Starting GreenOps

SUSTAINABLE COMPUTING IN PRACTICE

Today, we change into the transformative power of renewable energy and energy efficiency.

Frank Klöker

- Grew up in the dirtiest lignite mining area in the world
- Taking care of environment since 2023
- GreenOps Engineer at Deutsche Telekom

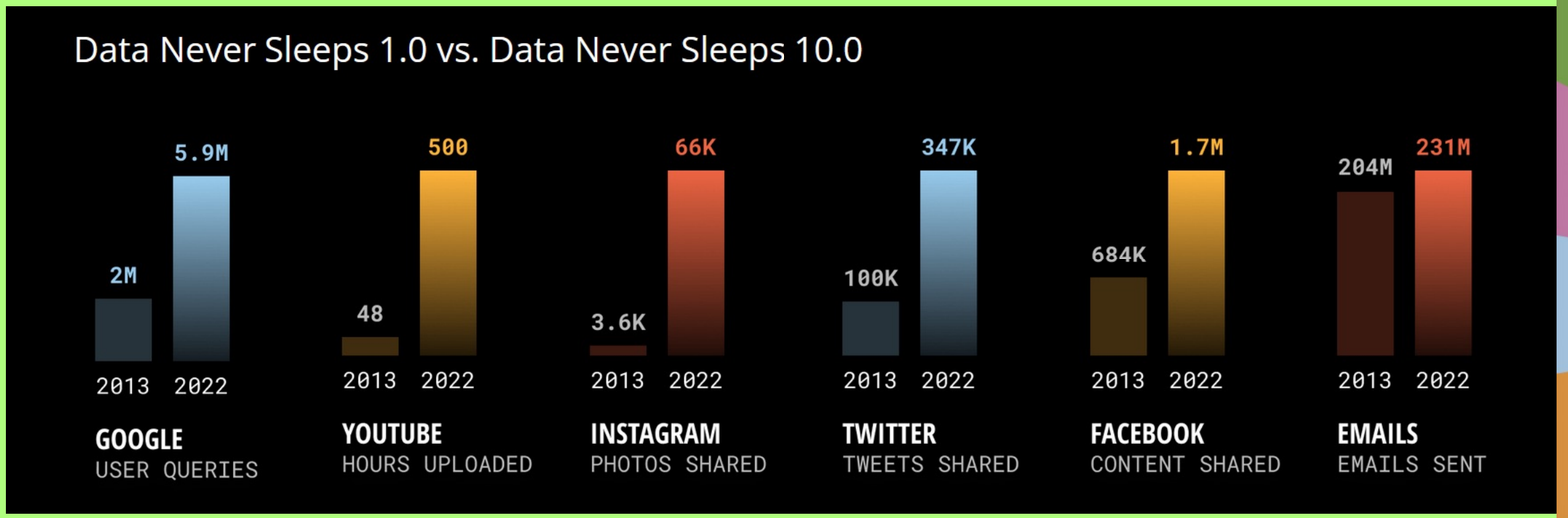
Facts

- Data center are the most CO^2 driver per industrie sector
- Cloud Computing is 5 times greener then regular data center
- Power consumption increased +12% per year

