


The background of the slide is a sunset sky with a bright yellow sun low on the horizon. In the foreground, the silhouette of an oil pumpjack is visible against the darkening sky. The text is overlaid on the sky.

Better than the New Oil

Sustainable IT on the Radar



2021: 20% more floods
(2000-2020)

21 July 2021

22 July 2022


2022: More Heatwaves

100 km

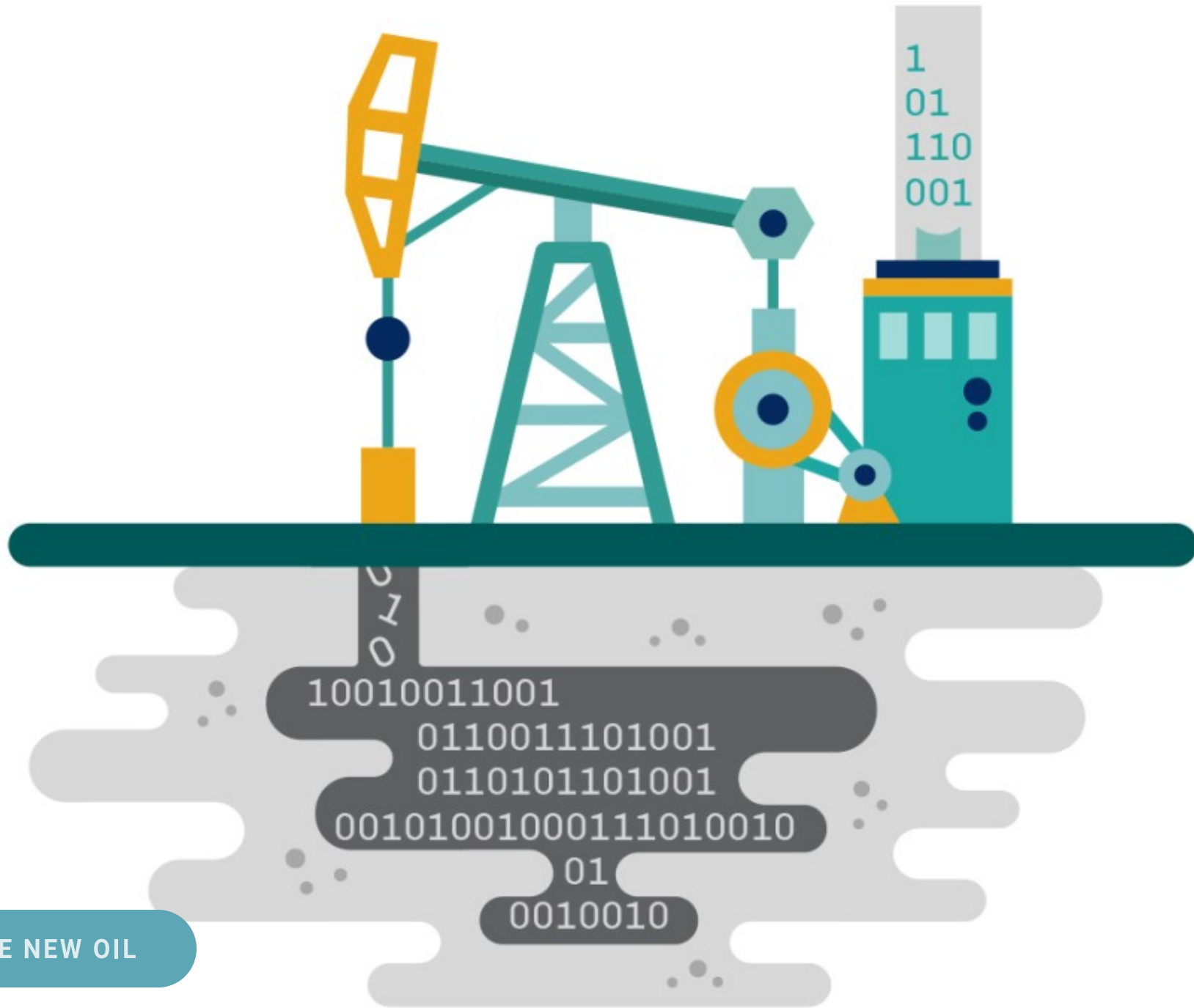


PROGRAMME OF THE
EUROPEAN UNION

Copernicus
Europe's eyes on Earth

An aerial photograph of a city, likely Chongqing, China, showing a river with a large section of exposed, dry, brownish ground. A prominent red bridge spans the river. The city skyline with numerous skyscrapers is visible in the background under a clear sky. The foreground shows the dry, cracked earth and small pools of water remaining in the riverbed.

2022: China 70-day Heatwave



BETTER THAN THE NEW OIL





How Did I End Up Here?

A photograph of a winding asphalt road on a mountain ridge. The road curves to the right and is bordered by a blue metal guardrail. In the background, there are steep, rocky mountains under a clear blue sky. A white text box is overlaid on the center of the image, containing the text "What's your current impact?".

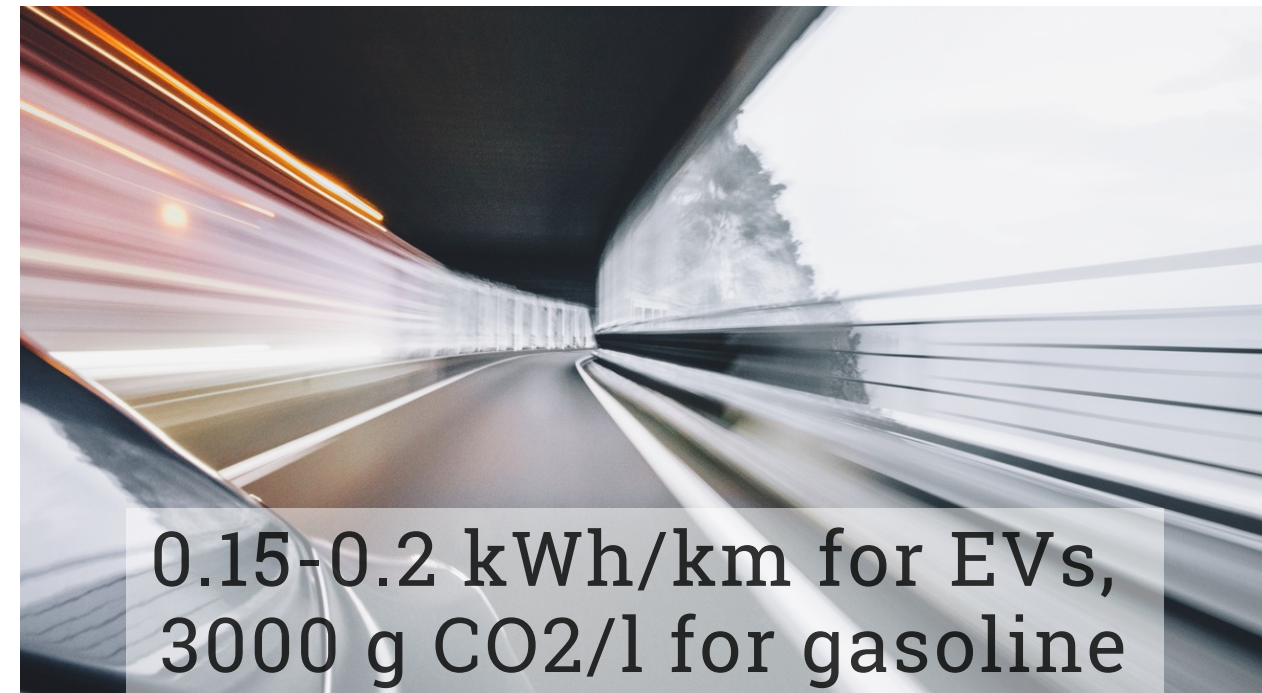
What's your current impact?



3.000 kWh/year



8.5t CO₂/year



0.15-0.2 kWh/km for EVs,
3000 g CO₂/l for gasoline



500 g CO₂eq/kWh

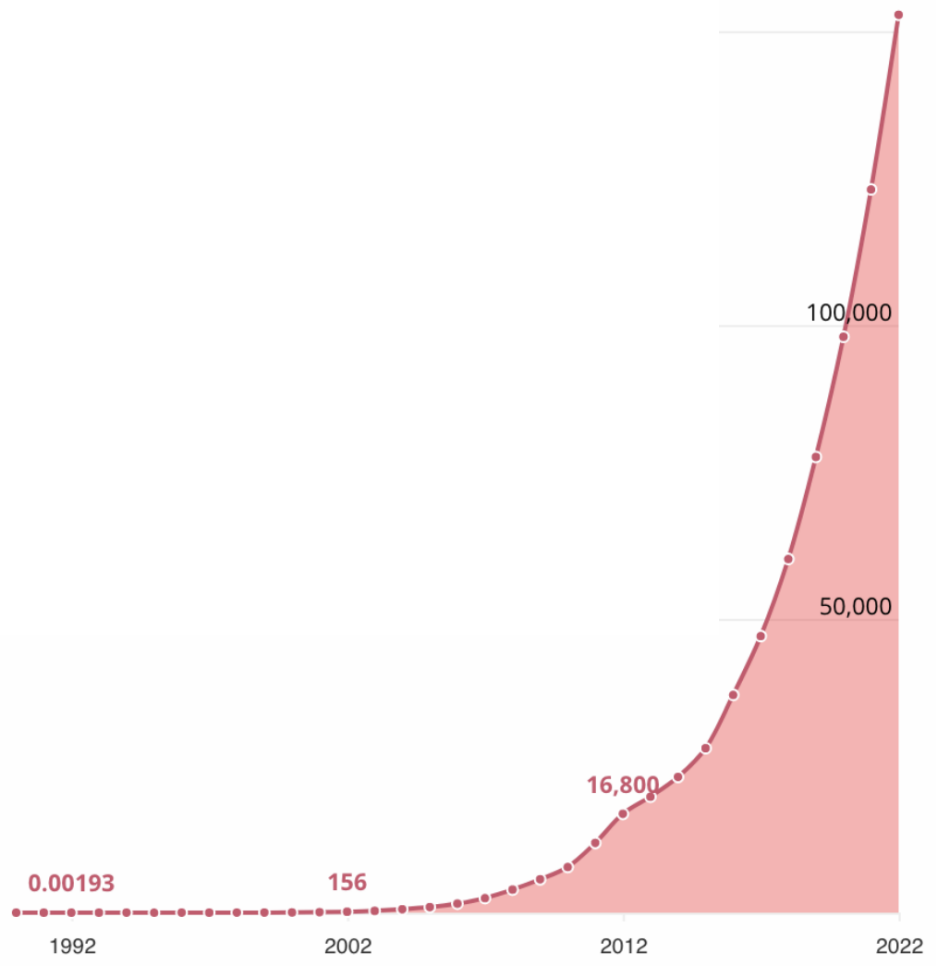


Estimating CO₂ is tough!

