# Getting to a fossil free internet by 2030

A tour of the tech and policy changes to get us there

GREENWEBFOUNDATION.ORG

Chris Adams

2023.02.04

# 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 -** direct public spending for net zero
**Green Web Foundation -** make the web green
**Green Software Foundation -** Policy WG chair
**Branch Magazine** - climate / tech magazine
**Environment Variables** - podcast on green software

**Contact:** chris@thegreenwebfoundation.org | @mrchrisadams

# What we'll cover today

1. Why a fossil free internet by 2030

2. A framework to think about it - *Consumption, Intensity, Direction*

3. Using the framework to look ahead at policy and tech changes

# 1

# Why a fossil free internet by 2030

# Why a fossil free internet by 2030

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

1.

# Why a fossil free internet by 2030

1. **Achievable** - Big firm buy in already, but doable at small scale too.
2. **Save carbon** - climate emergency, remember?
3. **Save lives** - 5m+ avoidable deaths / year from poor air quality globally, primarily from burning fossil fuels
4. **Save money** - fossil fuels are expensive with volatile prices
5. **Improve retention among staff** - ppl 💚 greener firms
6. **Energy security** - geopolitics and local resiliency

# A framework to think about digital sustainability: *Consumption, Intensity, Direction*

2

# A model for thinking about digital sustainability - **CID**

## Consumption

Can I change how much we need?

## Intensity

Can I change how much harm is done?

## Direction

Can I change where we are headed?

# A model for thinking about digital sustainability - **CID**

## Consumption

Can I change how much we need?

## Intensity

Can I change how much harm is done?

## Direction

Can I change where we are headed?

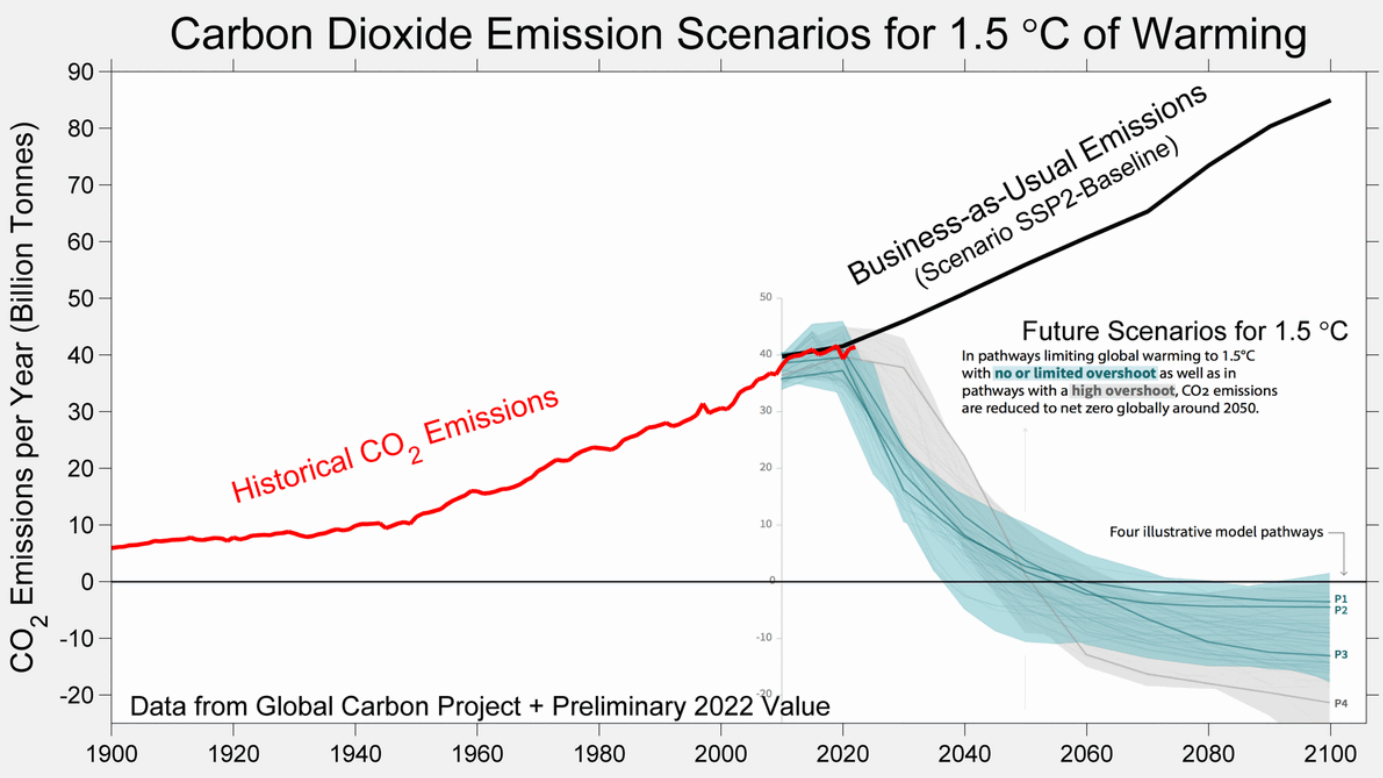


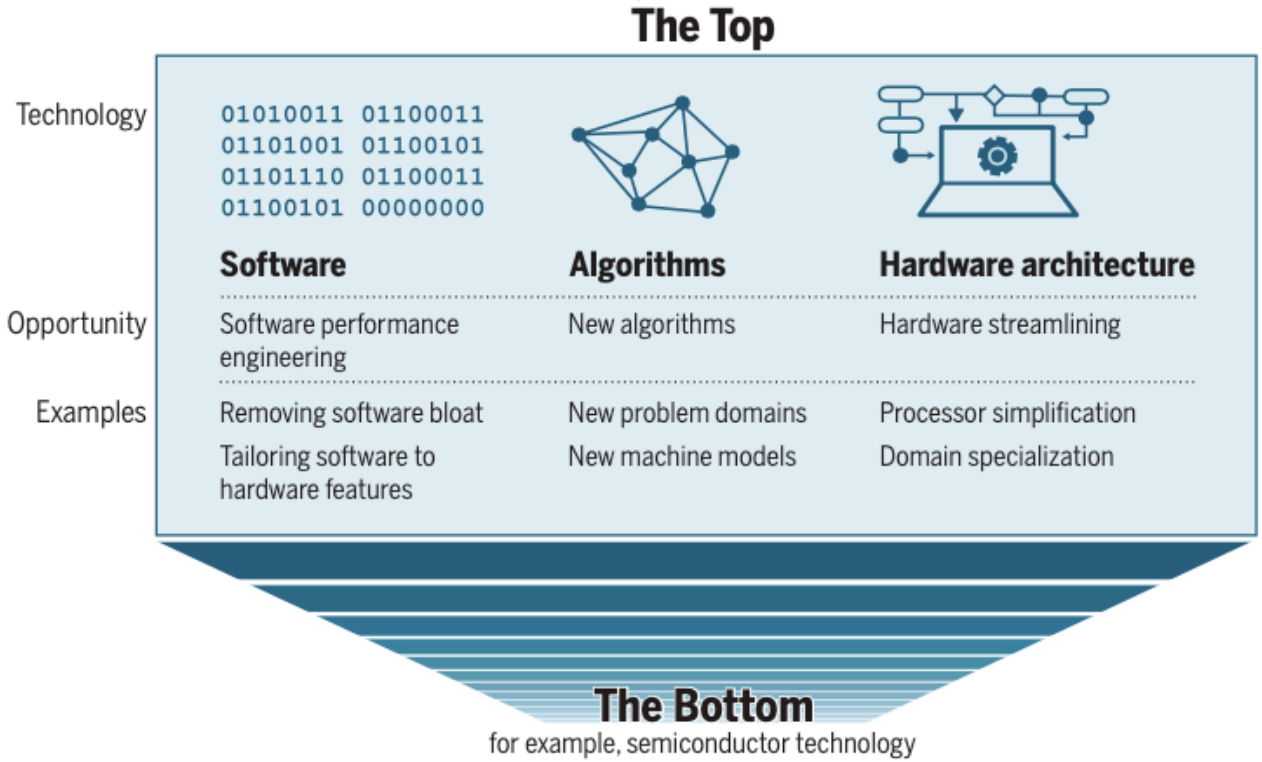

Image: Dr. Robert Rohde / Data: Global Carbon Project & IPCC

> the Paris Agreement will require the information and communication technology (ICT) industry to reduce greenhouse gas (GHG) emissions by 45 per cent from 2020 to 2030

2020 - ITU, GeSI, GSMA & SBTi set science-based pathway in line with Paris Agreement - ICT industry to reduce greenhouse gas emissions by 45 per cent by 2030

# How are we doing so far?

| | 2015 | 2021 | Change |
|---|---|---|---|
| **Internet users** | **3 billion** | **4.9 billion** | **+ 60 %** |
| **Internet traffic** | **0.6 ZB** | **3.4 ZB** | **+ 440 %** |
| **Data centre workloads** | **180 million** | **650million** | **+ 260 %** |
| **Data centre energy use (excluding crypto)** | **200 TWh** | **220 - 320 TWh** | **+ 10-60%** |
| **Crypto mining energy use** | **4 TWh** | **100 - 140 TWh** | **+ 2,300 - 3,300%** |
| **Data transmission network energy use** | **220 TWh** | **260 - 340 TWh** | **+ 20 - 60%** |




**Performance gains after Moore's law ends.** In the post-Moore era, improvements in computing power will increasingly come from technologies at the "Top" of the computing stack, not from those at the "Bottom", reversing the historical trend.

