
Google
Energy strategy
at Google

Agenda for Midwestern Governors Association

- Introduction
- Measuring Progress Toward 24/7 Carbon-free Energy
- Setting Google's 2030 Target
- A Roadmap to 24/7 Carbon-free Energy
- Working Together to Build a Carbon-free Economy

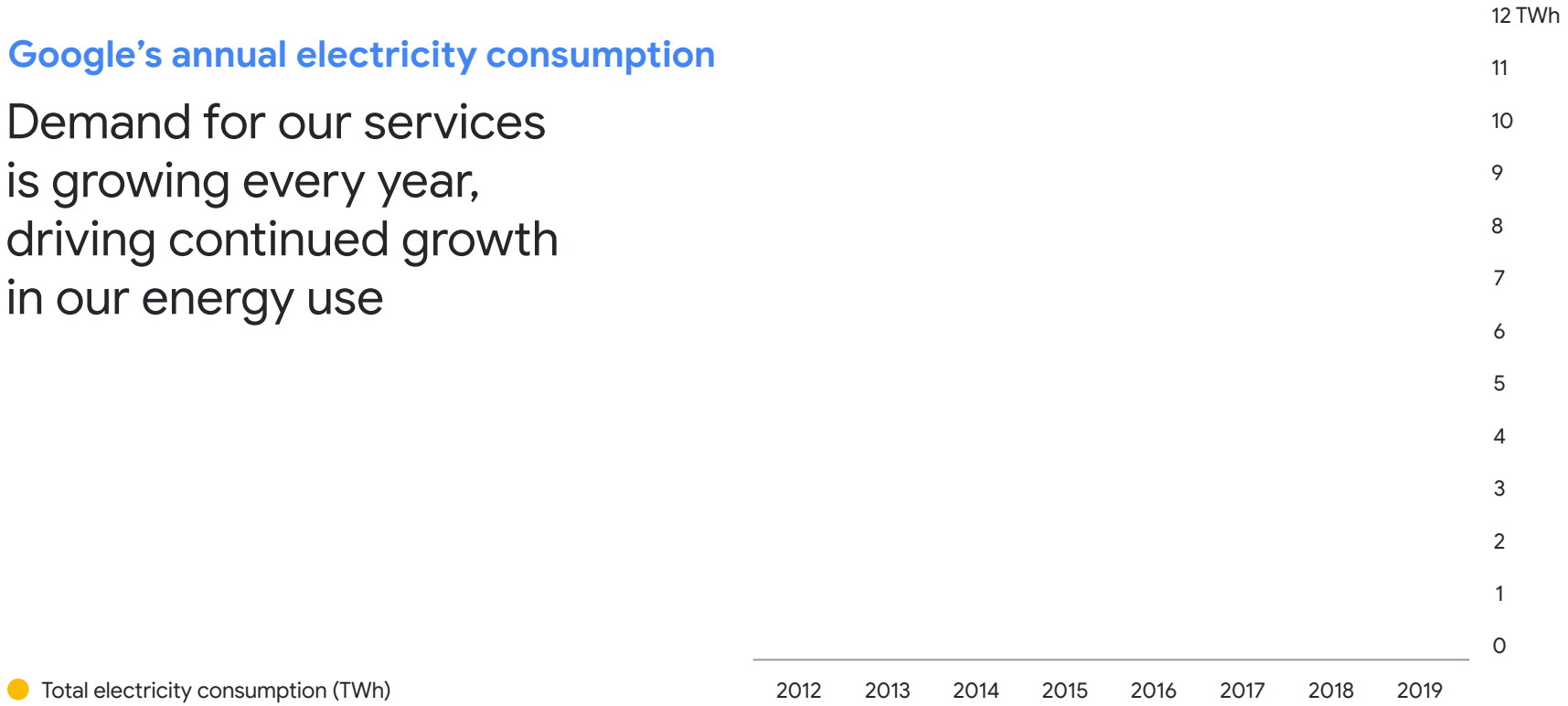
Google

Google Search I'm Feeling Lucky

Products with >1 billion users

Google's annual electricity consumption

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



Source: Google Internal Data

Google


This Google data center campus is the size of 235 football fields
Google


Google

What we're doing

24/7 Clean Energy

Google's Energy Journey

Carbon Neutrality

(Offsetting emissions)

Since 2007

Google has purchased enough high-quality carbon offsets and renewable energy to bring our net operational emissions to zero.

100% Renewable Energy

(Reducing emissions)

Since 2017

Google has matched its global, annual electricity use with wind and solar purchases. However, our facilities still rely on carbon-based power in some places and times.

