



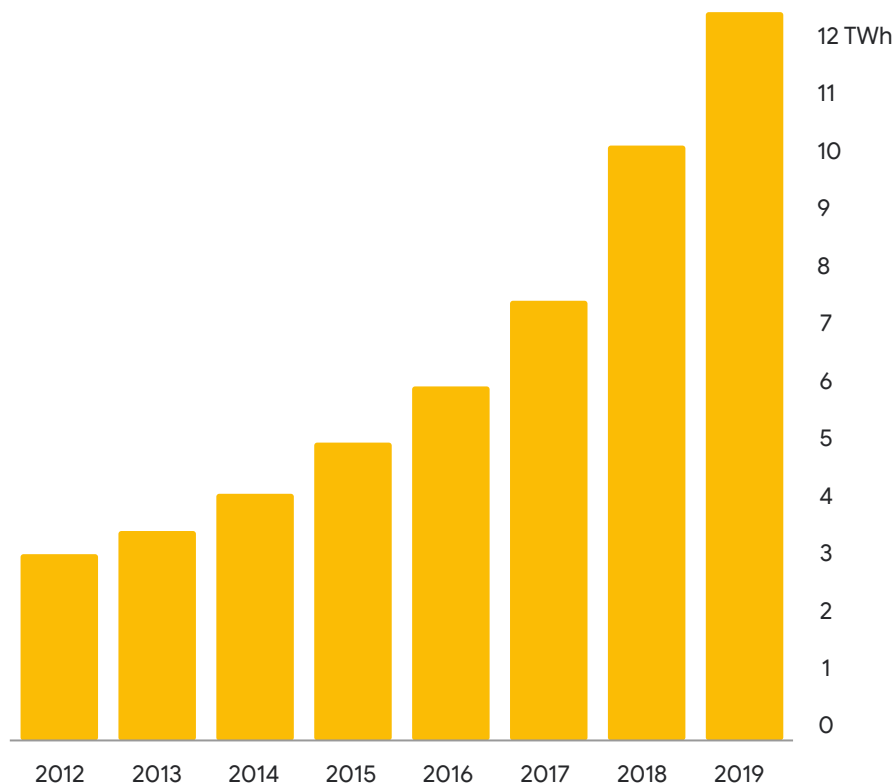
Google

# Google's Path to 24/7 Carbon-Free Energy

Maud Texier, ESIG Fall Workshop,  
October 13th, 2020

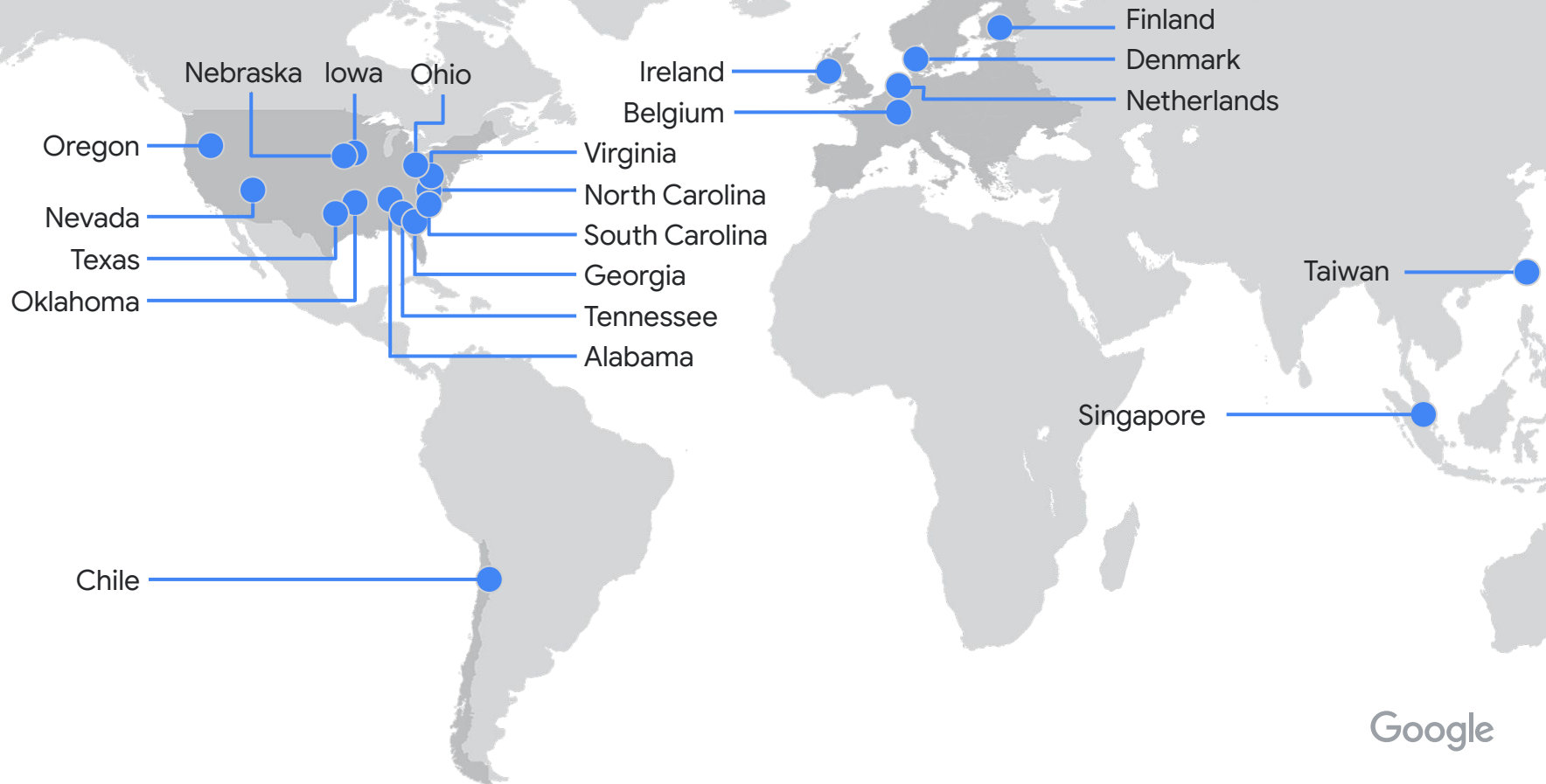
## Google's annual electricity consumption