# A model for thinking about digital sustainability - **CID**

| Consumption | **Intensity** | Direction |
| --- | --- | --- |
| Can I change how much we need? | Can I change how much harm is done? | Can I change where we are headed? |

# High carbon intensity

Mining coal, burning it to create steam, to turn turbines to generate electricity.

Typical carbon intensity:

~ 1001g CO2eq / KWh

Source: NREL: Life Cycle Emissions Factors for Electricity Generation Technologies

# Lower carbon intensity

Harvesting energy to generate power directly.

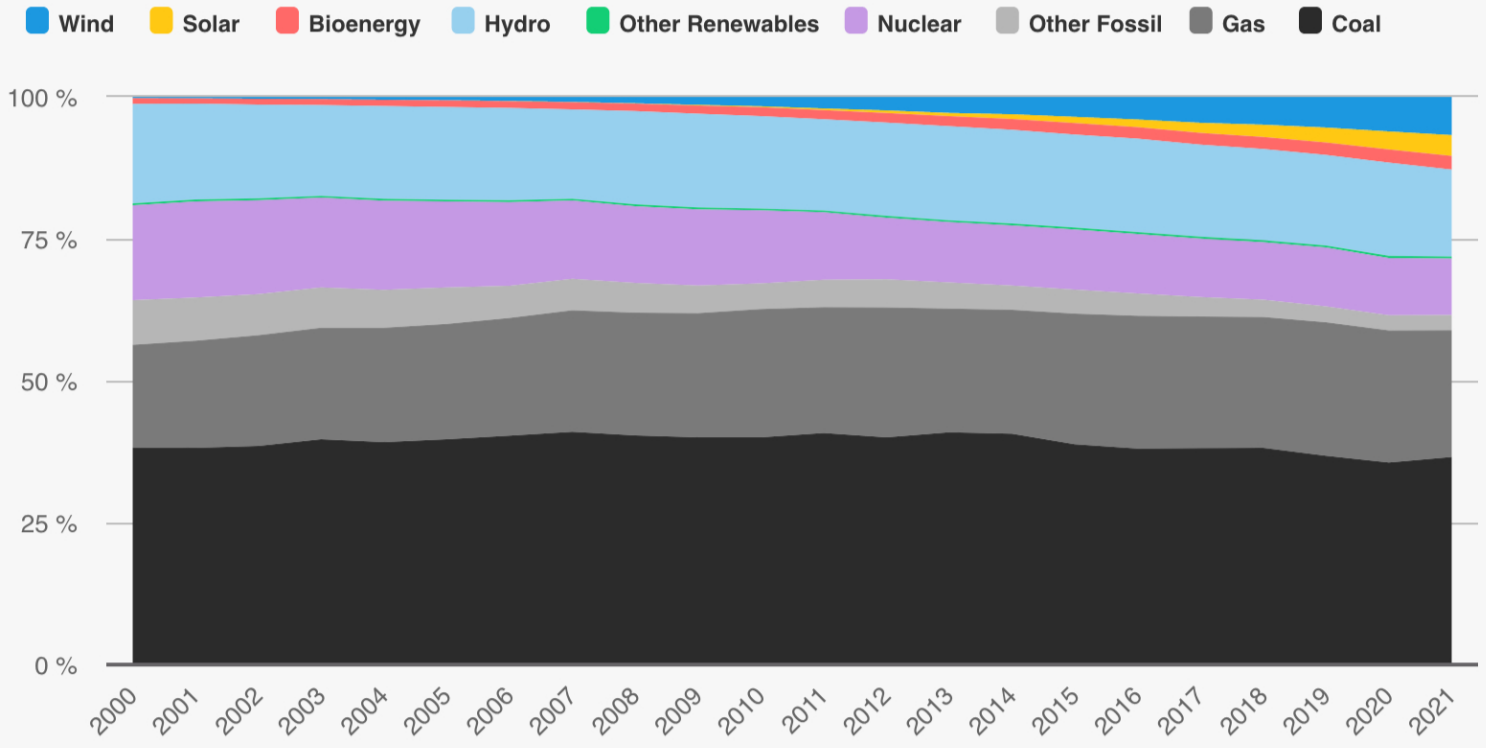
Typical carbon intensity:

~ 57g CO2eq / KWh

Source: NREL: Life Cycle Emissions Factors for Electricity Generation Technologies

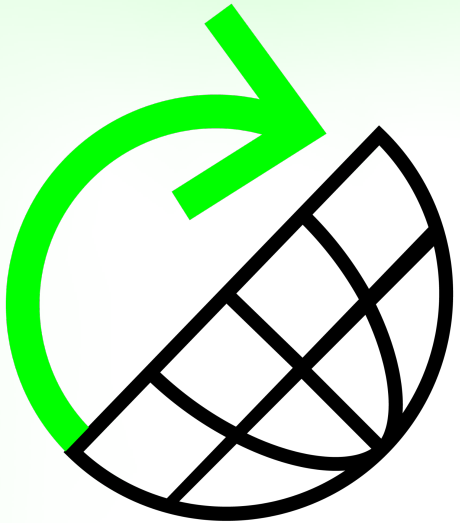
# World electricity generation by source

Percentage share



# Common strategies for improving carbon intensity of compute

1. **geographic migration**: move workloads *through space* to where more clean energy is on the grid
2. **temporal migration:** move workloads *through time* to when more clean energy is on the grid



# A model for thinking about digital sustainability - **CID**

## Consumption

Can I change how much we need?

## Intensity

Can I change how much harm is done?

## Direction

Can I change where we are headed?

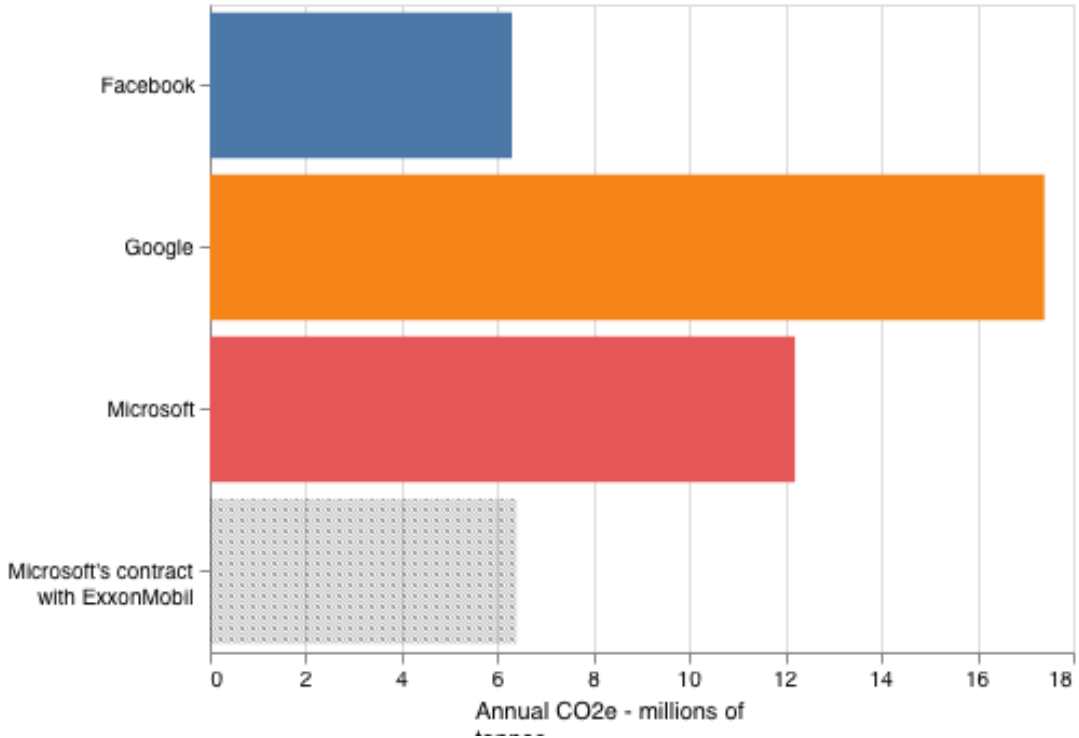
“

# TECHNOLOGY IS A SOCIAL, POLITICAL AND ENVIRONMENTAL ACCELERANT

CADE DIEHM, *New Design Congress*

# What's the carbon footprint of that oil and gas contract?

Reported corporate emissions for 2019, compared to estimated annual emissions from single oil and gas contract