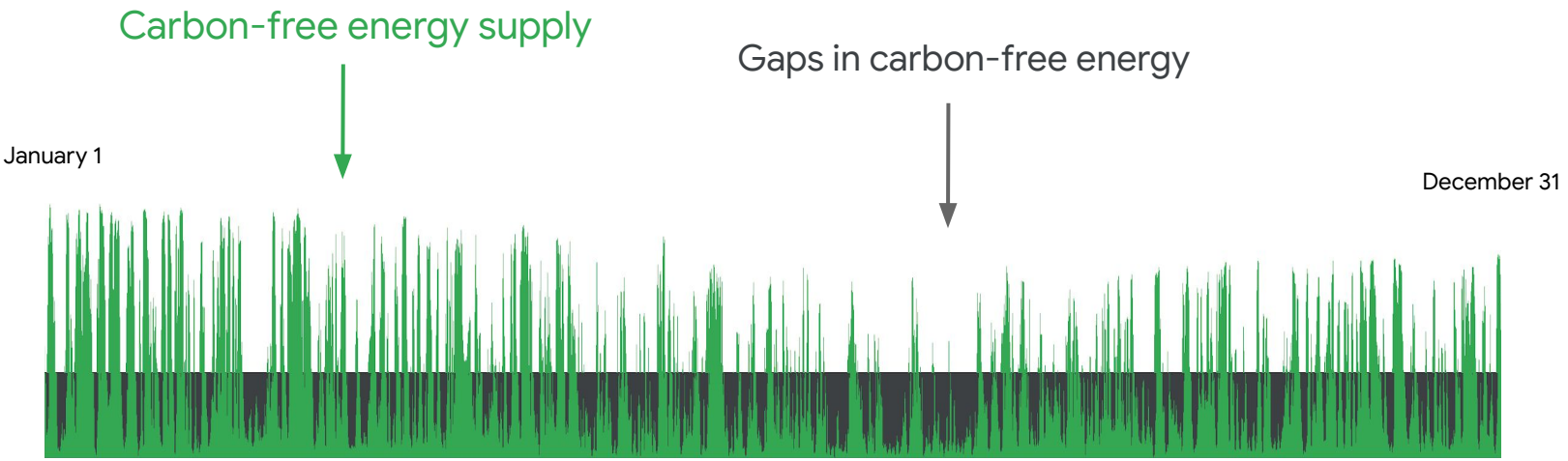
24/7 Carbon-free Energy

(Eliminating emissions)

By 2030

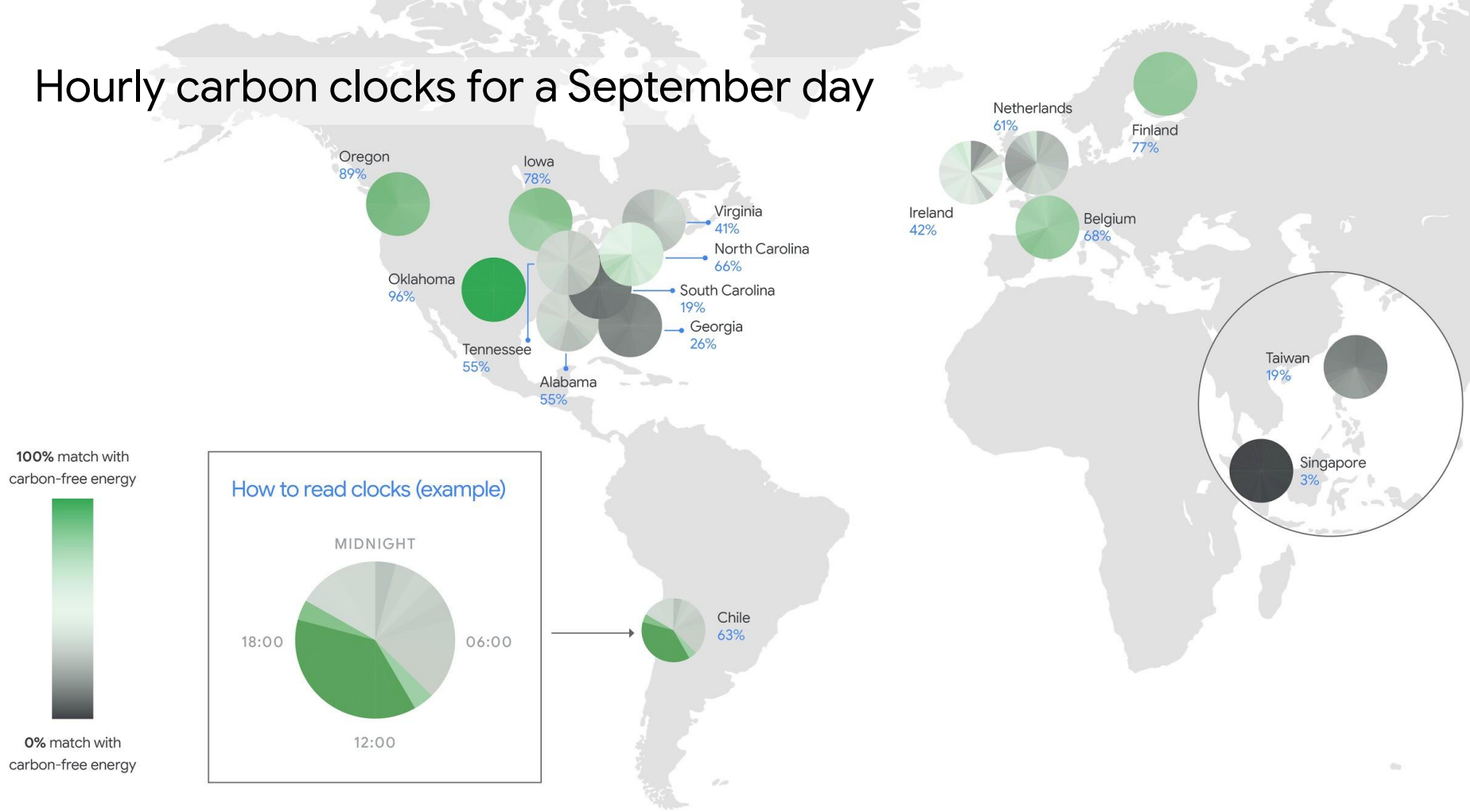
Google intends to match its operational electricity use with nearby (on the same regional grid) carbon-free energy sources in every hour of every year.

