

Sustainability at the software layer

Optimising for cost and carbon with carbon-aware software design

Chris Adams, The Green Web Foundation

This talk is online - bit.ly/sust-soft-layer

Hello!

I'm Chris. My background:

Loco2 - Low CO2 travel in Europe by train

A.M.E.E (Avoid Mass Extinction Engine) - CO2 calculation as an API

Icebreaker One - data infrastructure for a net zero future

Spend Network - public spending analysis for net zero

Green Web Foundation - make the web green

ClimateAction.tech - largest community online of technologists
transition into climate

Get in touch:

chris@thegreenwebfoundation.org, @mrchrisadams everywhere else



What we'll cover...

Trends in the layers above, and below the datacentre - trends in software design, and trends in energy markets

Our two main levers - efficiency and carbon intensity

Green, Open, Lean, Decentralised (GOLD) - a way to think about decarbonising digital

**We are in a climate crisis
largely because we keep
burning fossil fuels, instead
of finding a path off them**

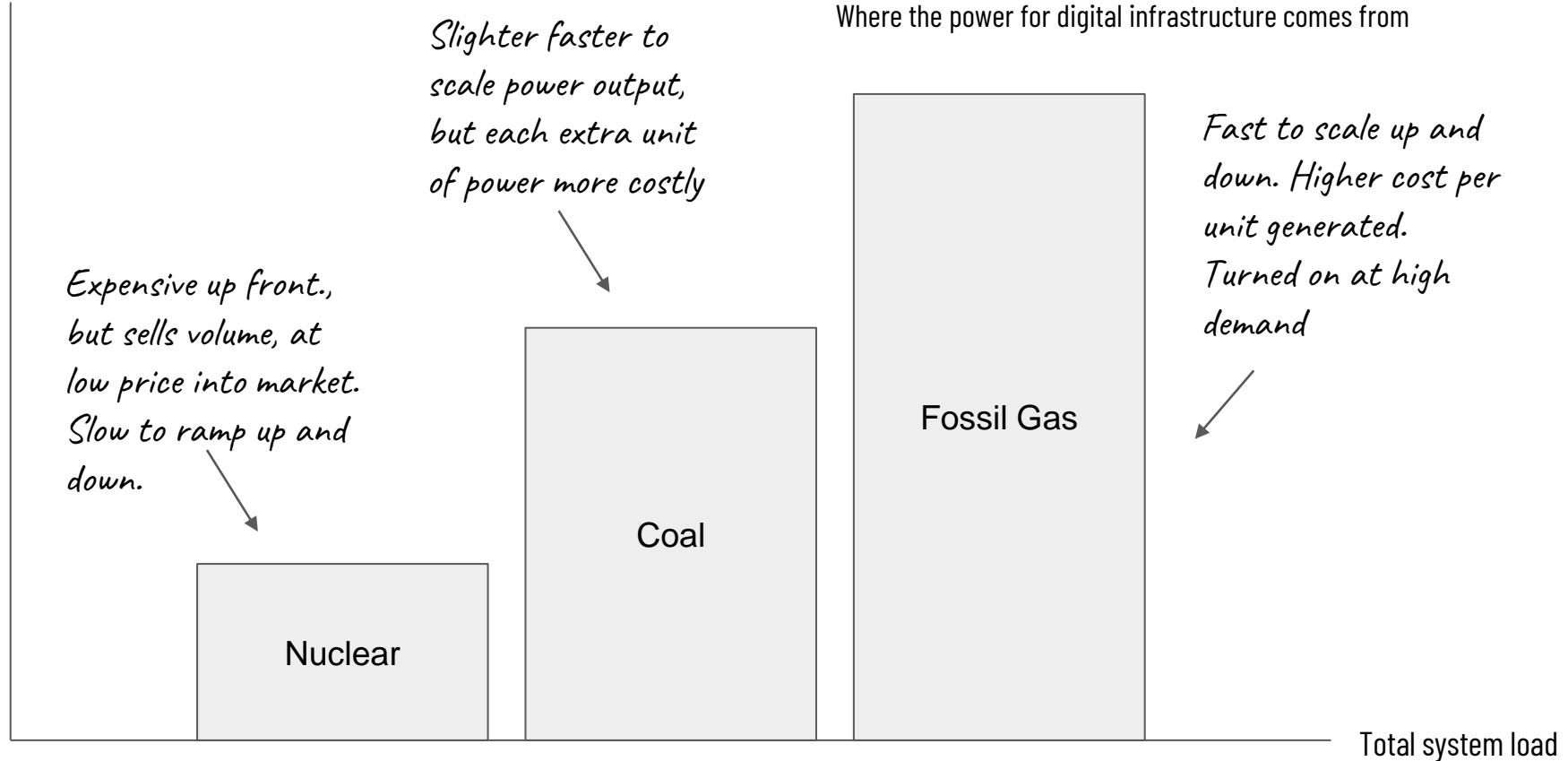
**The internet is the
biggest machine in the
world and it mostly runs
on fossil fuels.**

Grokking the grid

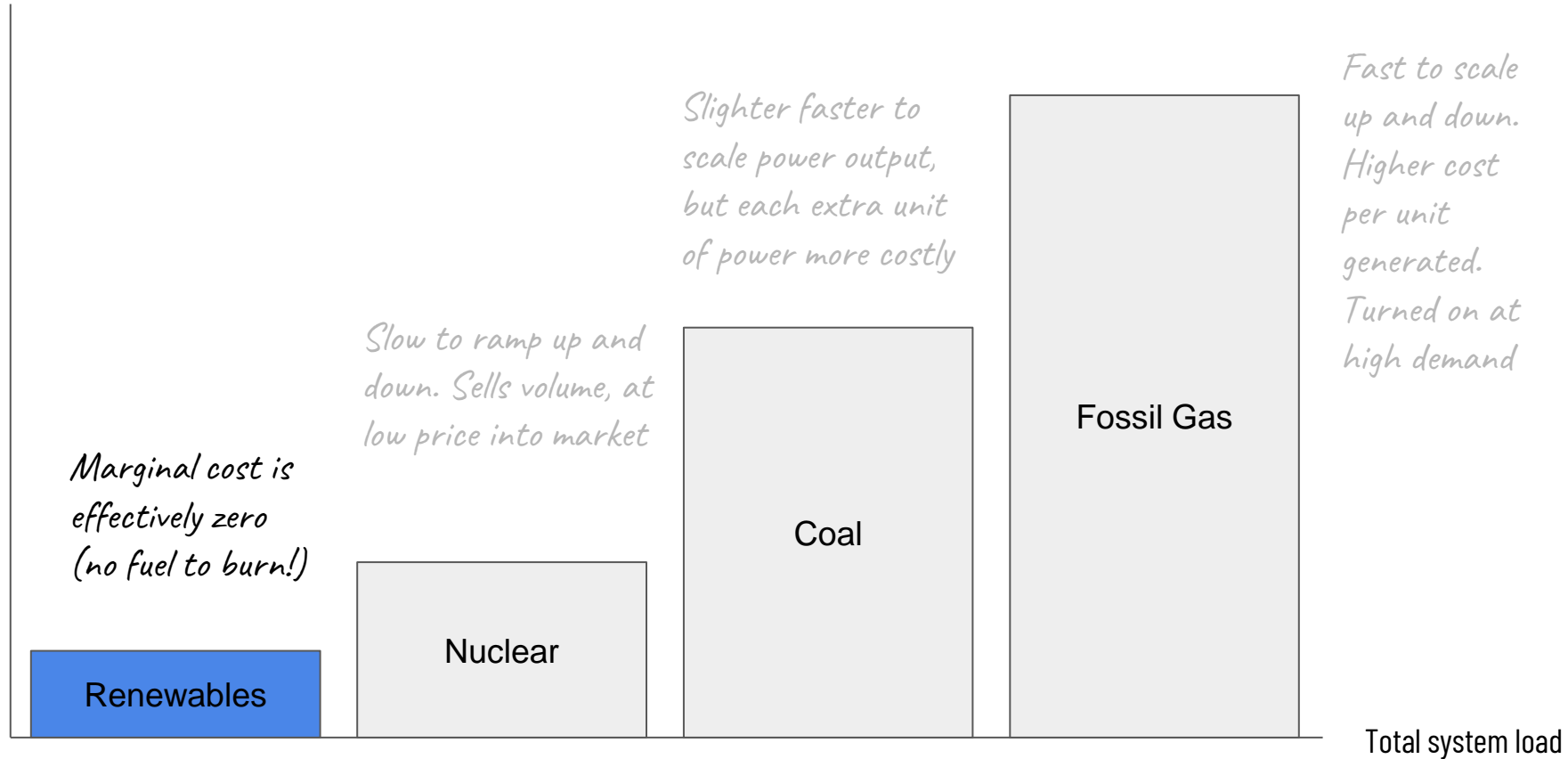
Just enough on electricity market design to help you
see cloud differently