# REPOWERING COAL

- Overview
- Carbon Emissions
- Costs
- Plant Owners

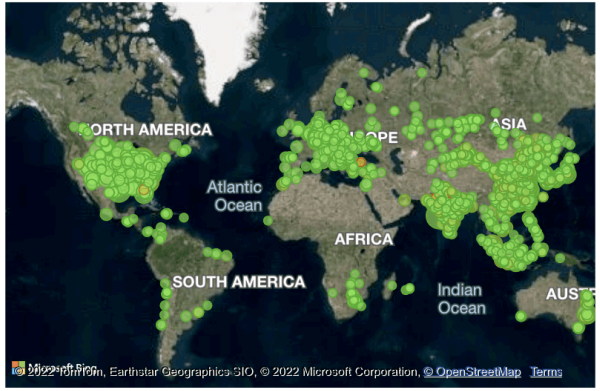
Country: All | State: All | Fleet Owner: All | Plant Name: All | Reset

**2399**
Number of operational plants

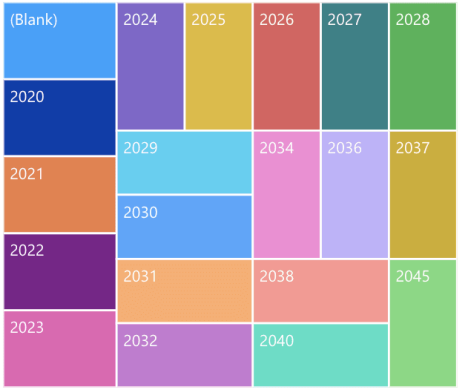
**2257**
Nameplate Capacity (GWe)

**21**
Average of Remaining plant lifetime (years)

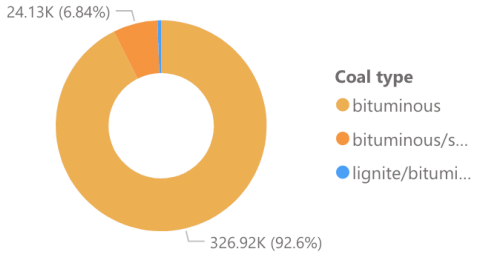
## Operational Coal Plants yet to be repowered



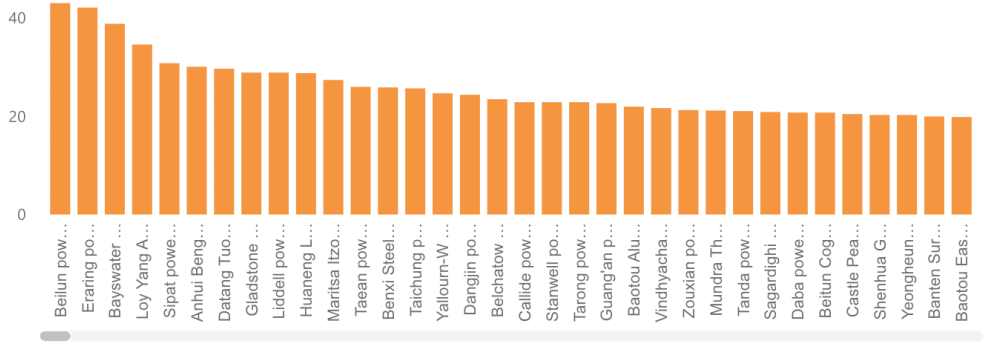

## Retirement Year by Capacity




## Coal Type




## Annual CO2 (million tonnes / annum) by plant

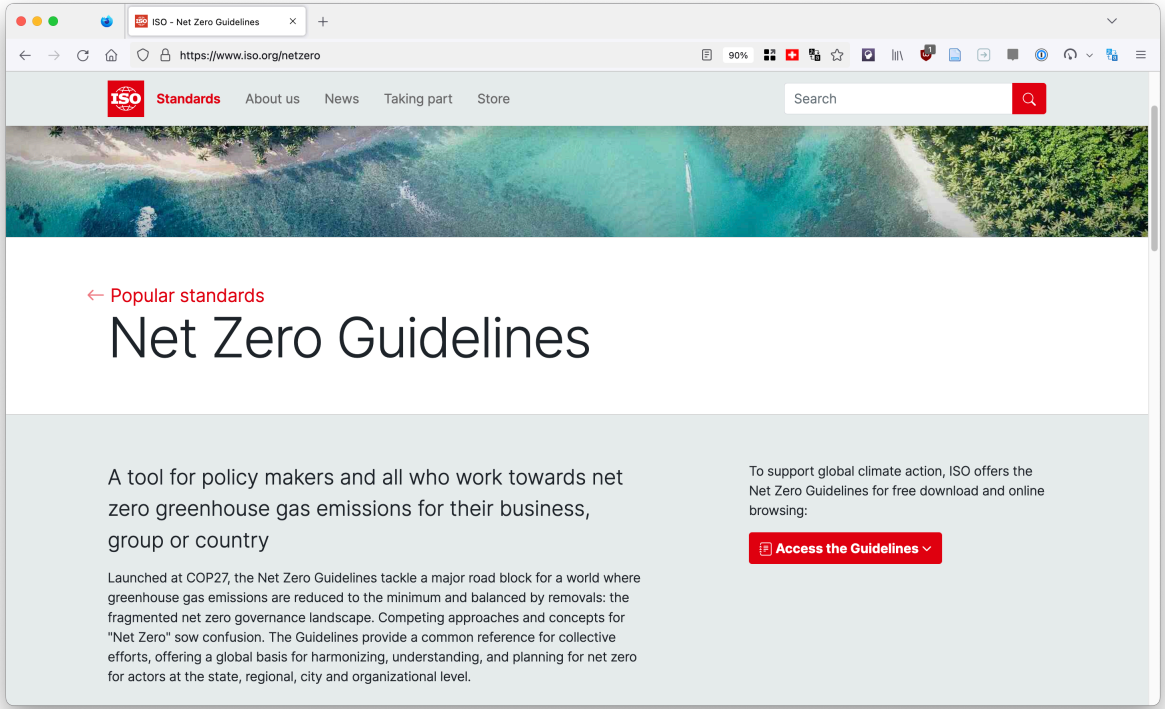



Source: https://www.terrapraxis.org/projects/repowering-coal

# 3

# Using the framework to look ahead at policy and tech changes

# Emerging sustainability reporting standards

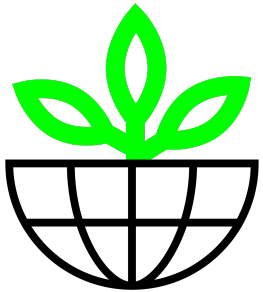


# Emerging corporate reporting standards

**ISO Net Zero Guidelines:** Net zero claims are no longer considered credible without halving emissions by 2030, if they don't include all supply chain, and if they don't have interim targets every 3-5 years.

