Reducing carbon in the digital realm

c36c 2019

@mrchrisadams

This talk is online:

http://bit.ly/c36c-reduce-carbon

About me

Loco2 - Low CO2 Travel in Europe by train

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

Green Web Foundation - Make the web green

ClimateAction.tech - online community for folk in tech to discuss climate action

What we'll cover

Measuring carbon

A mental model for reducing carbon

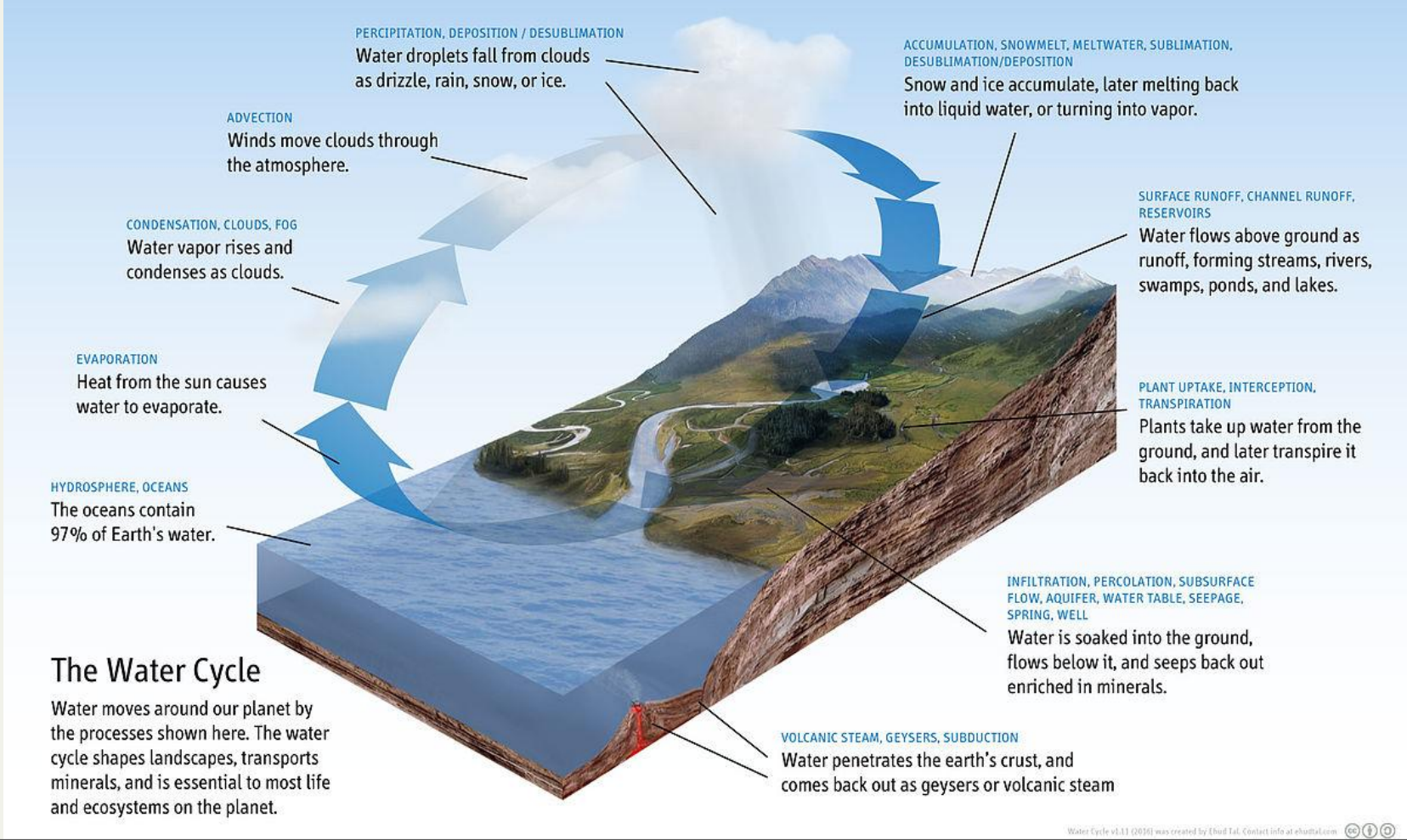
Where to go next

What we'll cover

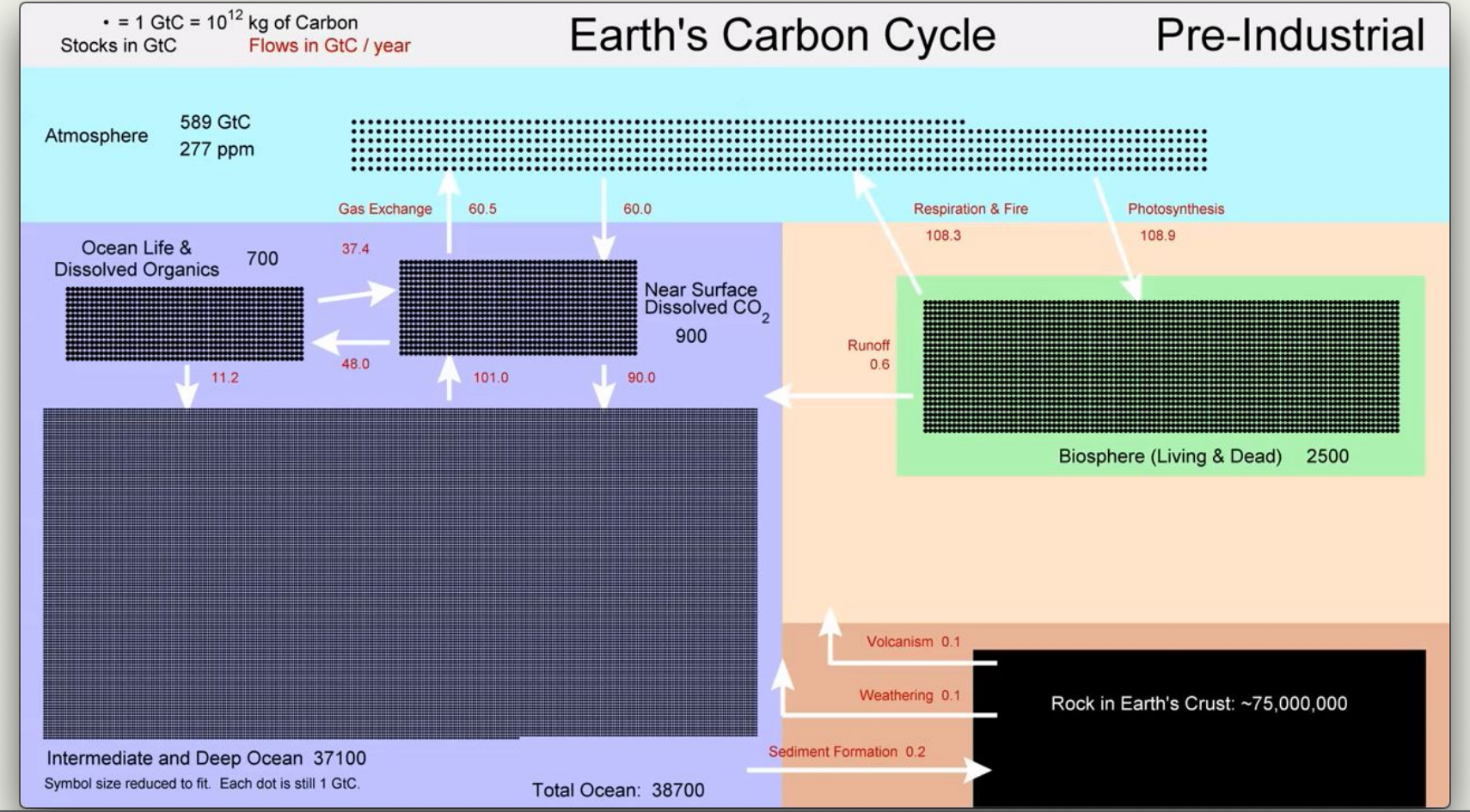
Measuring carbon

A mental model for reducing carbon

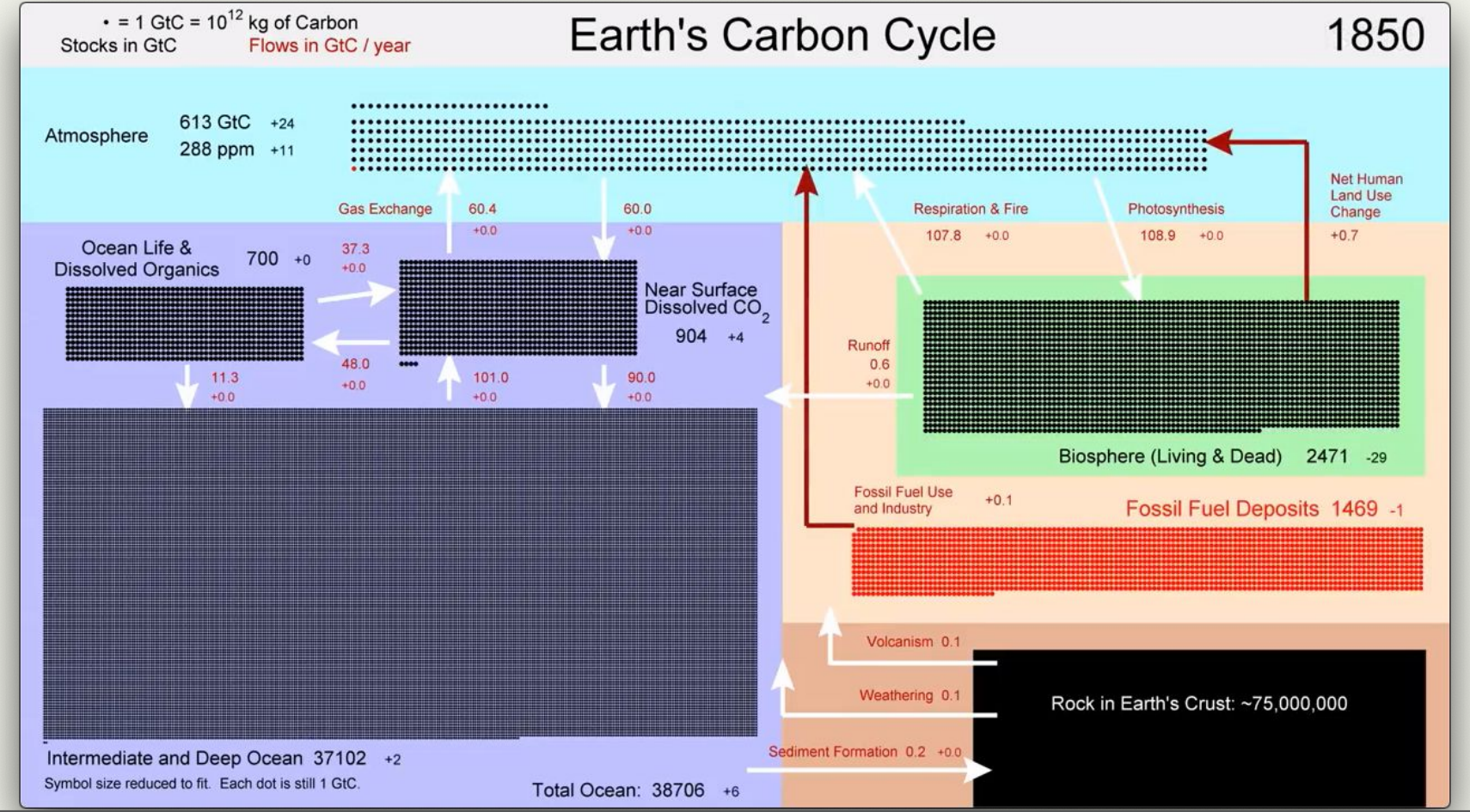
Where to go next



The water cycle: - wikiwand.com/en/Water_cycle



The Earth's Carbon Cycle: - Robert Rohde - youtu.be/dwVsD9CiokY



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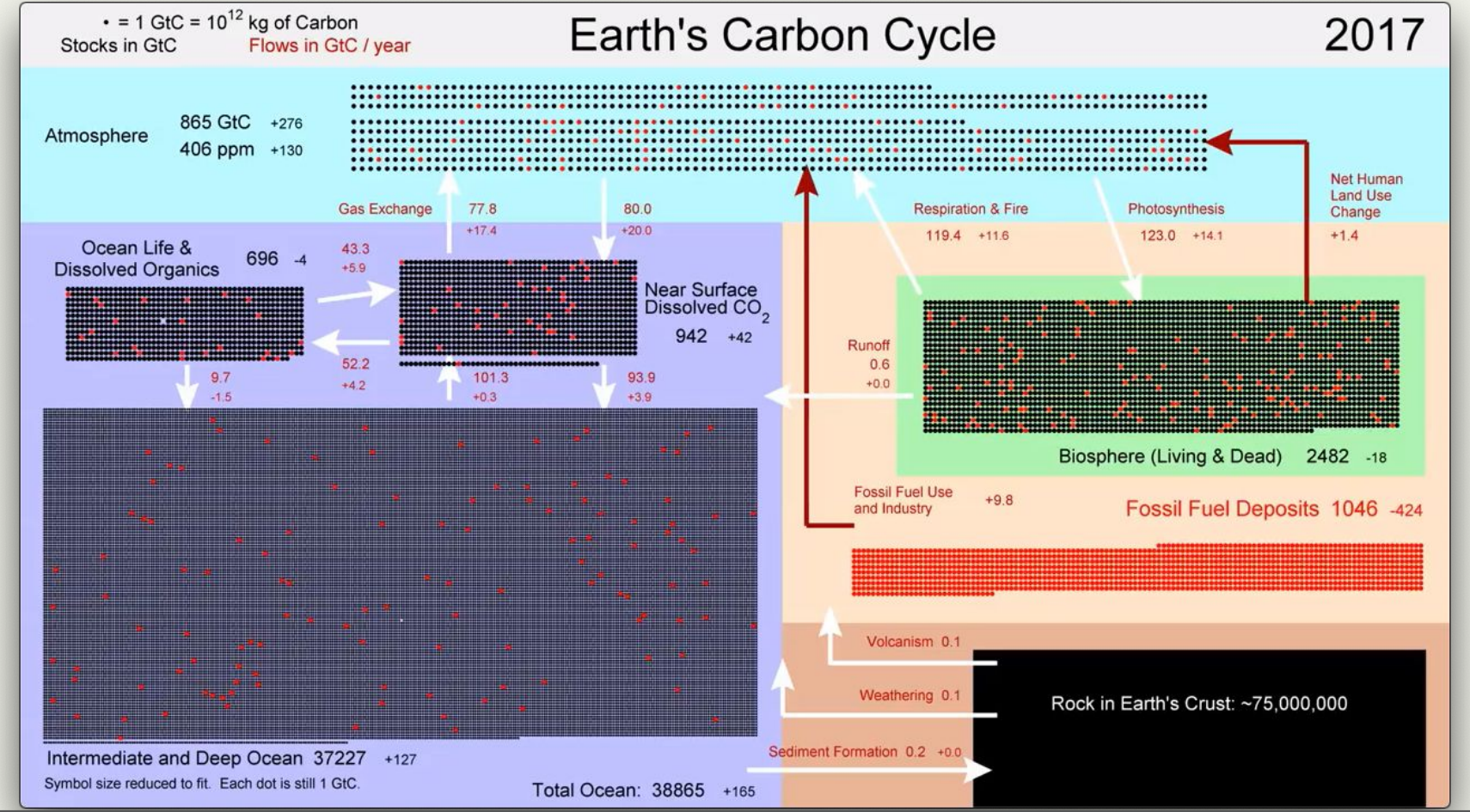


The Earth's Carbon Cycle: - Robert Rohde - youtu.be/dwVsD9CiokY


Teaching climate crisis thread for 4-7 year-olds, by @JKSteinberger

How to measure carbon emissions, communicated through the medium of hot beverages

Scope 1

Emissions from burning fossil fuels to make hot coffee

Scope 2

Emissions from electricity generated on your behalf, to make coffee

Scope 3

Emissions from activity in your supply chain, so you can have coffee

In 2017, Stripe became a carbon-neutral company

Though Stripe doesn't make a physical product—our API powers online commerce for millions of businesses around the world—our operations still contribute to global climate change. So, we decided to take action by measuring our greenhouse gas footprint and purchasing enough carbon offsets to reach net-zero emissions.