Created by KI (DALL-E-3) 15.03.2024

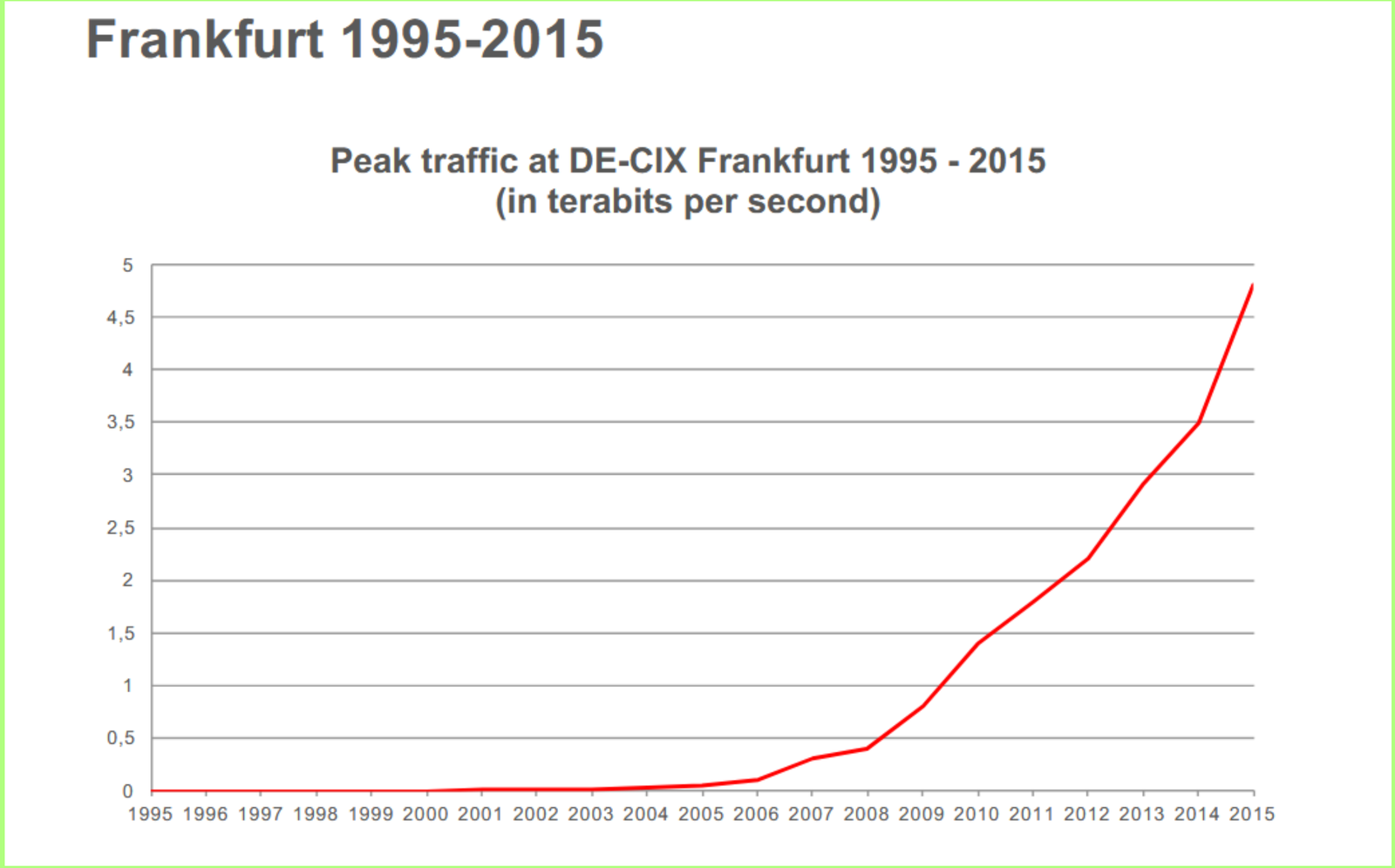
(c) https://www.climatiq.io/blog/measure-greenhouse-gas-emissions-carbon-data-centres-cloud-computing