Hourly carbon-free energy performance at an example data center

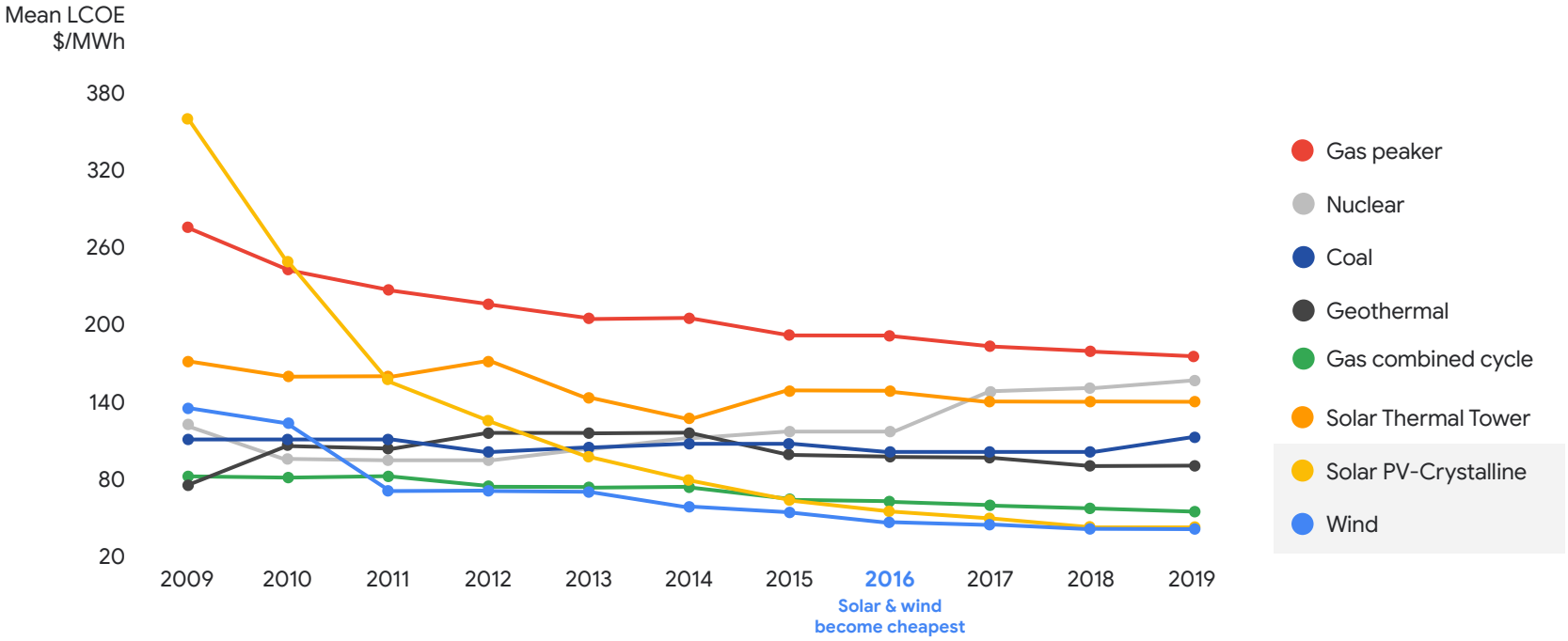


Iowa data center hour by hour (2018)

Hourly carbon clocks for a September day



Renewables are more cost effective than ever



Source: Lazard's Levelized Cost of Energy Analysis

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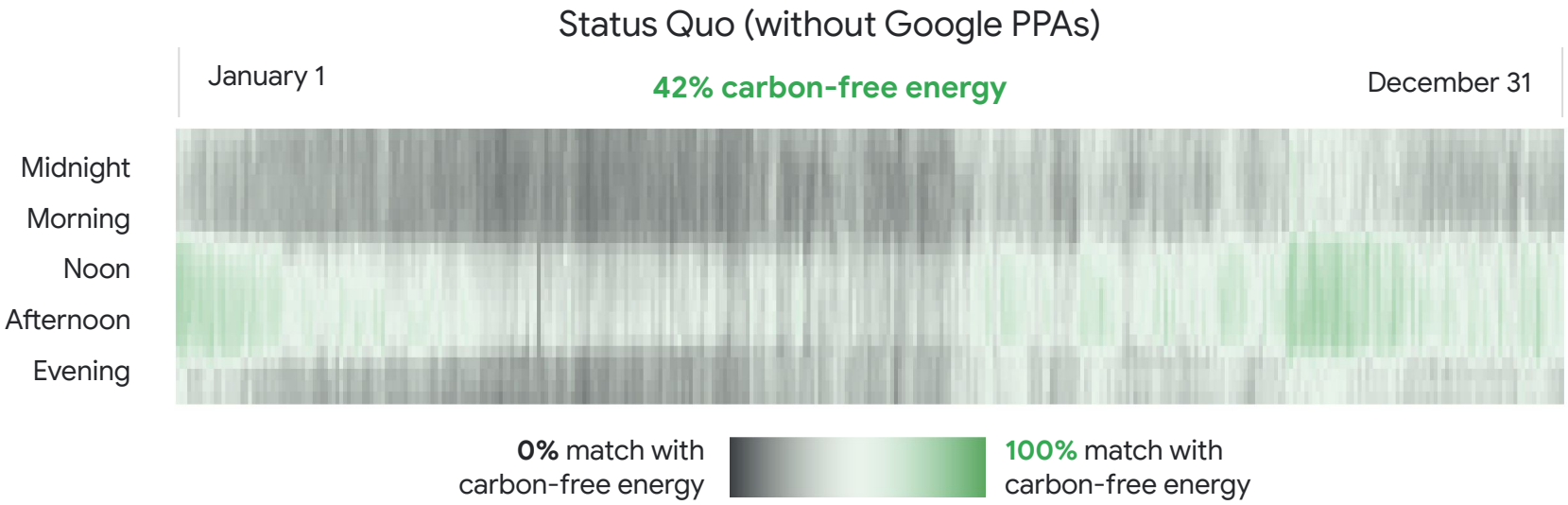
Google is the world's
largest corporate
purchaser of
renewable energy
Google