Marginal cost of *energy*

Where the power for digital infrastructure comes from

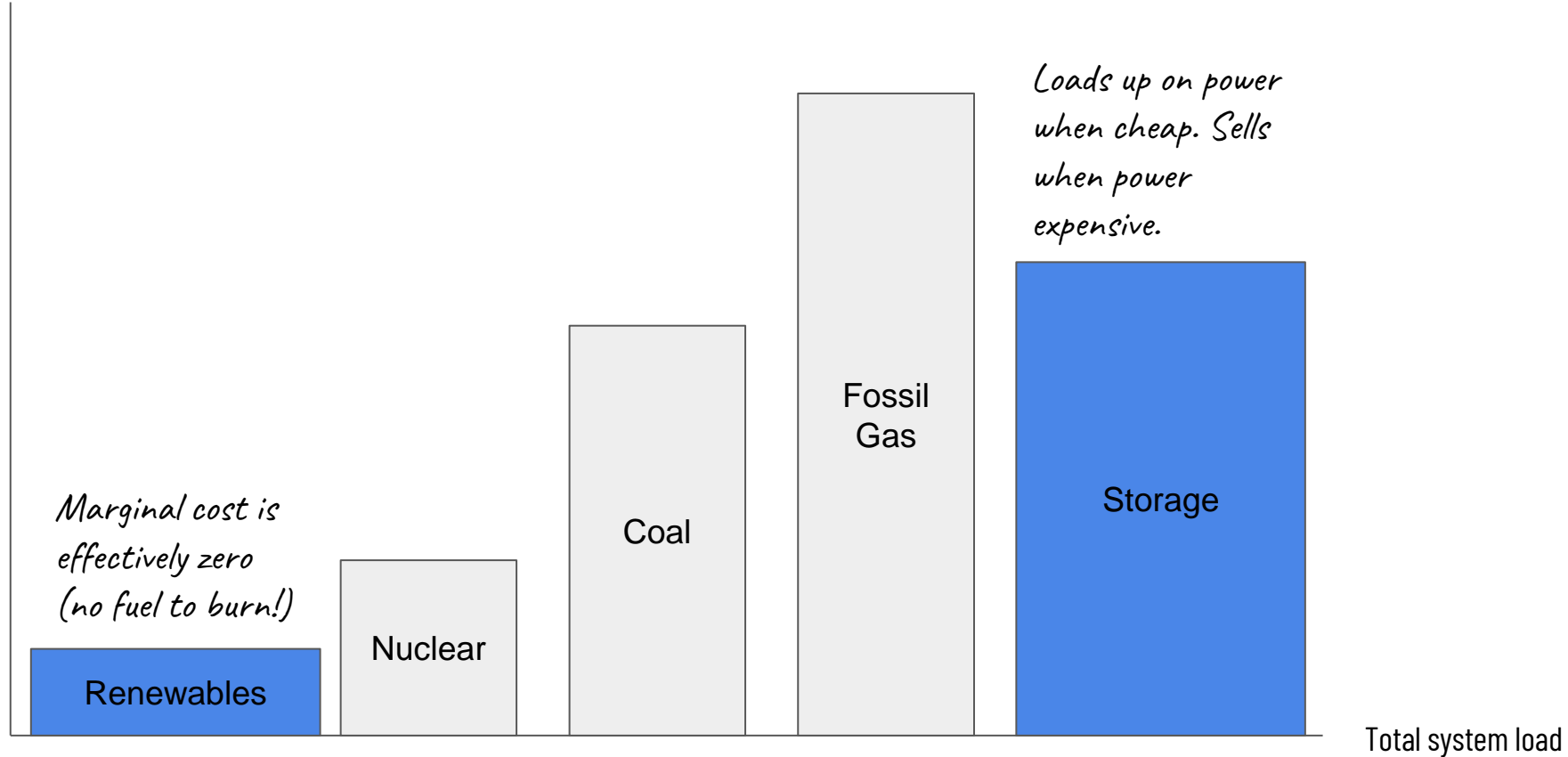


Marginal cost of *energy*



Cost of per KWh of generation

Marginal cost of *energy*



A recent survey of 1,200 companies across six countries showed that, of those sourcing renewables, 92% are doing so in order to reduce electricity costs

Renewable Energy Buyer's Toolkit
<http://resource-platform.eu/toolkit/>

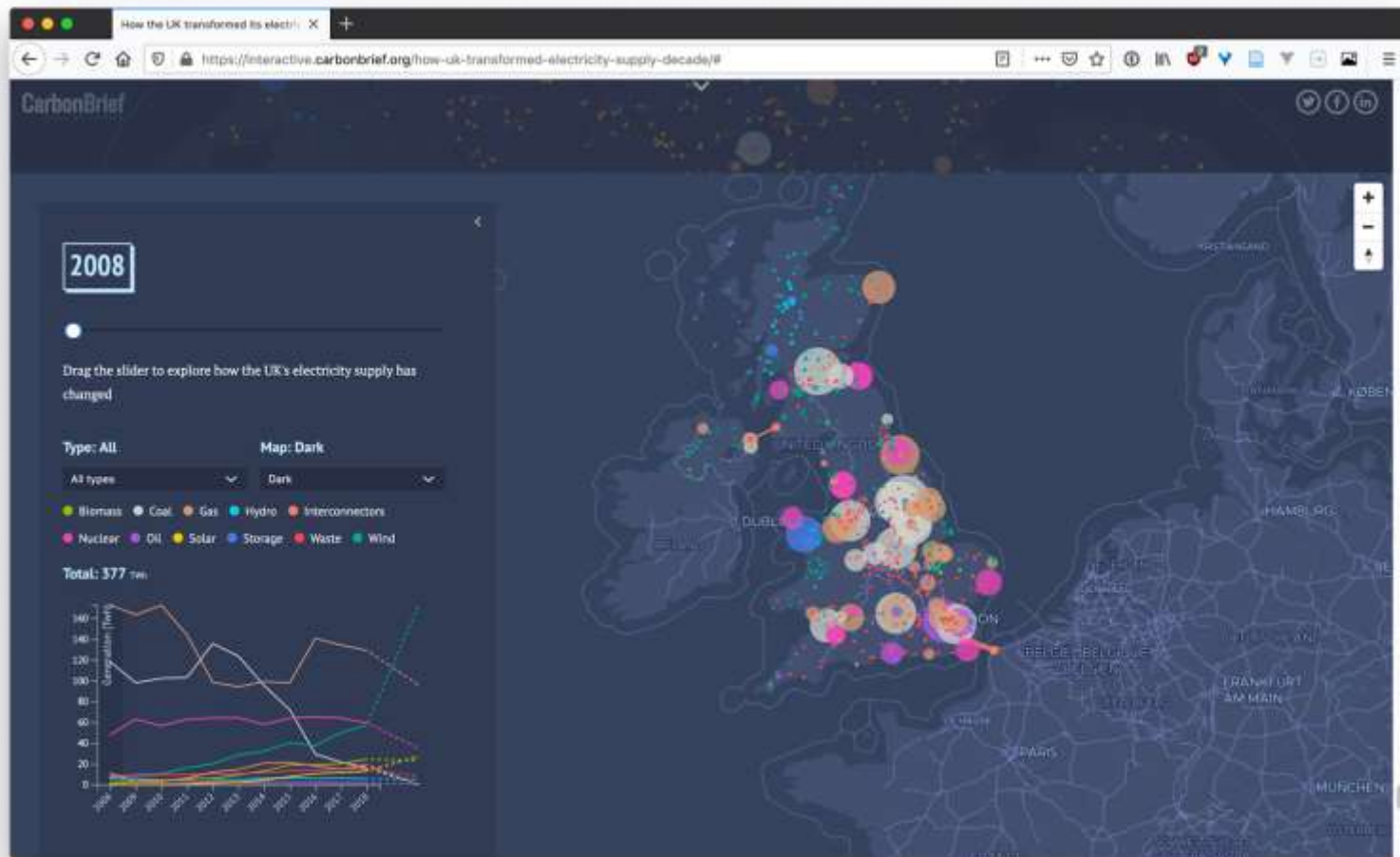
Fossil energy versus green, non-fossil energy



