Green Coding Workshop

Green Coding Berlin

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Who we are

https://www.green-coding.berlin

Agenda

24.11.2023

- **PART 1 -**
    - Hello [5 Mins]
    - Requirements / Systems we use [10 Mins]
        - Note: We offer breakouts for professional practitioners! (Talk to Didi and Dan :))
    - Basics [15 Mins]
        - Where do software emissions come from
        - What is energy / power / CO2
    - How to get to power metrics in a system [10 Mins]
    - Easy tools to get first energy readings (perf_events, scaphandre, XGBoost ML, SDIA Model etc.) [30 min]
    - Cloud [30 Minutes]
- **PART 2**
    - Quick presentation GMT - Eco-CI - PowerHOG
        - Hands-On in Groups

Requirements

For the workshop

- You must have a Github account.
- Linux System? -> Live Systems?
- Windows Systems? -> WSL2
- macOS Systems?
- Basic Install for everybody:
  - sudo apt update
  - sudo apt install curl git stress-ng -y
  - # or
  - brew install stress-ng
  - brew install curl

Where do software emissions come from?

Components

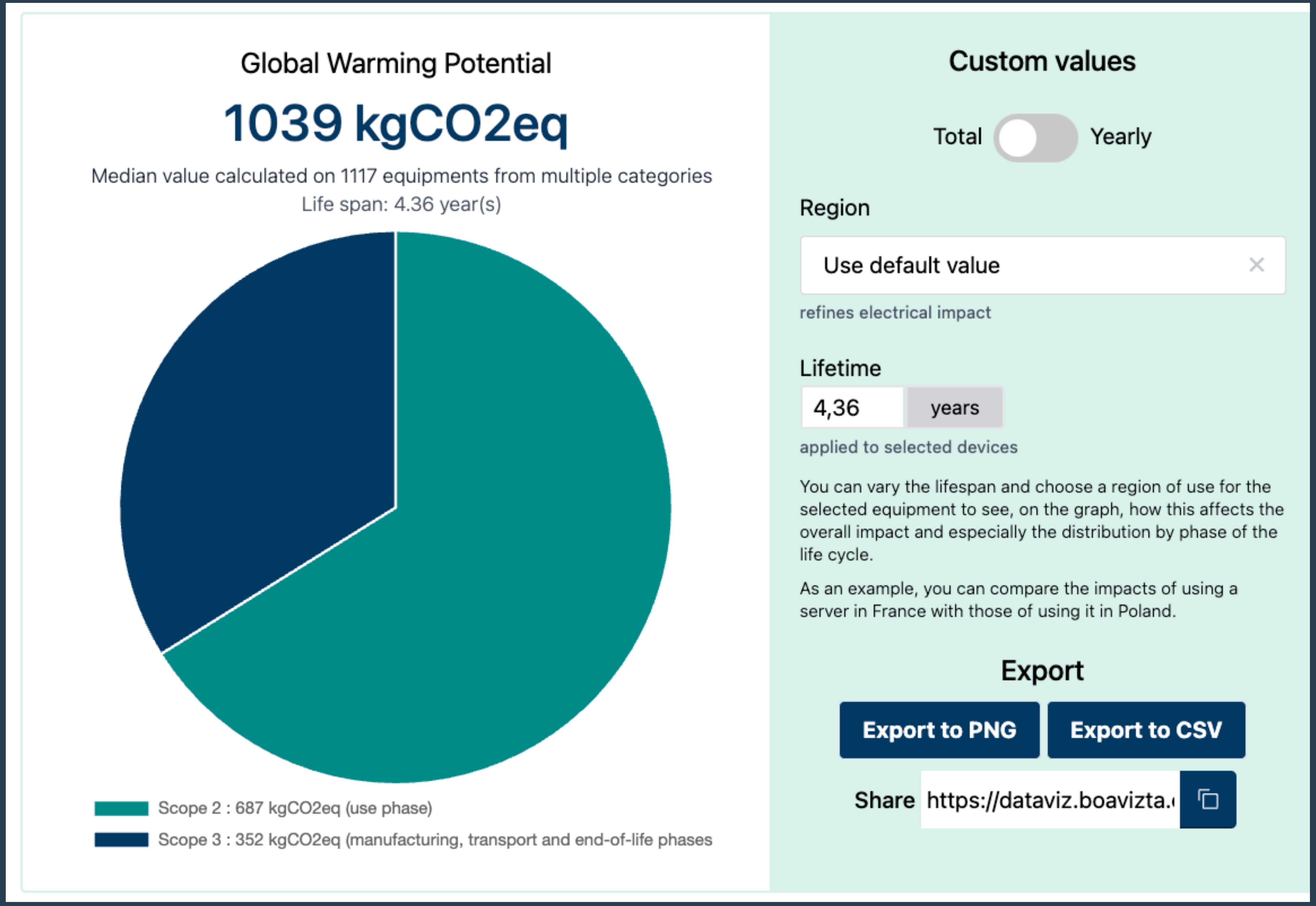
- Operational emissions - We will do this hands on!
  - Energy (and thus CO2 through fossil fuels)
- Embodied Emissions - Done through data sheets
  - Carbon (workshop focus)
  - Water consumption
  - Land use
  - Toxic Metals
  - ...