We began 2017 at an estimated 18,000 metric tonnes of emissions. The GHG Protocol Corporate Standard assesses greenhouse gas emissions on three dimensions. Stripe estimated all three emission scopes, in tonnes of carbon dioxide equivalent (TCO2E), to determine the magnitude of our impact.

SCOPE 1

DIRECT GHG

Emissions from sources owned or controlled by Stripe, e.g. natural gas burned to heat our buildings.

320 TCO2E

SCOPE 2

INDIRECT GHG

Emissions from purchased energy sources, e.g. the electricity we buy from utility companies.

880 TCO2E

SCOPE 3

OTHER INDIRECT GHG

Emissions from operations that are not directly owned or controlled by Stripe. This includes many sources, but we've chosen to focus on servers, employee commuting, and business travel.

16800 TCO2E

Stripe's climate reporting page, from 2018

Amazon's CO2 footprint in 2018 - 44m tonnes
(about the same as Finland)

Scope 1
4.9m tonnes

Scope 2
4.7m tonnes

Scope 3
34.7m tonnes

Google's CO2 footprint in 2018 - 1.2m tonnes

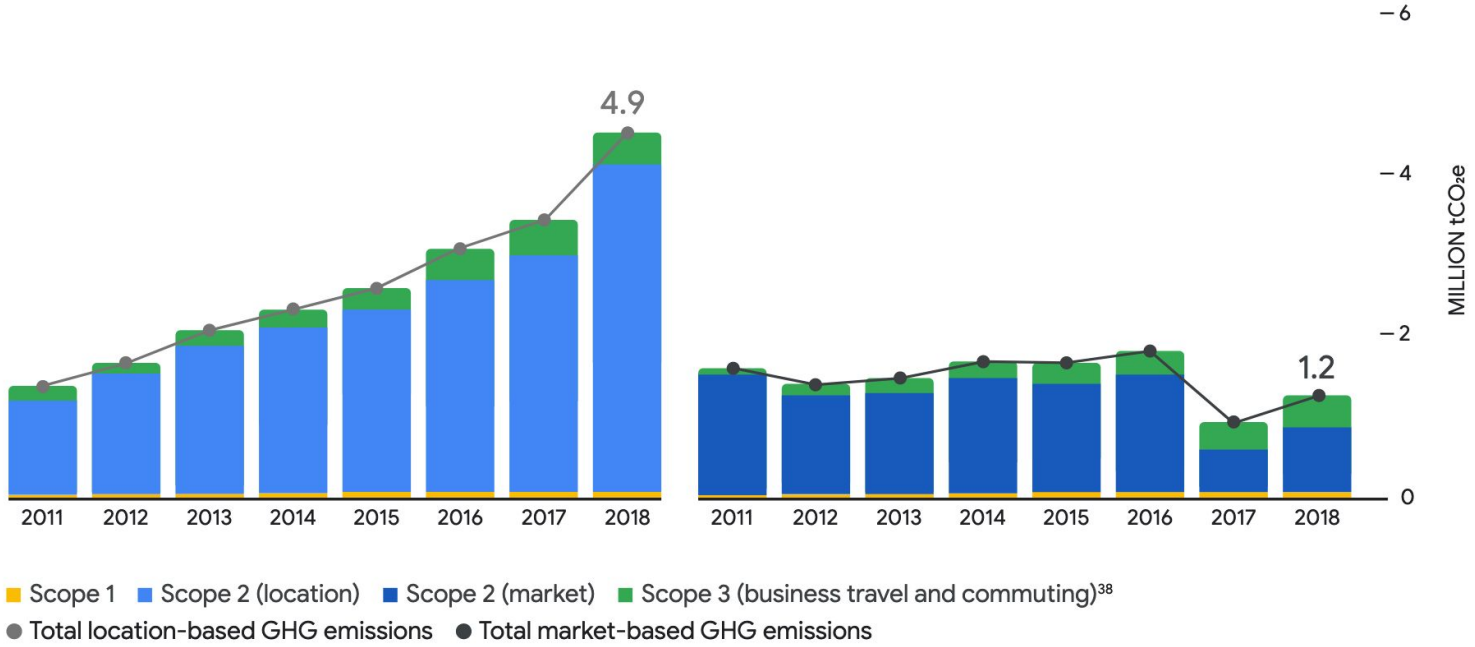
(about the same as Liberia)

Figure 7

GHG EMISSIONS WITHOUT RENEWABLE ENERGY PURCHASES

Figure 8

GHG EMISSIONS WITH RENEWABLE ENERGY PURCHASES



Apple's CO2 footprint in 2018, *for just its facilities* - *0.6m tonnes*
(about the same as The Gambia)

Scope 1
0.05m tonnes

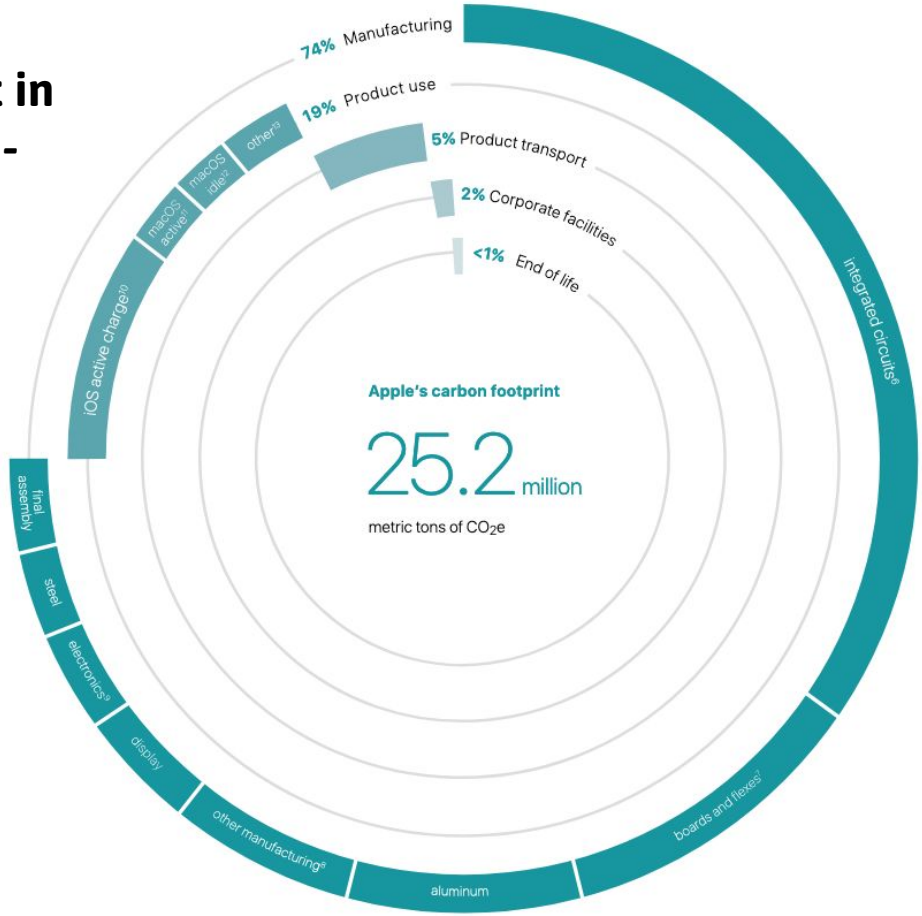
Scope 2
0.08m tonnes

99% renewable energy (0.7m tonnes avoided through sourcing renewable energy)

Scope 3
0.5m tonnes

~0.3m tonnes, from business travel,
~0.2m tonnes from employee commuting

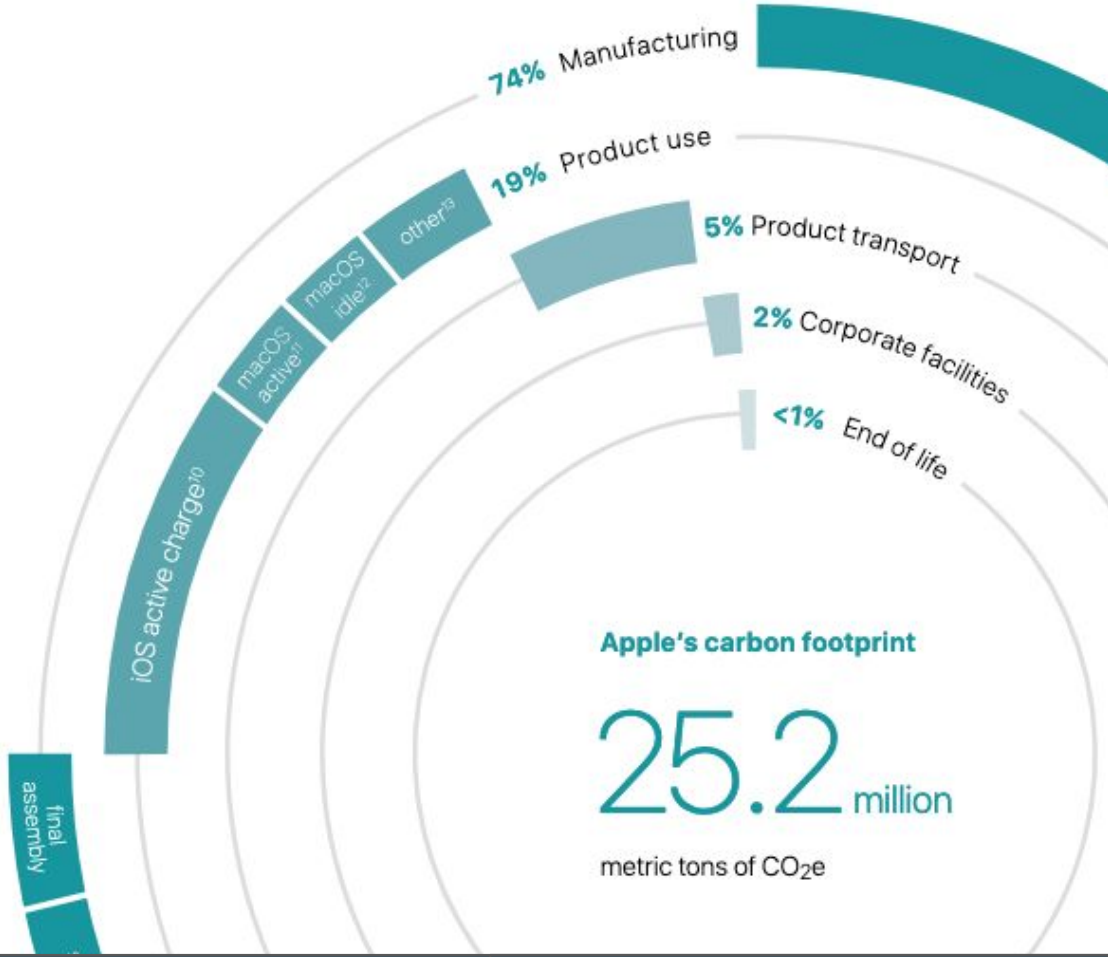
Apple's CO2 footprint in 2018, *for its products* - *25.2m tonnes*
(about the same as Mongolia)