**EU CSRD (European Union Corporate Sustainability Reporting Directive):** Comes into force in 2024, for every company with more than 250 employees. *You need to start collecting data in 2023 to report for 2024!* 😱

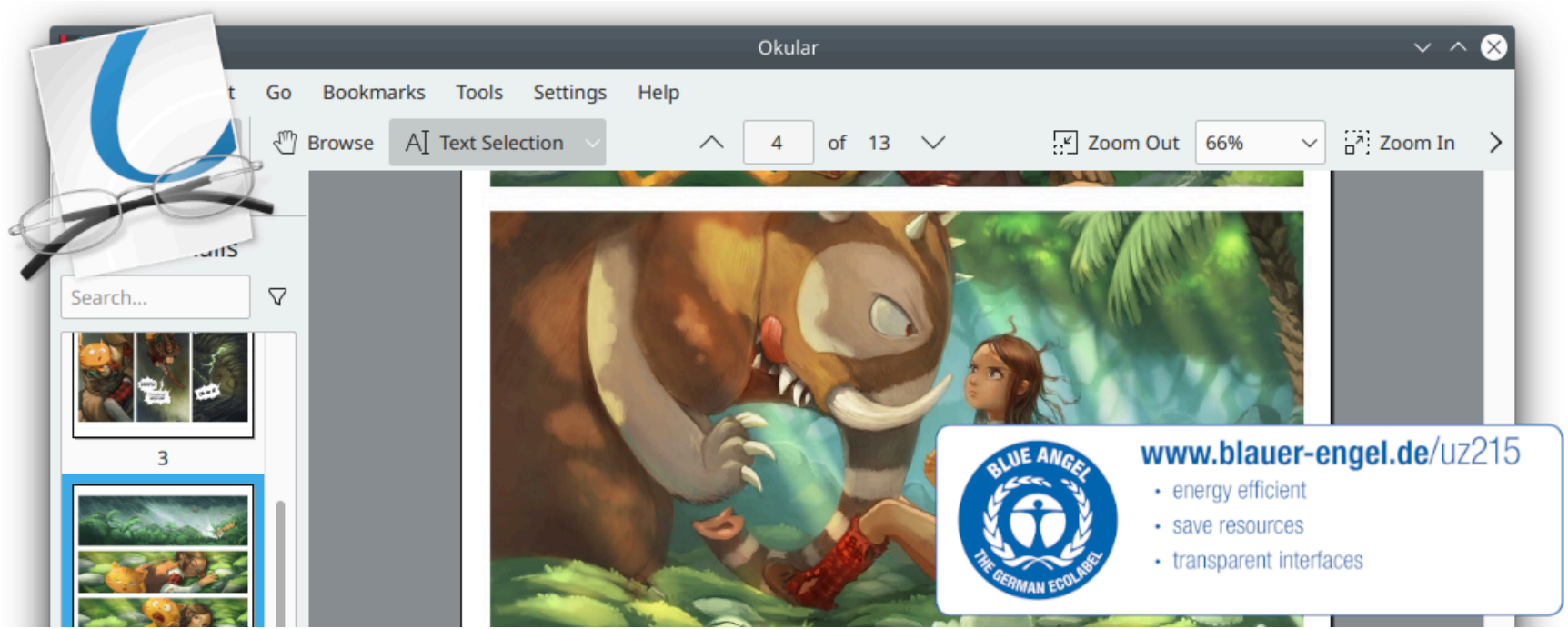
**IFRS (International Financial Reporting Standards) Foundation:** voted unanimously to require company disclosures on Scope 1, Scope 2 and Scope 3 greenhouse gases (i.e. entire supply chain).



# Consumption

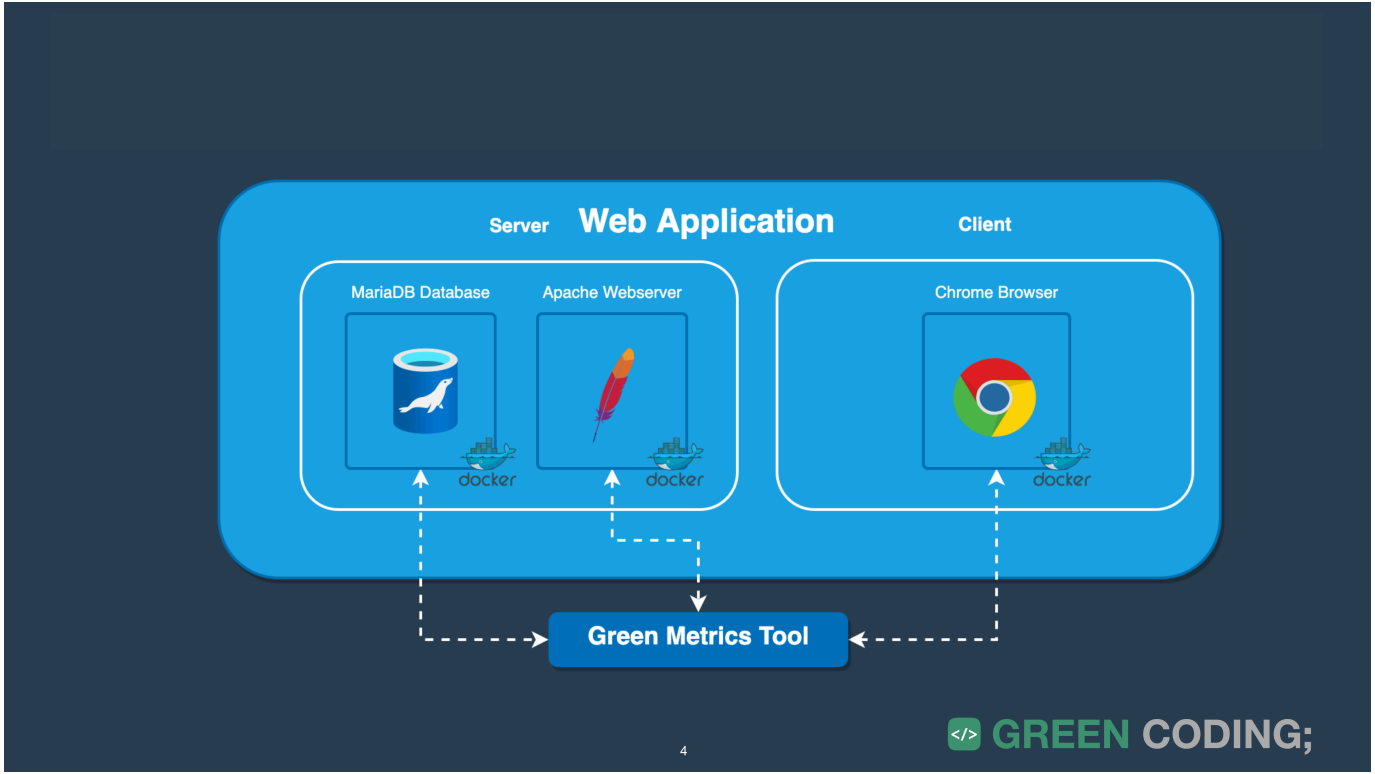
## Can I change how much we need?

# Emerging sustainable software standards

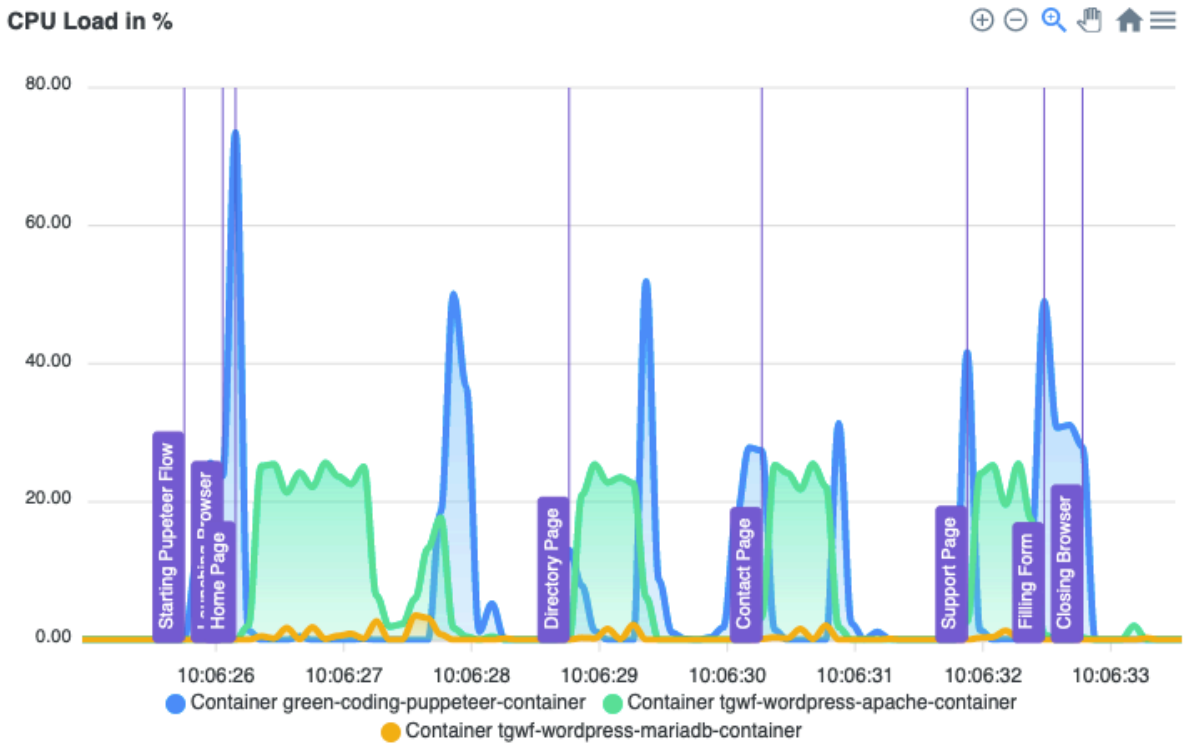


# Green Metrics tool - end to end measurement

Measuring from the outside with the AGPL licensed Green Metrics Tool (GMT)