Embodied Carbon

Using Life-Cycle-Assessment databases

- **Boavizta**
  https://dataviz.boavizta.org/manufacturerdata
- **Microsoft**
  https://tco.exploresurface.com/sustainability/calculator
- **Dell**

  Example: https://www.delltechnologies.com/asset/en-us/products/servers/technical-support/Full_LCA_Dell_R740.pdf
- ... many more



Global Warming Potential

1039 kgCO2eq

Median value calculated on 1117 equipments from multiple categories
Life span: 4.36 year(s)

🟩 Scope 2 : 687 kgCO2eq (use phase)

🟦 Scope 3 : 352 kgCO2eq (manufacturing, transport and end-of-life phases

Custom values

Total ○ Yearly

Region: Use default value ×

refines electrical impact

Lifetime: 4,36 years

applied to selected devices

You can vary the lifespan and choose a region of use for the selected equipment to see, on the graph, how this affects the overall impact and especially the distribution by phase of the life cycle.

As an example, you can compare the impacts of using a server in France with those of using it in Poland.

Export

Share https://dataviz.boavizta.

Source: https://dataviz.boavizta.org/manufacturerdata

Quick recap on energy and CO2

Technical details - What you must know for this workshop

- What is a TDP?
  - https://ark.intel.com/content/www/us/en/ark/products/96900/intel-xeon-processor-e7-8894-v4-60m-cache-2-40-ghz.html
- What is a kWH?
  - Watts * usage time
- From TDP to kwH
  - https://www.green-coding.berlin/co2-formulas/#from-specs-to-kwh
- What is a Joule?
  - https://www.green-coding.berlin/co2-formulas/#from-joules-to-kwh
- From kwH to CO2e / Grid Carbon Intensity
  - https://app.electricitymaps.com/map
- From Network to CO2e
  - https://www.green-coding.berlin/co2-formulas/#gigabytes-to-kwh

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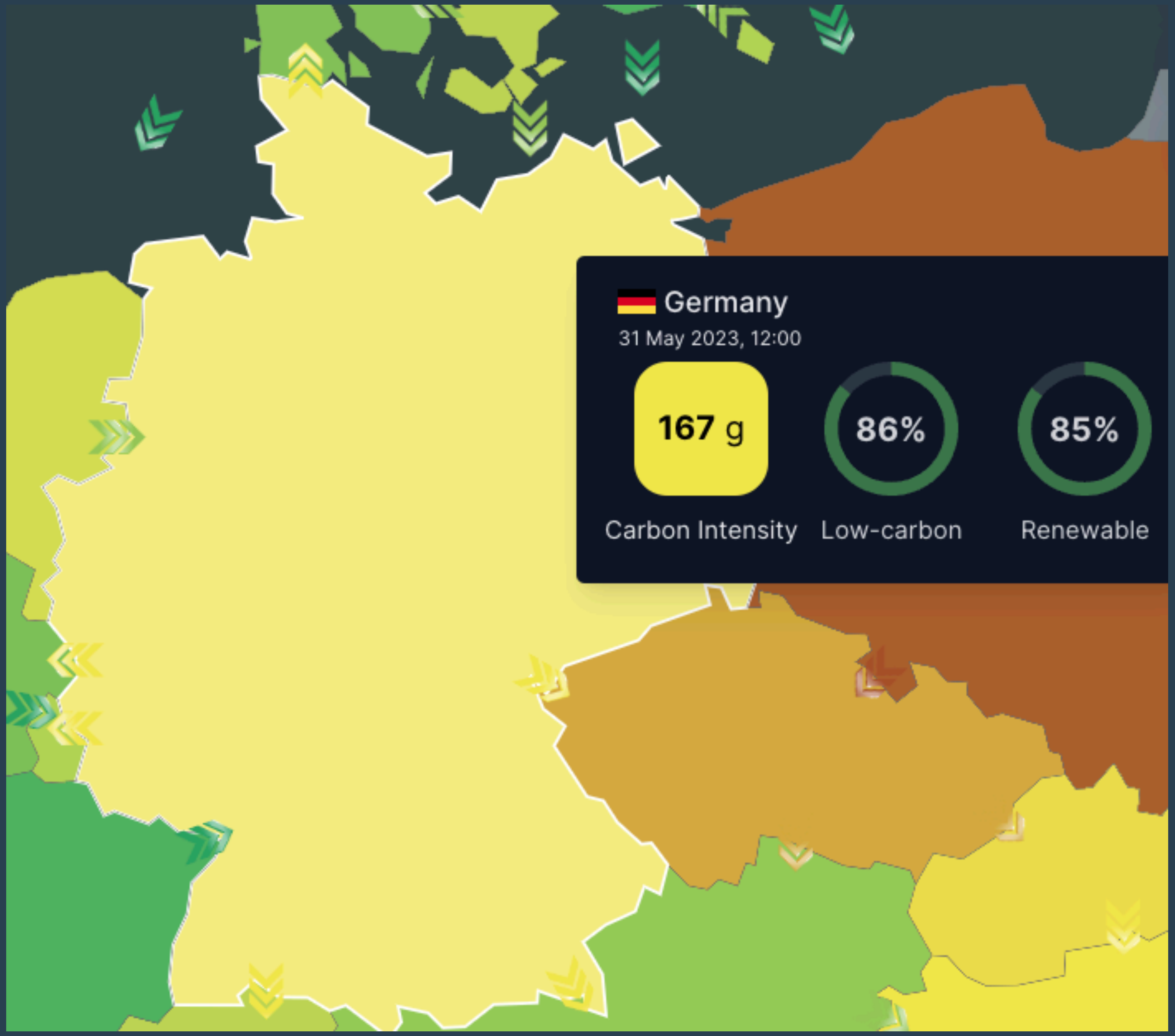
Getting from energy to CO2