Scenario: every hour of electricity use at Chile data center

Without solar and wind PPAs, less than half our energy use in Chile would be matched with carbon-free sources on an hourly basis



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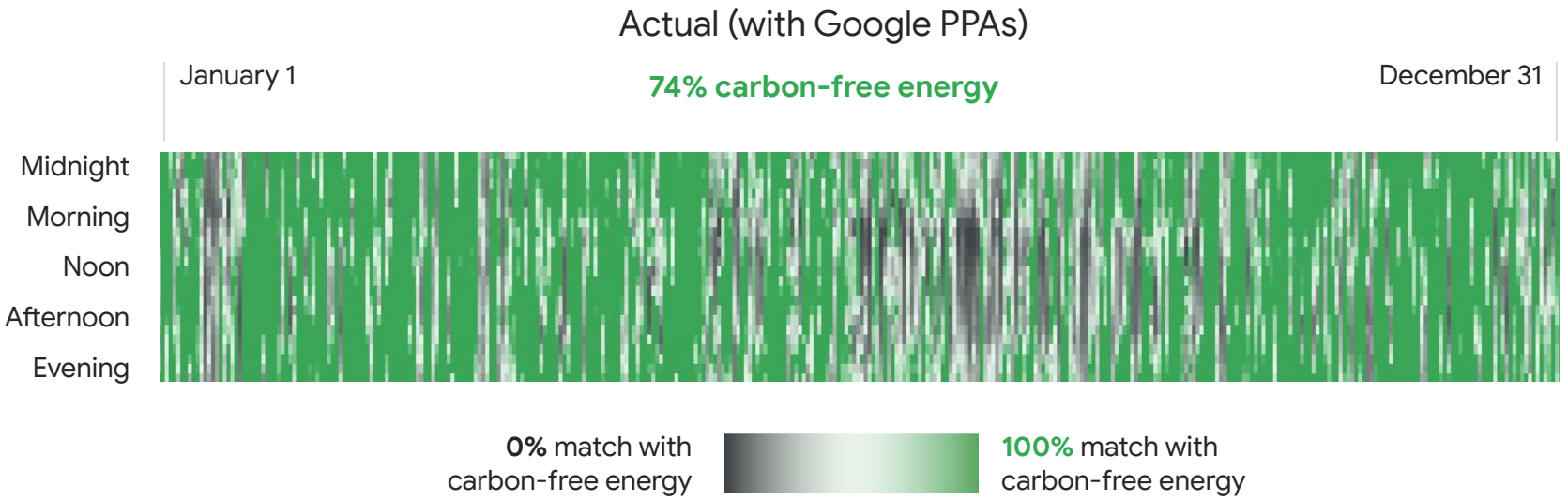
Actual: every hour of electricity use at Iowa data center

PPAs have had a transformative impact on greening our energy profile



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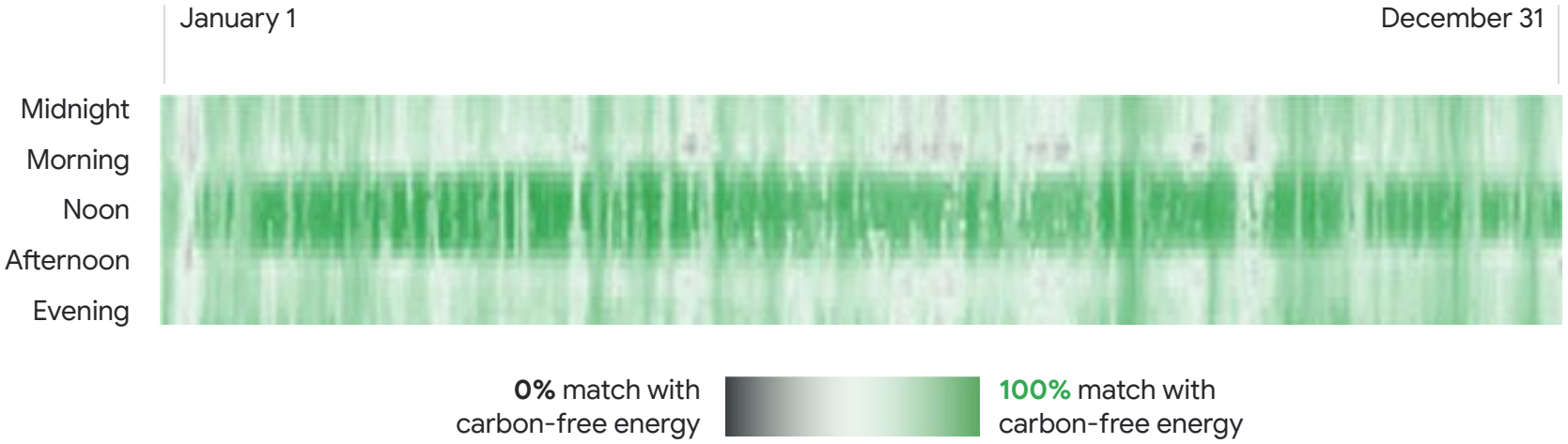
We aspire to source **100%** carbon-free energy at all times



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Carbon-intelligent load-shifting