Demand for our services is growing every year, driving continued growth in our energy use

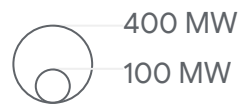


● Total electricity consumption (TWh)

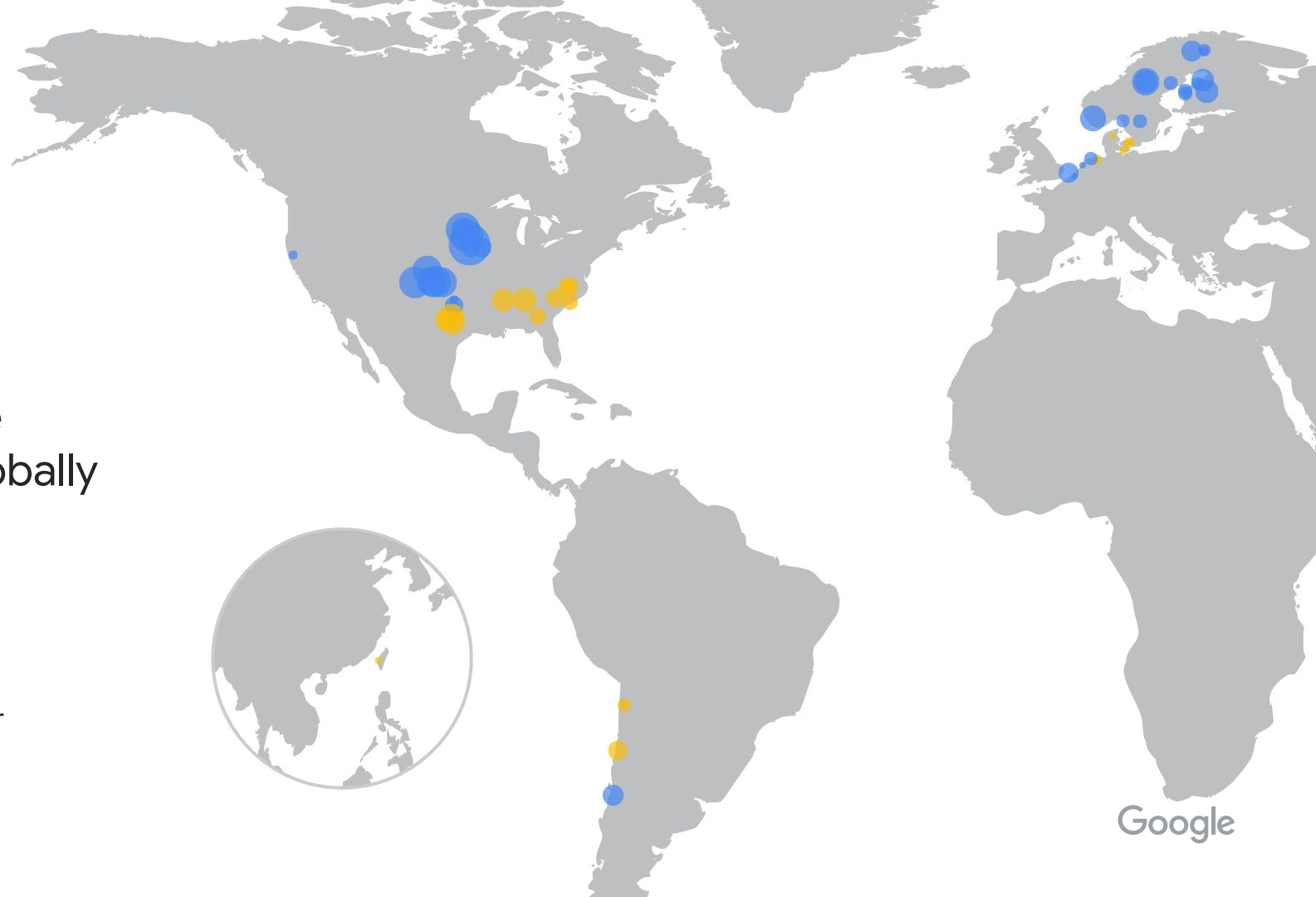
# Google Data Centers



# More than 5 GW of renewable energy globally

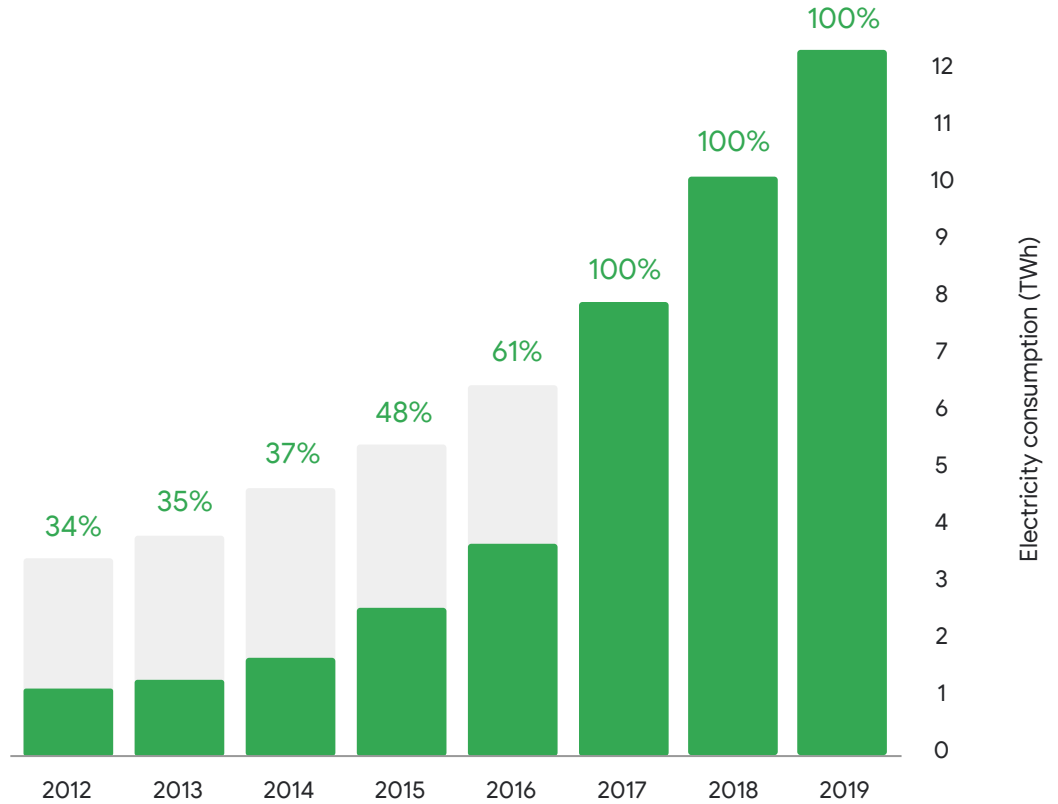