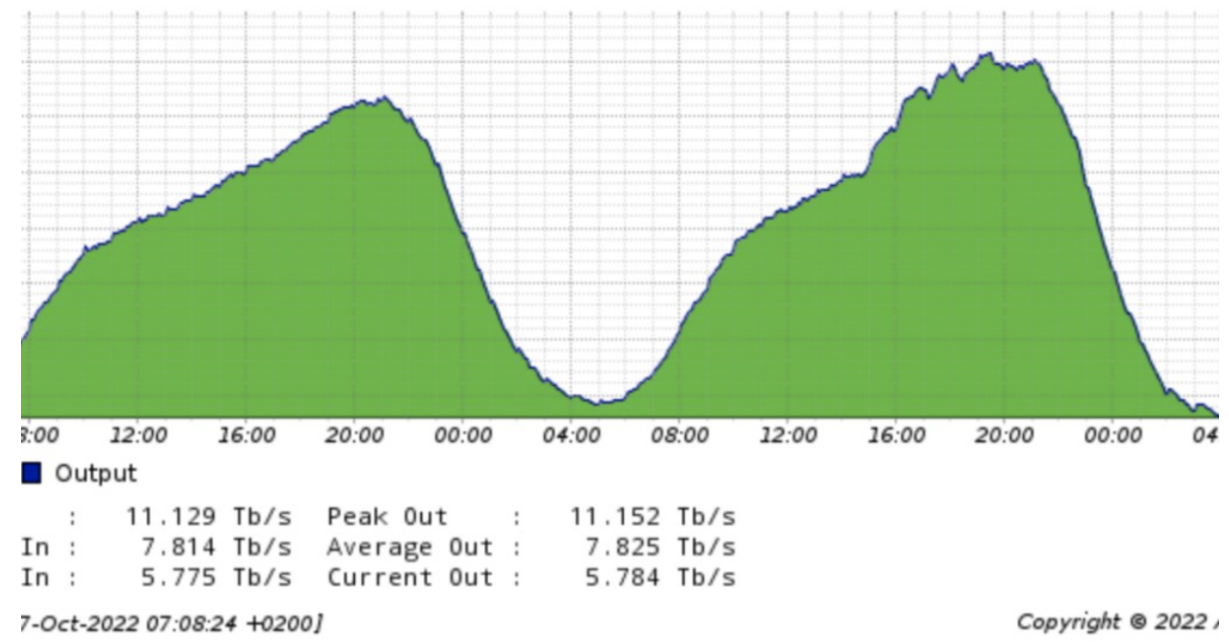
THE CARBON FOOTPRINT
OF EVERYTHING

MIKE BERNERS-LEE

NEW EDITION - UPDATED AND EXPANDED



Global Internet traffic

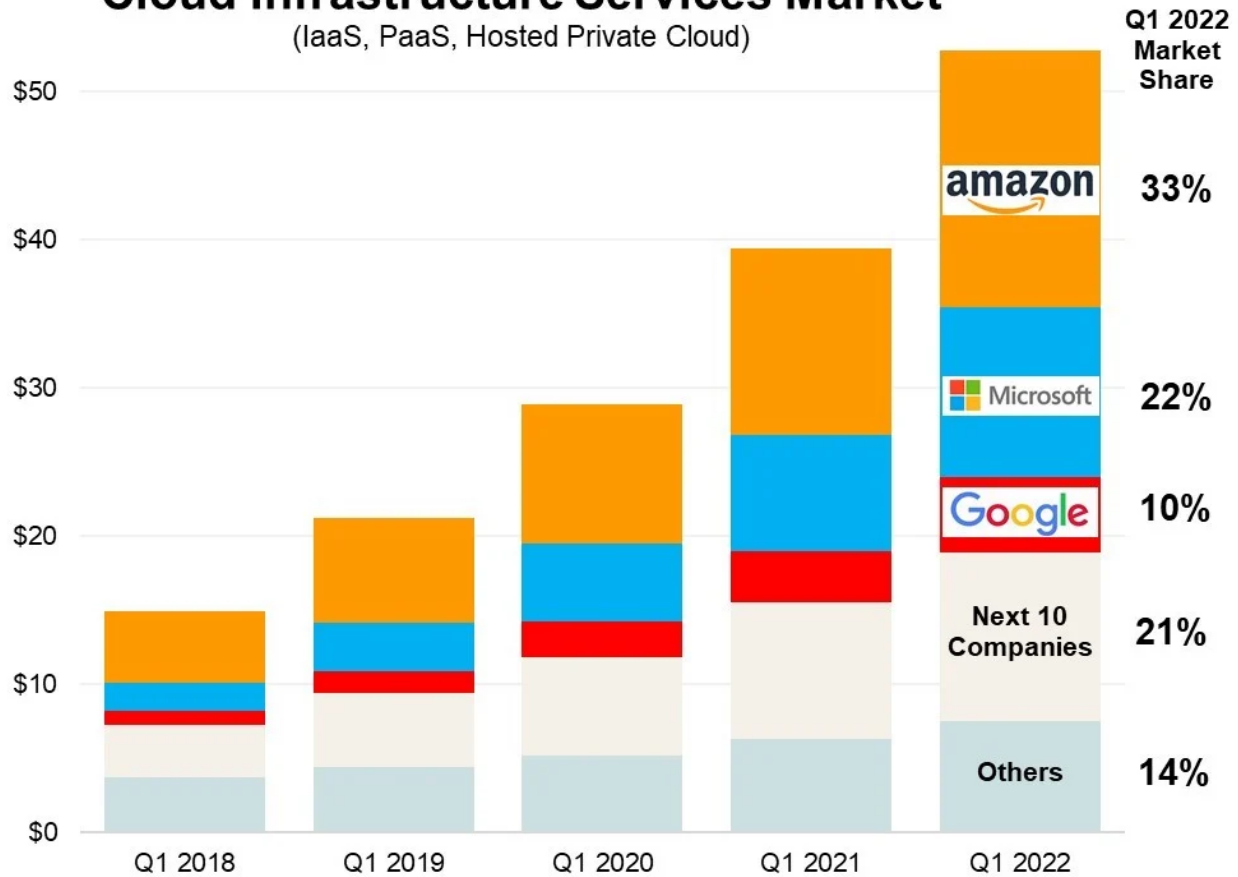


AMS-IX breaking records

Let's bring it back to IT

Cloud Infrastructure Services Market

(IaaS, PaaS, Hosted Private Cloud)



Source: Synergy Research Group

Snowflake Gets \$479M, Reaches Decacorn Status With \$12.4B Valuation

Databricks raises \$1.6B at \$38B valuation as it blasts past \$600M ARR

Meta raises \$10 billion in first-ever bond offering



Which numbers are true regarding global IT energy consumption?