This is all Scope 3

Apple's CO2 footprint in 2018, *<u>for its products</u>* - *25.2m tonnes*
(about the same as Mongolia)

This is all Scope 3



What we'll cover

Measuring carbon

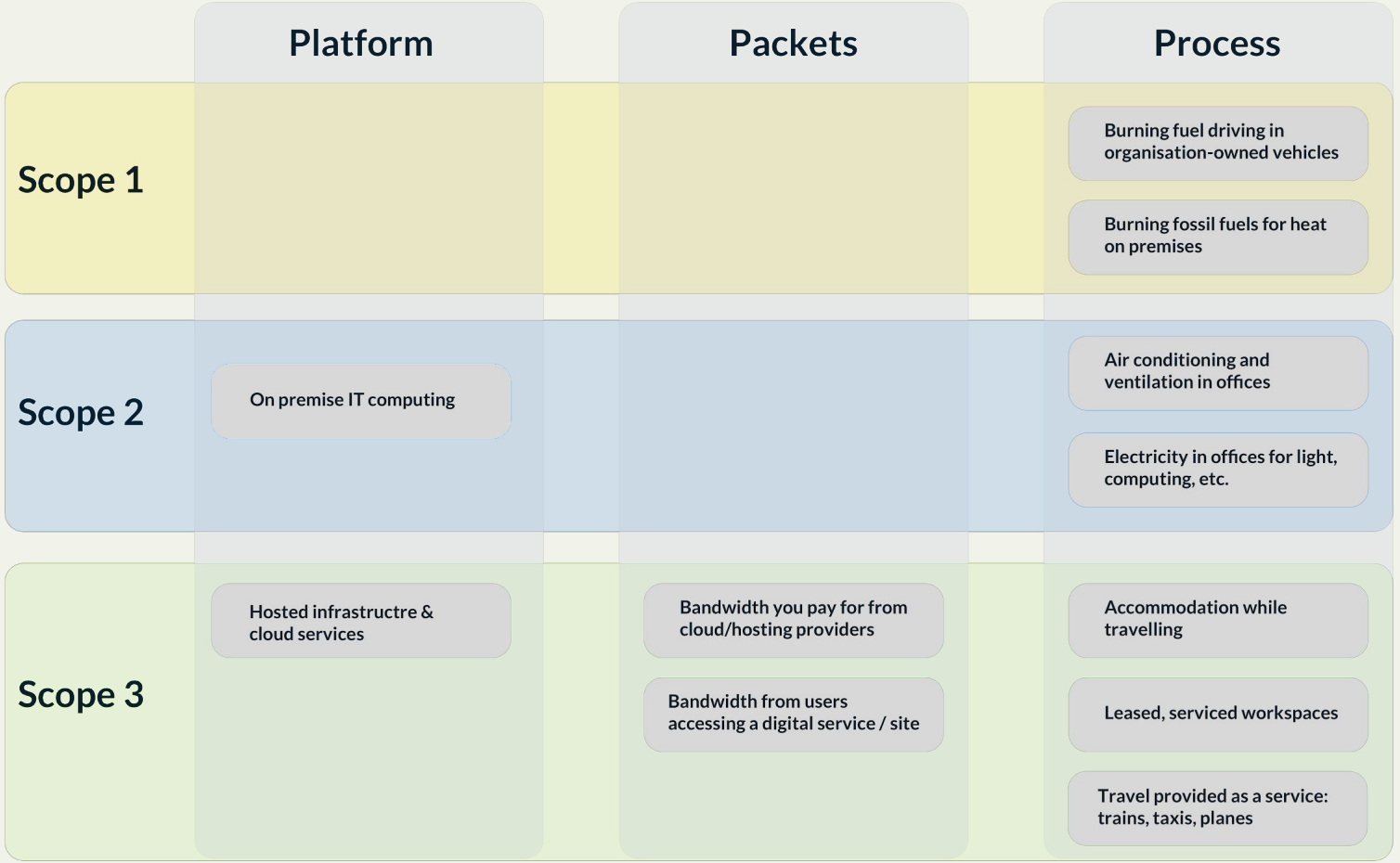
A mental model for reducing carbon

Where to go next

Platform - infrastructure you run

Packets - infrastructure other folk run

Process - how your org works


Platform
Packets
Process
Scope 1
Burning fuel driving in organisation-owned vehicles
Burning fossil fuels for heat on premises
Scope 2
On premise IT computing
Air conditioning and ventilation in offices
Electricity in offices for light, computing, etc.
Scope 3
Hosted infrastructre & cloud services
Bandwidth you pay for from cloud/hosting providers
Bandwidth from users accessing a digital service / site
Accommodation while travelling
Leased, serviced workspaces
Travel provided as a service: trains, taxis, planes