● Wind ● Solar



# Renewable energy purchasing compared with total electricity use

- Total electricity consumption
- Renewable energy

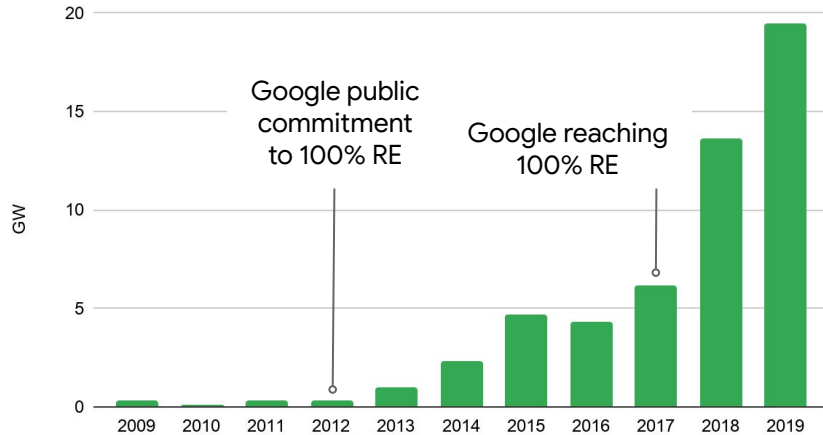


# Google has led the path for 100% renewable energy and corporate PPAs

Google was the first corporation to develop PPAs at scale and reach a 100% target...