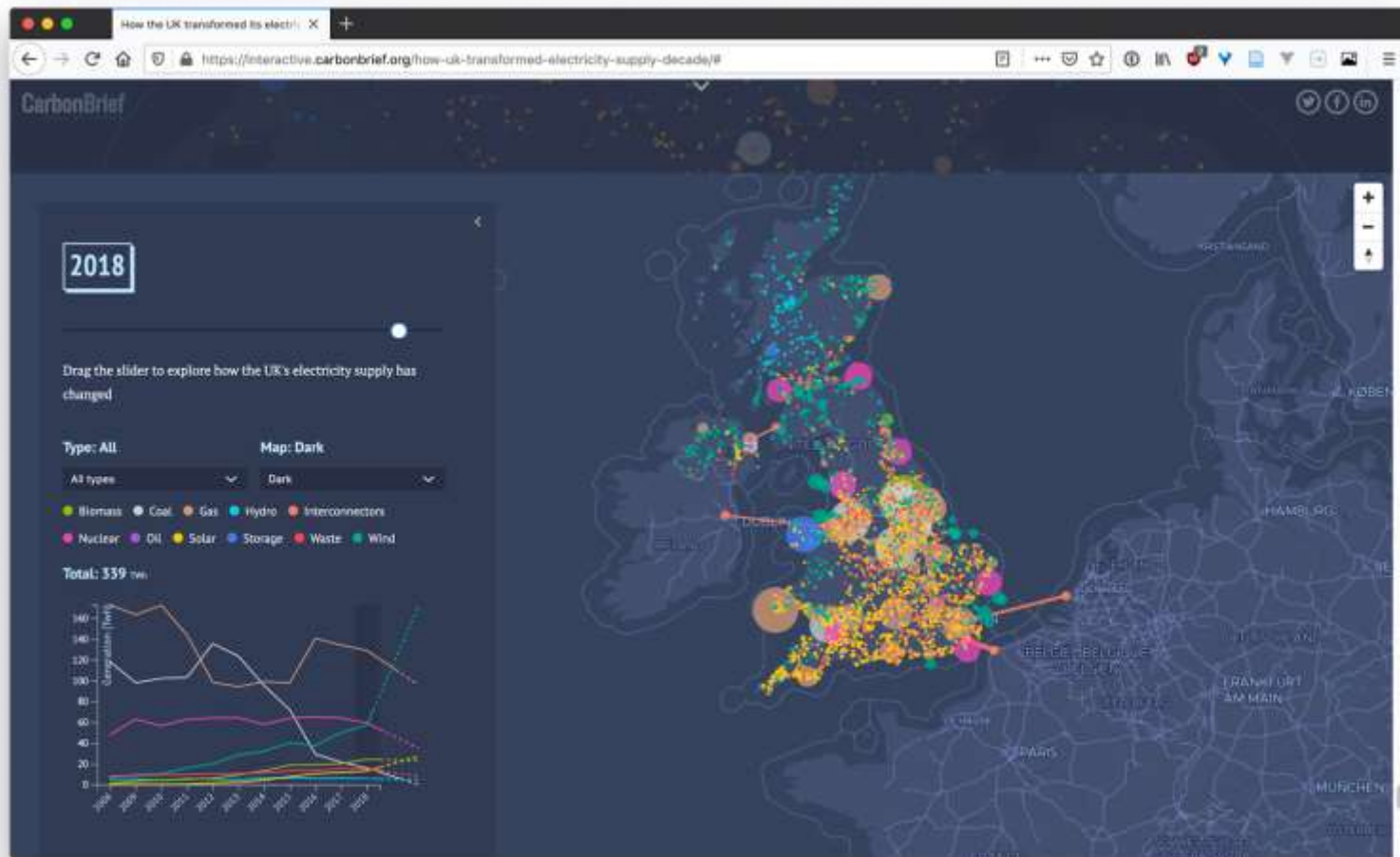
You don't have direct control over what others feed into the grid.

If you know the mix going into the grid, you can at least account for it.

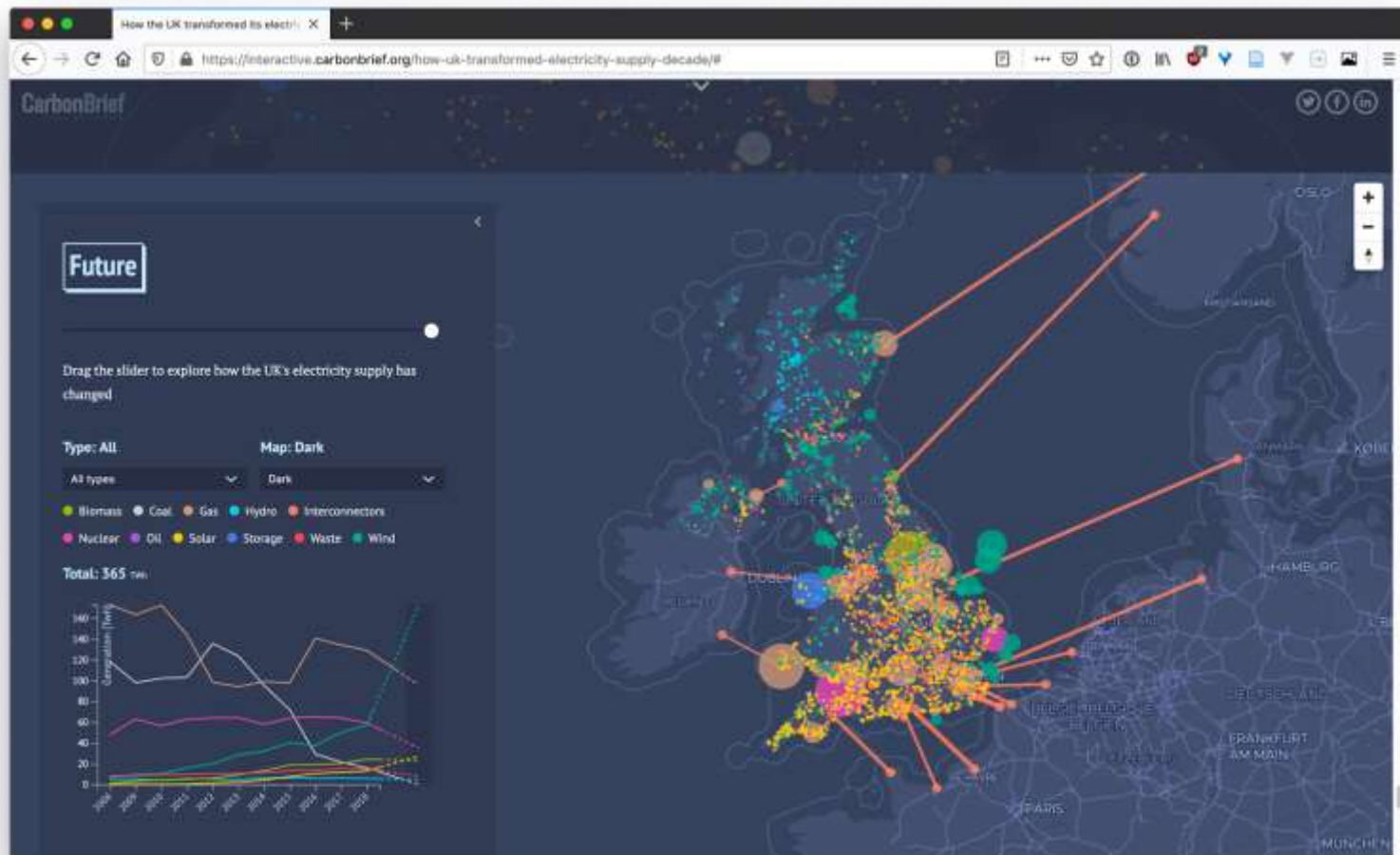
This energy comes from the wind and sun. No carbon more carbon emissions from burning fuel!