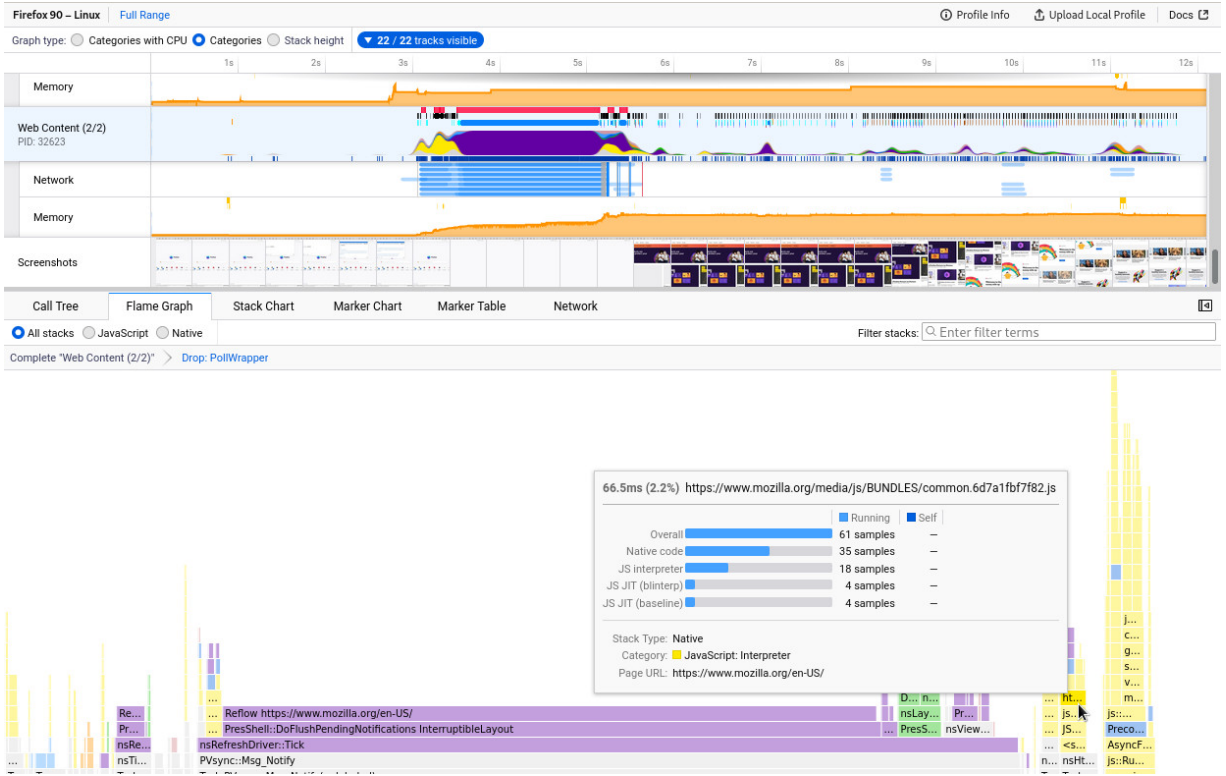
# Green Metrics tool - output



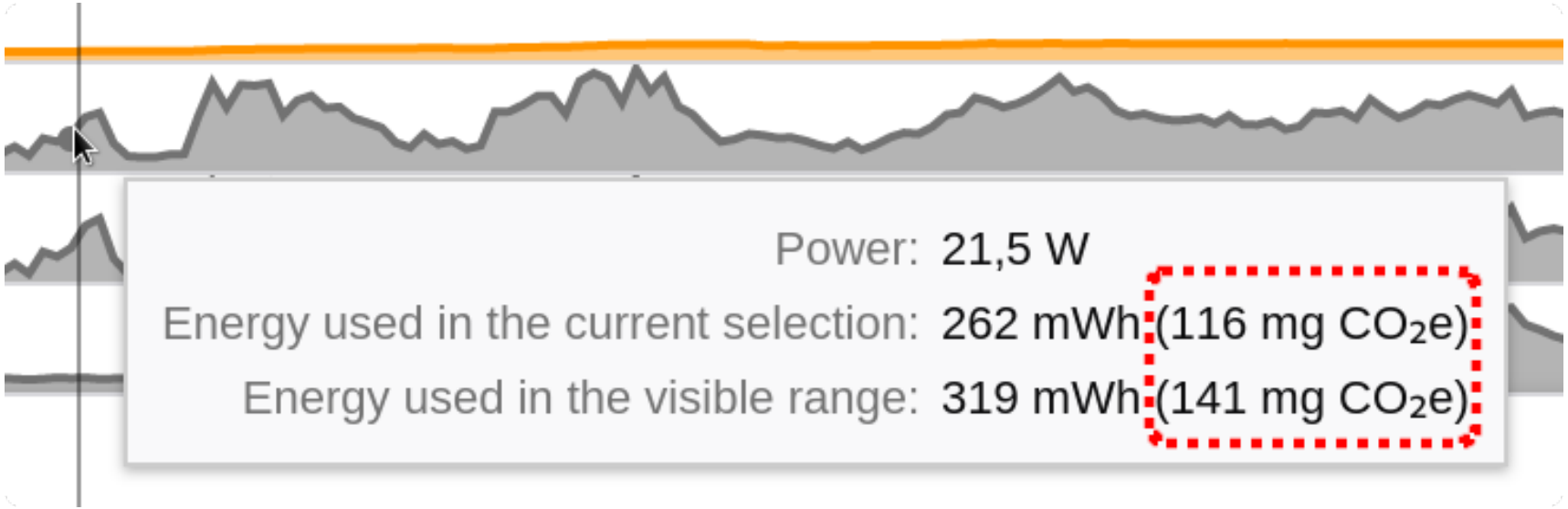
# Tracking direct usage with Firefox profiler

You can measure from the inside too!

If you have used profiler or perf tool, you can measure to optimise for consumption of resources.



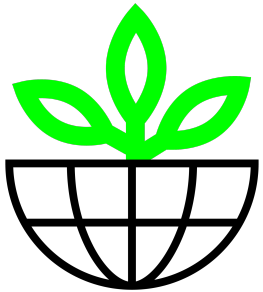
# Adding carbon metrics with CO2.js



# Optimising the right parts for consumption

**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 | | |



# Intensity

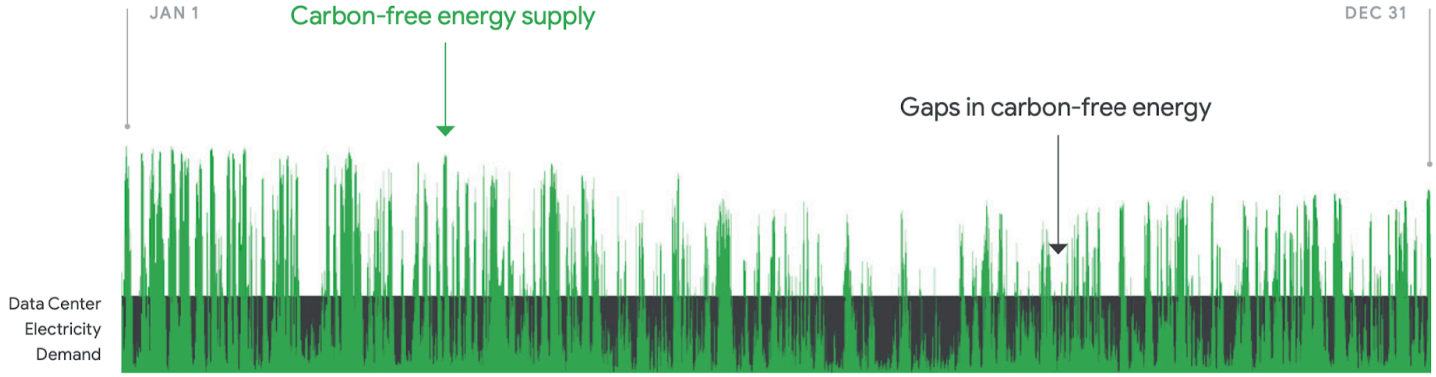
## Can I change how much harm is done?