Using grid emission factors

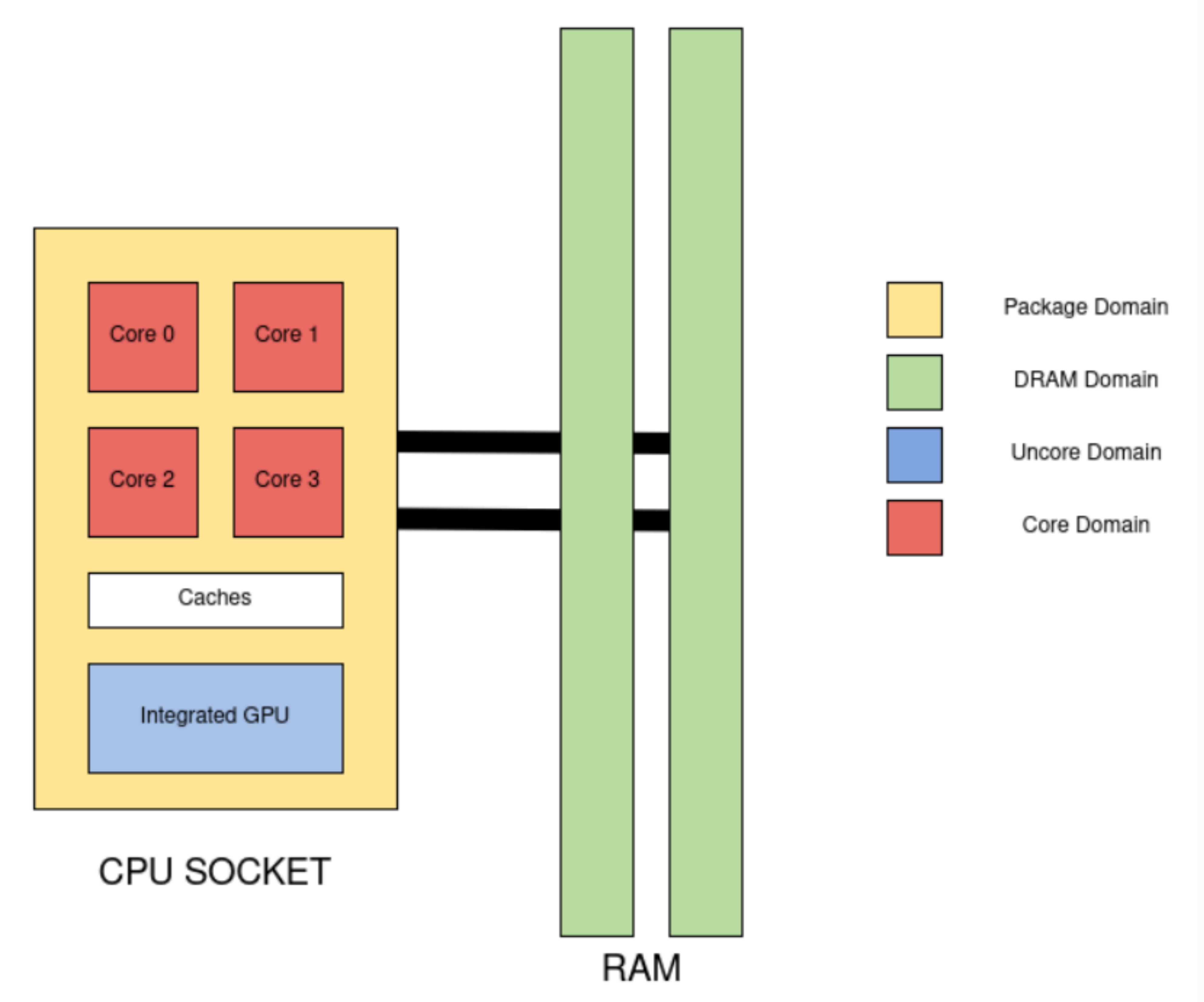
- Electricitymaps
  https://www.electricitymaps.com/
- Bundesnetzagentur
  https://www.smard.de/home
- Wattime
  https://www.watttime.org/
- Carbon-Aware-SDK
  https://github.com/Green-Software-Foundation/carbon-aware-sdk
- … many more



Source: https://app.electricitymaps.com/zone/DE

How do we measure energy?