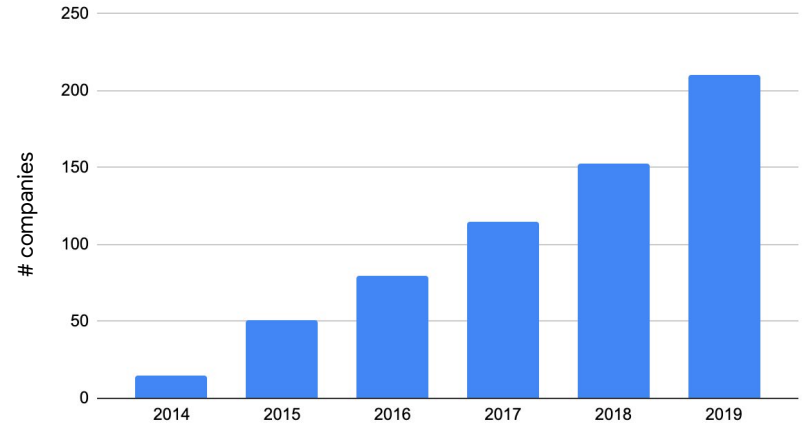
...Since then, many other corporations have followed suit and are on their own path to 100%

Global Corporate PPA Volumes



Source: Bloomberg New Energy Finance

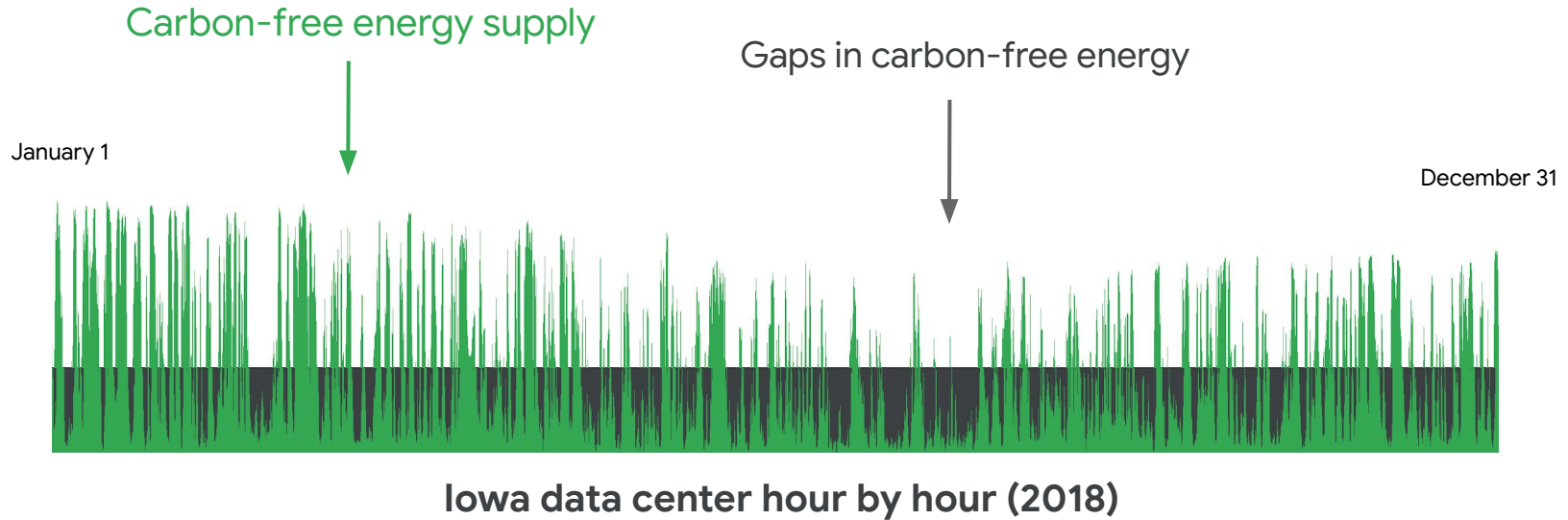
Number of companies with "RE100" pledges