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

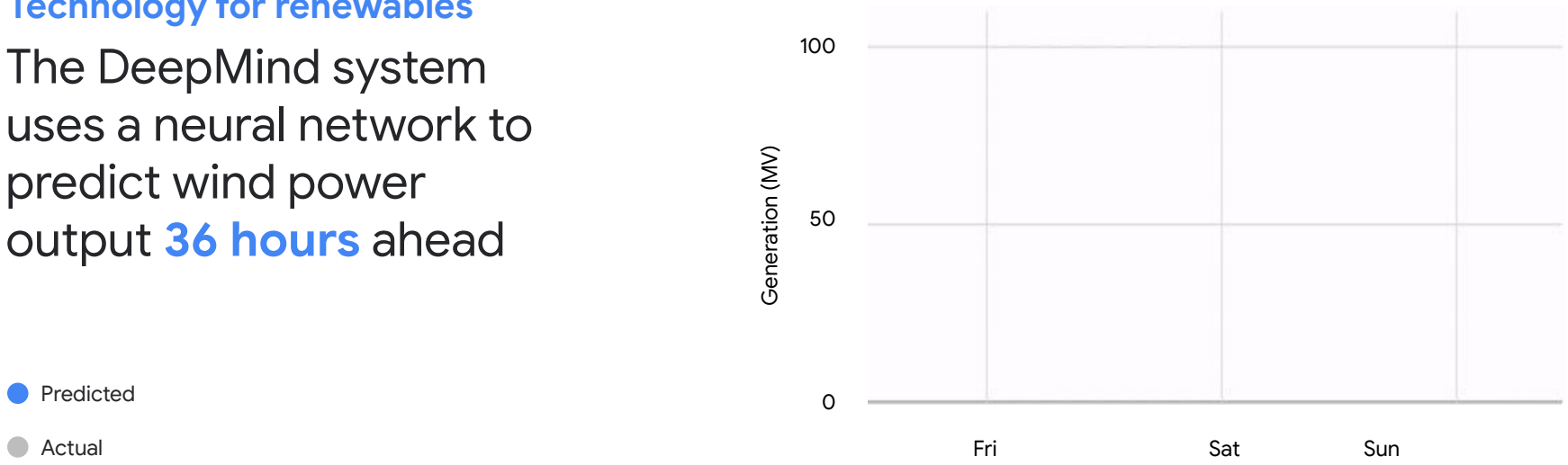
Conventional compute load

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

Google

Technology for renewables

The DeepMind system uses a neural network to predict wind power output **36 hours** ahead