How the UK transformed its electricity supply in a decade ([link](https://interactive.carbonbrief.org/how-uk-transformed-electricity-supply-decade/#))



How the UK transformed its electricity supply in a decade ([link](https://interactive.carbonbrief.org/how-uk-transformed-electricity-supply-decade/#))



**Cost per unit of
compute**

*Most expensive per request. But
you only ever pay per request, and
the platform scales for you.*

*More pricey for same
performance, but
easier to spin /up and
down.*

*Pricier still, but you
literally have a slider
for scaling up/down.*

*Expensive up front,
but if used all the
time, cheaper in long
run. Hard to scale
up/down*

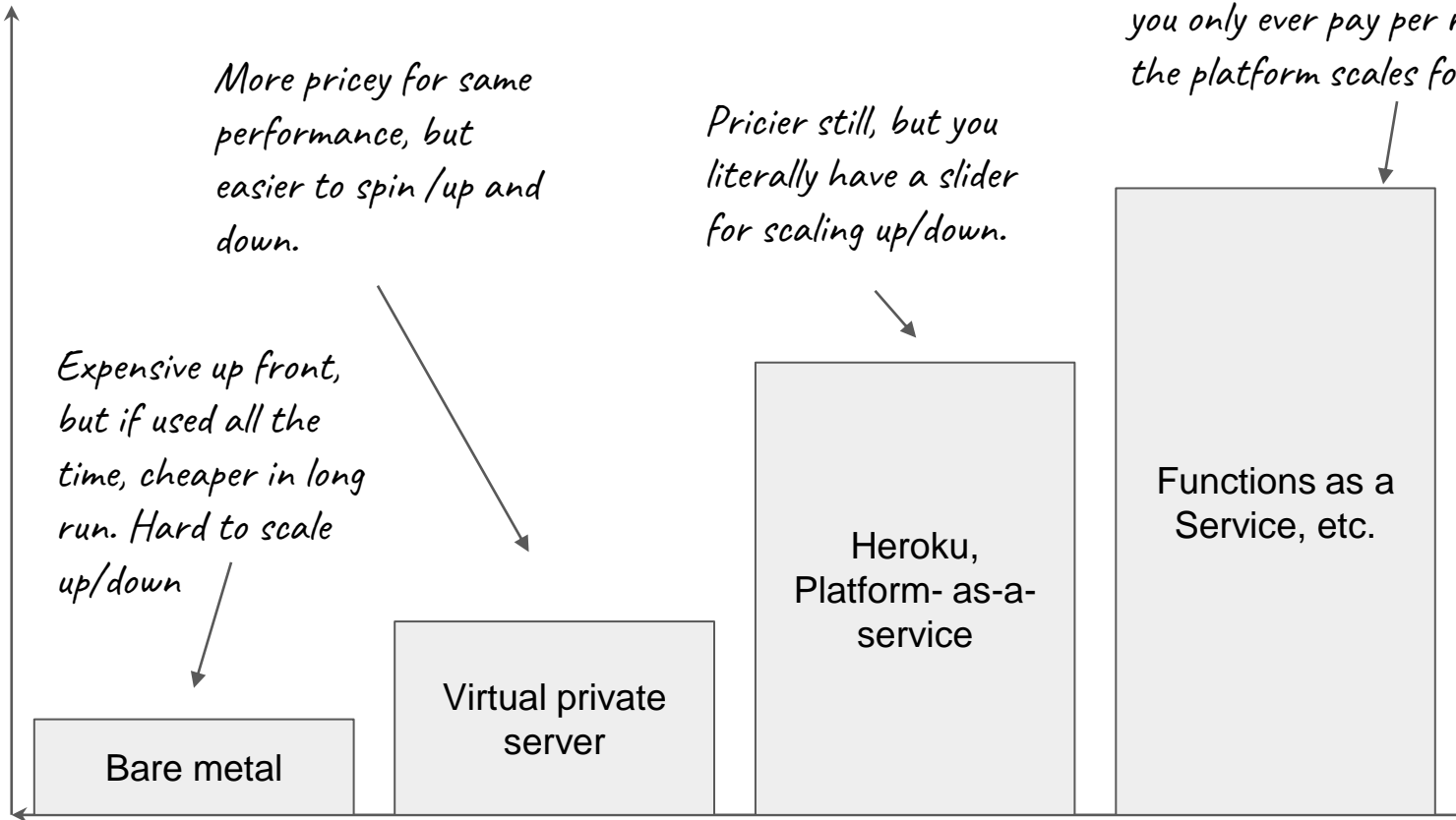
Functions as a
Service, etc.

Heroku,
Platform- as-a-
service

Virtual private
server

Bare metal

**Degree of
abstraction**



“many workloads are spiky or drop to zero for extended periods... applications used in the workplace may only be active for 40 of the 168 hours in a week.”

Adrian Cockroft
@adrianco: AWS, ex Netflix

Lessons from other fields

The power of POUR in the accessibility movement.

Perceivable

Operable

Usable





Robust

// *The idea is to create a POUR web site, so to speak. The pun may be a bad one, but if it helps developers memorize the principles, then it has served its purpose.*

Supreme Court hands victory to blind man who sued Domino's over site accessibility

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Tucker Higgins
@TUCKER-HIGGINS-82162296
#TUCKERHIGGINS


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KEY POINTS

- The Supreme Court denied a petition from pizza giant Domino's on Monday to hear whether its website is required to be accessible to the disabled, leaving in place a lower court decision against the company.
- The case was originally brought by a blind man named Guillermo Robles, who sued the pizza chain after he was unable to order food on Domino's website and mobile app despite using screen-reading software.
- The decision not to grant the case is a loss for the company and a win for disability advocates, who have argued that if businesses do not have to maintain accessible

TRENDING NOW

 1 GM to invest more than \$2 billion in U.S. manufacturing to increase electric vehicle production

 2 Biden's tax plan could boost tax rates to 62% for some New Yorkers and Californians, studies

Accessibility and inclusive design as a way to avoid risk ([link](#))

Greening government: ICT and digital services strategy 2020-2025

Policy paper

Greening government: ICT and digital services strategy 2020-2025

Published 10 September 2020

Contents

- Commendation by the Senior Responsible Owner
- Demand
- Control
- Supply
- Sustainable ICT and digital services strategy: targets for 2020-2025 policy paper
- Appendix A – strategy deliverables
- Appendix B – strategy summary

Commendation by the Senior Responsible Owner

ICT and digital services are increasingly held up as a key component of any solution to the global climate crisis and associated targets and goals. These include the UK government's commitment to net zero carbon by 2050, the Greening Government Commitments 2020-2025, The UN Sustainable Development Goals and the 25 Year Environment Plan. We have shown recently how ICT and digital services can enable our civil and public servants working from home, increasing resilience during an international crisis.

As documented in our [annual reports since 2012](#), we have migrated large portions of our ICT infrastructure from our estates to our service providers. While this is clearly best practice, and we have been able to show a reduction in our carbon footprint, our footprint and associated impact have effectively been off-shored. A full carbon footprint of our ICT services was required. To tackle this, we published our HMG (Her Majesty's Government) [Sustainable Technology Strategy 2018-2020](#) and have spent the last 2 years working with industry to publish as accurate figures as possible. This provides our new baseline for 2020-2025.

Similar signals from public sector on sustainability as on accessibility ([link](#))

Greening government: ICT and digital services strategy

4a. 100% traceability of ICT at end of life (mapping).

4b. Carbon footprint of the services we are consuming.

4c. 100% compliance with the Social Value Framework, MSAT and [transparency in supply chains](#).

Sustainability statements

5. All departments will provide strategy statements approved by technology and digital leaders. These will set out how they will use technology and digital services to help implement the 25 Year Environment Plan, the UN Sustainable Development Goals and the outcomes defined in this strategy.