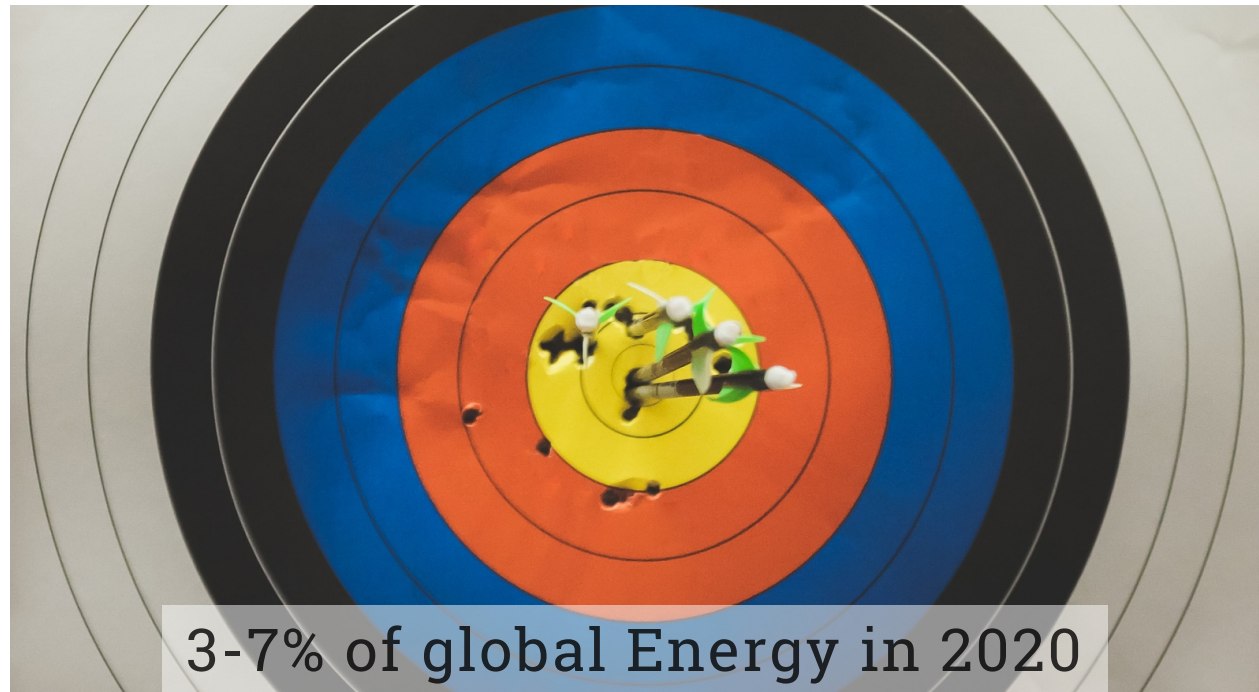
100% Renewable by 2030



21-51% of global Energy in 2030



Emissions will remain at 2%



3-7% of global Energy in 2020



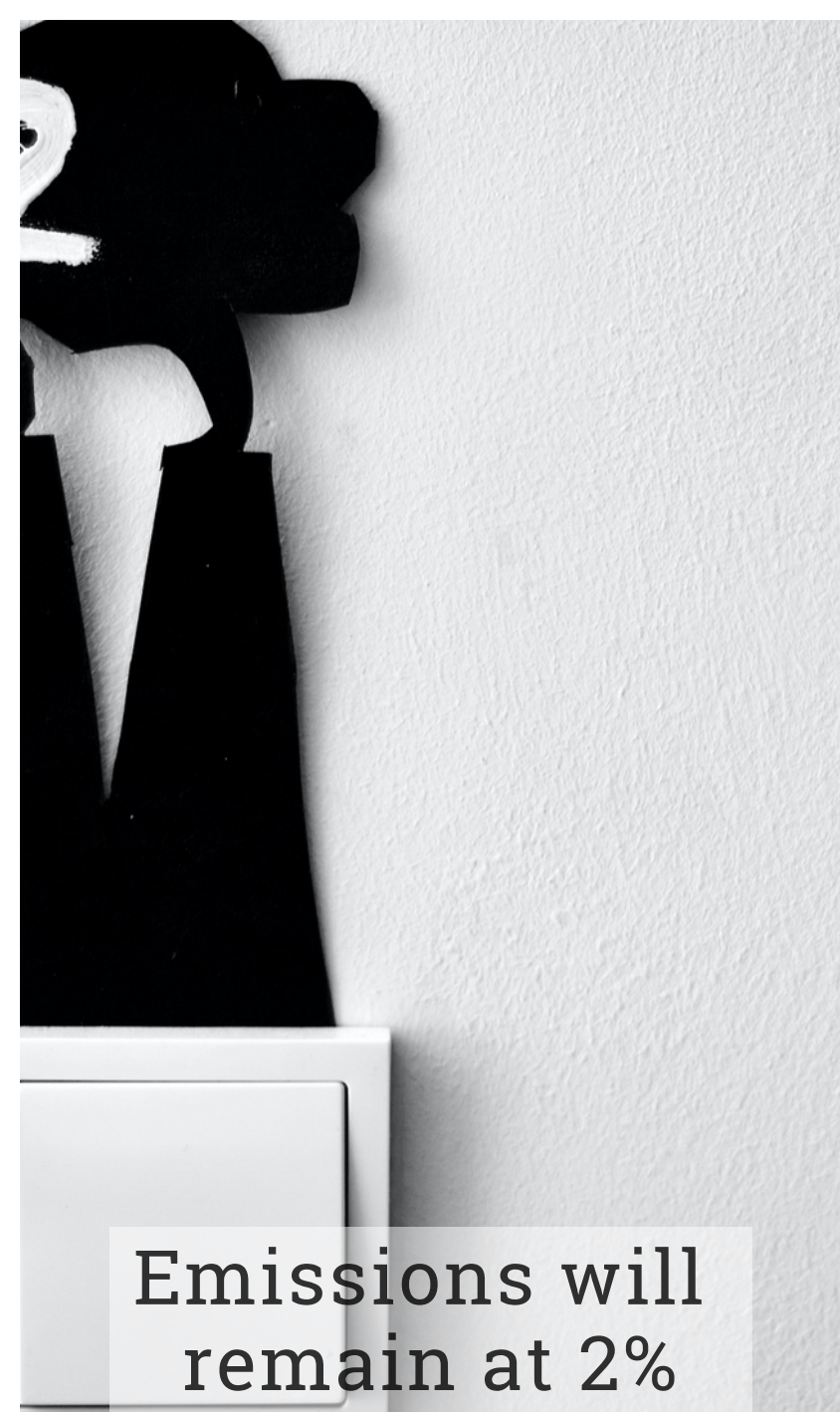
21-51% of Global Energy in 2030



(Green) Consultancies

THE SHIFT PROJECT

Specific non-profits



Emissions will remain at 2%

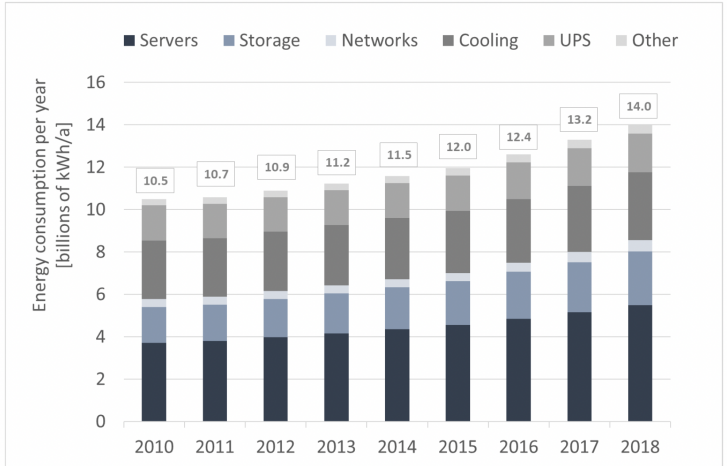
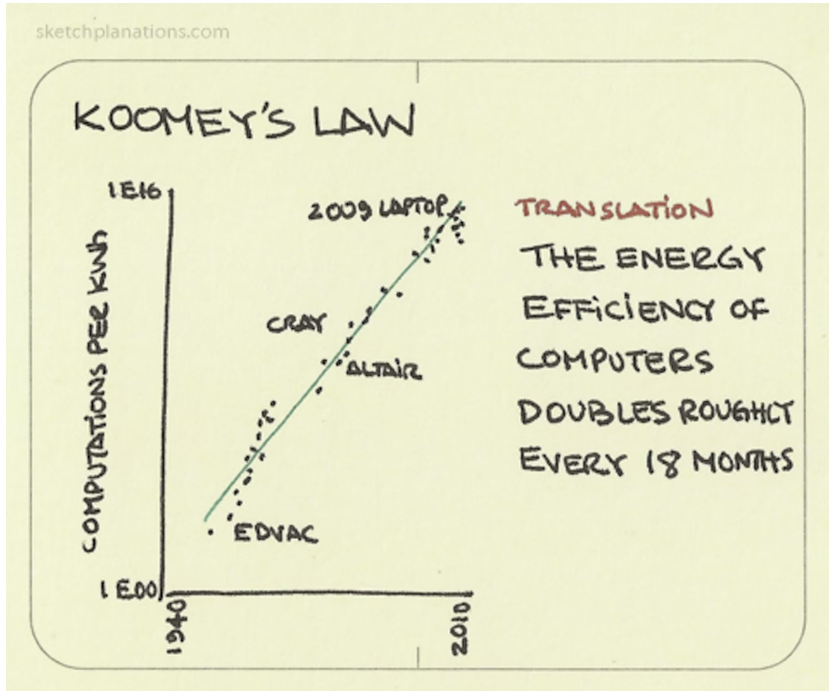


Figure 1: Energy consumption of servers and data centers in Germany in the years 2010 to 2018 (Source: Borderstep)

JEVON'S PARADOX

FUEL EFFICIENCY GAINS TEND TO **INCREASE**,
NOT DECREASE, FUEL USE.