Facts



https://www.domo.com/data-never-sleeps

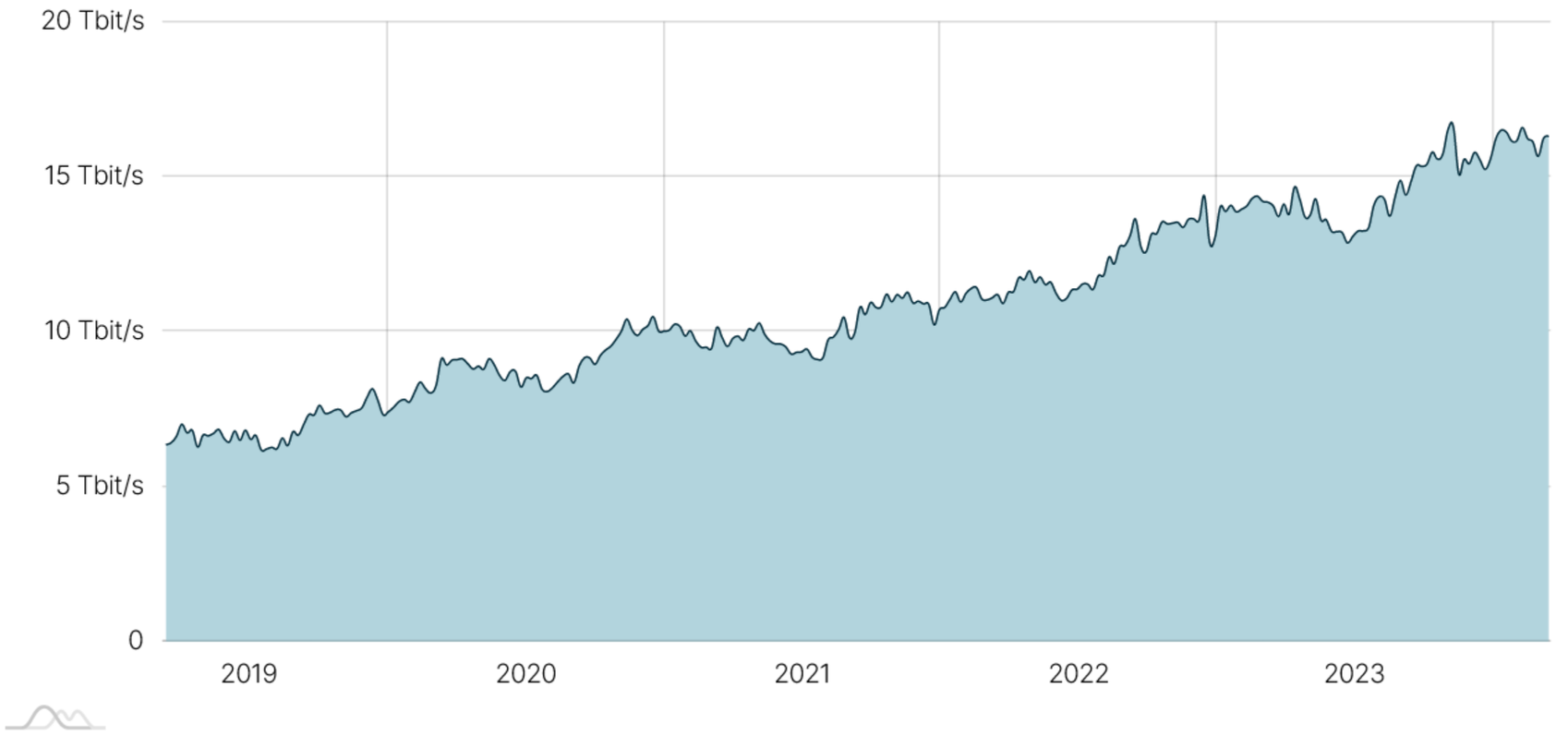
The old days…



(c) https://www.denog.de/media/DENOG7/22-Tremmel-DE-CIX_Update.pdf

Current…

Traffic Frankfurt – 5 Jahre



ALL-TIME PEAK
16.62 Tbit/s

GRAPH PEAK
16.62 Tbit/s

GRAPH AVERAGE
7.69 Tbit/s

CURRENT
13.69 Tbit/s

(c) https://www.de-cix.net/de/standorte/frankfurt/statistiken

MAKING EVERY WATT COUNT

Cost savings

Lowering energy bills for consumers and businesses.