Two easy methods: Wall-Plug vs. Hardware/Software-Interfaces. Servers: IPMI



Intel RAPL
Source: https://pyjoules.readthedocs.io/en/stable/devices/intel_cpu.html

Wall-Plug power meter

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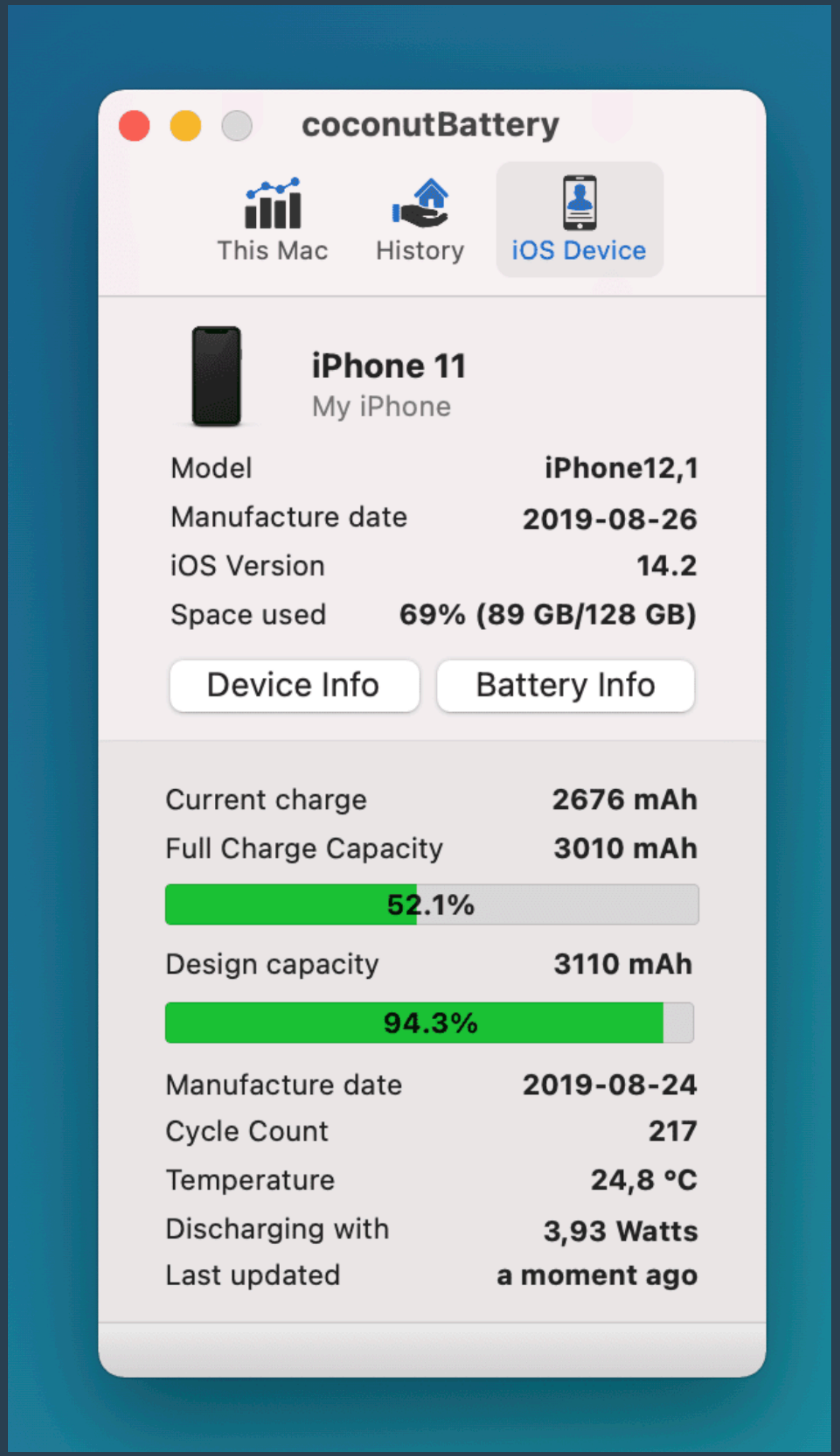
How do we measure energy?