# Green energy - annual vs hourly

FIG. 2

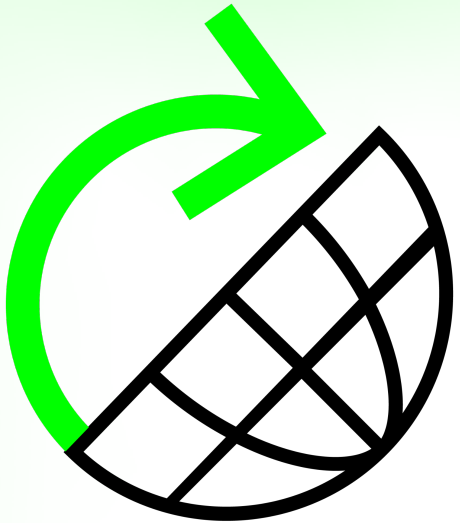
**Hourly carbon-free energy performance at an example data center**

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.

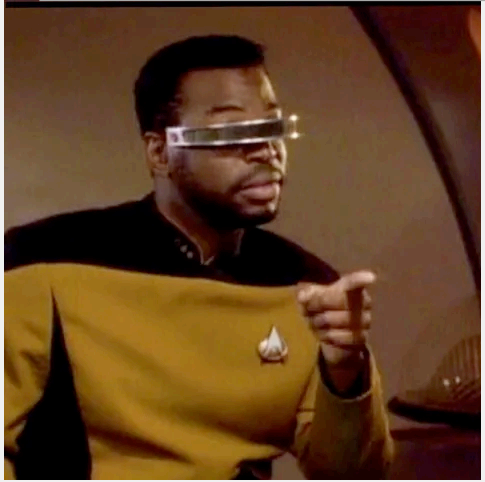


# Common strategies for improving carbon intensity of compute

1. **spatial migration**: move workloads *through space* to where more clean energy is on the grid
2. **temporal migration:** move workloads *through time* to when more clean energy is on the grid



kubernetes



low carbonetes

For more: see the Carbon Intensity Aware Scheduling in Kubernetes session at FOSDEM today. Slides are online already!

# What our computers run on

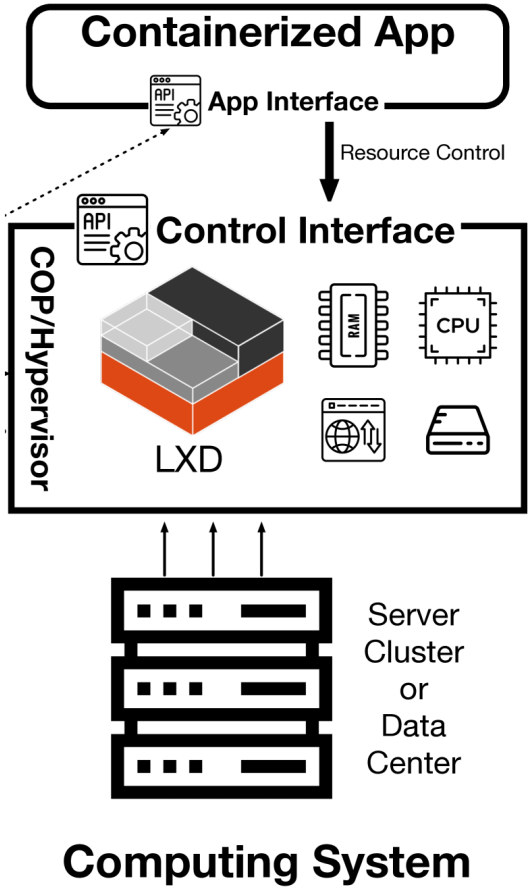
| Type | Carbon intensity | Dispatchable | Supply limited by |
|---|---|---|---|
| On-site renewables | Very low | No (in most cases) | Local environment |
| Energy storage (usually batteries) | Derived from source | Yes | Local storage capacity |
| Grid Energy | Variable | Yes | Local grid capacity<br><br>Fallout from violent invasions of neighbouring countries, pushing up prices beyond affordability |

# Hypervisors

We can use virtualisation to take a big physical machine, and abstract the hardware into resources like compute, network, ram and storage.

Once we done this we have fine grained control over how we allocate the resources, to compose into sets of smaller virtual machines.

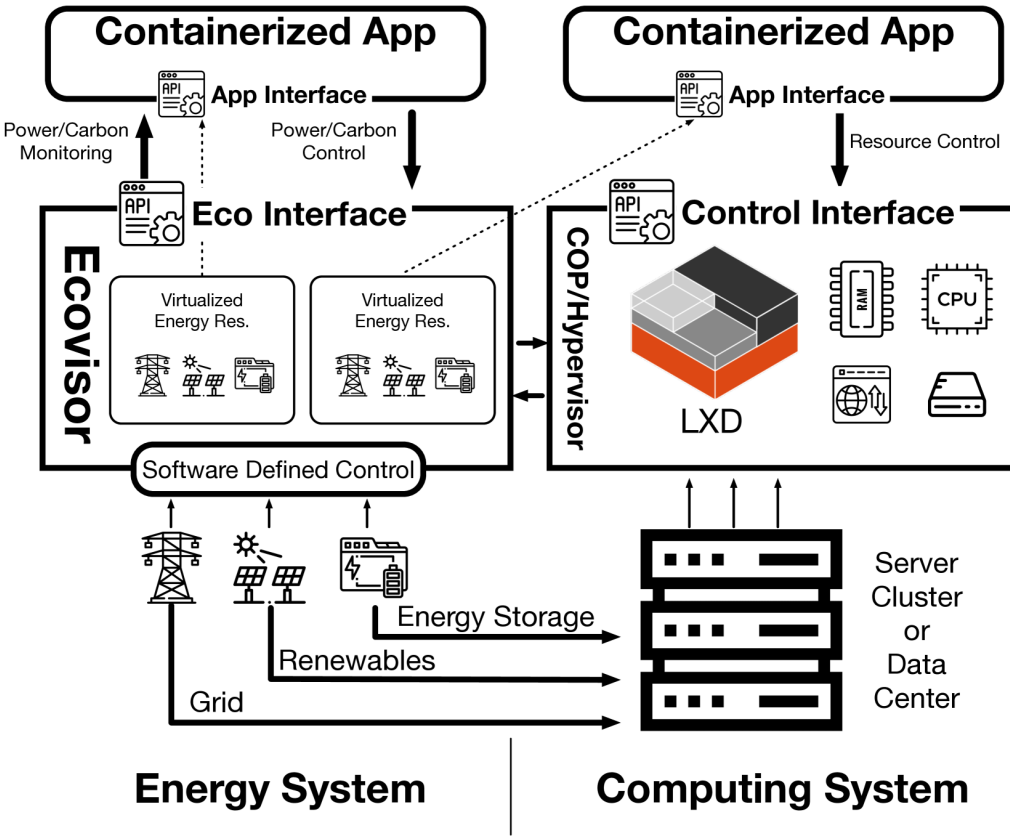
This allows for more efficient use of the hardware, and respond to changes more easily.



# Ecovisors

You can do the same with the *power computers use*. Power is usually presented as a single stream, even when we have batteries built in laptops.

