPENDICES

Glossary

The topics as defined below were used to assess regional priorities in the interviews conducted to inform this study.

Economic topic	Definitions
Employment creation	Number of jobs - direct, indirect or induced - that are created as a result of a data center operator's employment opportunities and workforce upskilling programs, as well as induced workforce outcomes.
Contribution to local businesses & industry sectors	Contracts with local businesses, adjacent sectors supported, and other positive or negative externalities related to data center operators' engagements around a point of presence.
Contribution to tax income	National & local taxes on data center land use, equipment, and other taxed activities paid to governments.
Social topic	Definitions
Education	Local educational programs supported and financed through a data center operator's investments and partnerships.
Employee health & wellbeing	Physical safety protection and mental support provided to data center employees and contractors.
Diversity, equity & inclusion	Support, development, and/or empowerment of talent from vulnerable and historically under-represented groups in a way that supports equal access.
Contribution to digital infrastructure & connectivity	Investments in local digital infrastructure, cabling and connectivity.
Contribution to data privacy & cybersecurity	Reinforced data security and reliability as a result of a data center's adherence to high privacy and cybersecurity standards.

Environmental topic	Definitions
Emissions reduction	Efforts to change energy consumption and other drivers of emissions (i.e., greenhouse gases) resulting from data center operations.
Energy use & impact on grid	Use of non-renewable or renewable energy impacting energy prices, capacity, and regional grid, and efforts to reduce the amount of energy used through operations.
Waste recycling & sustainable materials	Waste produced from data center equipment and operations as generated, recycled, or reduced through the employment of sustainable materials.
Water usage & treatment	The withdrawal, consumption, and discharge of water in operations, including impacts to local water quality.
Biodiversity & land preservation	The impacts of a data center's physical presence and operations on natural resources, including deforestation, species impacted, and restoration programs.



Glossary

Acronyms

AI	artificial intelligence	MW	megawatt
CDN	content delivery network	MWh	megawatt-hour
CFE	carbon-free energy	NGO	non-governmental organization
CO₂e	carbon dioxide equivalent	OSHA	Occupational Safety and Health Act
CS	computer science	POP	point of presence
dBA	A-weighted decibel	PPA	power purchase agreement
DC	data center	PUE	power usage effectiveness
DEI	diversity, equity, inclusion	RCM	reliability-centered maintenance
ESG	environmental, social and governance	REC	renewable energy certificate / credit
GCP	Google Cloud Platform	SDM	space division multiplexing
GDP	gross domestic product	SROI	social return on investment
GHG	greenhouse gas	STEM	science, technology, engineering and mathematics
HVAC	heating, ventilation, and air conditioning	tCO₂e	metric tons of carbon dioxide equivalent
IT	information technology	UX	user experience
ML	machine learning	WUE	water usage effectiveness



APPENDICES

Methodology

Direct, indirect, induced economic impact calculations – input-output models and assumptions

To calculate economic impacts, this report uses an input-output model developed by IMPLAN. IMPLAN defines input-output analysis as “A means of examining inter-industry relationships within an economy. It captures all monetary market transactions between industries in a given time period. The resulting mathematical formulae allow for examinations of the effects of a change in one or several economic activities on an entire economy (impact analysis).” For more information on IMPLAN, and their assumptions made as part of their input-output analyses, refer to the articles on [Input-Output Analysis and Assumptions](#) and [Detailed Key Assumptions of IMPLAN & Input-Output Analysis](#).

Based on IMPLAN's input-output tables, a set of multipliers that reflects the capital investments and operating expenditures from Google's data centers were created to derive GDP, employment and labor income multipliers.

As part of this analysis, the following industries were considered: Advertising, public relations and related services, Air transportation, Air travel, Automobile manufacturing, Broadcast and wireless communications equipment manufacturing, Business support services, Commercial and industrial machinery and equipment rental and leasing, Computer terminals and other computer peripheral equipment manufacturing, Construction of new power and communication structures, Electric power transmission and distribution, Electronic and precision equipment repair and maintenance, Electronic computer manufacturing, Employment services, Facilities support services, Ground travel, Hotels and motels, including casino hotels, Legal services, Maintenance and repair construction of nonresidential structures, Management consulting services, Monetary authorities



and depository credit intermediation, Office administrative services, Office supplies manufacturing (excluding paper), Other amusement and recreation industries, Other computer related services, including facilities management, Other electronic component manufacturing, Other snack food manufacturing, Postal service, Rail travel, Real estate & rental/leasing, Retail, Transit and ground passenger transportation, Utilities, Wired telecommunications carriers, Wireless telecommunications carriers, Wood office furniture manufacturing.

OECD better life index

This report investigates how the presence of Google's data centers have affected the economic, social and environmental conditions in the country. In addition to the set of indicators outlined throughout the report, it also considers the [OECD Better Life Index](#) as a method of measuring the overall well-being of a community. The OECD Better Life

Index includes the following eleven topics (and indicators): Housing (Housing expenditure, Dwellings with basic facilities, Rooms per person), Income (Household net wealth, Household net adjusted disposable income), Jobs (Job security, Personal earnings, Long-term unemployment rate, Employment rate), Community (Quality of support network), Education (Years in education, Student skills, Educational attainment), Environment (Water quality, Air pollution), Civic Engagement (Stakeholder engagement for developing regulations, Voter turnout), Health (Self-reported health, Life expectancy), Life Satisfaction (Life satisfaction), Safety (Homicide rate, Feeling safe walking alone at night), Work-Life Balance (Time devoted to leisure and personal care, Employees working very long hours).

Thank you

To the many individuals across Google and Deloitte who made this report possible.
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DISCLAIMER: This report ("Report") was prepared by Deloitte Consulting LLP ("Deloitte") for Google LLC ("Google") during the period of May 2023 to December 2023. The purpose of the report is to assess the social, environmental and economic impacts of Google data centers in Changhua County, Taiwan from the years of 2017-2022. The modeling, analysis and results shown as part of the Report are based on information provided directly by Google LLC, publicly available information and third-party information. Any revisions to those data will affect the assessments shown as part of the Report. In preparing this Report, Deloitte has, without independent verification, relied on the accuracy of information made available by Google. Where information has been obtained from third-party sources and proprietary research, this is clearly referenced.