Appendix A – strategy deliverables

We have: defined procurement principles and standards. These are (in summary):

- 100% renewable energy and/or carbon neutral suppliers
- 0% to landfill and an annual increase in reuse and material recycling
- increased transparency across HMG, suppliers and the supply chain
- 100% traceability of ICT at end of life
- a yearly increase in procured ICT and services that is remanufactured/refurbished

We will: publish guides on key topics – what good looks like and how to do it - on topics such as:

- inclusion within the TCoP

[↑ Contents](#)

Explicit commitments, and references to supply chain ([link](#))

Green

Open

Lean

Distributed

Green

**as in green energy, and low
carbon power**

Open

Lean

Distributed

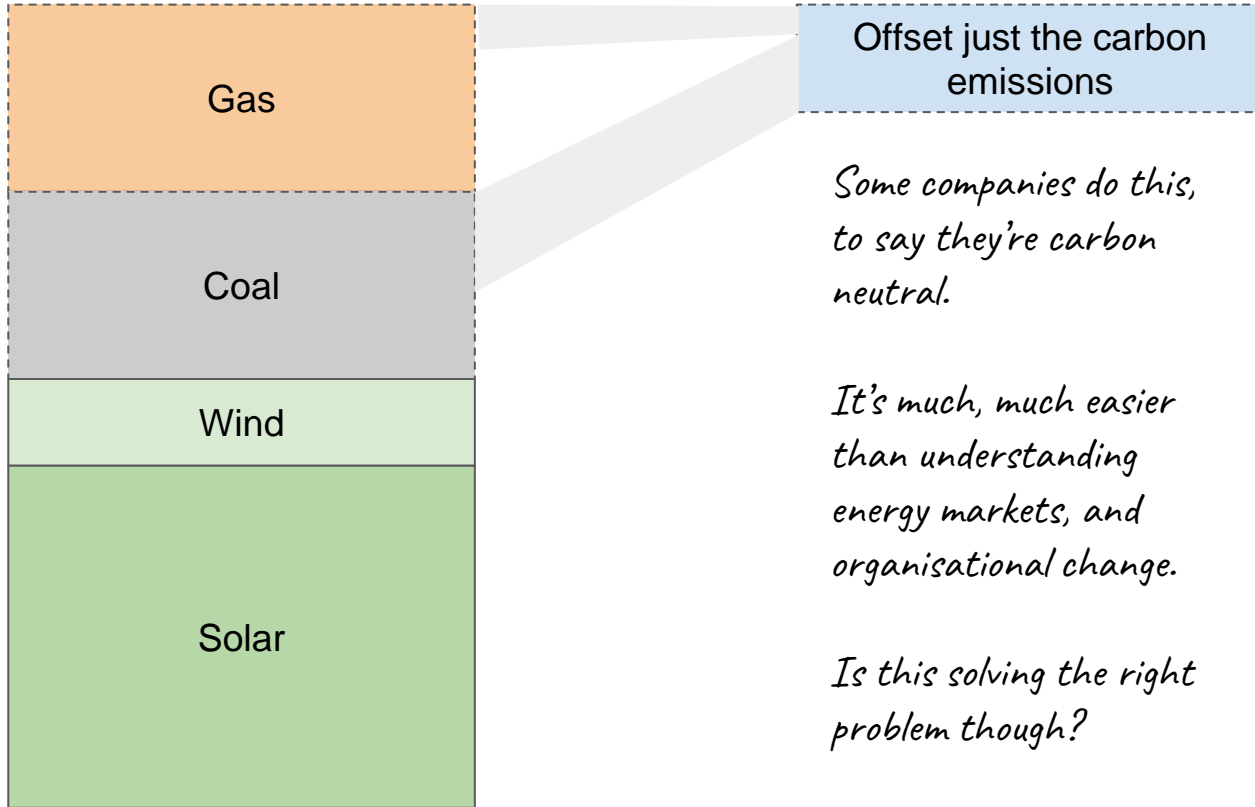
Running on green power when you use the grid



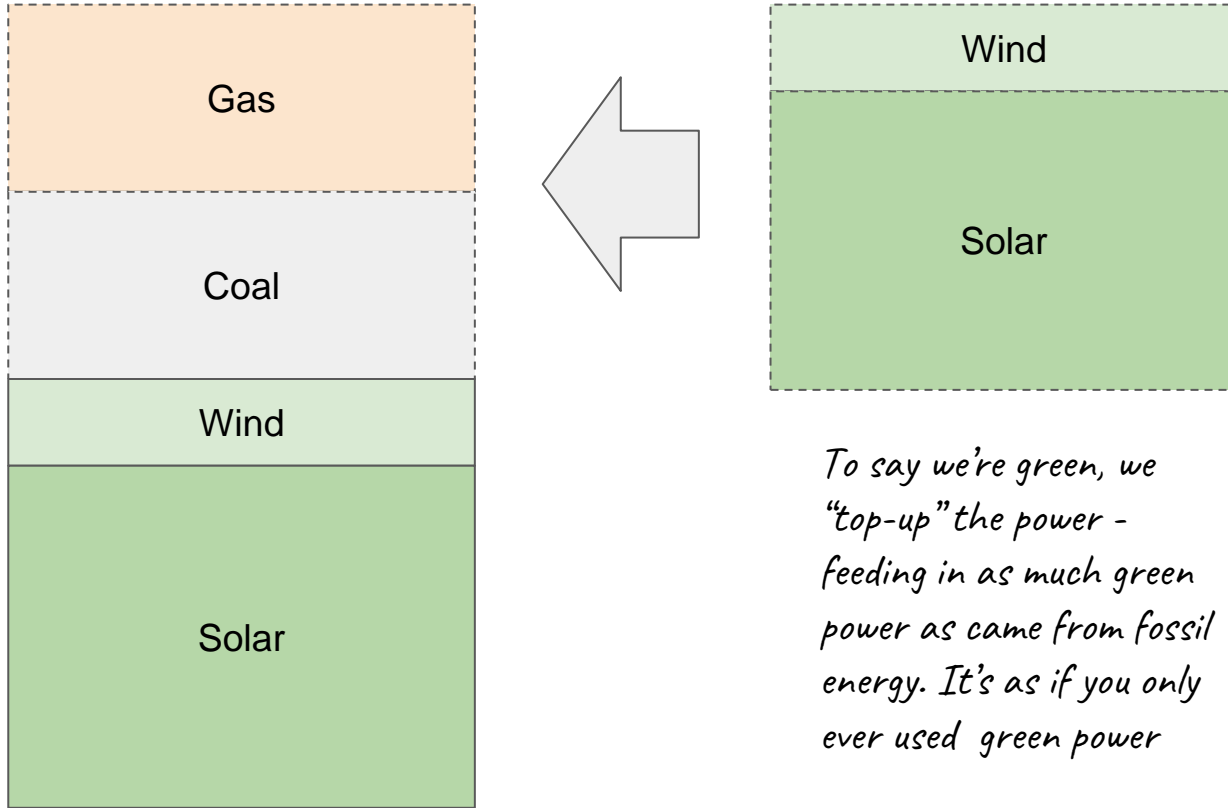
What do we do about this?



Accounting for fossil fuel energy



Accounting for fossil fuel energy



To say we're green, we "top-up" the power - feeding in as much green power as came from fossil energy. It's as if you only ever used green power

Google and Microsoft do this right now, among others.

They do this on an annualised basis, so not every hour is balanced out to be 'fossil-free'.

Accounting for fossil fuel energy, on an hour by hour basis

FIG. 2

Hourly carbon-free energy performance at an example data center

While Google buys large amounts of wind and solar power (symbolized by green spikes below), these resources are variable, meaning that our data centers still sometimes rely on carbon-based resources.



For now, if you're using the grid, there will still be times where you're running on fossil fuels.