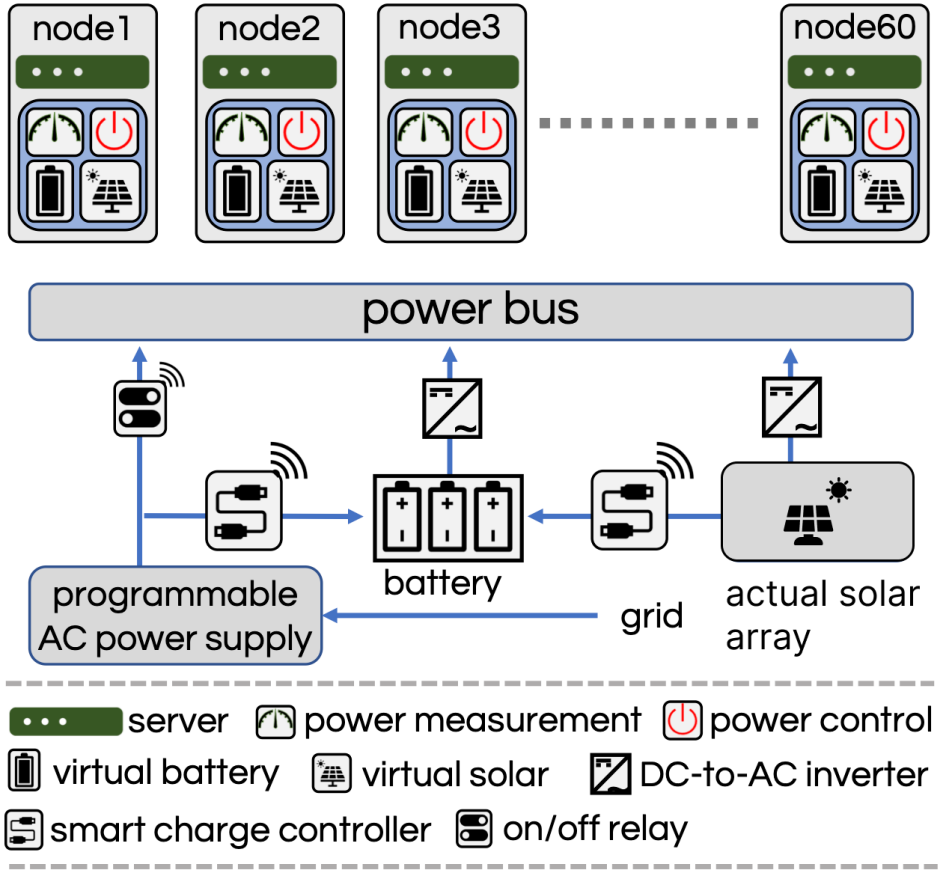
But if you virtualise the power as *grid*, *renewables* and *energy storage*, then you can allocate these resources the like how you allocate compute, memory, storage, and network with virtual machines



# Ecovisors

Virtual machines and other kinds of containers are allocated set amounts of each kind of power in addition to the usual resources, and given visibility into the amounts they have, on a schedule.

Applications can do more when there is more green energy available, and do less when there less available, to maximise the use of green energy and reduce carbon intensity.



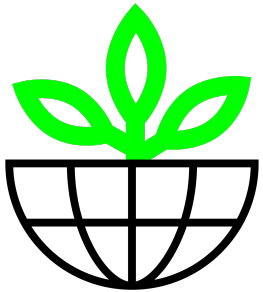
# A sample Ecovisor API for an application to implement

| Function Name | Type | Input | Return Value | Description |
|---|---|---|---|---|
| `set_container_powercap()` | Setter | ContainerID, kW | N/A | Set a container's power cap |
| `set_battery_charge_rate()` | Setter | kW | N/A | Set battery charge rate until full |
| `set_battery_max_discharge()` | Setter | kW | N/A | Set max battery discharge rate |
| `get_solar_power()` | Getter | N/A | kW | Get virtual solar power output |
| `get_grid_power()` | Getter | N/A | kW | Get virtual grid power usage |
| `get_grid_carbon()` | Getter | N/A | $g{\cdot}CO_2/kW$ | Get current grid carbon intensity |
| `get_battery_discharge_rate()` | Getter | N/A | kW | Get current rate of battery discharge |
| `get_battery_charge_level()` | Getter | N/A | kWh | Get energy stored in virtual battery |
| `get_container_powercap()` | Getter | ContainerID | kW | Get a container's power cap |
| `get_container_power()` | Getter | ContainerID | kW | Get a container's power usage |
| `tick()` | Notification | N/A | N/A | Invoked by ecovisor every $\Delta t$ |

Table 1: *Ecovisor's narrow API that provides application's visibility and control over their virtual energy system.*

Ecovisor: A Virtual Energy System for Carbon-Efficient Applications

Abel Souza, Noman Bashir, Jorge Murillo, Walid Hanafy, Qianlin Liang, David Irwin, Prashant Shenoy



# Direction

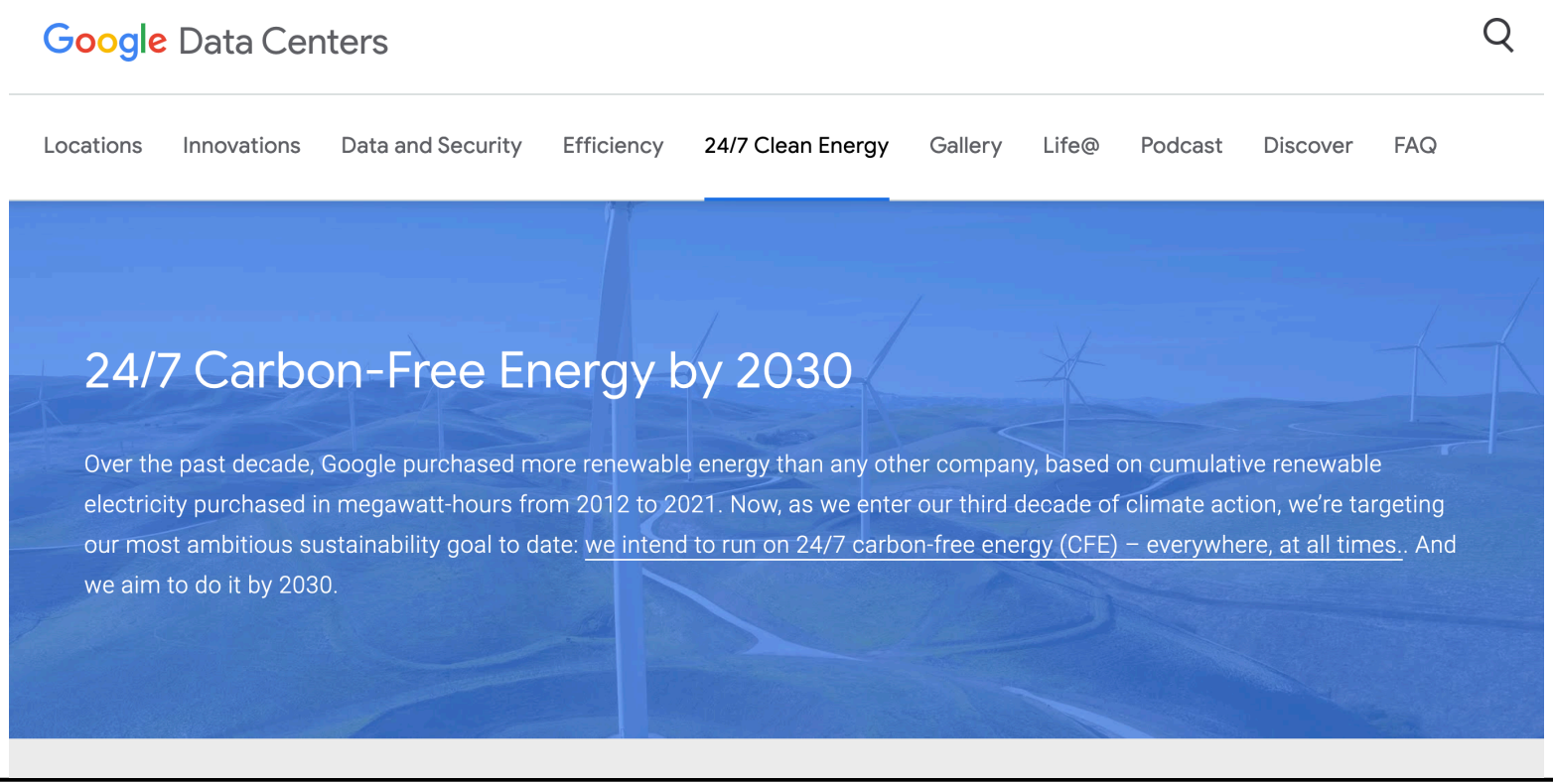
## Can I change where we are headed?