Platform - infrastructure you run

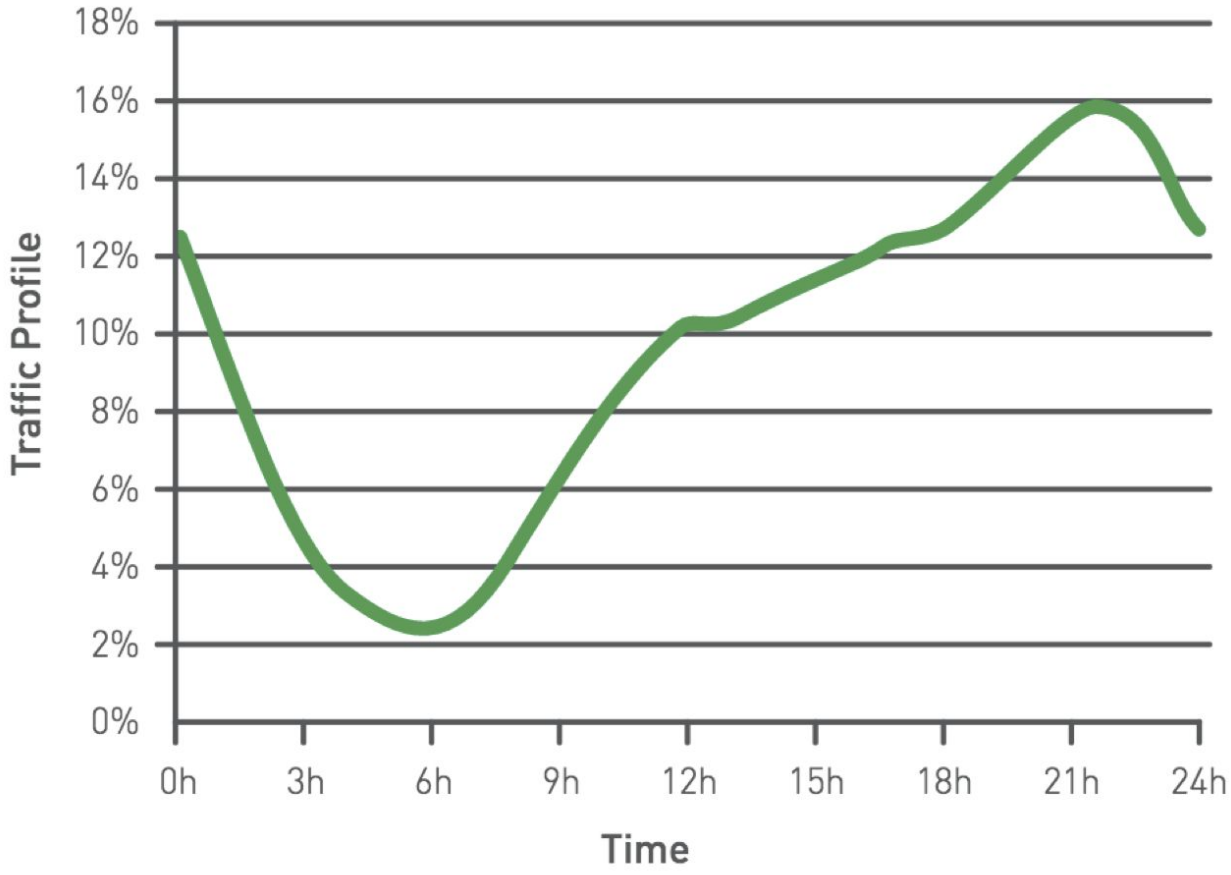
Provisioning - how

Provider - who

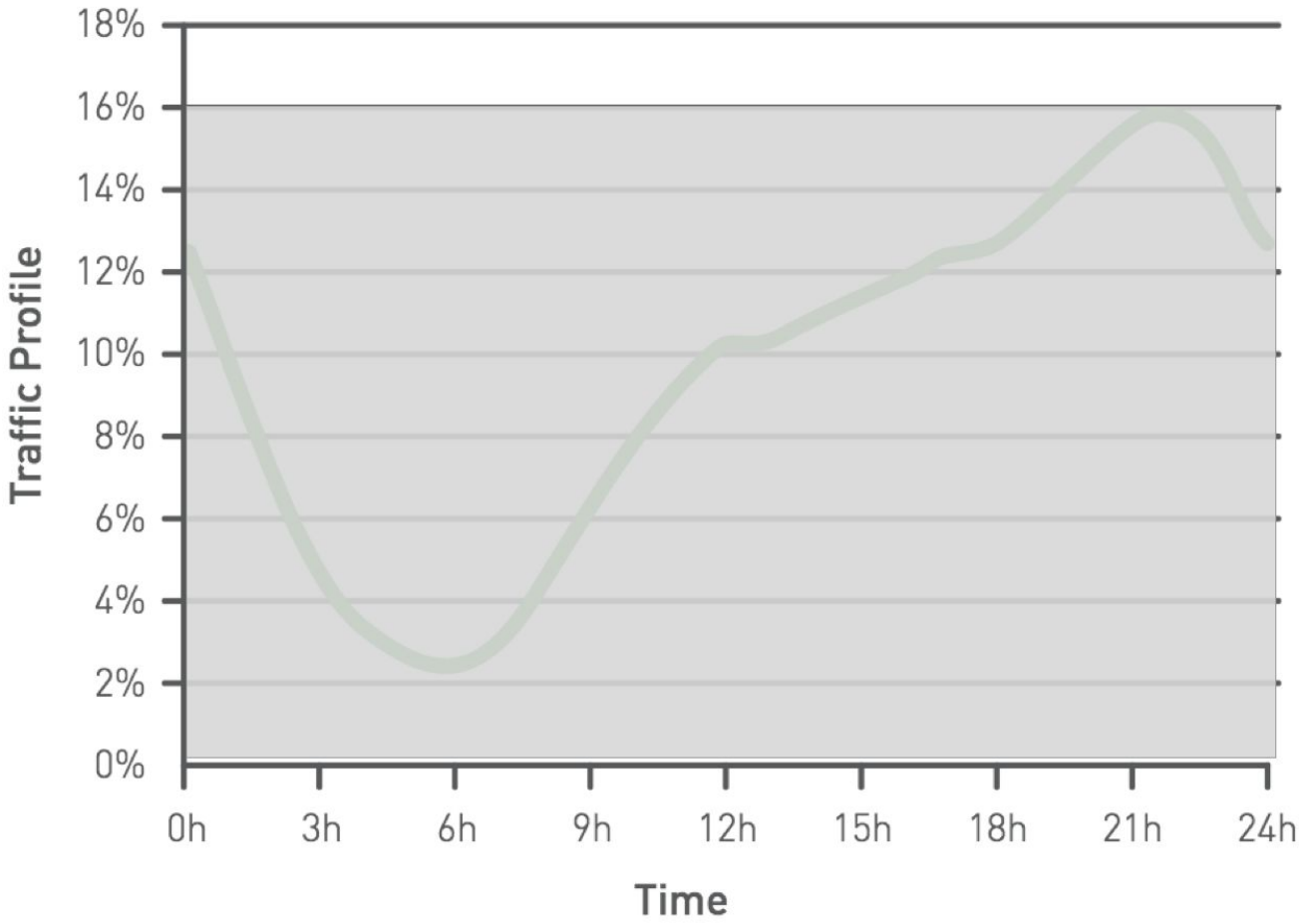
Programming Language - what

Provisioning -

How you match capacity to use



Our usage patterns of the internet (CEEE Power of Wireless Cloud report)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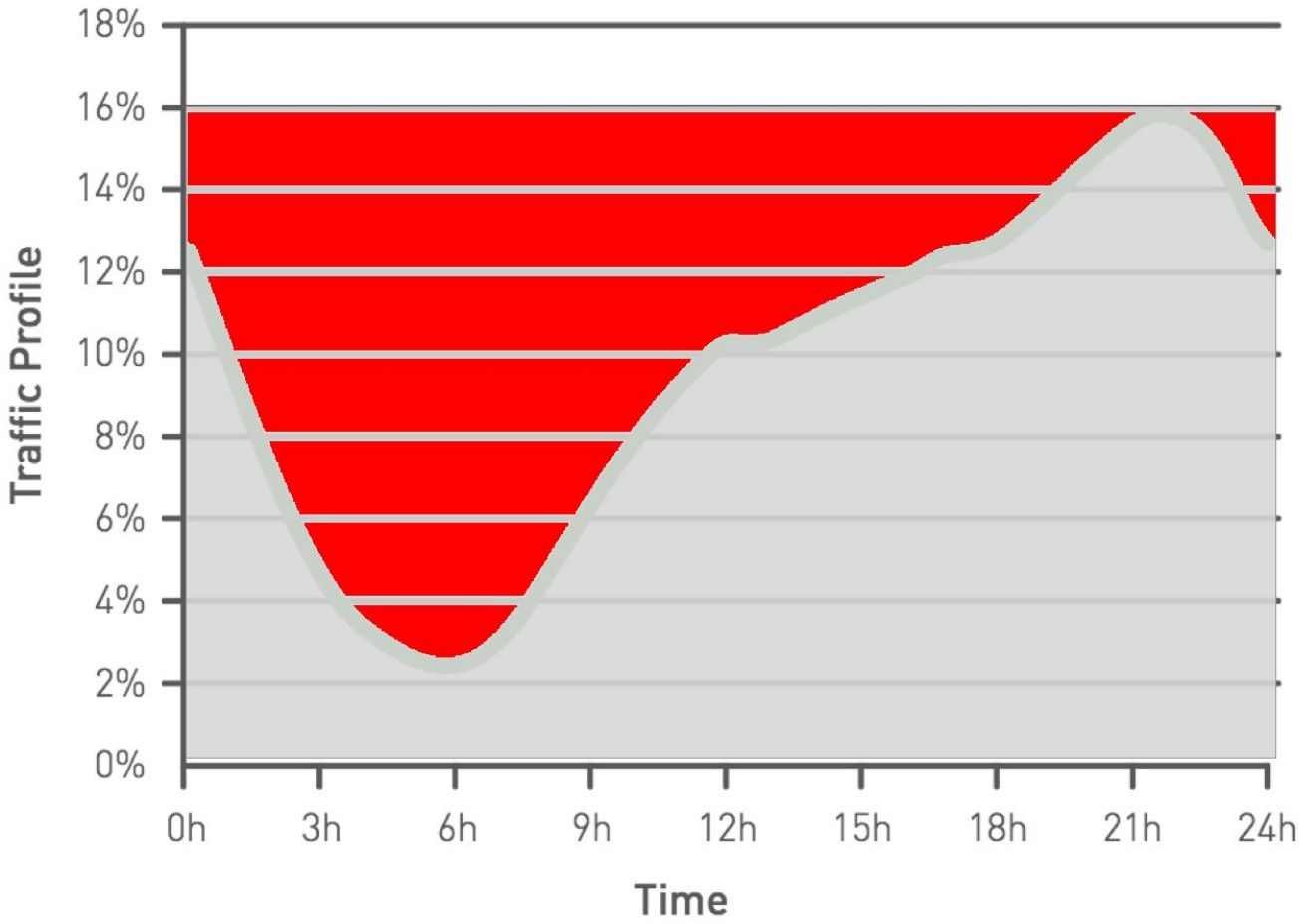
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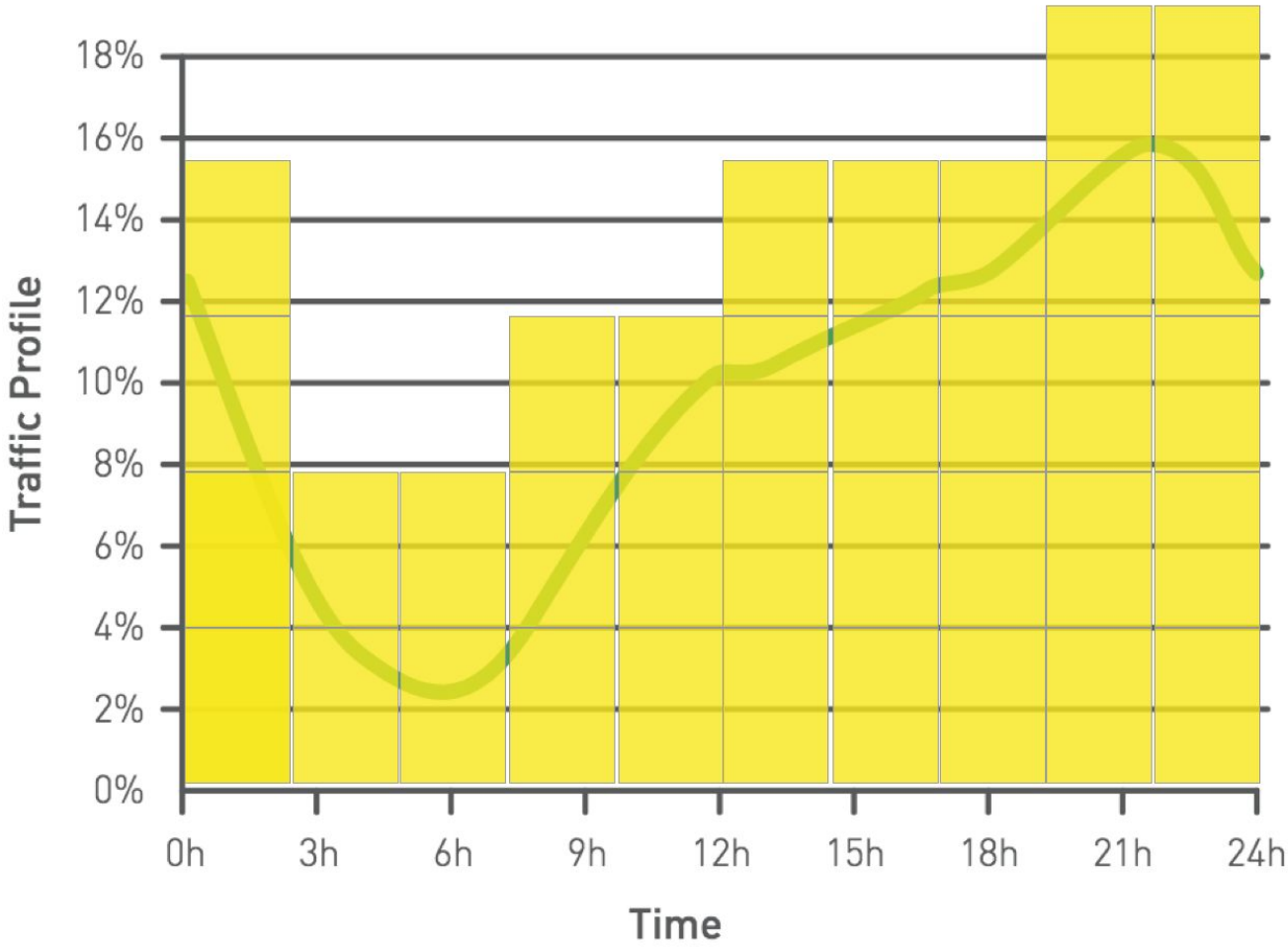
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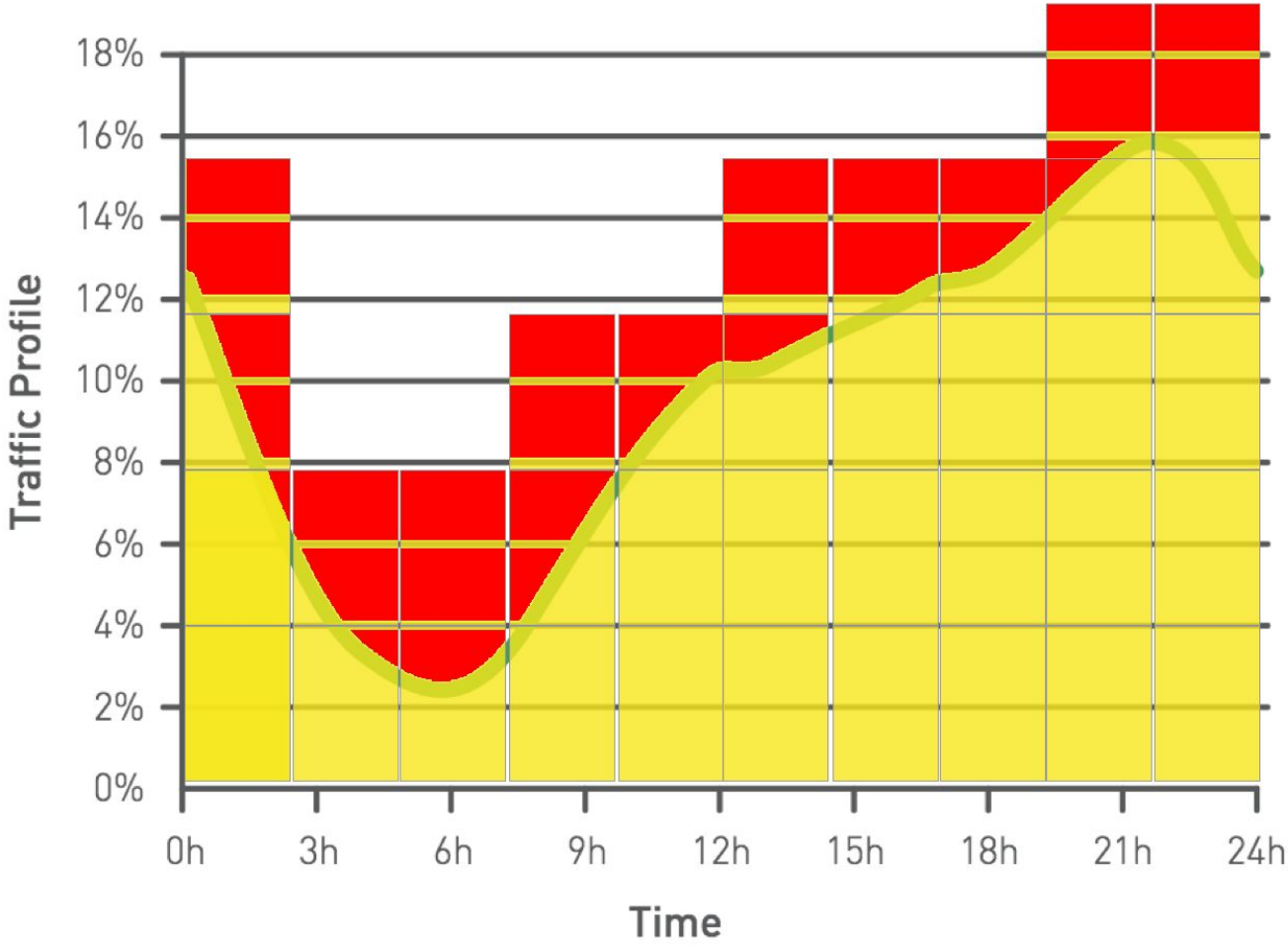
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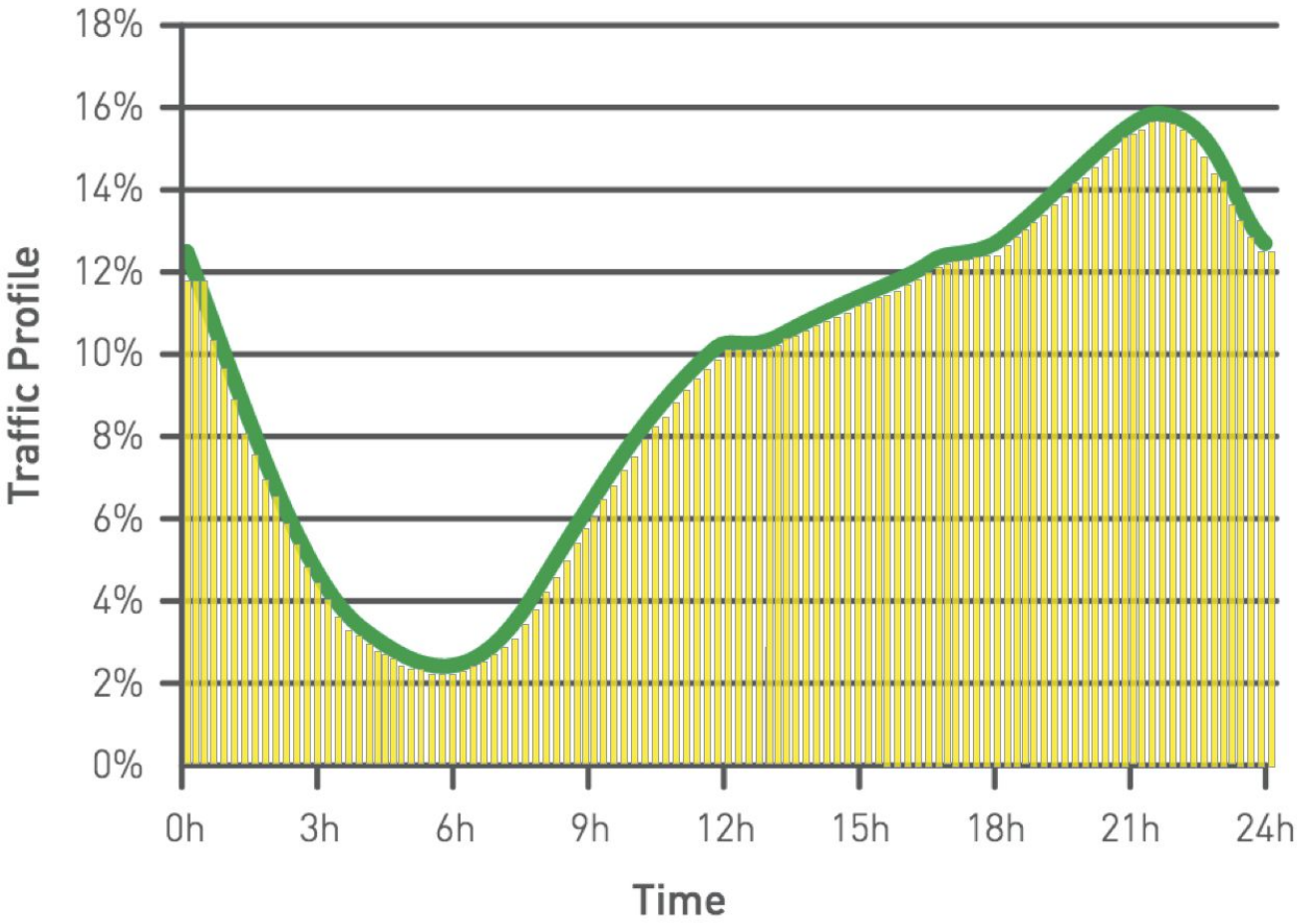
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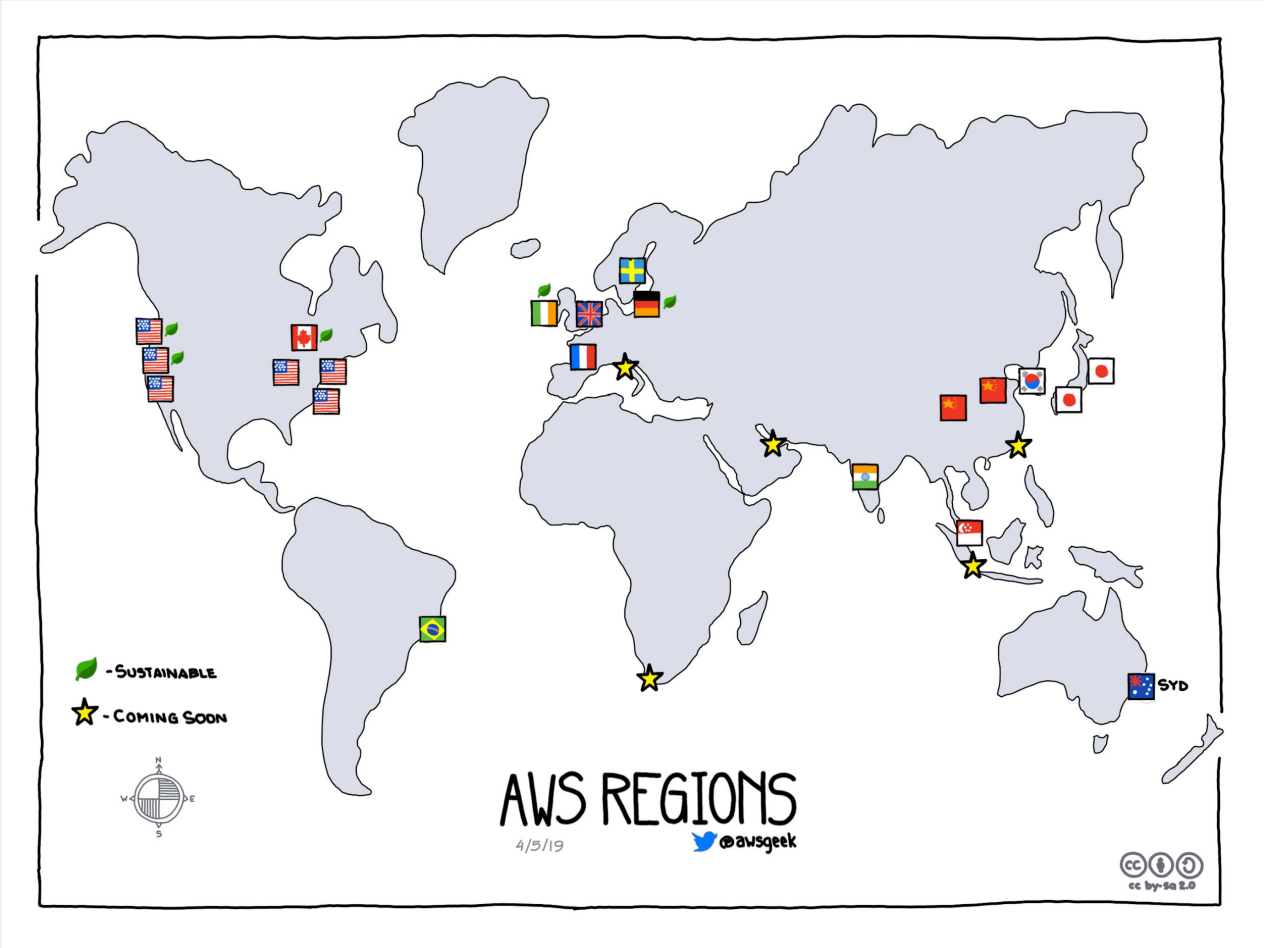
24h
Time