A possible alternative: Through battery drain on mobile devices

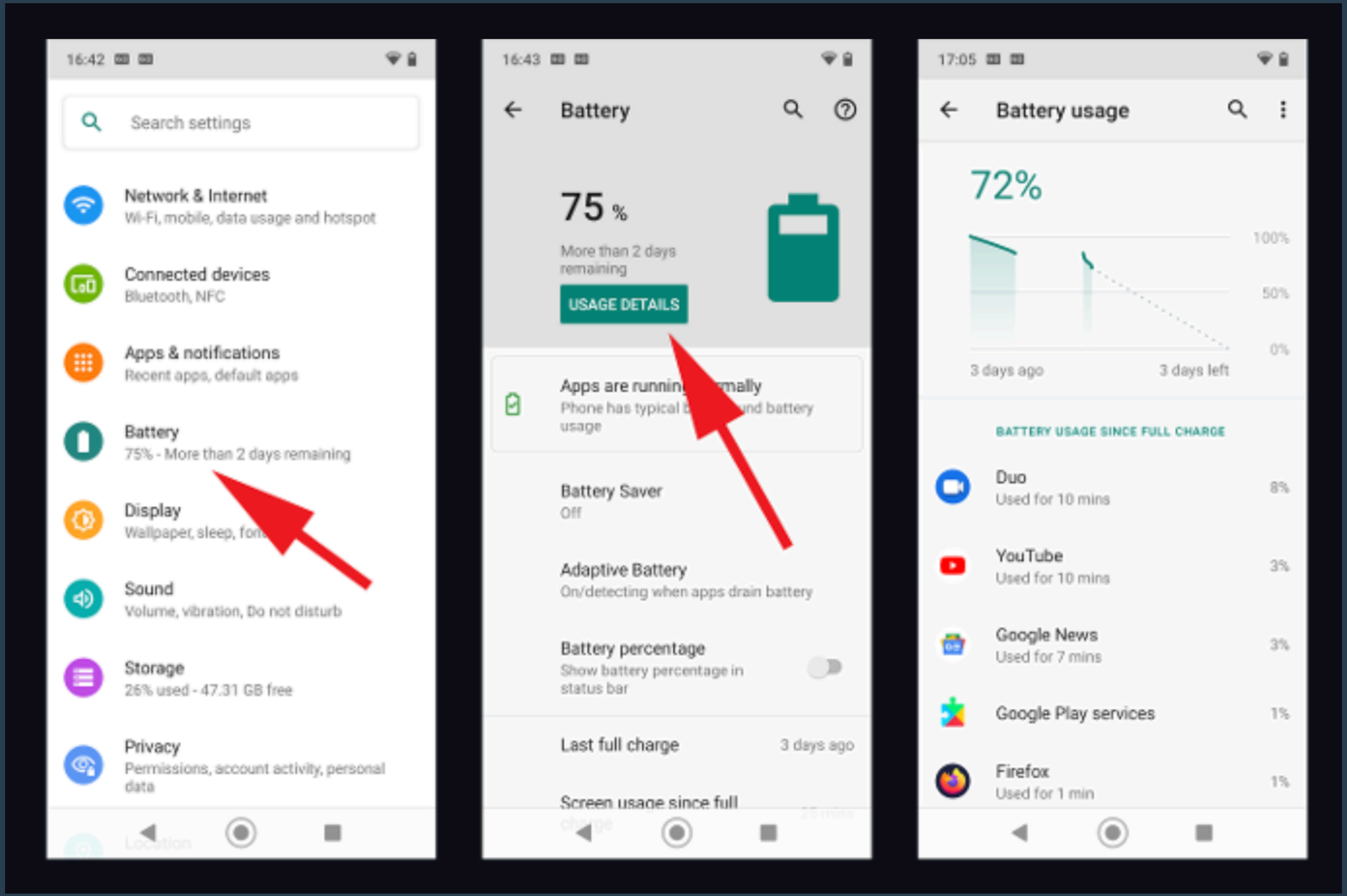


iPhone 11
My iPhone

Model	iPhone12,1
Manufacture date	2019-08-26
iOS Version	14.2
Space used	69% (89 GB/128 GB)

Current charge	2676 mAh
Full Charge Capacity	3010 mAh
	52.1%
Design capacity	3110 mAh
	94.3%
Manufacture date	2019-08-24
Cycle Count	217
Temperature	24,8 °C
Discharging with	3,93 Watts
Last updated	a moment ago