Environmental impact

Reducing overall energy consumption and mitigating climate change.

Resource Conversation

Preserving natural resources and promoting sustainability.

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Calculation…

1 kWh

DE: 55.000.000 kWh =

198.000.000.000.000 J

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1 Joule [J] = 1 Wattsekunde [Ws] = 1 VAs = 1 N m = 1 kg m^2 s^{-2}.

The old days…

$$\text{Monthly TCO per VM} = \frac{\sum_{n=1}^{N} \frac{E_n+S_n+A_n+P_n+R_n}{(1+r)^n}}{\frac{V_1+V_2+V_3+\cdots V_N}{N}}$$

© http://wikibon.org/wiki/v/Calculating_Infrastructure_TCO_per_VM

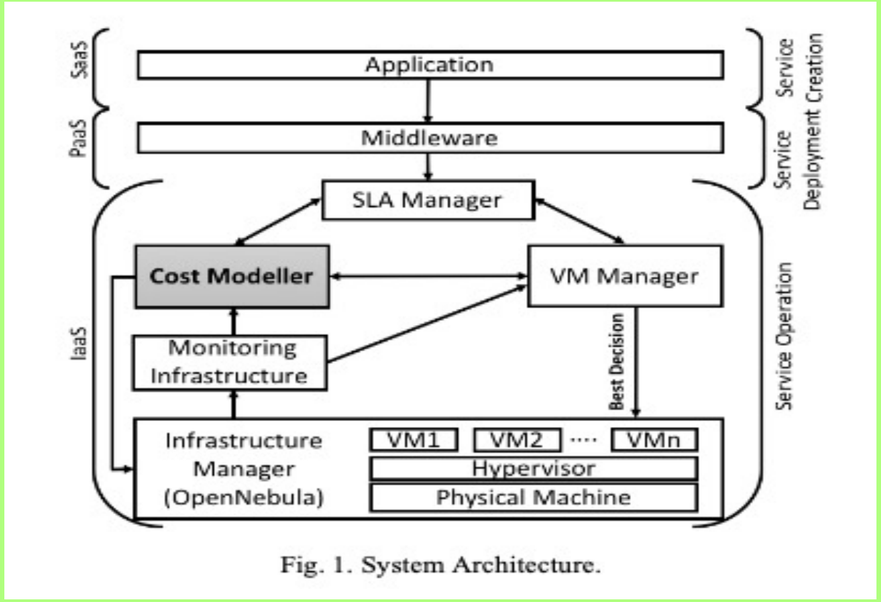

Fig. 1. System Architecture.

© https://eprints.whiterose.ac.uk/141570/7/Energy-based%20Cost%20Model%20of%20Virtual%20Machines%20in%20Cloud%20Environment.pdf

- ASCETIC: https://www.cetic.be/ASCETiC-en
- HAL Open Science https://inria.hal.science/hal-01276913/file/paper.pdf