You only get to pick two:

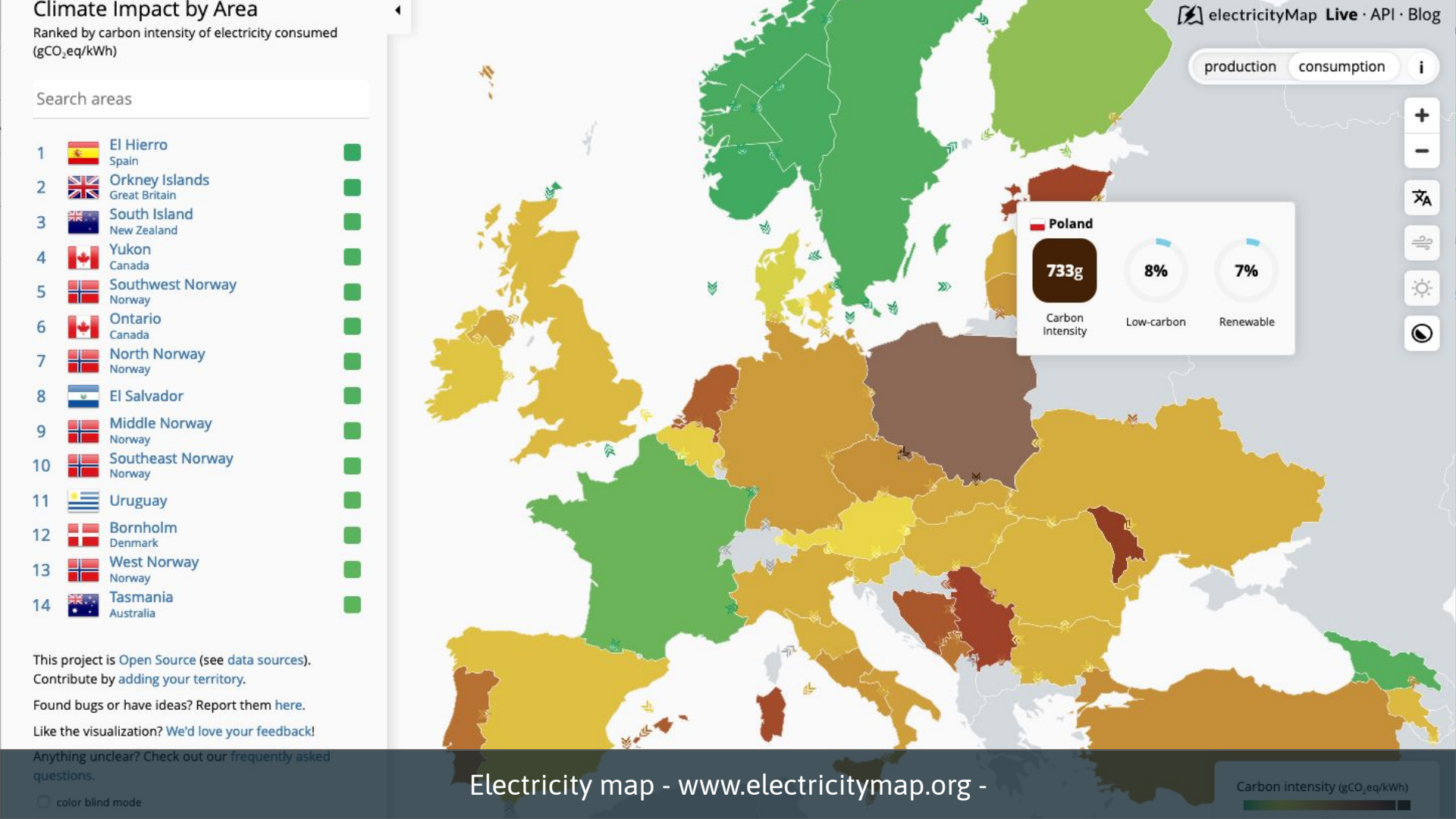
- **avoid using fossil fuels** - climate crisis, remember?
- **use mature hosted services** - instead of building everything yourself
- **avoid oligopoly** - diverse ecosystems are healthy ecosystems