Google

Advancing Energy Technology Innovation

Existing variable renewables

Solar

Wind

Next-gen technologies

Carbon capture and storage

Demand optimization

Low-cost / long-duration energy storage

Firm carbon-free resources

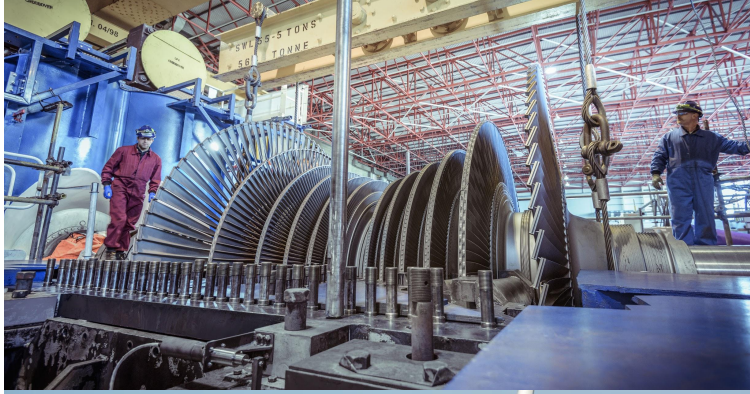
Carbon-neutral hydrogen

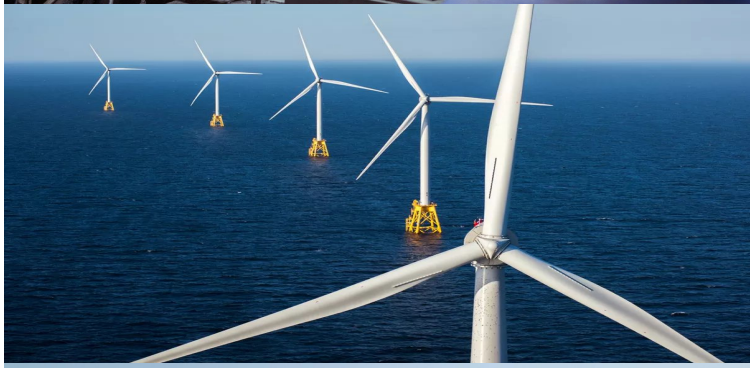
Geothermal

Low-impact biomass

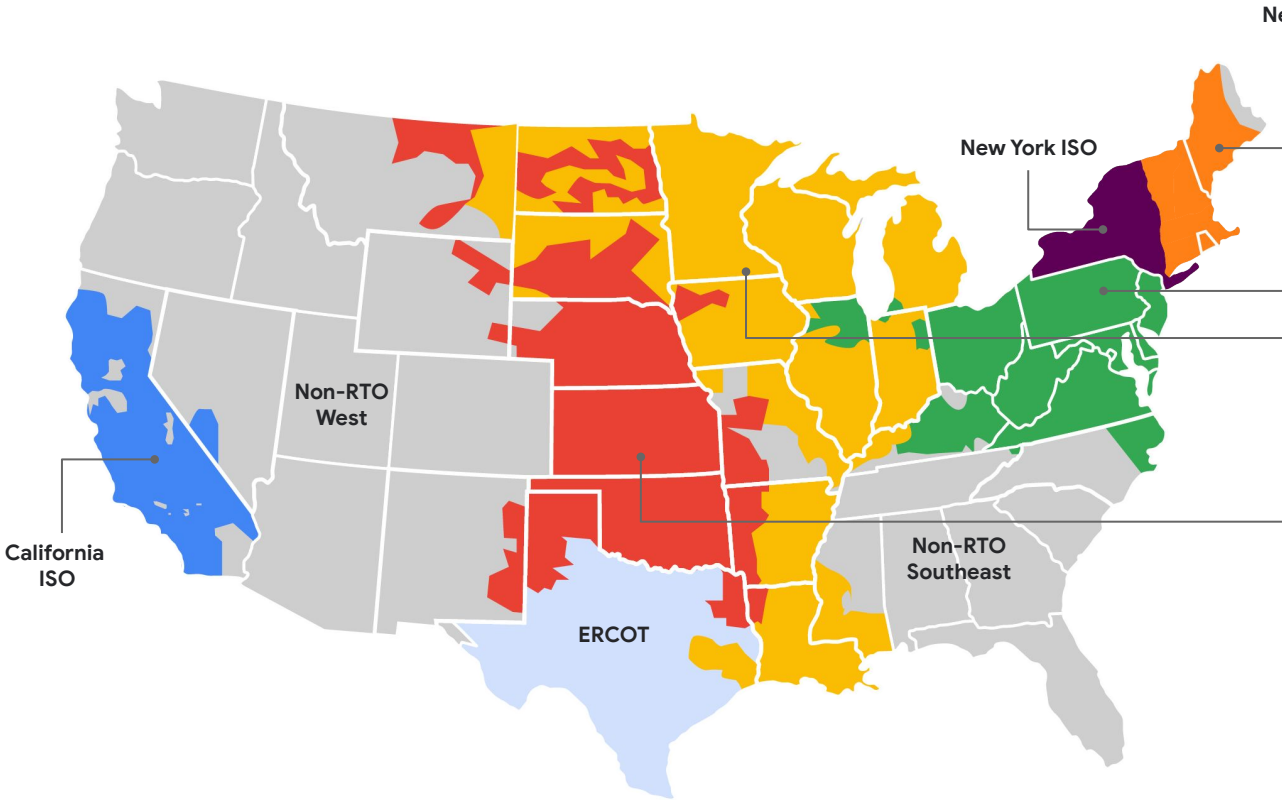
Low-impact hydro

Nuclear





Competitive power markets help consumers



PJM Interconnection

PJM's market operations produce an annual savings of more than **$3.2-$4 billion**

Midcontinent ISO

In 2019, **MISO** provided more than **$3.2-$3.9 billion** in value for its market participants

Southwest Power Pool

SPP's market has provided more than **$2.7 billion** in savings since 2014

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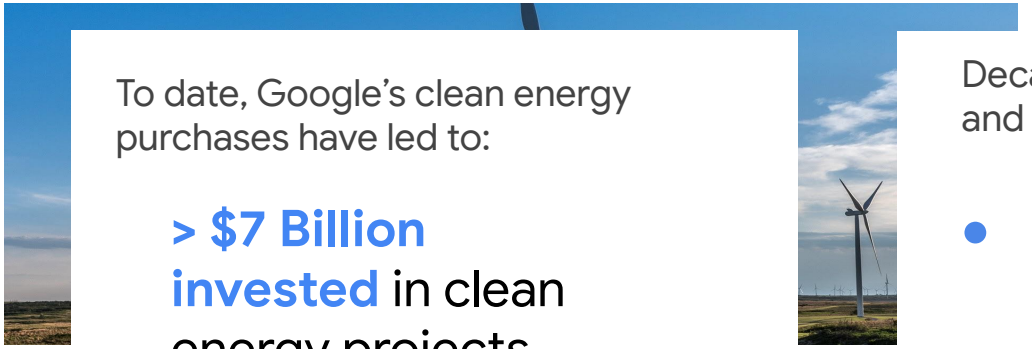
The Economic impact of 24/7 Carbon-Free Energy

- Our efforts to move toward 24/7 carbon-free energy will create more than 10,000 clean energy jobs globally by 2025
- Grid decarbonization will catalyze jobs and lower costs*:
  - **13% lower** electricity costs
  - **$1.2 trillion avoided** health and environmental costs
  - **500K additional jobs** every year

*Source: 2035 Electric Decarbonization Modeling Study, UC Berkeley Goldman School of Public Policy. Study modeled 90% decarbonization of the electricity sector nationally by 2035.

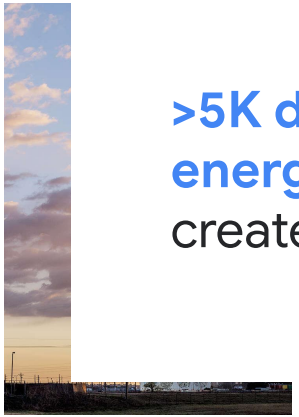
The economic benefits of 24/7 Carbon-free Energy

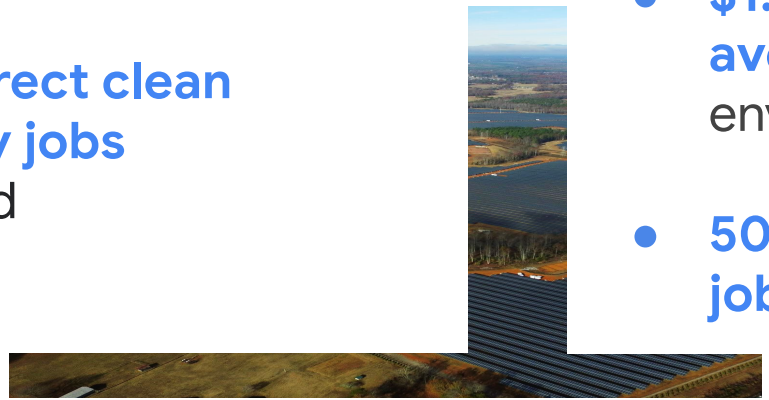


To date, Google's clean energy purchases have led to:

> $7 Billion invested in clean energy projects

>5K direct clean energy jobs created





Decarbonization will catalyze jobs and lower costs*:

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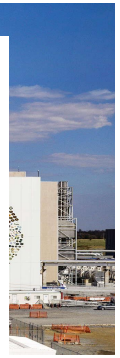

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Back Up

Foundational pillars for power markets

The rules that govern organized power markets must be updated to reflect the new power economy.