Source: RE100 2019 Annual Report

# ...but 100% RE does not fundamentally solve the problem

*Due to the variability associated with renewables, we still rely heavily on coal and gas from the grid during periods of low wind or solar*



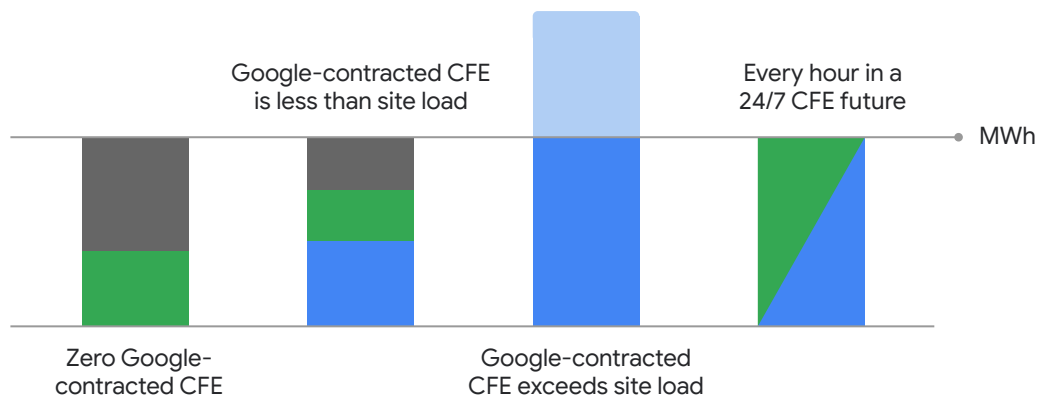
A world map with a green overlay. Numerous small white dots are scattered across the map, representing various locations. The text is overlaid on the map.

24/7 Carbon-Free Energy

By 2030, we intend to source carbon-free energy for Google's operations in all places, at all times

# Hourly scenarios in our carbon-free energy framework

- Grid carbon-based energy
- Grid carbon-free energy (CFE)
- Google-contracted CFE
- Excess Google-contracted CFE



# Example 24/7 CFE calculations by hour

For each hour in the year and for each Regional Grid

When  $MWh_{load}$  is greater than  $MWh_{CFE}$

$$\text{Google CFE} = ( MWh_{CFE} + (MWh_{Load} - MWh_{CFE}) \times CFE_{Grid} ) / MWh_{Load}$$

MWh CFE  
delivered

Net difference of remaining load  
not covered from CFE deliveries

**Example calculation (1 hr):**

CFE Volume = 15 MWh

Load = 35 MWh

Grid CFE = 60%

$27 \text{ MWh} = 15 \text{ MWh} + (35 \text{ MWh} - 15 \text{ MWh}) \times 60\%$