Provider -

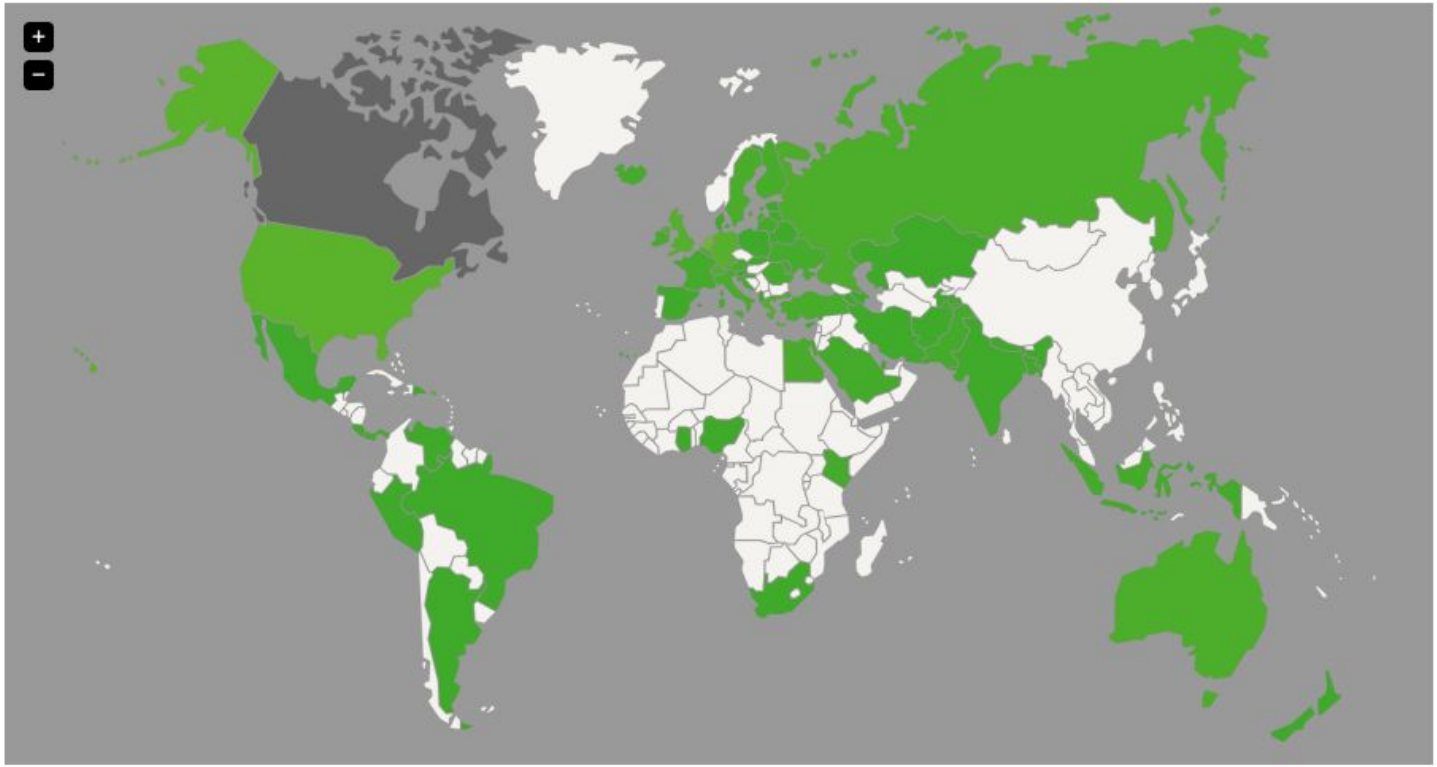
Who you get your compute from



AWS Region map - twitter.com/awsgeek/status/1113820651436085248



Electricity map - www.electricitymap.org -



THE DIRECTORY COMPRISES 501 GREEN HOSTING COMPANIES IN 62 COUNTRIES

Brief segway into energy market weirdness

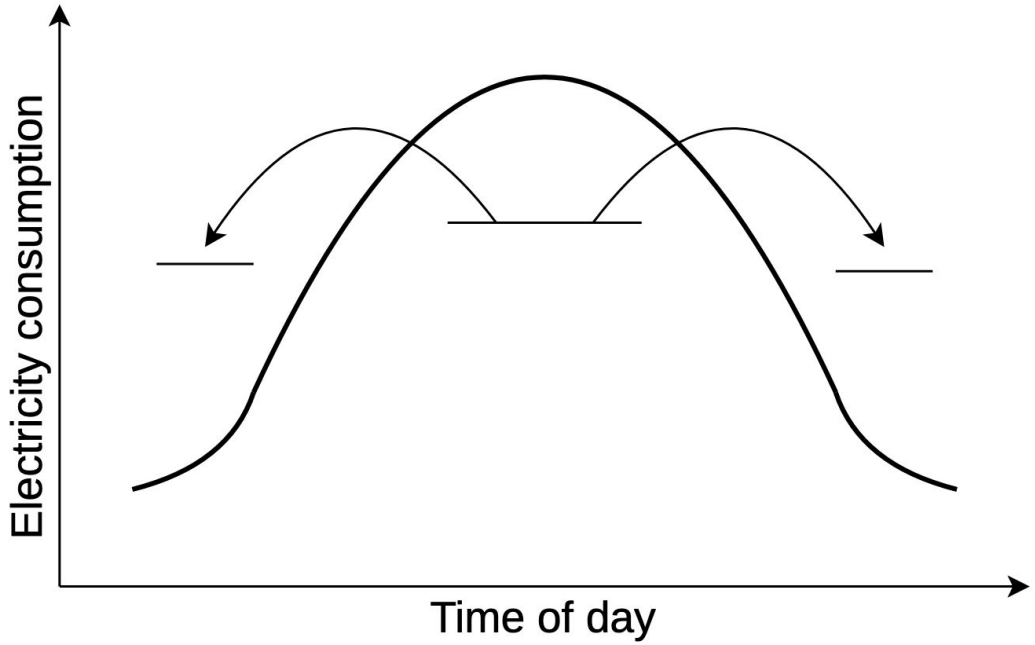
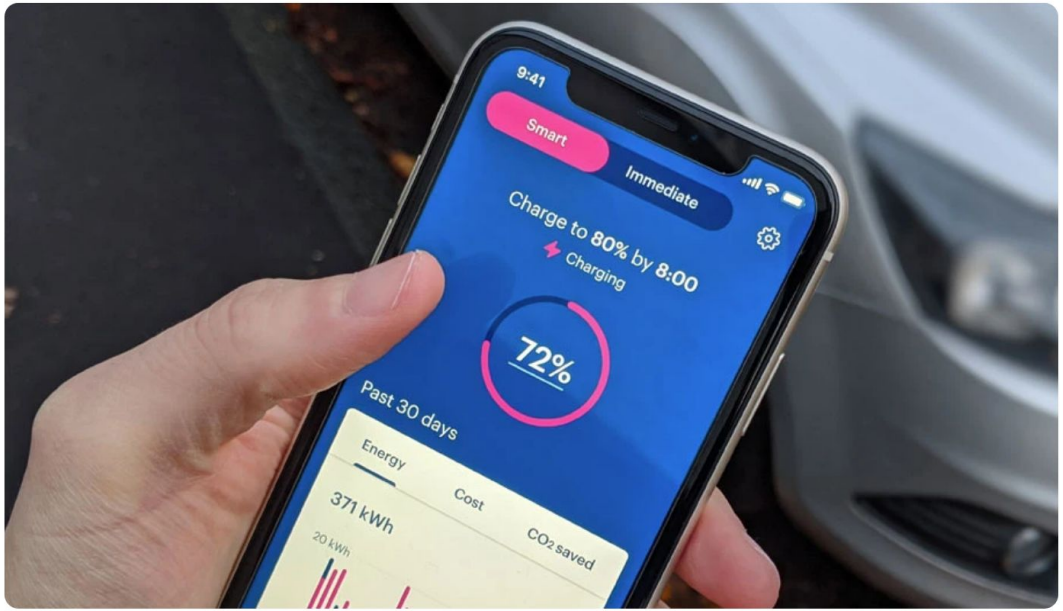


Fig. 1. Demand Side Managment (DSM) strategy - Load Shifting. The ‘duck curve’ of solar power generation can be observed, with energy generation peaking in the middle of the day

[8]



The way we charge electric cars could make better use of electricity on the grid. We're testing a new app with our members to help them charge their cars when power is cheaper and greener.

Bulb - smart charging of electric cars

A Low Carbon Kubernetes Scheduler

Aled James
Email: aledjms@gmail.com

Daniel Schien
University of Bristol, UK
Email: Daniel.Schien@bristol.ac.uk

***Abstract*—A major source of global greenhouse gas emissions is the burning of fossil fuels for the generation of electricity. The portion of electricity generated from fossil fuel varies across regions, and within a region with demand for electricity and the availability of renewable energy sources. Cloud providers operate data centres in locations around the planet. And certain kind of server computation can tolerate migrating between data centres.**

In this paper we describe the design and implementation of a low carbon scheduling policy for the open-source Kubernetes container orchestrator. We apply this scheduler in a form of demand side management by migrating consumption of electric energy to countries with the lowest carbon intensity of electricity.

The primary contributions of this text are (i) the scheduler's design, which provides a generic model for optimising workload placement in regions with the lowest carbon intensity (ii) an evaluation of its performance in a case study with a major public cloud provider (iii) an implementation of a demand side management solution that consumes electricity where, instead of when, grid carbon intensity is lowest.

***Index Terms*—Kubernetes; green computing; DSM; Demand Side Management; renewable energy; grid carbon intensity**

renewable ('green') energy as well as fossil fuel or nuclear based energy sources ('brown energy') in order to compensate for the intermittent nature of renewable energy generation. Solar photovoltaic (PV) power production primarily depends on the amount of solar irradiation (insolation) reaching the solar panel; however, that irradiation is not uniformly distributed over time [7]. In addition to the rotation of the earth, weather and intermittend clouds block the Sun's rays and thus influence solar power generation output.

Intermittency of availability of renewable energy sources is one of the factors driving demand side management (DSM) in the electric grid where consumers of electric grid alter their energy consumption patterns. In the area of energy systems management, demand side management (contrasts with supply side interventions) refers to any initiatives (technical interventions, pricing models and monetary incentives) that affect how and when electricity is being required by consumers. While much of the research on DSM focusses on domestic energy consumption there has also been work investigating DSM by

8.pdf

We had an energiewende.

We got cheap, green, distributed energy.

What if we had a *digitalwende*?

Cheap, green, distributed *compute*?

Programming language

Where appropriate, matching the language to the job can help, because different languages have different features and goals.


Resource consump
robur calendar June 2019
Panel Title
memory
cpu usage (stime, utime, vcpu ticks)
network byte throughput
vm exits
robur.c user CPU
14 s
robur.c system CPU
19.2 min
robur.c total bytes in
98.9 MB
robur.c total bytes out
241 MB
robur.c total cpu ticks
1.981 Tri
robur.c current resident mem...
71.8 MB

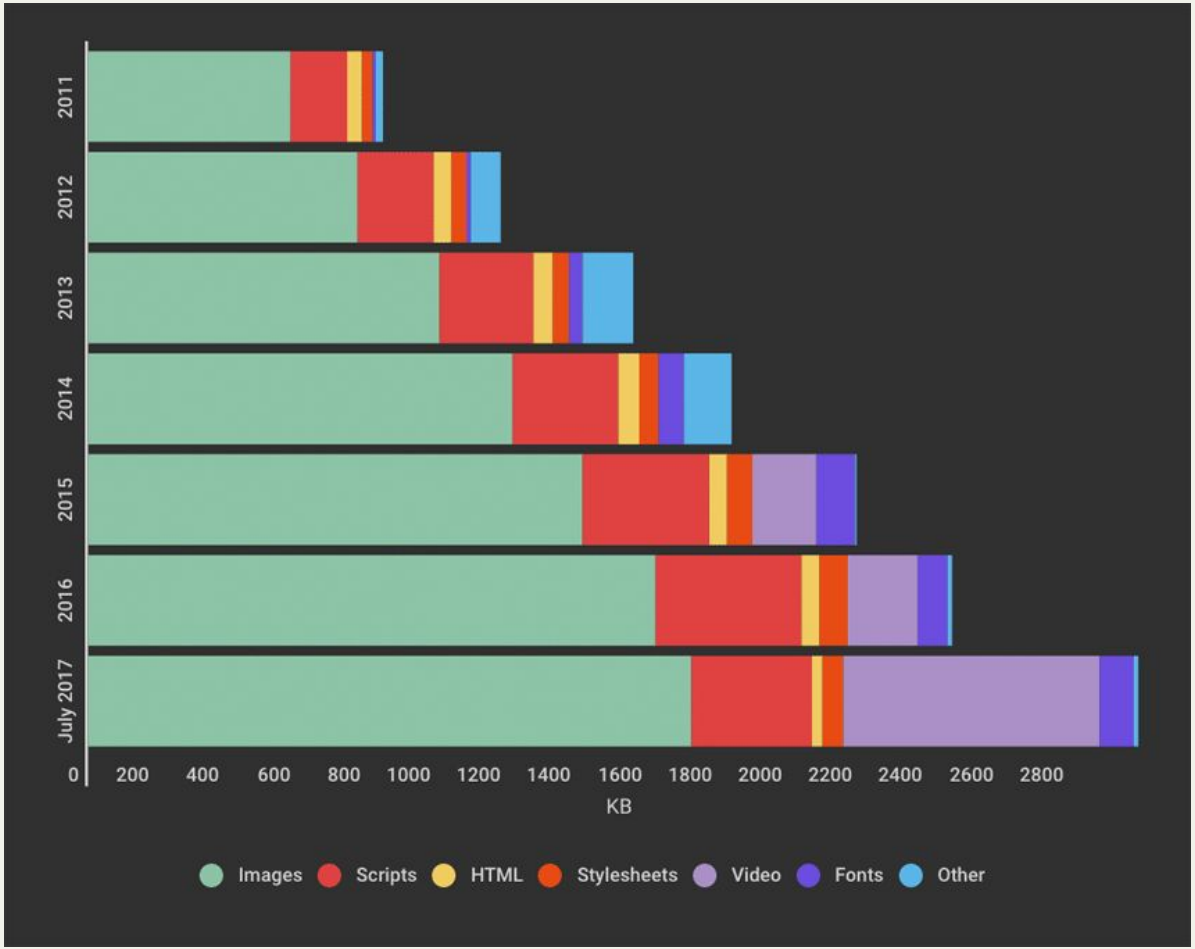
Table 5. Pareto optimal sets for different combination of objectives.

Time & Memory	Energy & Time	Energy & Memory	Energy & Time & Memory
C • Pascal • Go	C	C • Pascal	C • Pascal • Go
Rust • C++ • Fortran	Rust	Rust • C++ • Fortran • Go	Rust • C++ • Fortran
Ada	C++	Ada	Ada
Java • Chapel • Lisp • Ocaml	Ada	Java • Chapel • Lisp	Java • Chapel • Lisp • Ocaml
Haskell • C#	Java	OCaml • Swift • Haskell	Swift • Haskell • C#
Swift • PHP	Pascal • Chapel	C# • PHP	Dart • F# • Racket • Hack • PHP
F# • Racket • Hack • Python	Lisp • Ocaml • Go	Dart • F# • Racket • Hack • Python	JavaScript • Ruby • Python
JavaScript • Ruby	Fortran • Haskell • C#	JavaScript • Ruby	TypeScript • Erlang
Dart • TypeScript • Erlang	Swift	TypeScript	Lua • JRuby • Perl
JRuby • Perl	Dart • F#	Erlang • Lua • Perl	
Lua	JavaScript	JRuby	
	Racket		
	TypeScript • Hack		
	PHP		
	Erlang		
	Lua • JRuby		
	Ruby		

Packets -

Infrastructure you ***do not*** control

You can only control ***how much you send*** over the wire instead.