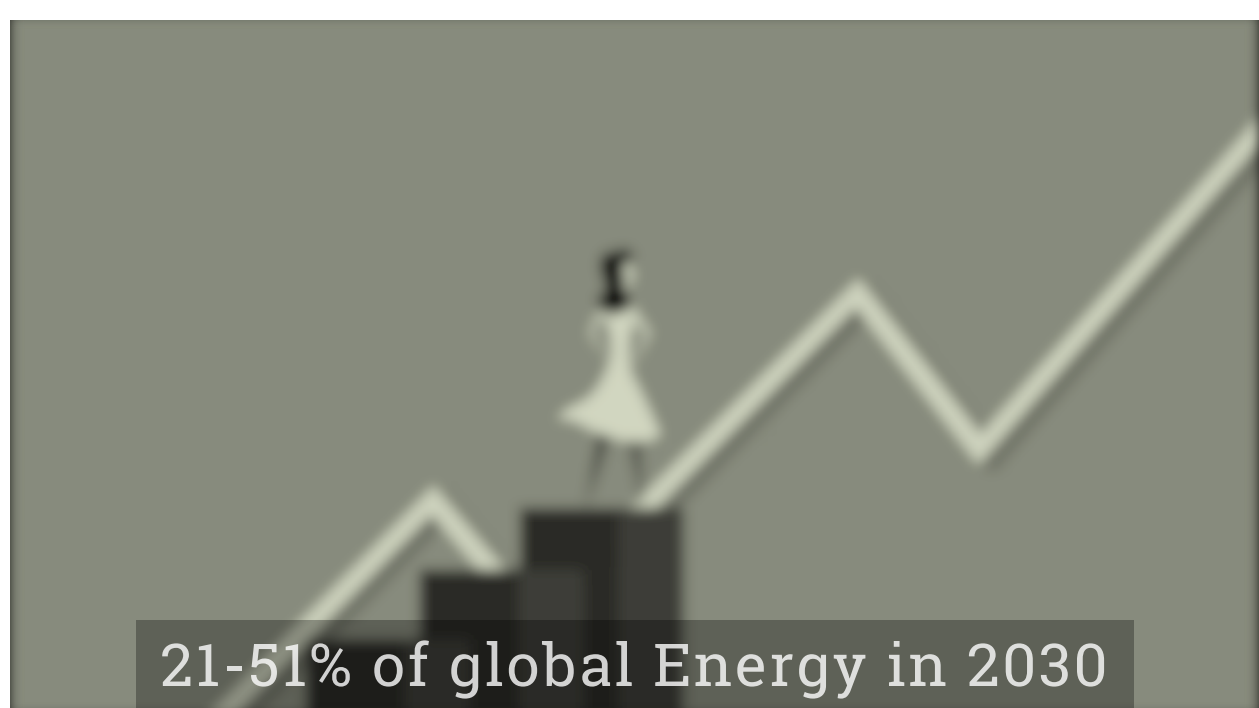


sketchplanations

NO! Because Rebound Effects



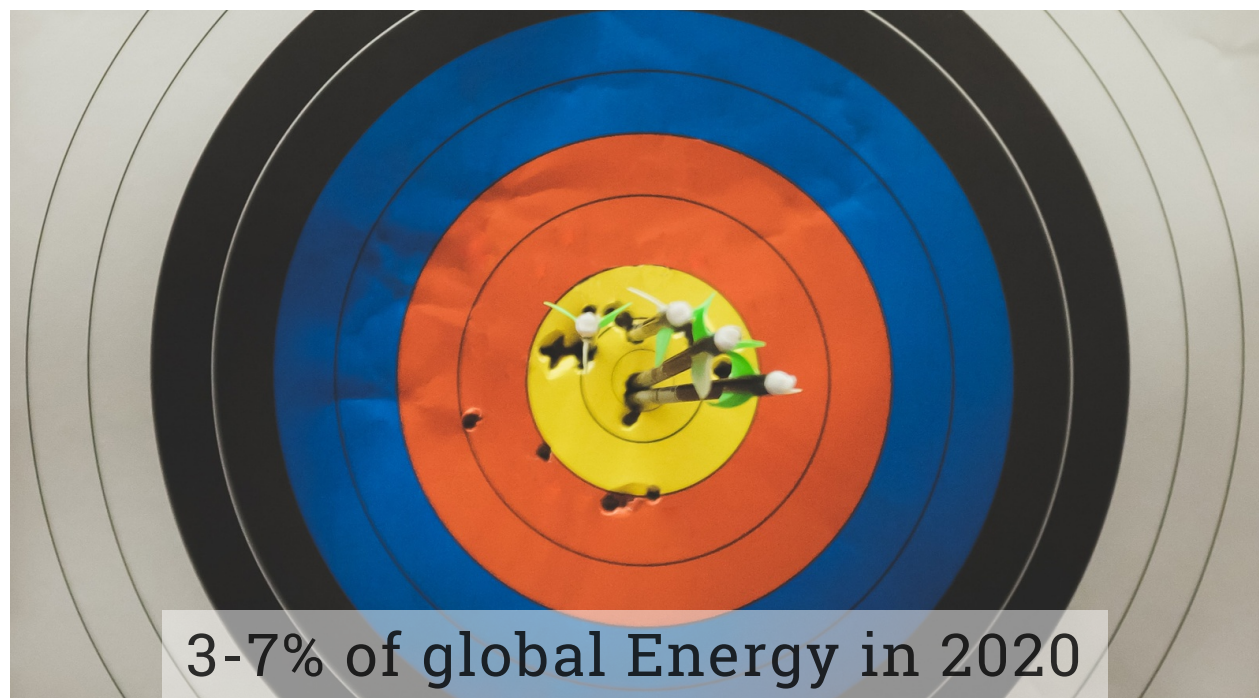
100% Renewable by 2030



21-51% of global Energy in 2030



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3-7% of global Energy in 2020

Cloud 100% renewable



2025



2025



Cloud 100% renewable



2025



2025



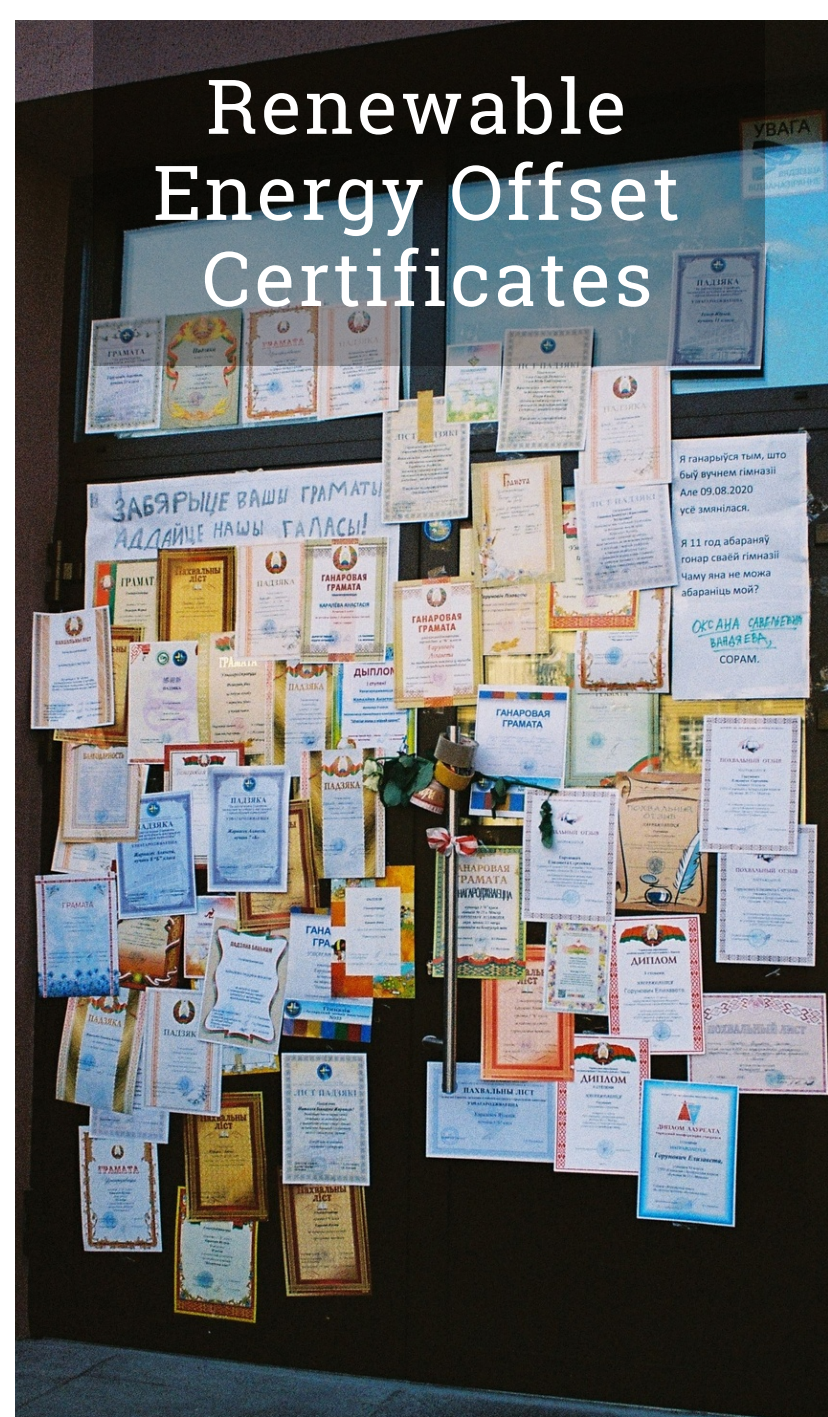
2007 (!) *

*Carbon-free datacenters by 2030

Purchasing Renewable Energy



Renewable Energy Offset Certificates



Carbon Accounting Dashboards



Purchasing Renewable Energy

A photograph of an offshore wind farm in the ocean. Several white wind turbines with yellow bases are visible against a clear blue sky. The water is a deep blue, and the perspective is from a boat, as evidenced by the white wake in the foreground.

HOLISTICALLY, WE ARE NOT GREENER

Renewable Energy Certificates

ЗАБЯРЫЦЕ ВАШЫ ГРАМАТЫ
АДДАЙЦЕ НАШЫ ГАЛАСЫ!