Example: Coconut Battery for macOS / iOS



Network & Internet
Wi-Fi, mobile, data usage and hotspot

Connected devices
Bluetooth, NFC

Apps & notifications
Recent apps, default apps

Battery
75% - More than 2 days remaining

Display
Wallpaper, sleep, fon

Sound
Volume, vibration, Do not disturb

Storage
26% used - 47.31 GB free

Privacy
Permissions, account activity, personal data

75 %
More than 2 days remaining

Apps are runnin mally
Phone has typical b nd battery usage

Battery Saver
Off

Adaptive Battery
On/detecting when apps drain battery

Battery percentage
Show battery percentage in status bar

Last full charge 3 days ago

Screen usage since full charge

72%

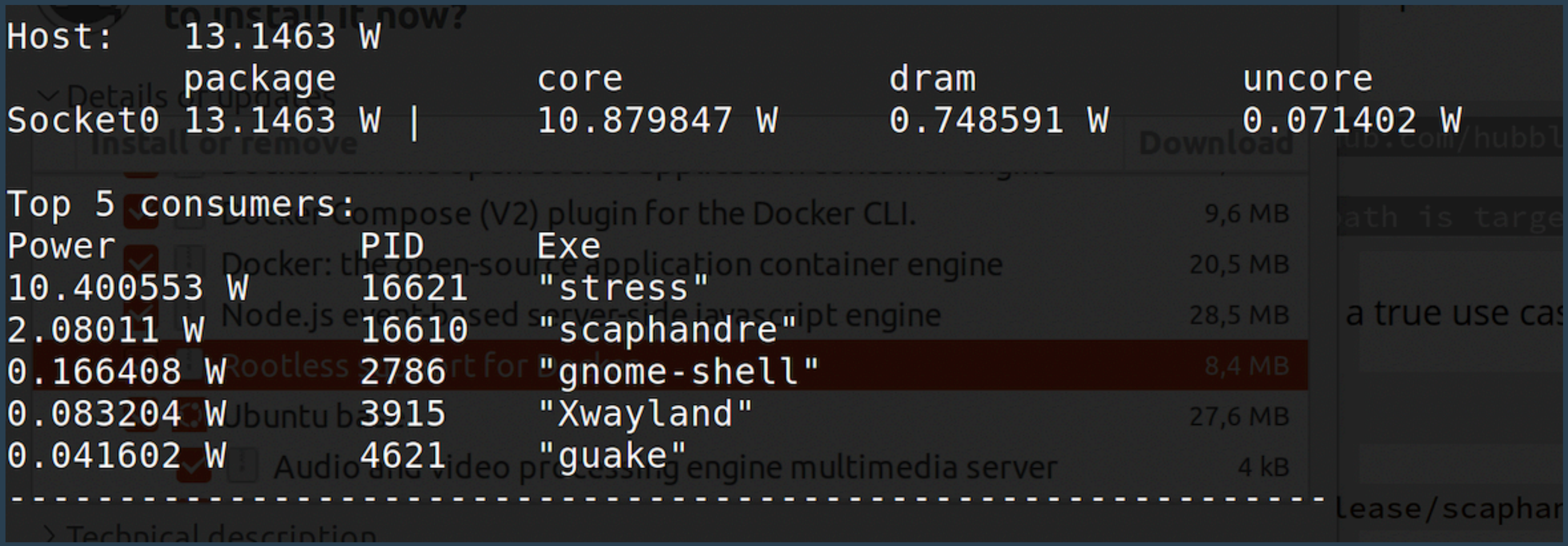
Duo Used for 10 mins	8%
YouTube Used for 10 mins	3%
Google News Used for 7 mins	3%
Google Play services	1%
Firefox Used for 1 min	1%

Android Battery usage (model)

Scaphandre - Hubblo

open-source RAPL based command line tool

- Neat feature: Can split by process



```
Host:   13.1463 W
        package          core             dram             uncore
Socket0 13.1463 W |      10.879847 W      0.748591 W       0.071402 W

Top 5 consumers:
Power       PID     Exe
10.400553 W  16621   "stress"
2.08011 W    16610   "scaphandre"
0.166408 W   2786    "gnome-shell"
0.083204 W   3915    "Xwayland"
0.041602 W   4621    "guake"
------------------------------------------------------------
```

Let's run Scaphandre!

via https://hubblo-org.github.io/scaphandre-documentation/tutorials/compilation-linux.html

```
## Could not get it working with current version ...
# from https://www.rust-lang.org/tools/install
curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh
source "$HOME/.cargo/env"

git clone https://github.com/hubblo-org/scaphandre.git
cd scaphandre
cargo build # binary path is target/debug/scaphandre
git checkout v0.5.0
sudo ./target/debug/scaphandre run stdout -t 0

# But if you have docker in rootless mode:
sudo docker run -v /sys/class/powercap:/sys/class/powercap -v /proc:/proc -ti hubblo/scaphandre stdout -t 15

# now we run stress to see changes in separate terminal
stress-ng -c 1
```

perf_events

- sudo apt install linux-tools-$(uname -r)
- perf list | grep power # to see what we have available on the system
- perf stat -e power/energy-pkg/ # to read package

- ## Mini Benchmark
- perf stat -e power/energy-pkg/ sleep 10 # to get system baseline over ten seconds
- perf stat -e power/energy-pkg/ stress-ng -c 1 -t 10 # to get system baseline over ten seconds

- # Look at IPC
- perf stat -e instructions,cache-misses stress-ng -c 1 -t 1 # to get system baseline over ten seconds