Green

Open

open data, open source & transparency

Lean

Distributed

Climate Impact by Area

Ranked by carbon intensity of electricity consumed
(gCO₂.eq/kWh)

Search areas

- | | | | |
|----|--|---------------------------------|---|
| 1 |  | El Hierro
Spain |  |
| 2 |  | Orkney Islands
Great Britain |  |
| 3 |  | South Island
New Zealand |  |
| 4 |  | Yukon
Canada |  |
| 5 |  | Southwest Norway
Norway |  |
| 6 |  | Ontario
Canada |  |
| 7 |  | North Norway
Norway |  |
| 8 |  | El Salvador |  |
| 9 |  | Middle Norway
Norway |  |
| 10 |  | Southeast Norway
Norway |  |
| 11 |  | Uruguay |  |
| 12 |  | Bornholm
Denmark |  |
| 13 |  | West Norway
Norway |  |
| 14 |  | Tasmania
Australia |  |

This project is [Open Source](#) (see data sources).
Contribute by adding your territory.

Found bugs or have ideas? [Report them here](#).

Like the visualization? [We'd love your feedback!](#)

Anything unclear? Check out our [frequently asked questions](#).

☐ color blind mode

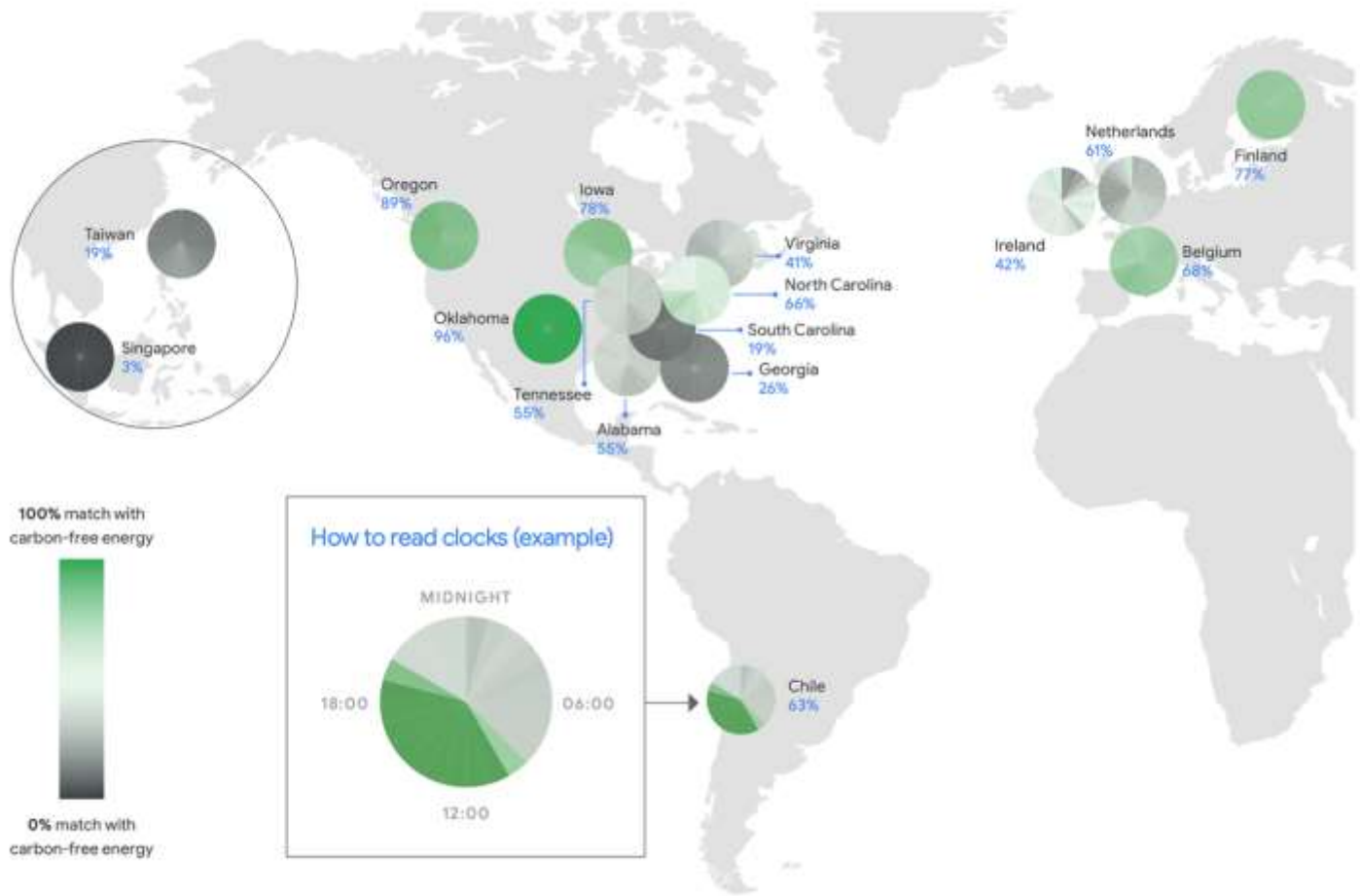
electricityMap **Live** · [API](#) · [Blog](#)

production consumption i



Carbon intensity (gCO₂.eq/kWh)

Electricity Map takes open data and makes it easy to use via an API



Google's Carbon clocks - transparency on datacentre carbon intensity






Green


Open


Lean


**make the carbon you emit
count**

Distributed

Carbon results for
[i.sdialliance.org/roadmap-launch-event](https://www.websitecarbon.com/website/i-sdialliance-org-roadmap-launch-event/) Share     

 Uh oh! This web page is dirtier than **55%** of web pages tested

 Oh my, **1.07g of CO2** is produced every time someone visits this web page.

 This web page appears to be running on **sustainable energy**

[The coach](#) helps you find performance problems on your web page using web performance best practice rules. And gives you advice on accessibility, privacy and best practices.



Coach score

Total score **76**

[Performance score](#) **71**

[Privacy score](#) **80**

[Accessibility score](#) **80**

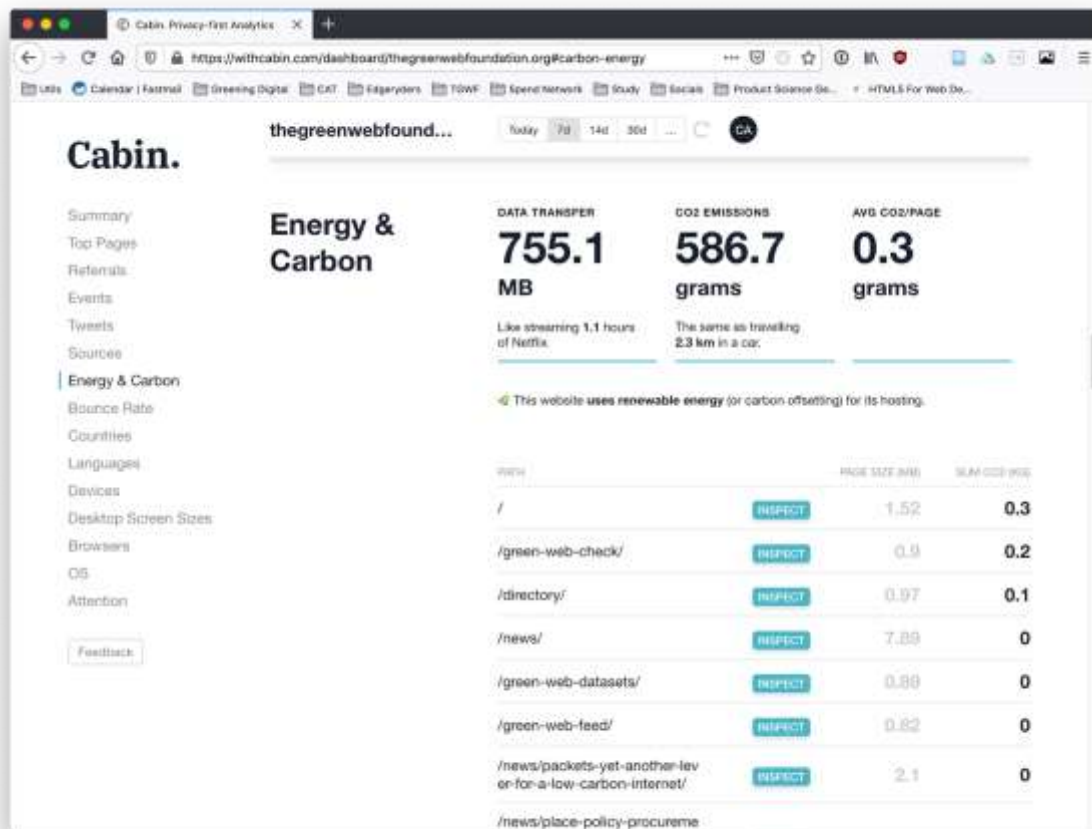
[Best practice score](#) **81**

The sustainable web plugin

We know using the internet means using electricity to power servers. And because most of that electricity comes from burning fossil fuels, it means every byte sent has a cost in carbon as well as power. The sustainable web plugin combines the latest in peer reviewed science and open data from the [Green Web Foundation](#) to help you build greener, more sustainable websites and applications!