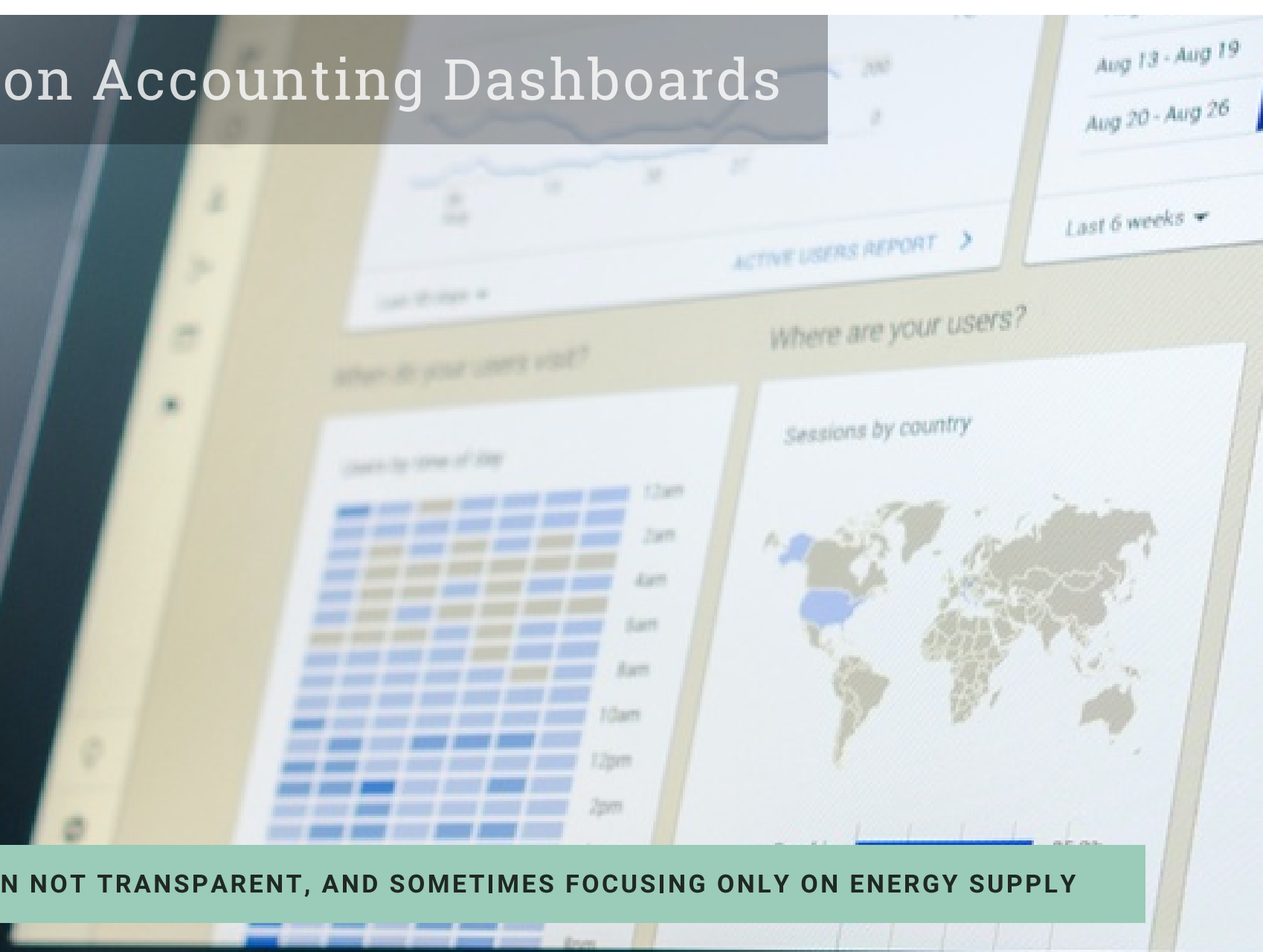
Я ганарыўся тым, што
быў вучнем гімназіі
Але 09.08.2020
усё змянілася.

Я 11 год абараняў
гонар сваёй гімназіі
Чаму яна не можа
абараніць мой?

ОКСАНА СЯВЕНЧЕНА
ВАНДЗЕВА,
СОРАМ.

REMAIN HEAVILY CRITICIZED AND HARD TO AUDIT PROPERLY

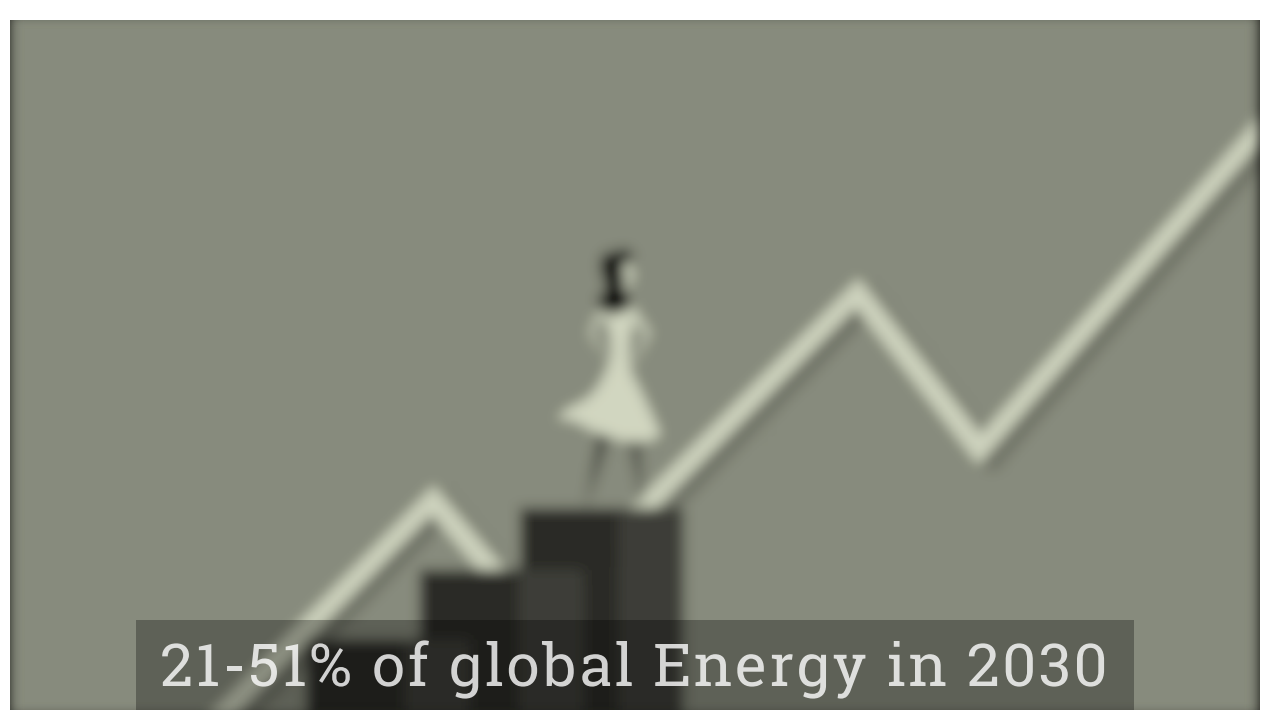
Carbon Accounting Dashboards



NOT GRANULAR, OFTEN NOT TRANSPARENT, AND SOMETIMES FOCUSING ONLY ON ENERGY SUPPLY



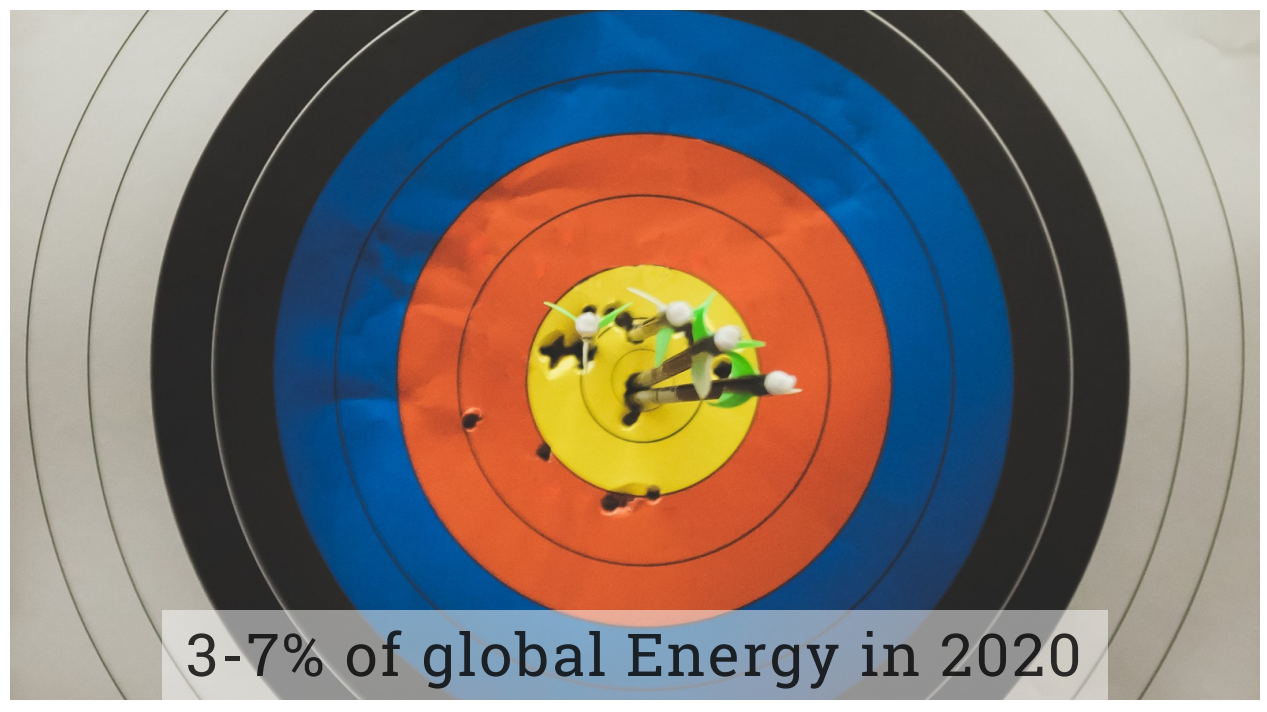
100% Renewable by 2030




21-51% of global Energy in 2030



Emissions will remain at 2%



3-7% of global Energy in 2020



We need more trustworthy
lower-level energy measurements



IN ORDER TO REALLY TAKE INDIVIDUAL, CORPORATE RESPONSIBILITY

SDIA



Deloitte.