Avg (mean) page size is 3mb - speedcurve.com/blog/web-performance-page-bloat

https://www.google.com/gmail/about/
Nov 4, 2018, 11:37 AM PST
Emulated Nexus 5X, Simulated Slow 4G network

93	50	43	86	100
Performance	Progressive Web App	Accessibility	Best Practices	SEO

Score scale: 90-100 50-89 0-49

Performance

93

Metrics

First Contentful Paint	1.6 s	First Meaningful Paint	1.6 s
Speed Index	3.3 s	First CPU Idle	3.5 s
Time to Interactive	3.7 s	Estimated Input Latency	40 ms

estimated and may vary.

Lighthouse - break the build when you break your perf budget

Sustainable Web

These checks show changes to make to reduce the carbon emissions from what you build. Climate crisis, remember?

Page summary

- **Page is built using resources from servers running on fossil fuels**

  Burning fossil fuels to power servers is avoidable, and contributes to climate breakdown. See the W3C Ethical Web Principles, on Sustainable Web, and learn more at The Green Web Foundation

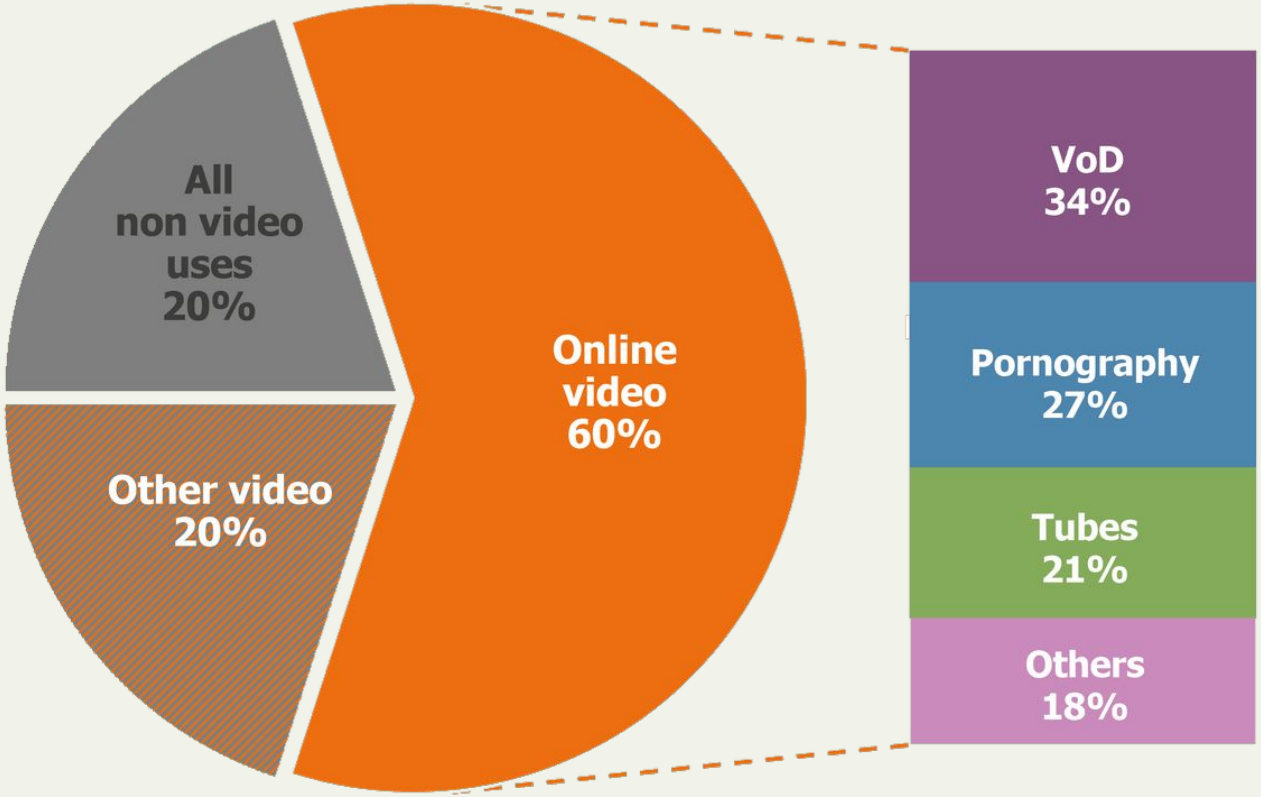
Greenhouse - Lighthouse, but for carbon emissions

The web must be an environmentally sustainable platform

“The web, as a whole, is a big source of carbon emissions, because it is a big consumer of power.

New web technologies should not make this situation worse. We will consider power consumption and the resulting emissions when we introduce new technologies to the web”

W3C Technical architecture group



Distribution of online data flows between different uses of digital technologies and of online video in 2018 in the world

Changing how we design sites is not enough. Video dwarfs web traffic.

Process - how your org works

Decisions you make, about where and how you work, that cause emissions.

Process - how your org works

Inward - greening ***of*** digital projects.

Less visible to the end user.

WHOLEGRAIN digital

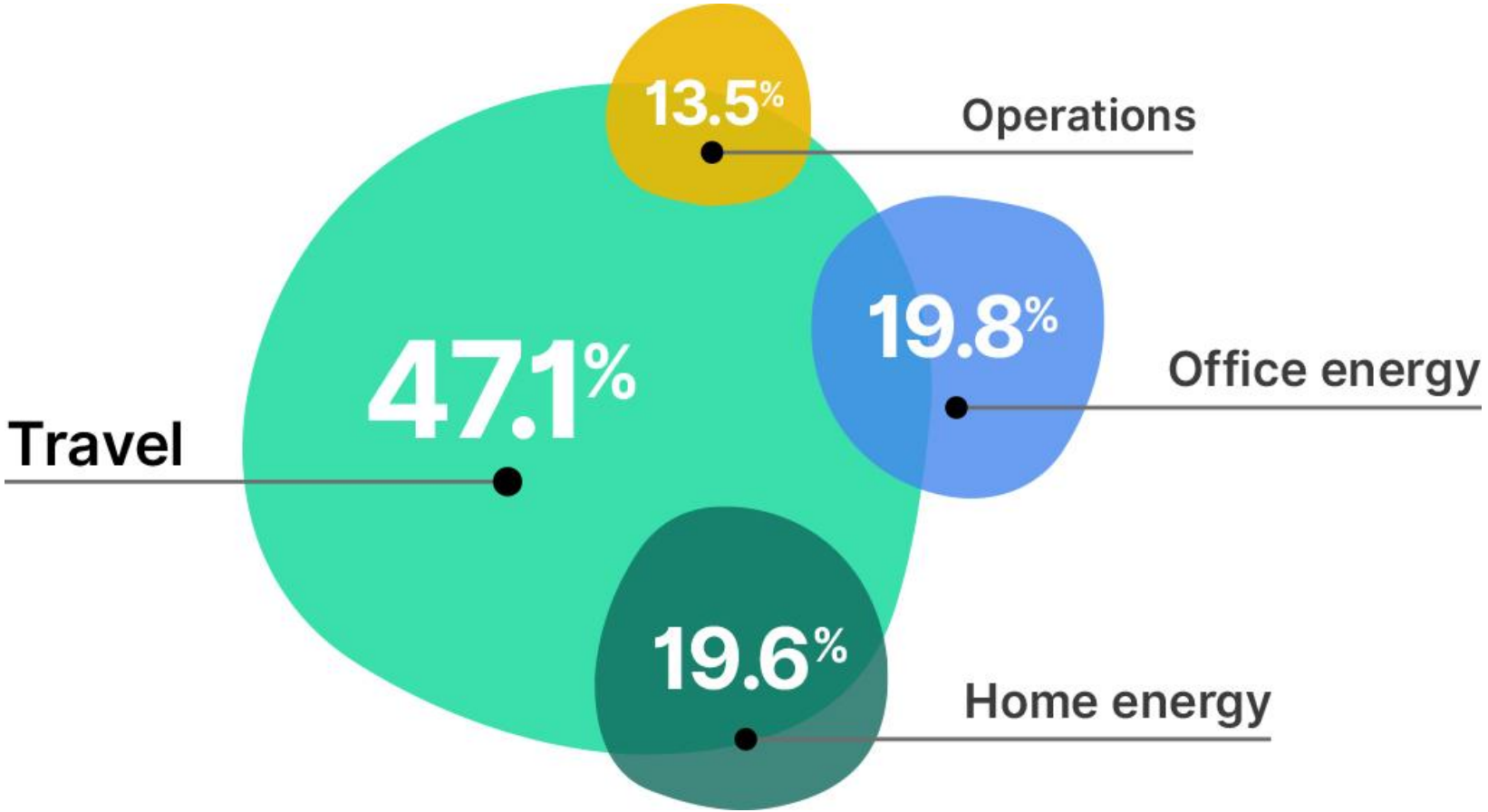
Work Services About us Team Blog Call 0207 112 8240 Get in touch

We make WordPress better, for everyone.

We deliver the highest quality website design and development for positive businesses, charities and the public sector, powered by WordPress and green energy.

Established 2007 | London

About us Get in touch



Once you run on green infrastructure, travel & offices are the next largest source of emissions (link)

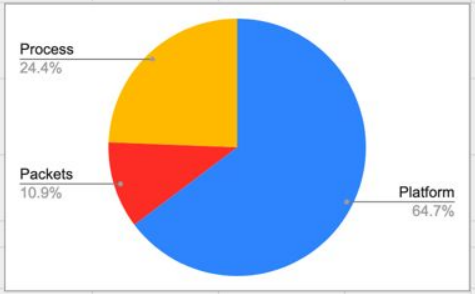
v.1.0.7 digital project calculations [redacted]

File Edit View Insert Format Data Tools Add-ons Help Last edit was on November 18

Estimated emissions from project:

Project name:	[redacted]	Project URL:	[redacted]	Model version	1.0.6
Date start:	2019-05	Date end:	2020-05		

Platform	Emissions from infrastructure you control (your networks and hosting)	**420.00**	kg Co2e
Packets	Emissions from infrastructure you don't control (rest of the internet)	**70.74**	kg Co2e
Process	Emissions from the use of office space, or commuting while working on the project	**158.23**	kg Co2e
Total footprint		**648.96**	kg Co2e



To update these summary figures, update the cells in yellow in the Platform, Packets and Process Tabs

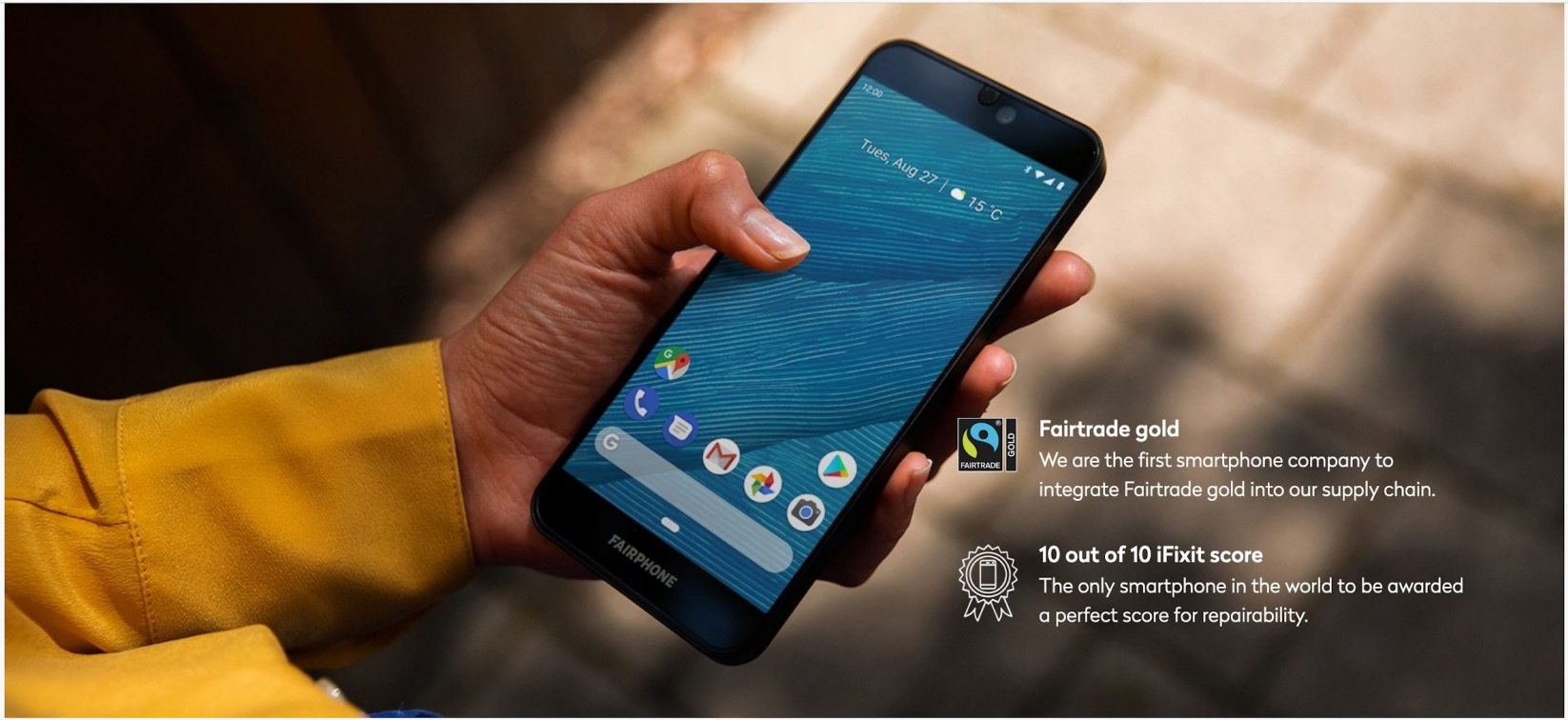
Total | Platform | Packets | Process | Methodology and Emission Factors

Link to template spreadsheet.