We work out how much energy it takes to serve a site, then work out how much CO2 is emitted to generate the power needed that electricity, based on what information we have about where the power comes from.





Matching supply of compute, to demand for compute

Scale up - get a bigger server

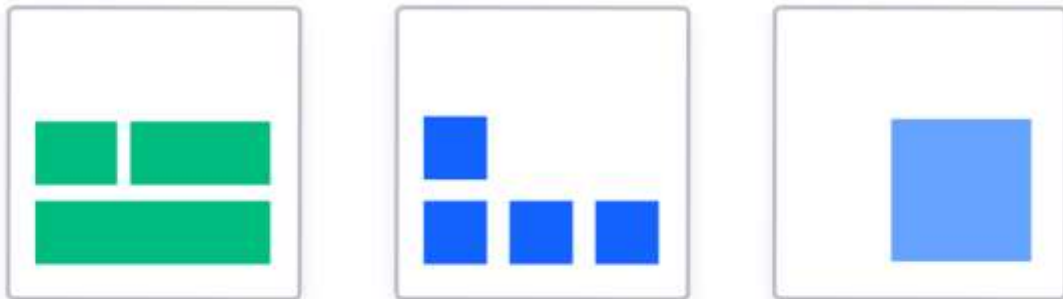
Scale out - add more servers

Scale in - add API compatible way to do the same work, faster or more efficiently

Scale-out

add more servers

WITHOUT BIN PACKING



WITH BIN PACKING



Smaller jobs, horizontally scaled - easier to increase utilisation. Not just for containers.

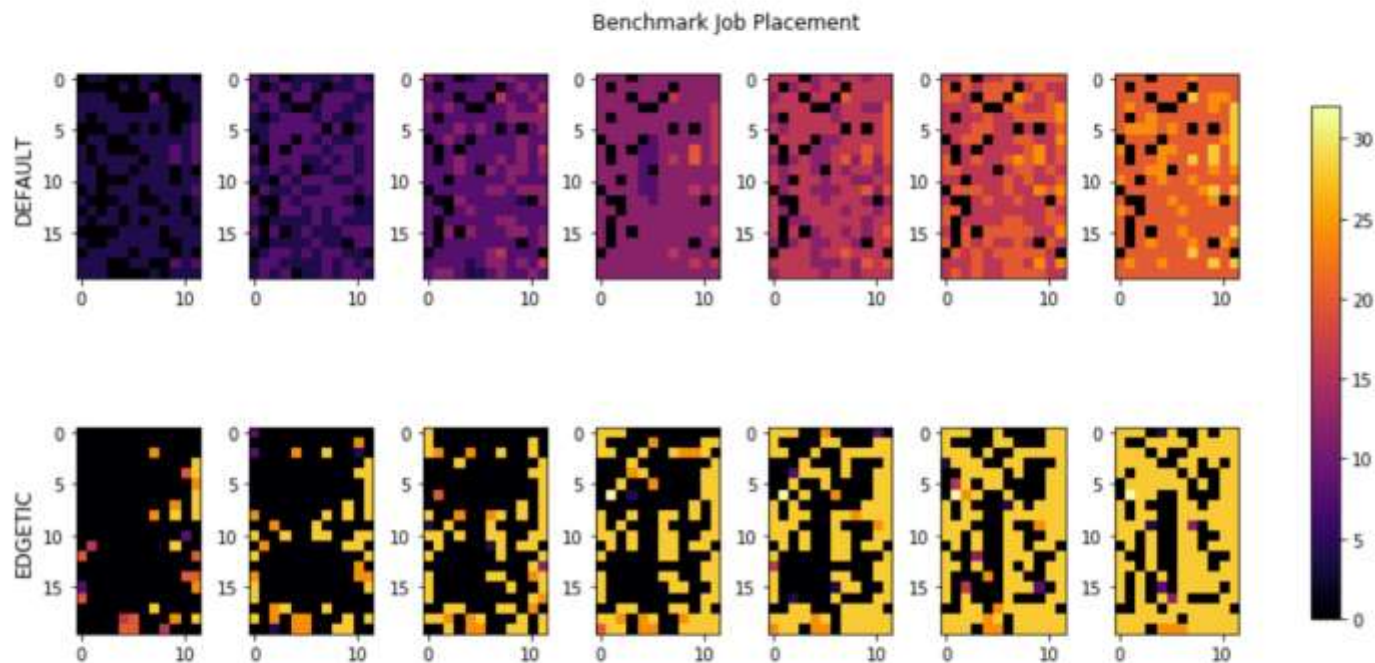


Figure 10. Comparison of cluster server utilization per job batch, using the default Kubernetes scheduler and the Edgetic scheduler

Even if you have the infrastructure - keeping more machines in a low power state helps.

Scale-in

add API compatible way to do the same work, faster or more efficiently

Medium

Zillow

COMCAST

SAMSUNG SDS

The Scylla Advantage

We reimplemented Apache Cassandra from scratch using C++ instead of Java to increase raw performance, better utilize modern multi-core servers and minimize the overhead to DevOps. Then we added our [Alternator](#) API, enabling you to run Amazon DynamoDB workloads anywhere and at a much lower cost.

See what's new in Scylla Open Source 4.0



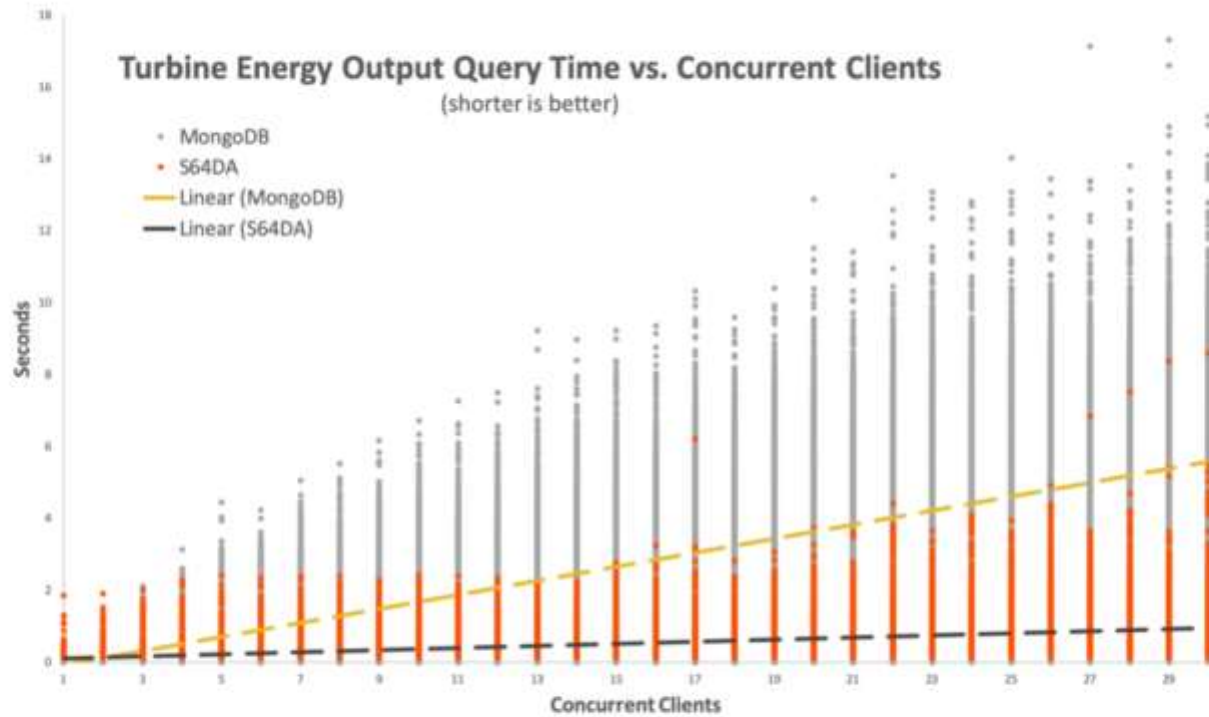
Scale in - at the software level with the likes of Scylla DB

Faster PostgreSQL performance

High-performance PostgreSQL extension for
faster analytics and easier scaling.