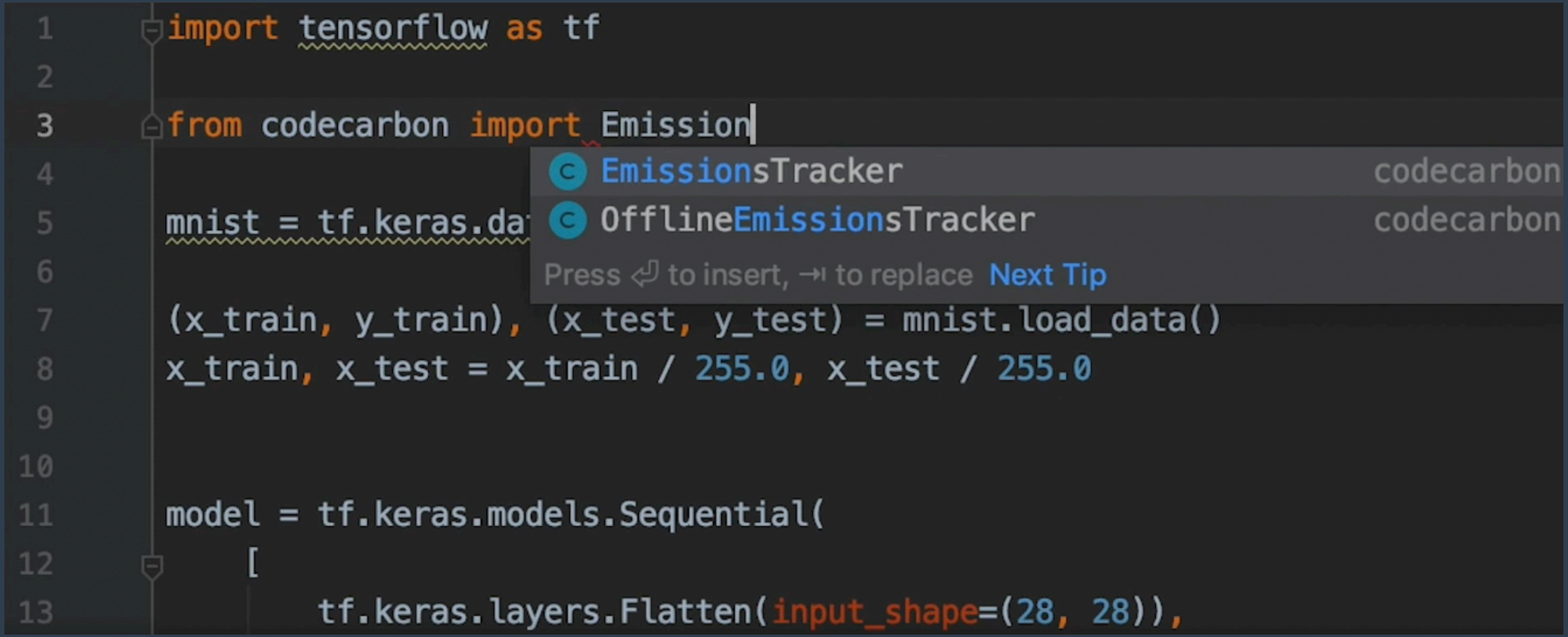
- # Look at "default" defailed view
- perf stat -d stress-ng -c 1 -t 1 # to get system baseline over ten seconds

codecarbon.io

Slide only due to time constraints :)