EY Building a better working world

KPMG

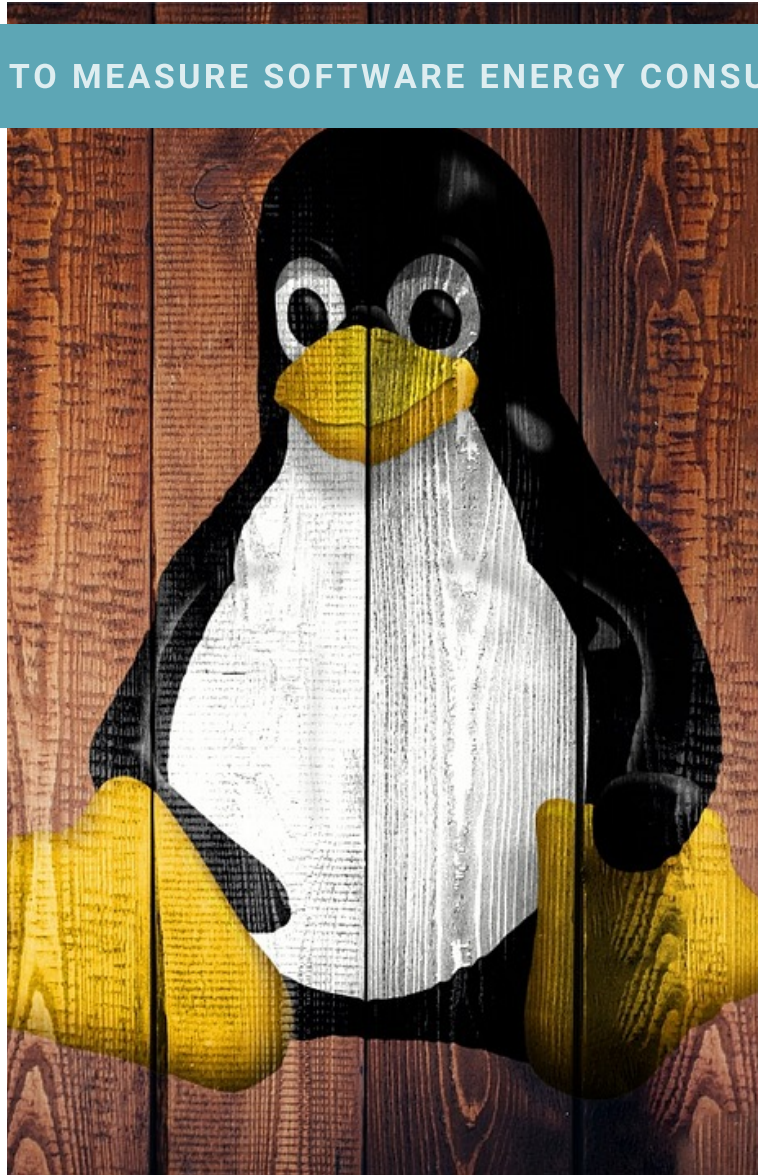
pwc



HOW TO MEASURE SOFTWARE ENERGY CONSUMPTION?



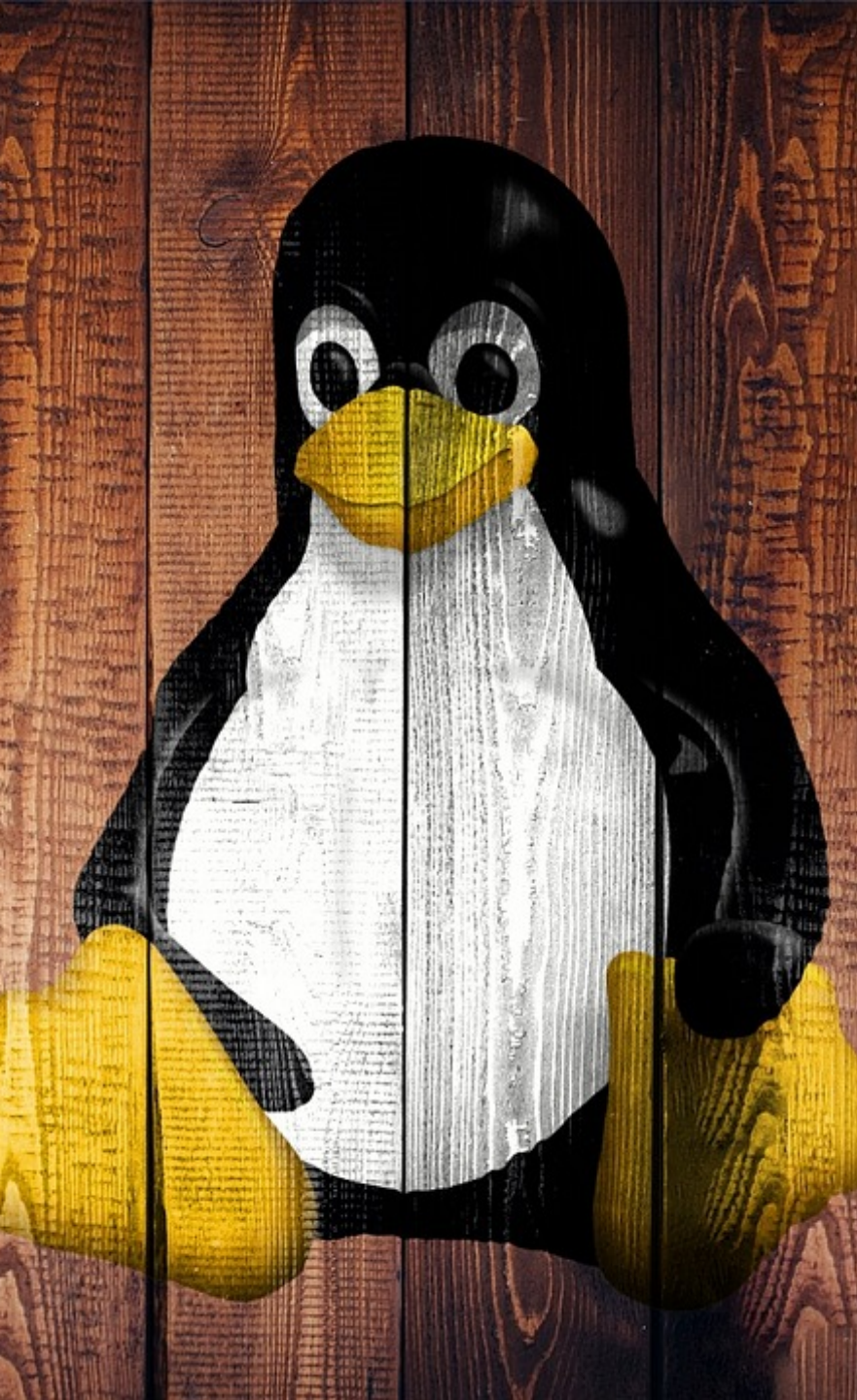
PHYSICAL METERS



RAPL



BEST-EFFORT ESTIMATIONS



Running Average Power Limit (RAPL)

- **DEVELOPED BY INTEL, FOR THERMAL MANAGEMENT PURPOSES**
- **SOFTWARE POWER MODEL BASED ON HARDWARE PERFORMANCE COUNTERS AND I/O MODELS**
- **MEASUREMENTS CPU-LEVEL, PROCESS-LEVEL**
- **LIMITATIONS**
 - Only works with specific chips
 - Root access required

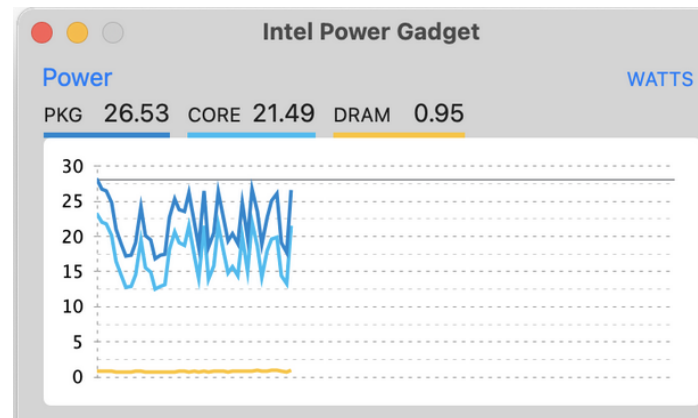
Ad-hoc tools

Example Output for a 5 second sleep command:

```
Performance counter stats for 'system wide':
```

```
   3.59 Joules power/energy-cores/
   8.18 Joules power/energy-ram/
   1.63 Joules power/energy-gpu/
  12.74 Joules power/energy-pkg/
  51.10 Joules power/energy-psys/
```