Google CFE for example hour =  $27/35 = 77\%$

**When  $MWh_{PPAs} > MWh_{Load}$ :**

CFE Volume = 40 MWh

Load = 35 MWh

Grid CFE = 60%

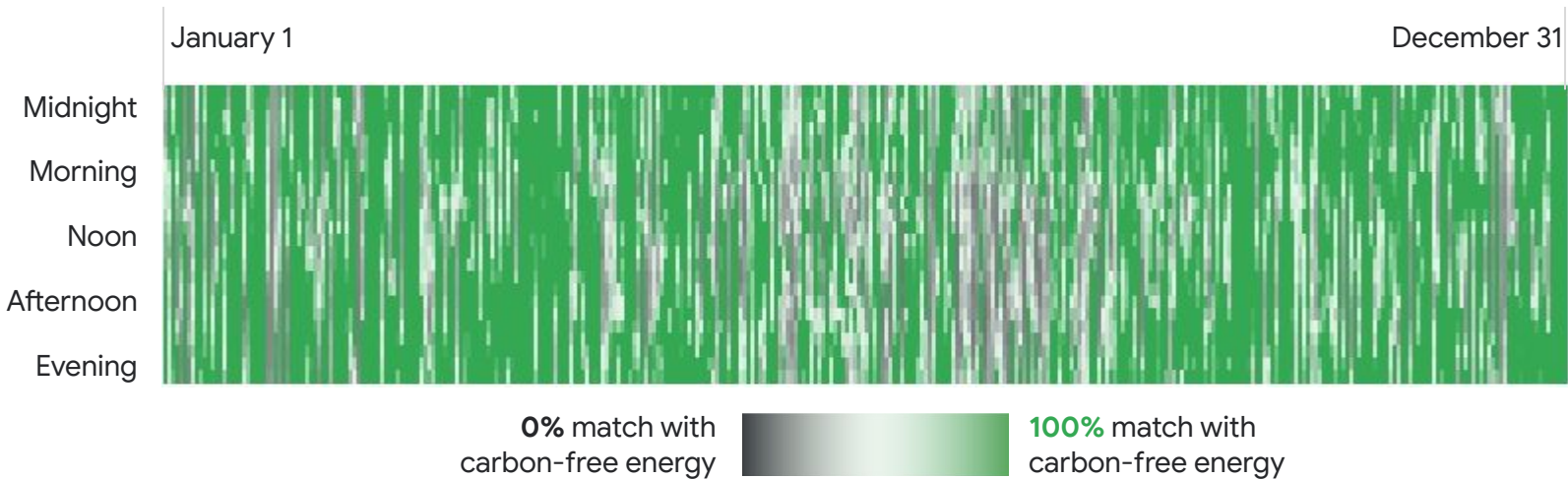
Google CFE = 100%

5 MWh of "excess CFE" (40 - 35 MWh)

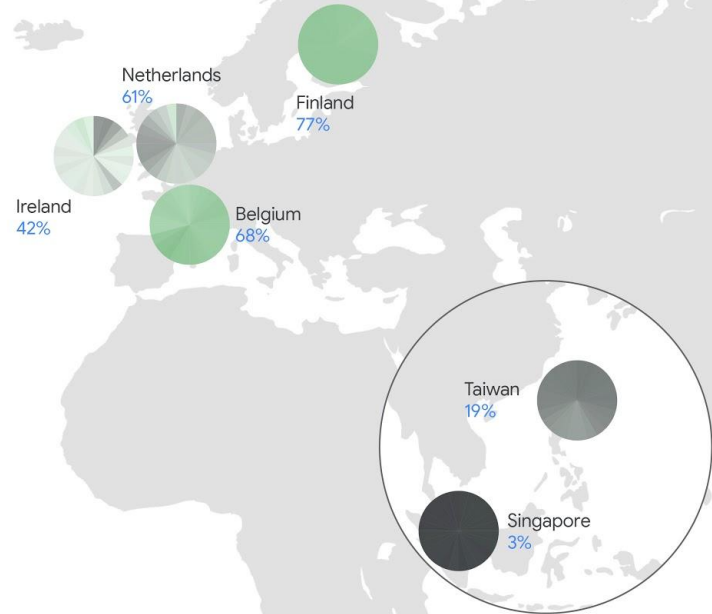
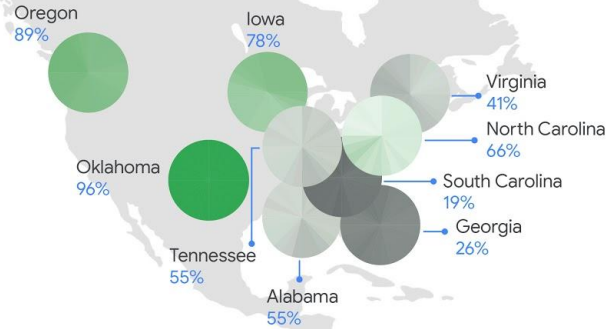
78%  
carbon-free  
energy