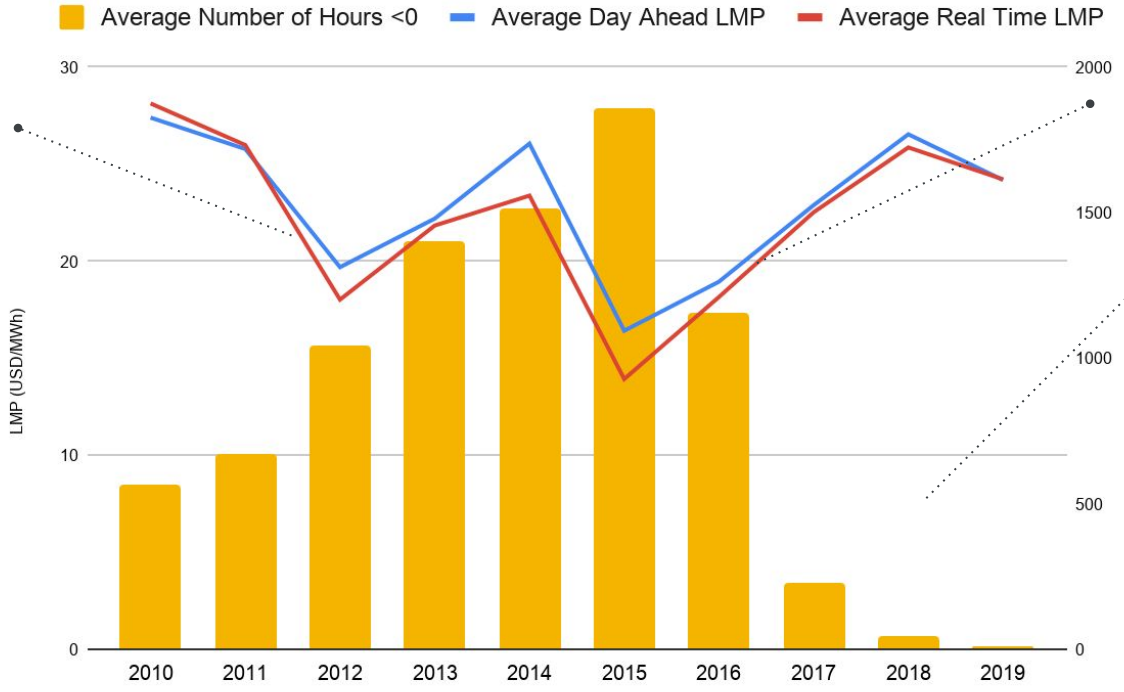
Namely, markets should optimize three key pillars:

Reliable and flexible delivery of power
Low cost
Carbon free

These pillars will need to be supported by reforms in **market design and operations, organizational governance, and grid planning.**