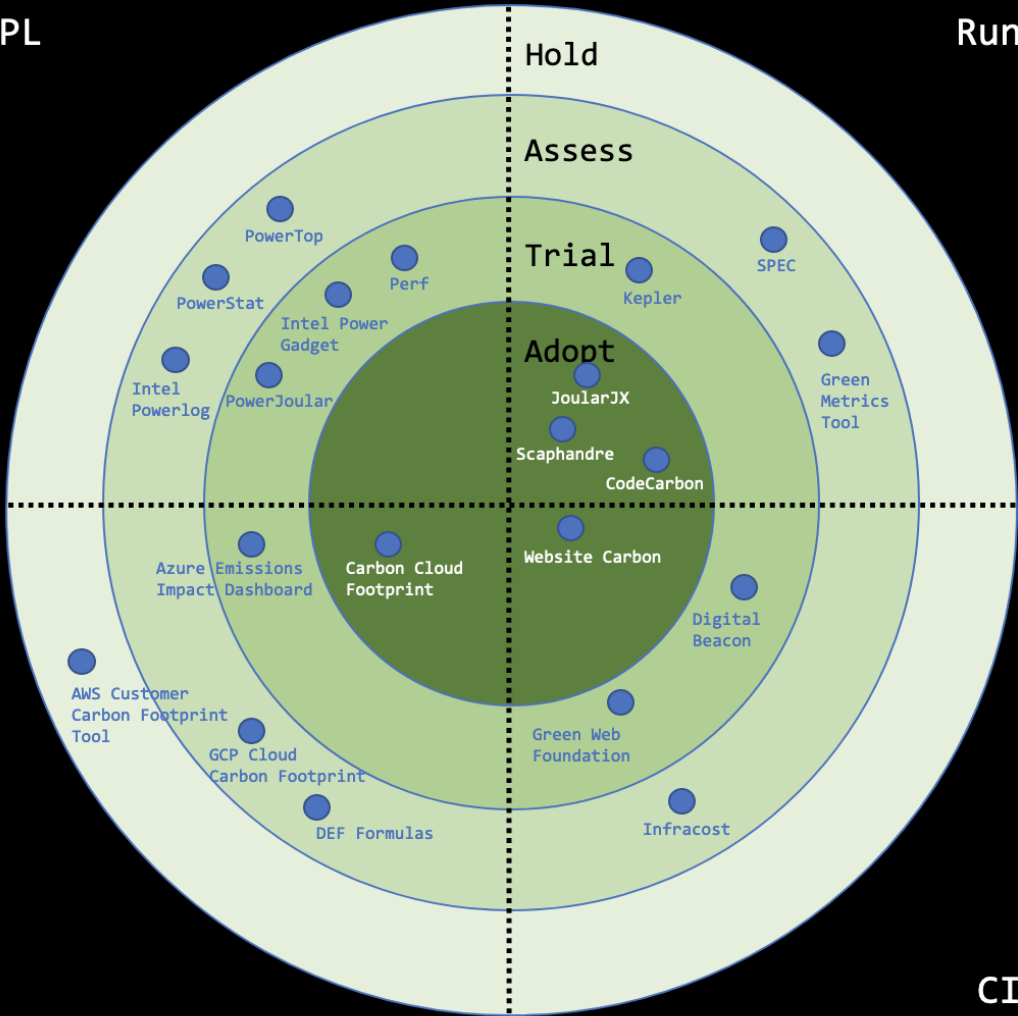
```
5.001965465 seconds time elapsed
```



And Measure! Introducing the first Sustainable Tech Radar!

Ad-hoc RAPL

Runtime RAPL



Cloud

CI/CD

RAPL-based Tools



SCAPHANDRE

Developed by Hubble.io, part of Boavizta
Works on Kubernetes and integrates with Prometheus/Grafana



BOAVIZTA

Embedded Carbon calculations using LCA
[Live Demo](#)



GREEN METRICS TOOL

Being developed by Green Coding Berlin
Focus mostly on singular runs
Work in progress
[Live Demo](#)

Estimations: when RAPL is not available



CLOUD PROVIDERS DASHBOARDS



CLOUD CARBON FOOTPRINT

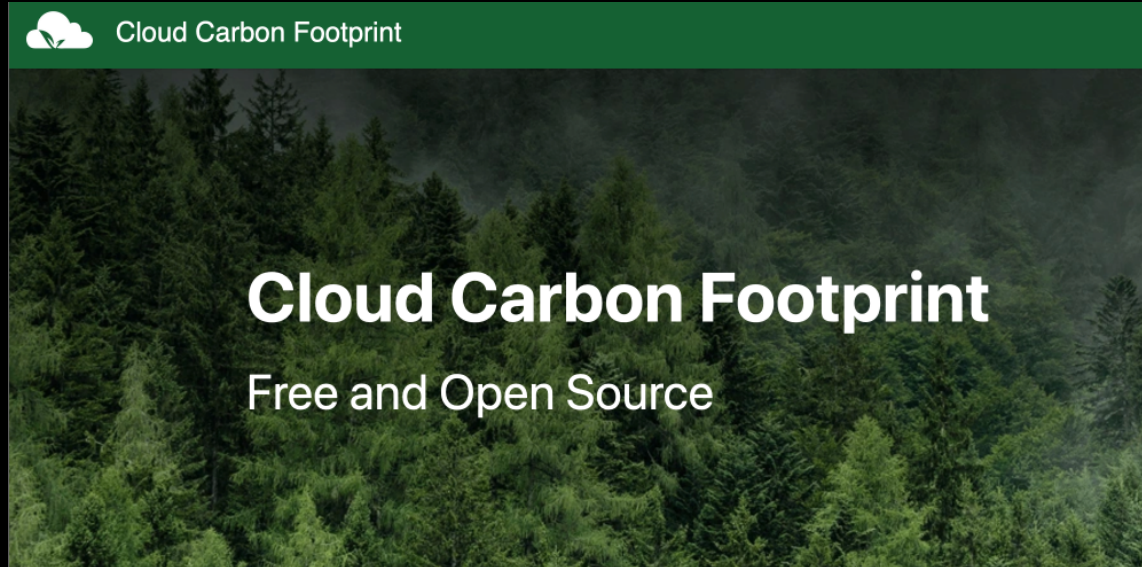
Open Source



SDIA

DEF Formulas

Cloud Carbon Footprint

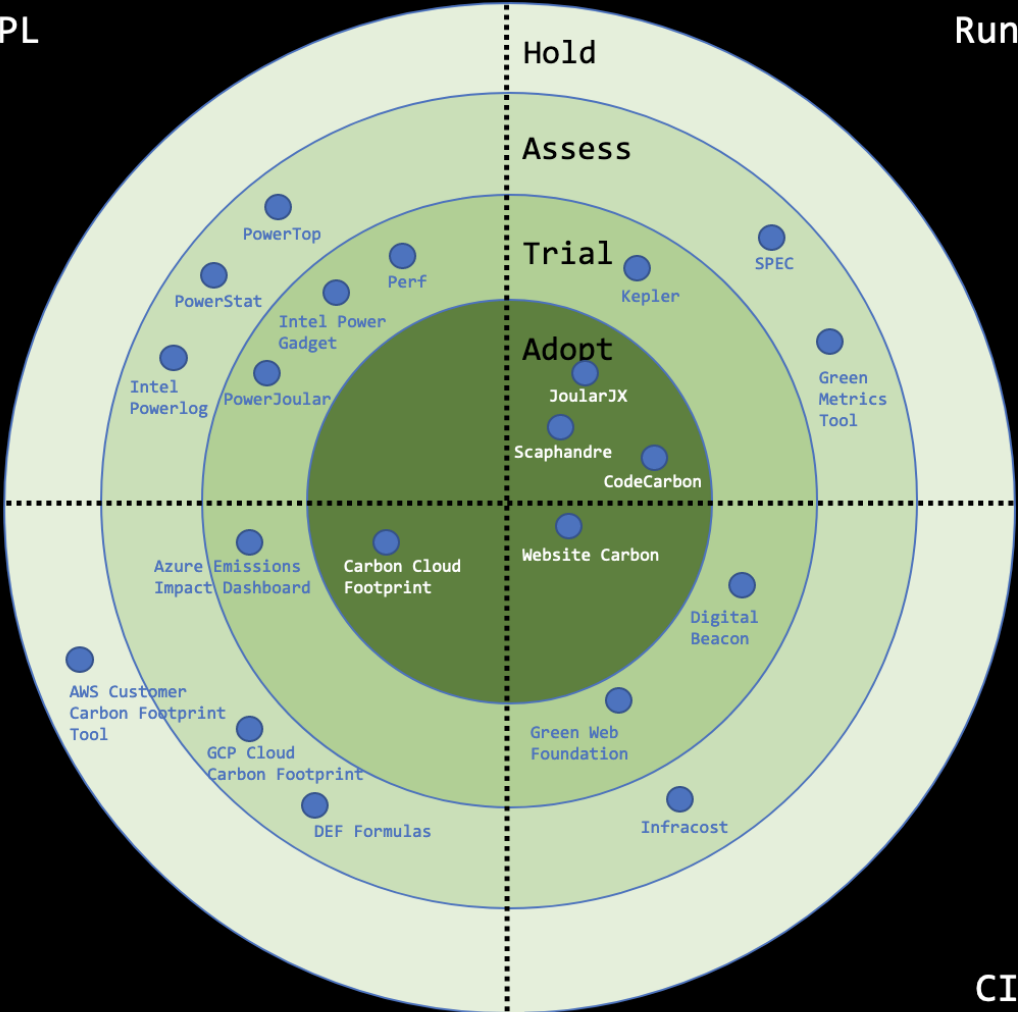


- **BASED ON RESEARCH BY THOUGHWORKS AND TEADS ENGINEERING (BENJAMIN DAVY)**
- **EMPIRICAL ESTIMATIONS WHERE POSSIBLE (BARE METAL)**
- **METHODOLOGY AND ASSUMPTIONS ARE WELL DOCUMENTED**
- **INCLUDES SCOPE 3**