Calculating Infrastructure TCO per VM

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eBPF

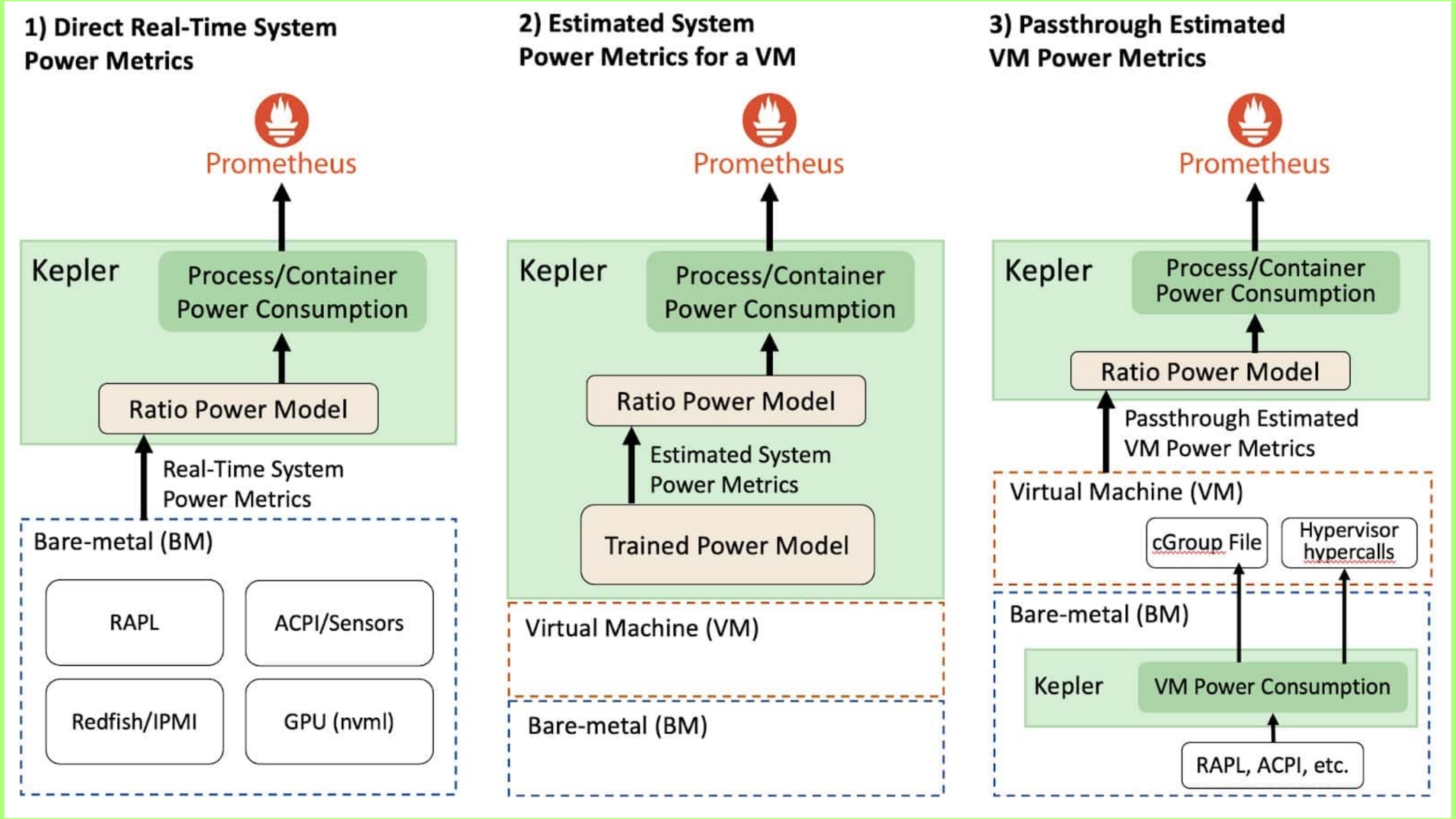
- **eBPF** (Extended Berkeley Packet Filter)
- a new feature of the Linux Kernel
- a bytecode interpreter to executes programs in the Kernel without changes in Kernel source code or load Kernel modules
- a sandbox in the Kernel
- bind programs on code paths (“hooks”) and execute event-driven
- includes helper calls to access memory segments
- for security and monitoring in network paket filter
- extended for programmable function without additional layer