MVP Approved

EOY 2011

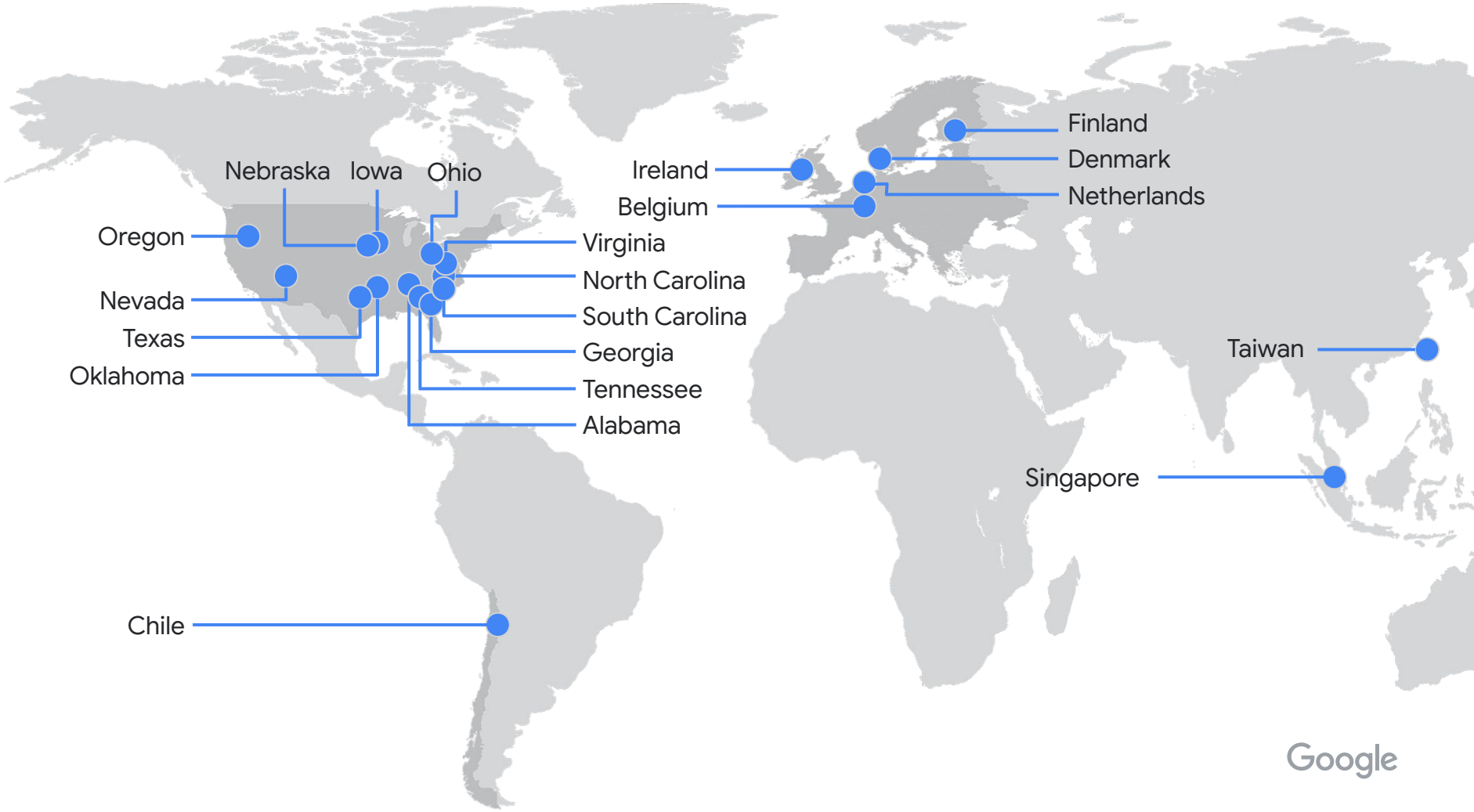


Placed in service

EOY 2015 - EOY 2018

The value of Transmission

MISO's MVP projects have helped relieve significant congestion on its system. The yellow bar reflects the number of hours for which the average hourly real time LMP was less than zero (a proxy for congestion and curtailment). This data is from a node near a Google PPA wind project.


Nebraska
Iowa
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Oregon
Nevada
Texas
Oklahoma
Virginia
North Carolina
South Carolina
Georgia
Tennessee
Alabama
Ireland
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Netherlands
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Chile
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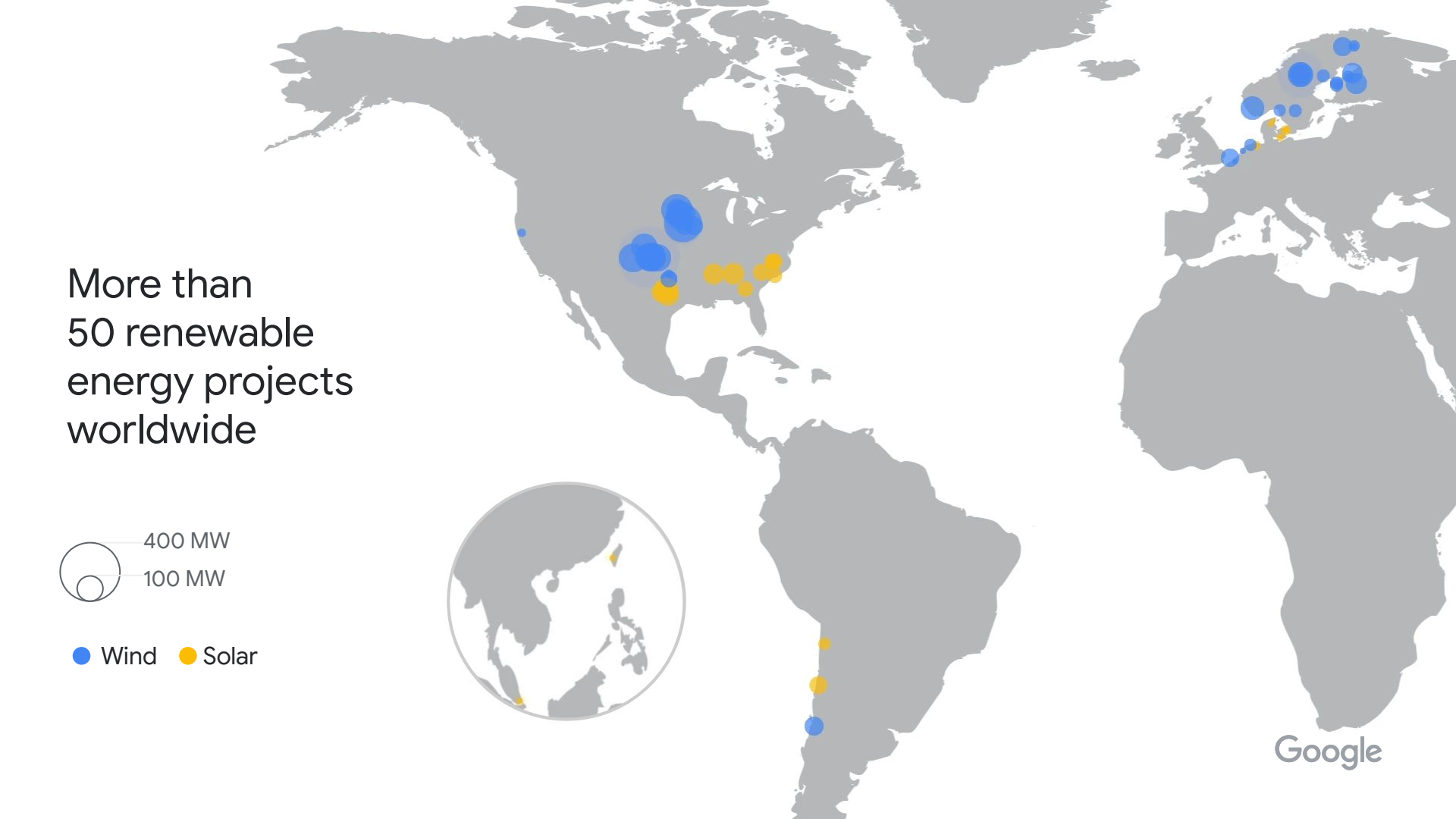
More than
50 renewable
energy projects
worldwide
400 MW
100 MW
Wind
Solar
Google