Sustainable Tech Radar

Ad-hoc RAPL

Runtime RAPL



Cloud

CI/CD

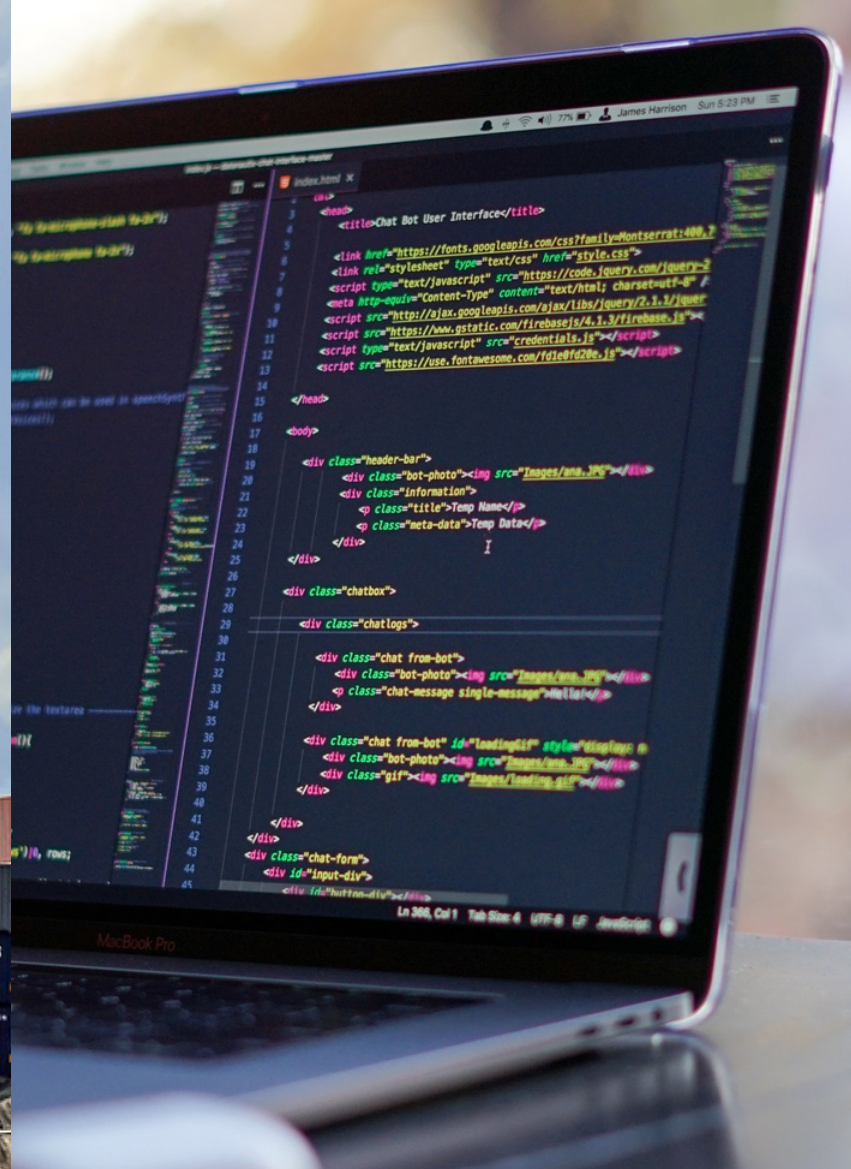
A large, dark wooden signpost is the central focus, with the word "RESULTS" carved into it in large, light-colored, three-dimensional letters. The signpost is mounted on a wooden post and is angled towards the right. The background is a dramatic sunset or sunrise over a mountain range, with the sky transitioning from a deep blue at the top to a bright orange and yellow near the horizon. The mountains are silhouetted against the bright light, creating a layered effect. The overall mood is one of achievement and forward-looking optimism.

RESULTS

WHAT ELSE CAN YOU DO?



Cloud &
Infrastructure

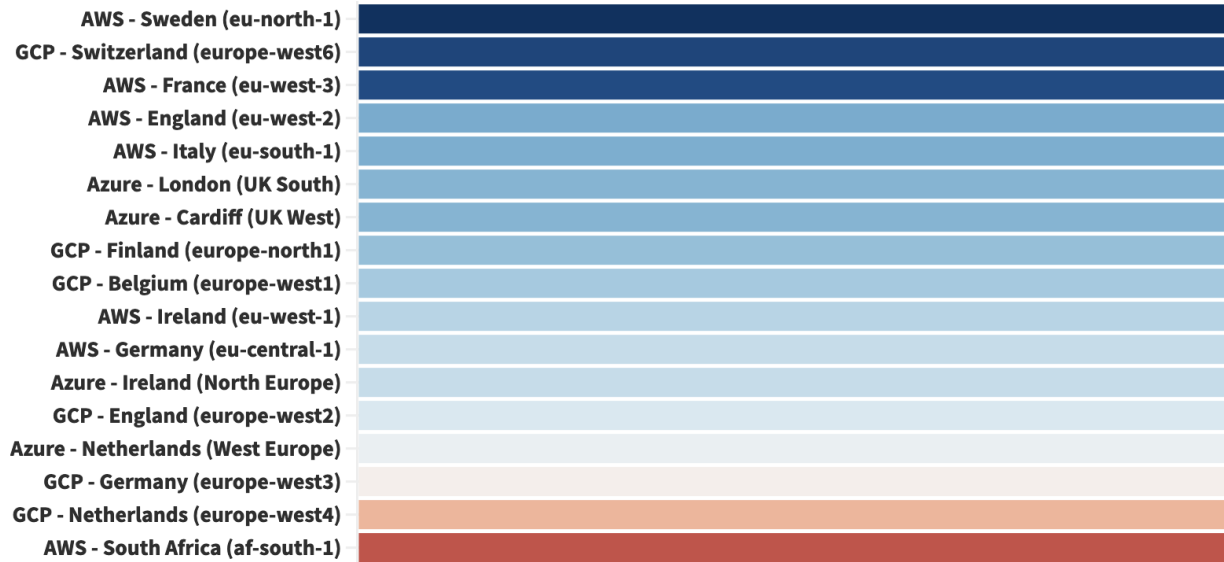


Code



Data

CPU Emission Factor (g of CO2e/h) 0 2.2

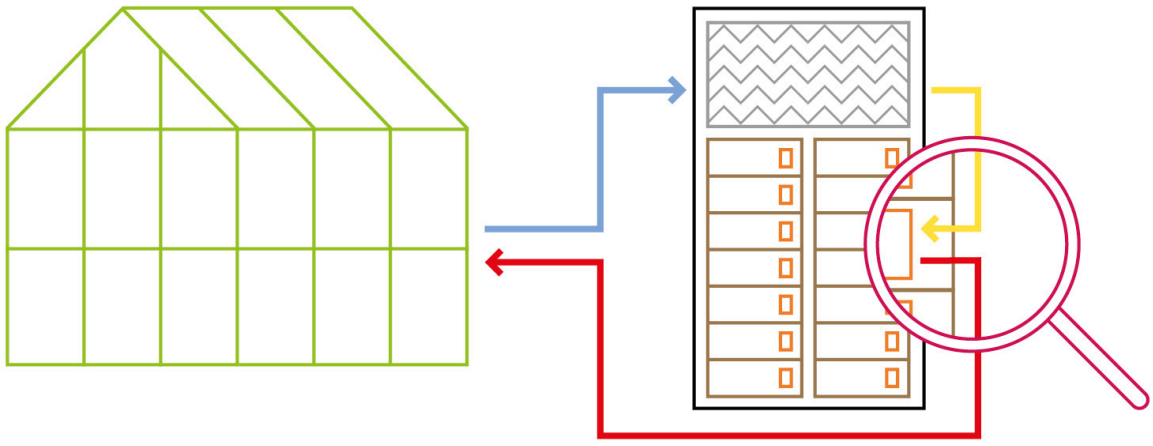


Relocation



Innovative Cloud

Much lower PUEs*!



*Power Usage Effectiveness



660 KB
February 2012



2159 KB
February 2022

Page/Code Bloat



Performance Testing

	Energy
(c) C	1.00
(c) Rust	1.03
(c) C++	1.34
(c) Ada	1.70
(v) Java	1.98
(c) Pascal	2.14
(c) Chapel	2.18
(v) Lisp	2.27
(c) Ocaml	2.40
(c) Fortran	2.52
(c) Swift	2.79
(c) Haskell	3.10
(v) C#	3.14
(c) Go	3.23
(i) Dart	3.83
(v) F#	4.13
(i) JavaScript	4.45
(v) Racket	7.91
(i) TypeScript	21.50
(i) Hack	24.02
(i) PHP	29.30
(v) Erlang	42.23
(i) Lua	45.98
(i) Jruby	46.54
(i) Ruby	69.91
(i) Python	75.88
(i) Perl	79.58



Efficient languages



Backwards Compatibility



Tiny Updates

1.7 MB

Is created every second by every person in 2020



Only store what is needed



Research before ineffective training iterations

SDIA



Thanks! Join Our Community!