“

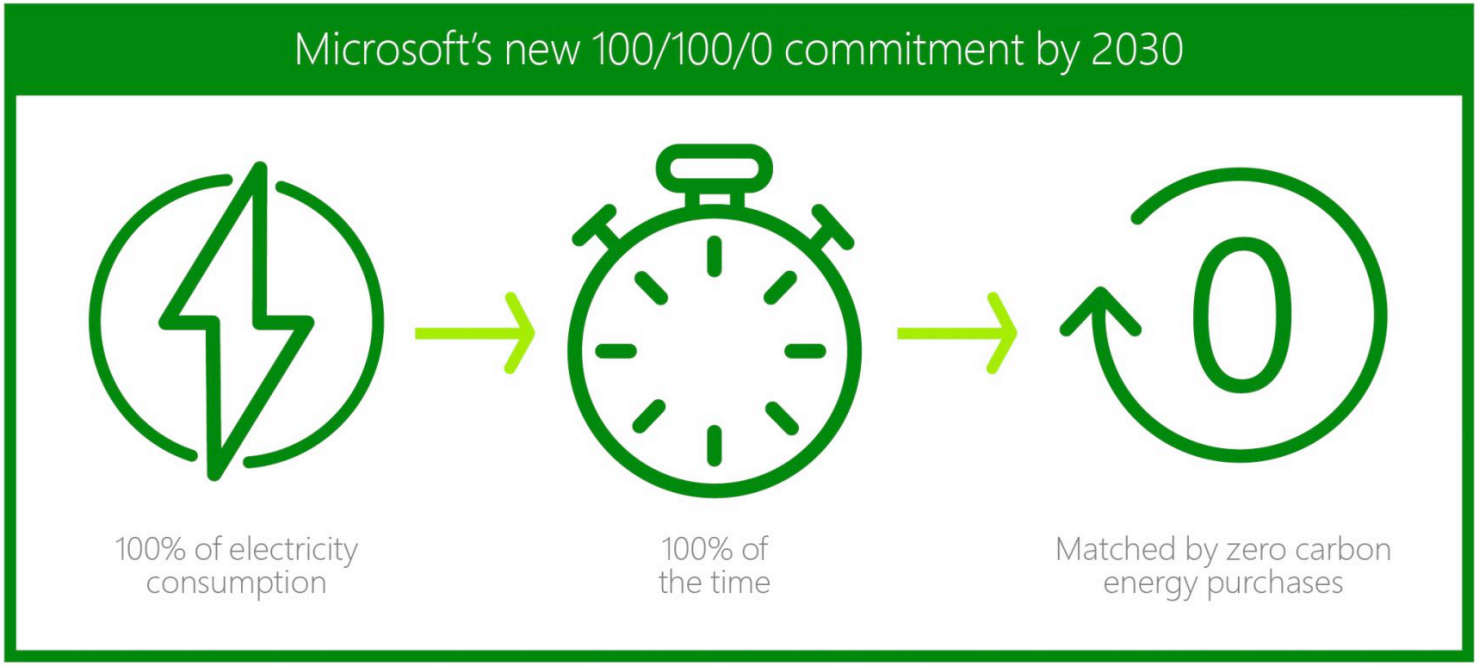
# The Green Web Foundation is working towards a fossil-free internet by 2030.

The internet should be a global public good—healthy for the planet and for the people who use it.

# Ambitious corporate targets (cont)



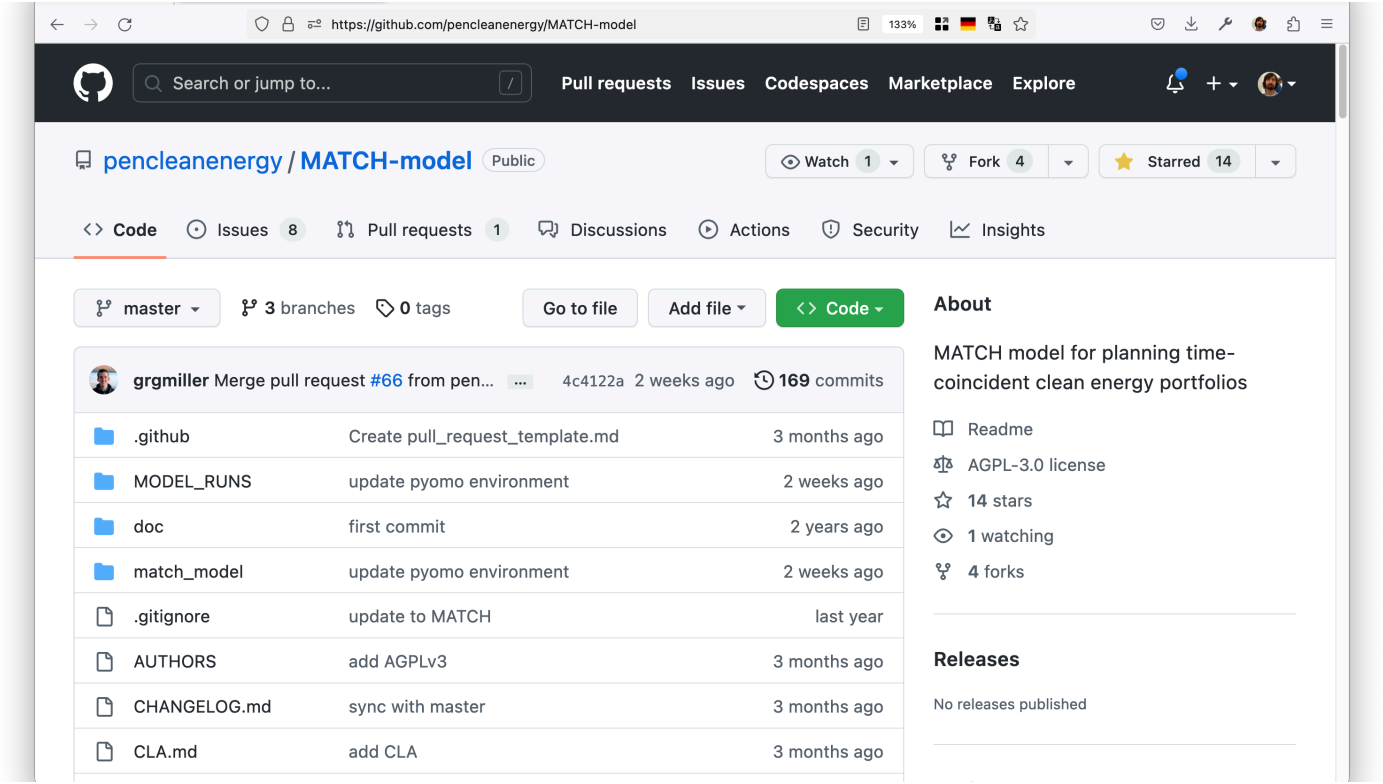
# Ambitious corporate targets (cont)



# Building targets into your governance


Source: https://www.peninsulacleanenergy.com/wp-content/uploads/2021/11/Whitepaper-OUR-PATH-TO-247-RENEWABLE-ENERGY-BY-2025.pdf

# Open sourcing  the way to set direction



"We have completely got rid of our dependency on Russian fossil fuels. It went much faster than we expected...

So we have the possibility to redirect or reorient the additional funding of REPowerEU – ≈€250 billion – to our net-zero industries."

European Commission President Ursula von der Leyen, 1st Feb 2023

# RECAP

4

# A model for thinking about digital sustainability - **CID**

| **Consumption** | **Intensity** | **Direction** |
| --- | --- | --- |
| Can I change how much we need? | Can I change how much harm is done? | Can I change where we are headed? |

# Why a fossil free internet by 2030

1. **Achievable** - Big firm buy in already, but doable at small scale too.
2. **Save carbon** - climate emergency, remember?
3. **Save lives** - 5m+ avoidable deaths / year from poor air quality globally, primarily from burning fossil fuels
4. **Save money** - fossil fuels are expensive with volatile prices
5. **Improve retention among staff** - ppl 💚 greener firms
6. **Energy security** - geopolitics and local resiliency

# Thanks!

If you want know more: we publish open source code and open data in this field, and if you want help we offer training and consulting.

**https://www.thegreenwebfoundation.org/fosdem/**

Chris Adams | **@mrchrisadams / @mrchrisadams@mastodon.social**

chris@thegreenwebfoundation.org

GREENWEBFOUNDATION.ORG