CODE CARBON

- Python
- RAPL-based
- NVIDIA GPU support



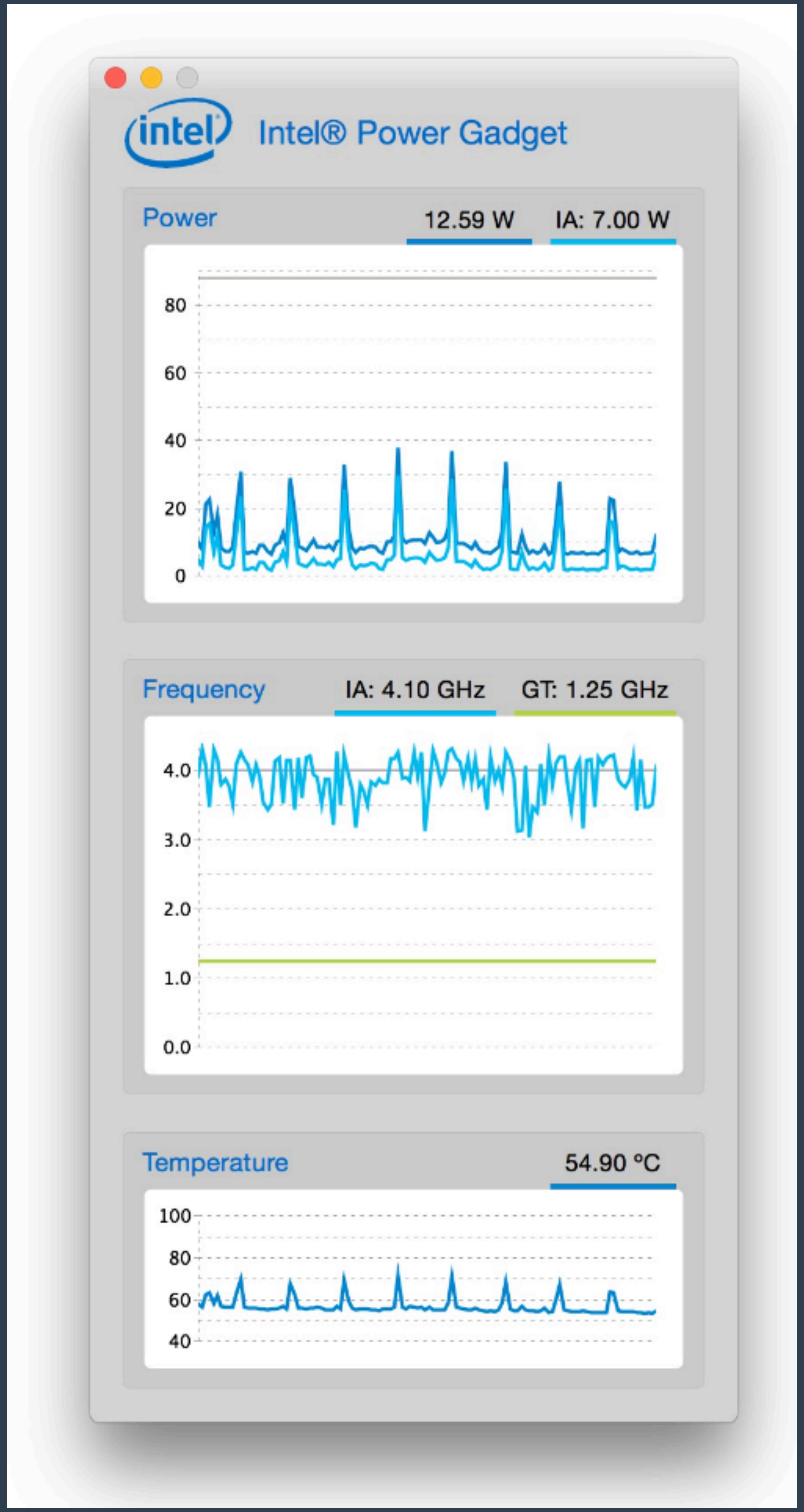
```
import tensorflow as tf

from codecarbon import Emission

mnist = tf.keras.da

(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0


model = tf.keras.models.Sequential(
    [
        tf.keras.layers.Flatten(input_shape=(28, 28)),
```

EmissionsTracker codecarbon
OfflineEmissionsTracker codecarbon
Press ⏎ to insert, ⇥ to replace Next Tip

Windows Tools

Intel Power Gadget

- Not distributed anymore.
- But you can try: https://www.computerbild.de/download/Intel-Power-Gadget-24653156.html



Cloud environments

SDIA Model - 1/3

- Assumes that 65% of the machines total energy is related to the CPU. We can extrapolate from there
    - **total_machine_power = ((cpu_utilization * TDP) / 6.5) * CPU_CHIPS**

Cloud environments

SDIA Model - 2/3

- Assumes that 65% of the machines total energy is related to the CPU. We can extrapolate from there
    - **total_machine_power = ((cpu_utilization * TDP) / 6.5) * CPU_CHIPS**

- Example for 12% CPU Utilization and 2 chips with a 160 W TDP:
    - (0.12 * 160) / 0.65 * 2 = **59.08 W**

Cloud environments

SDIA Model 3/3

- That, more or less, is for instance what CloudCarbonFootprint does. However, they integrate more components like memory etc. with static offsets.
  - https://www.cloudcarbonfootprint.org/docs/methodology/#energy-estimate-watt-hours
- For hard disks they use 0.001 kWh/Gb for instance
- How can we improve that …?

Cloud environments

XGBoost estimation 1/3

- Using ML Models based on power curves of actual machines
  - Non-Linear!
- https://www.spec.org/power_ssj2008/results/https://www.spec.org/power_ssj2008/results/

Cloud environments

XGBoost estimation 2/3

- Using ML Models based on power curves of actual machines
  - Non-Linear!
- Caveats:
  - CPU Frequency is needed to be assumed constant
- See our article on this in detail:
  - https://www.green-coding.berlin/case-studies/cpu-utilization-usefulness/
  - https://www.green-coding.berlin/case-studies/hyper-threading-and-energy/
  - etc.

Cloud environments

XGBoost estimation 3/3

- Let's install it!
    - https://github.com/green-coding-berlin/spec-power-model

macOS

powermetrics

- macOS Deeper dive
- Individual questions
- Measuring with powermetrics after the break

Part #2

In breakout groups

Green Metrics Tool Linux&WSL / Eco-CI / macOS

Green Metrics Tool - Cluster Setup

Current machines in the Green Metrics Tool Cluster

- Fujitsu ESPRIMO P956 - Blue Angel compatible (Ubuntu)
- Fujitsu TX1330 M2 - Single-Tenant Server (Ubuntu)
- Quanta Leopard - Multi-Tenant Server - SoftAWERE compatible (Ubuntu)
- Intel Mac 13" Q3-2015
- M1 Mac 13" Q1-2022