# Every hour of electricity use at our Iowa data center in 2019

Heat map includes contribution from grid CFE and Google's wind energy PPAs in MISO



# Where we stand currently



100% match with carbon-free energy



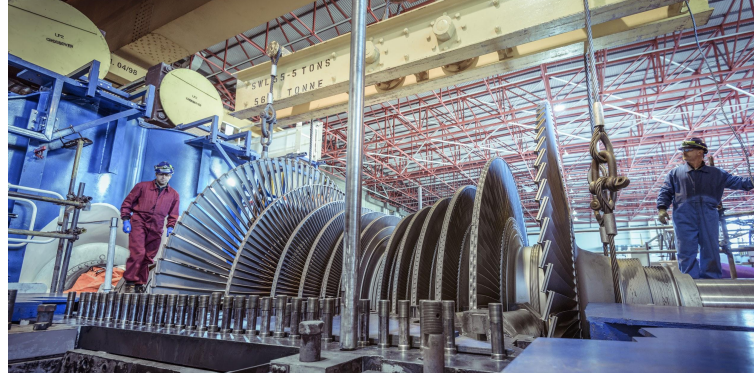
0% match with carbon-free energy



Globally, performance currently varies across sites; our global hourly clean energy average is **61%**

# Why 2030?

- The cost of clean energy technologies like solar PV, wind, and batteries has seen historic declines
- Governments and utilities are making strong clean energy commitments to speed grid decarbonization
- We are making progress on developing and commercializing new carbon-free technologies



## Our Third Decade of Climate Action:

# 24/7 Carbon-Free Energy by 2030

- **Transactions:** Buy more and different types of clean energy deployed locally
- **Technology:** Accelerate energy technology innovation
- **Policy:** Advocating for policy changes to decarbonize electricity grids



# 24/7 CFE: core pillar - transactions

## New transaction developments needed to deliver 24/7 CFE

- Push beyond the typical “as delivered” renewable PPA model
- Develop regional specific structures for delivery of CFE
- Capitalize on shared asset value with utility and other energy supplier partners

## Shared value example - Nevada

Google will purchase solar and battery storage capacity from NV Energy to better match future data center load with carbon-free energy. But the utility will also share use of the battery, delivering peak load capacity benefit for the system.

# 24/7 CFE: core pillar - technologies

## Solving the Technology Challenge

- Optimize existing clean energy production technologies
- Develop smart solutions for managing electricity demand
- Help accelerate commercialization of next-generation resources

## Existing variable renewables

Solar

Wind

## Next-gen technologies

Carbon capture and storage

Demand optimization

Low-cost / long-duration energy storage

## Firm carbon-free resources

Carbon-neutral hydrogen

Geothermal

Low-impact biomass

Low-impact hydro

Nuclear

# Carbon-intelligent load-shifting

Reducing data center carbon footprints by shifting flexible compute tasks to align with greener hours on the grid

## Conventional compute load

Execution of compute tasks throughout the day, regardless of carbon impact



# 24/7 CFE: core pillar - policy

## Policy is essential to accelerating decarbonization

- Rapidly develop and deploy clean energy technologies
- Create and design markets to advanced carbon-free energy
- Empower energy consumers

Google played a key role in launching two coalitions focused on expanding clean energy access and will continue work to make it easy for any organization, large or small, to choose carbon-free energy



# 24/7 CFE: data challenges

- We have identified three core challenge areas for 24/7 CFE data. Initial data tools deployed for our 24/7 CFE program have addressed these challenges to varying degrees.
- As other purchasers adopt similar frameworks, we expect more scalable tools will be valuable in the marketplace.

<b>1. Monitoring, reporting, analytics</b>	<b>2. Portfolio management &amp; optimization</b>	<b>3. Grid forecasting &amp; planning</b>
A time based REC clearinghouse/registry does not currently exist	Significant data exchange required (load, gen data) to develop accurate proposals	Grid CFE plays a critical role in the CFE calculation

A large wind turbine silhouette is the central focus, set against a deep blue night sky filled with stars. The horizon is illuminated with a warm orange and yellow glow from a setting or rising sun. In the distance, several other wind turbines are visible, some with red lights on their towers. A bright light source on the left creates a starburst effect. The overall scene is a serene and powerful representation of renewable energy.

Thank you

Google