[Download the Swarm64 technical overview](#)

Scale in - at the hardware level with Swarm64



Scale in - at the hardware level with Swarm64

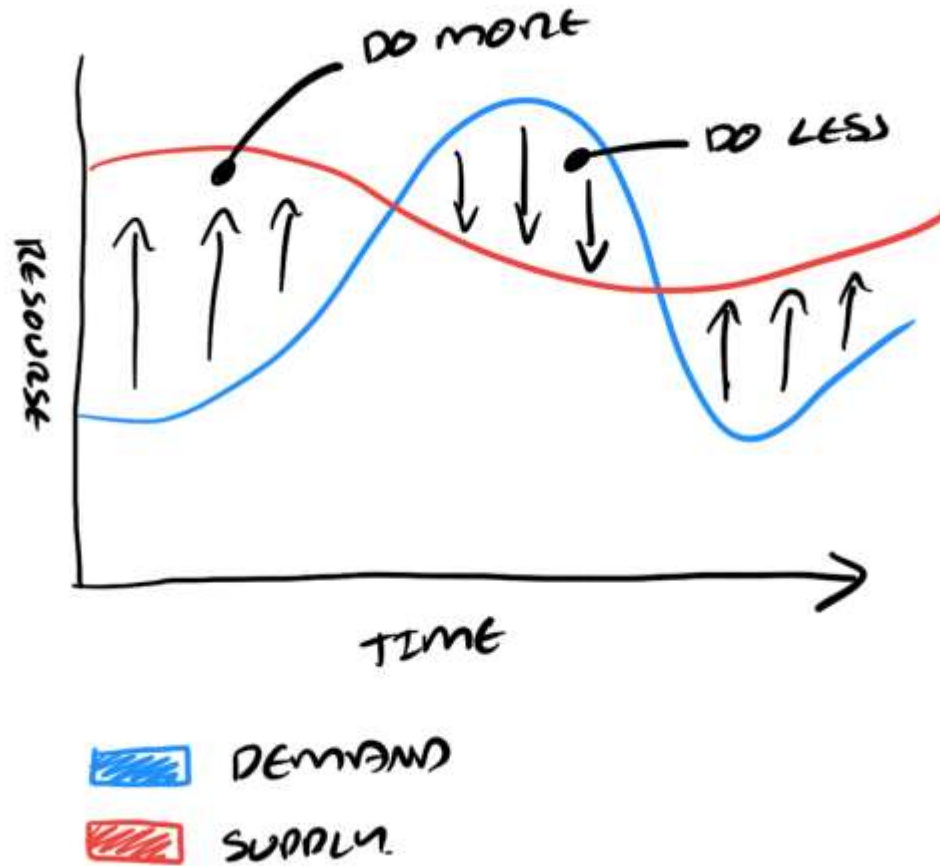
Green

Open

Lean

Distributed

**move work through time and
space to avoid carbon
emissions**



Not everything is equally urgent. Some work can wait for greener energy ([link](#))



LOW GRID INTENSITY

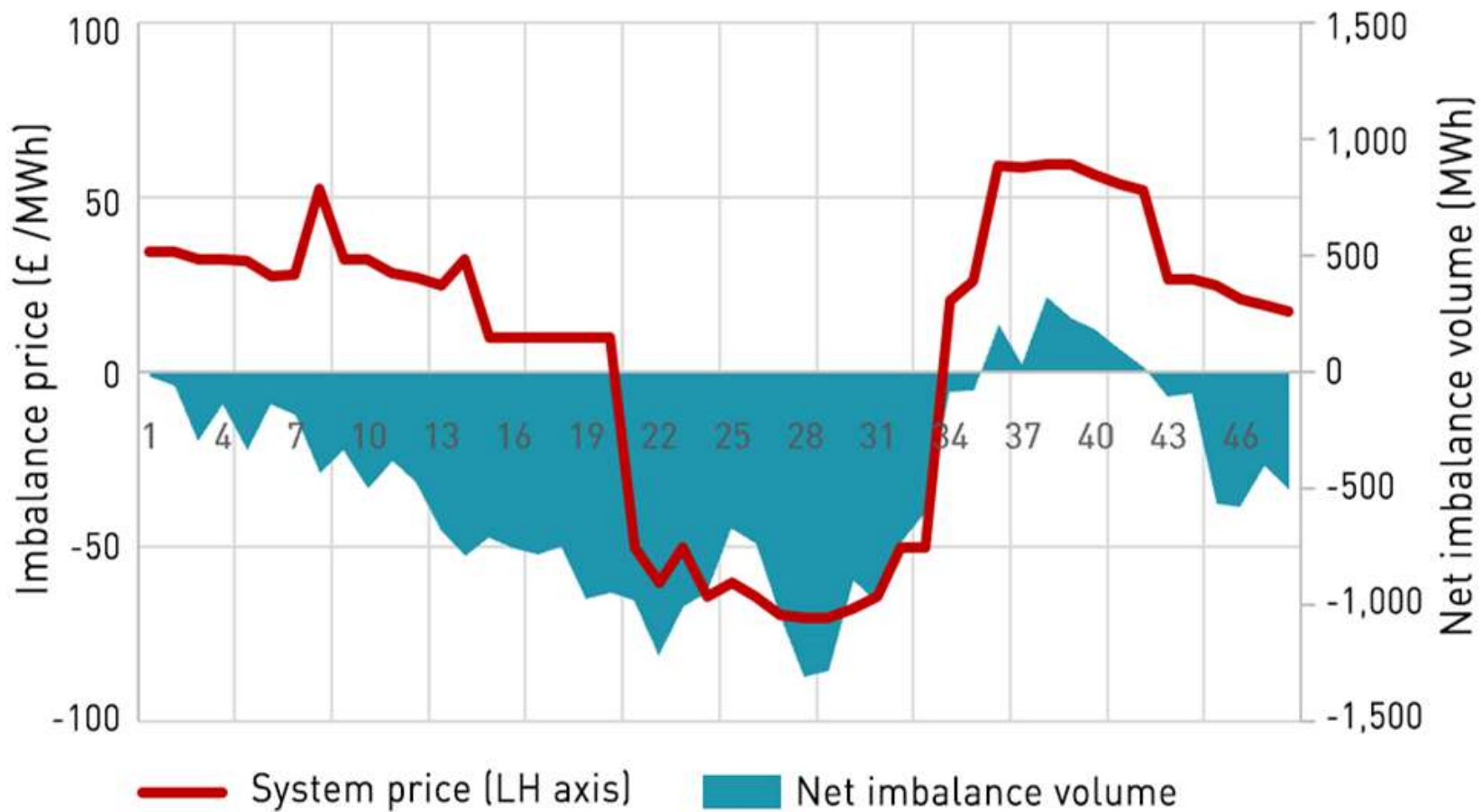


MEDIUM GRID INTENSITY



HIGH GRID INTENSITY

Carbon intensity as a creative constraint - Branch Magazine ([link](#))



The duck curve. When there's more being generated than can be used, you can be paid to use energy ([link](#))



Consumer facing demand pricing with Octopus Energy and their agile tariff ([link](#))

Conventional compute load

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



How Google move compute loads through *time* to when energy is cheap and green ([link](#))

In summary:

Two levers for carbon reduction: energy efficiency and carbon intensity

For green, think GOLD: Green, Open, Lean , Distributed.

Energy infra and digital infra: Patterns at the software layer let you take advantage of changes at the energy layer.

Thanks!

chris@thegreenwebfoundation.org
@mrchrisadams