Process - how your org works

Outward - greening ***through*** digital projects.

More visible to the end user.



Recycled and fair materials
Modular and repairable design
A commitment to fairness

Full-day battery life
12MP camera for quality photos
64GB internal storage

Easy to use Android 9
Qualcomm Snapdragon 632
See all tech specs

Fairphone's LCA Report for the FP2 handset

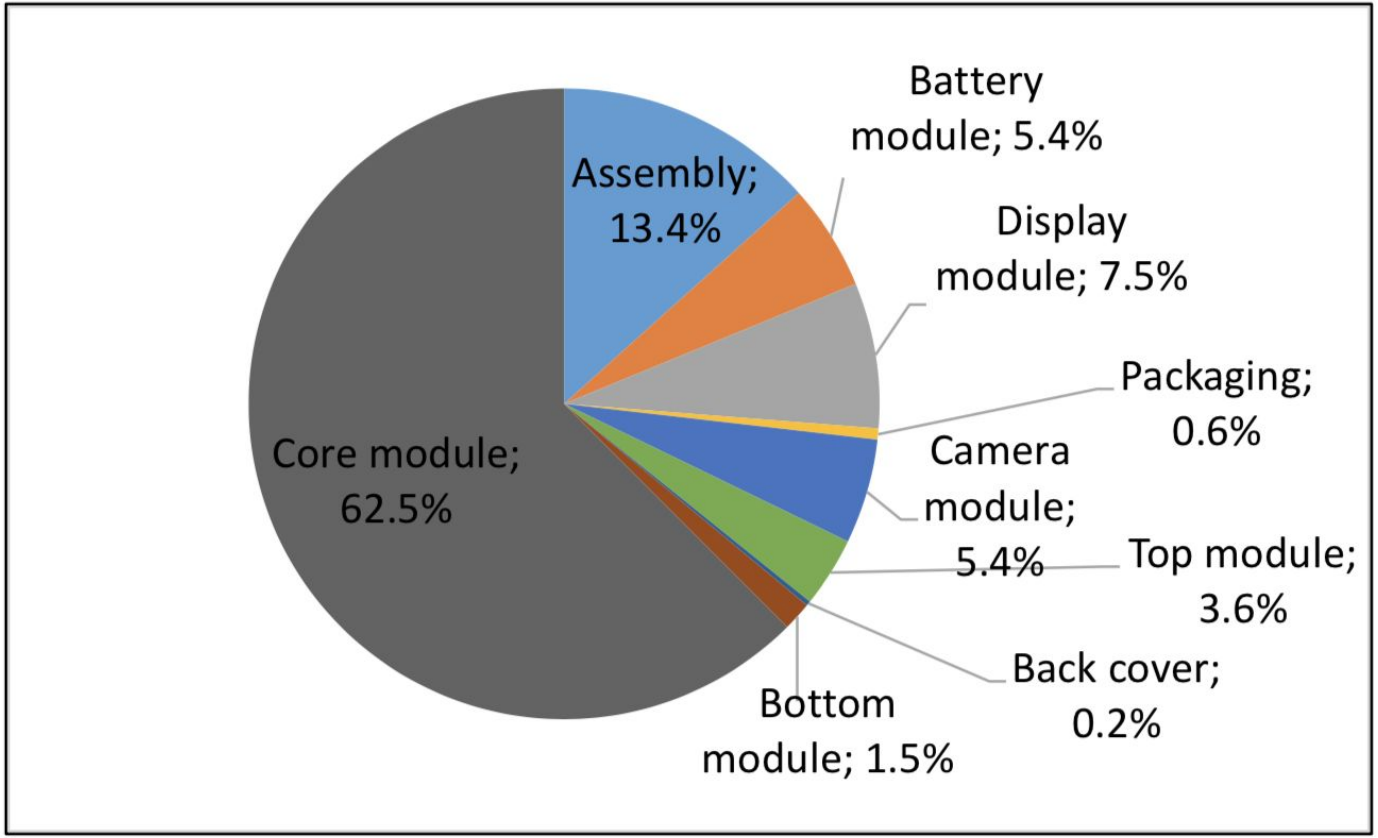


Figure 4-2: Relative impacts of the different modules of the production phase, impact category GWP

Fairphone LCA

for 3yrs vs 5yrs

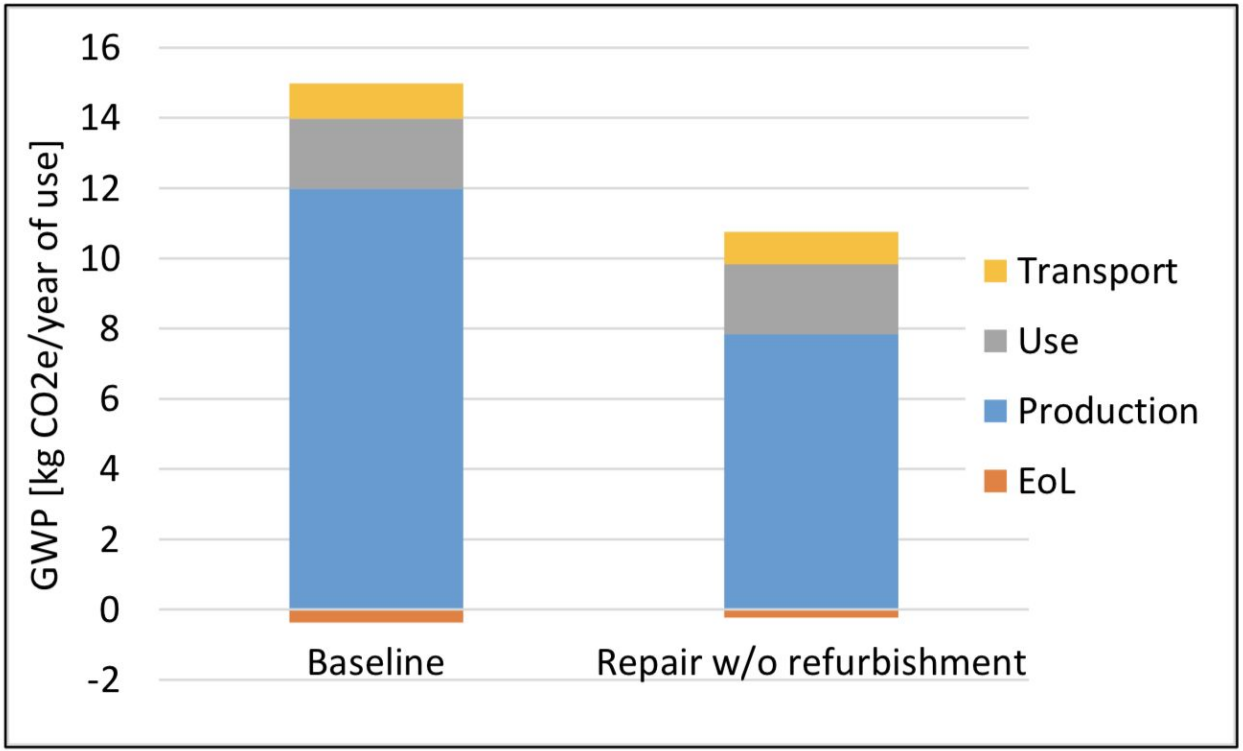
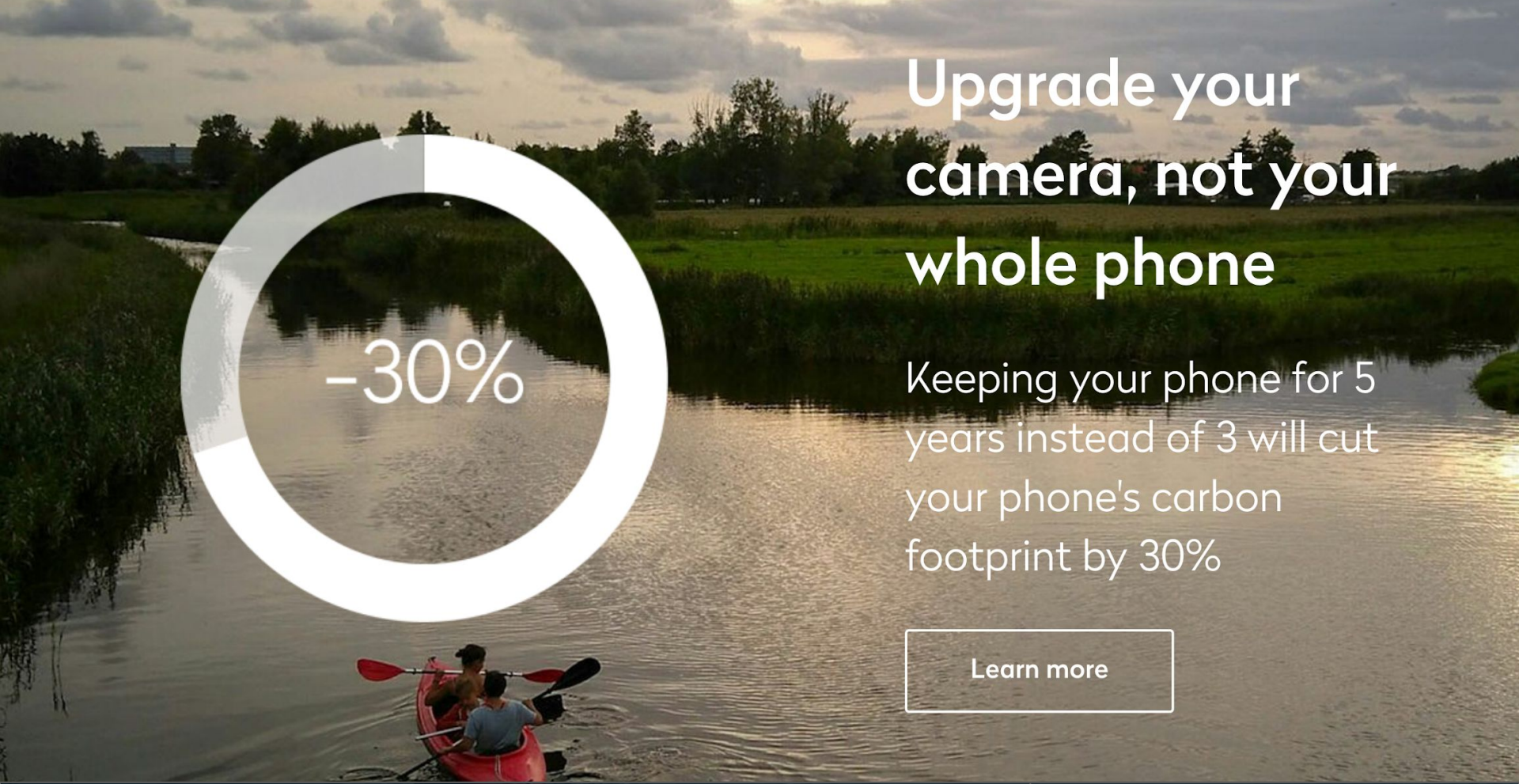


Figure 1-3: Results per year of use - baseline and repair scenario



Fairphone's marketing page for their FP2 camera

What we'll cover

Measuring carbon

A mental model for reducing carbon

Where to go next

“We will not use fossil fuel powered infrastructure for new services or projects.

We won’t accept work on projects to help extract more fossil fuels.”

ClimateAction.tech

Technology professionals using our skills, tools, and influence to amplify the Climate Movement.


Is your website hosted green?
One day the Internet will run entirely on renewable energy. The Green Web Foundation believes that day should be within reach, and develops tools to speed up the transition towards a green Internet
http://www.yourwebsite.com
CHECK
501.345.271 checks performed to date,
13% is powered by renewable energy

Sunday 6pm, lecture room M2

carbon.txt workshop

Help work out a convention for verifying green energy in the services we build

Thanks!

e: chris@thegreenwebfoundation.org
t: @mrchrisadams
training: thegreenwebfoundation.org
newsletter: greening.digital