(c) https://ebpf.io/what-is-ebpf

Kepler

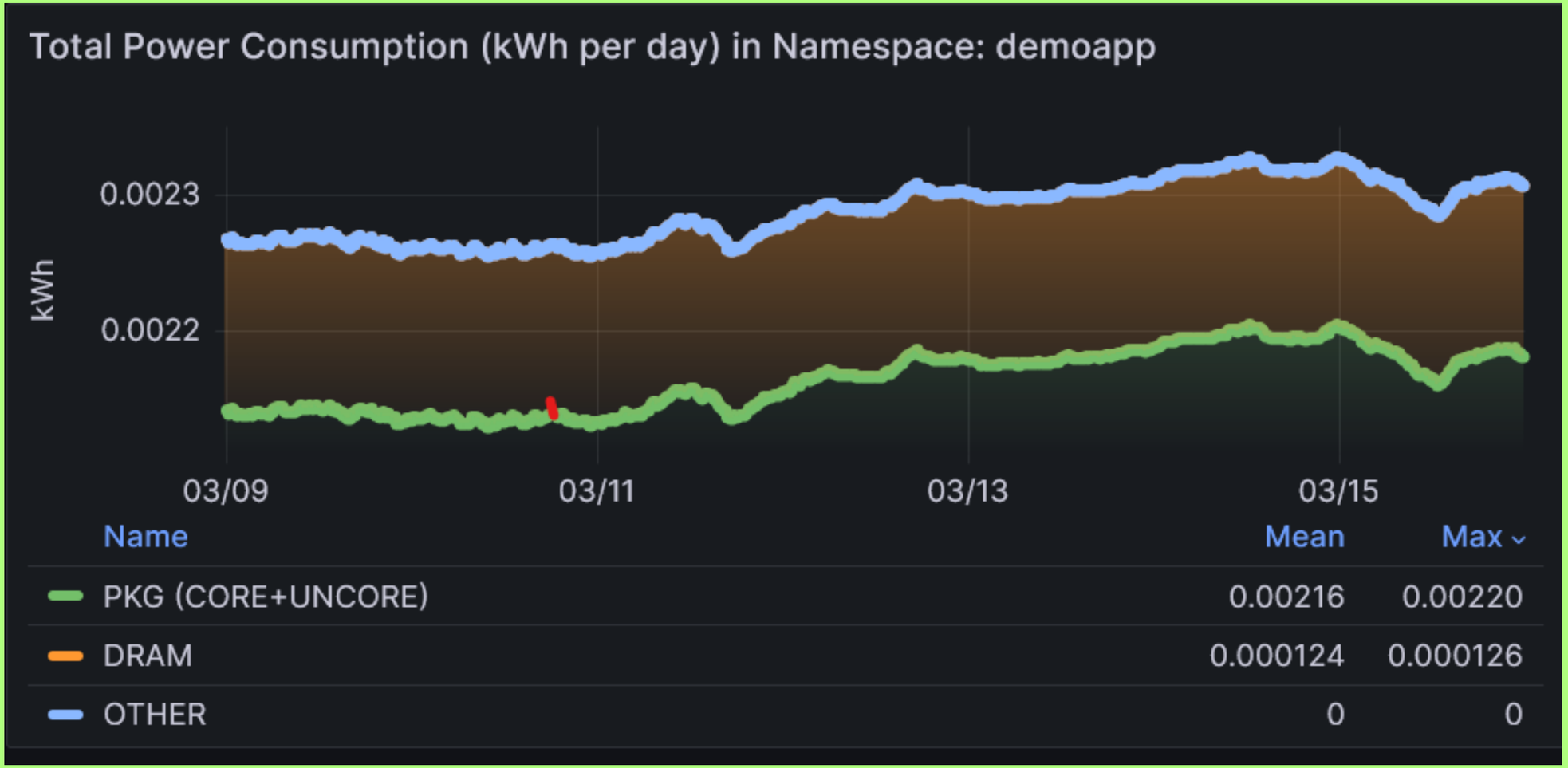
- **Kepler** (Kubernetes-based Efficient Power Level Exporter)
- for Prometheus
- uses eBPF to probe CPU performance counters and Linux kernel tracepoints.
- data and stats from cgroup and sysfs can then be fed into ML models to estimate energy consumption by Pods.
- pre-trained model
- pipeline to train your own model

Kepler



(c) https://sustainable-computing.io/usage/deep_dive/

Kepler



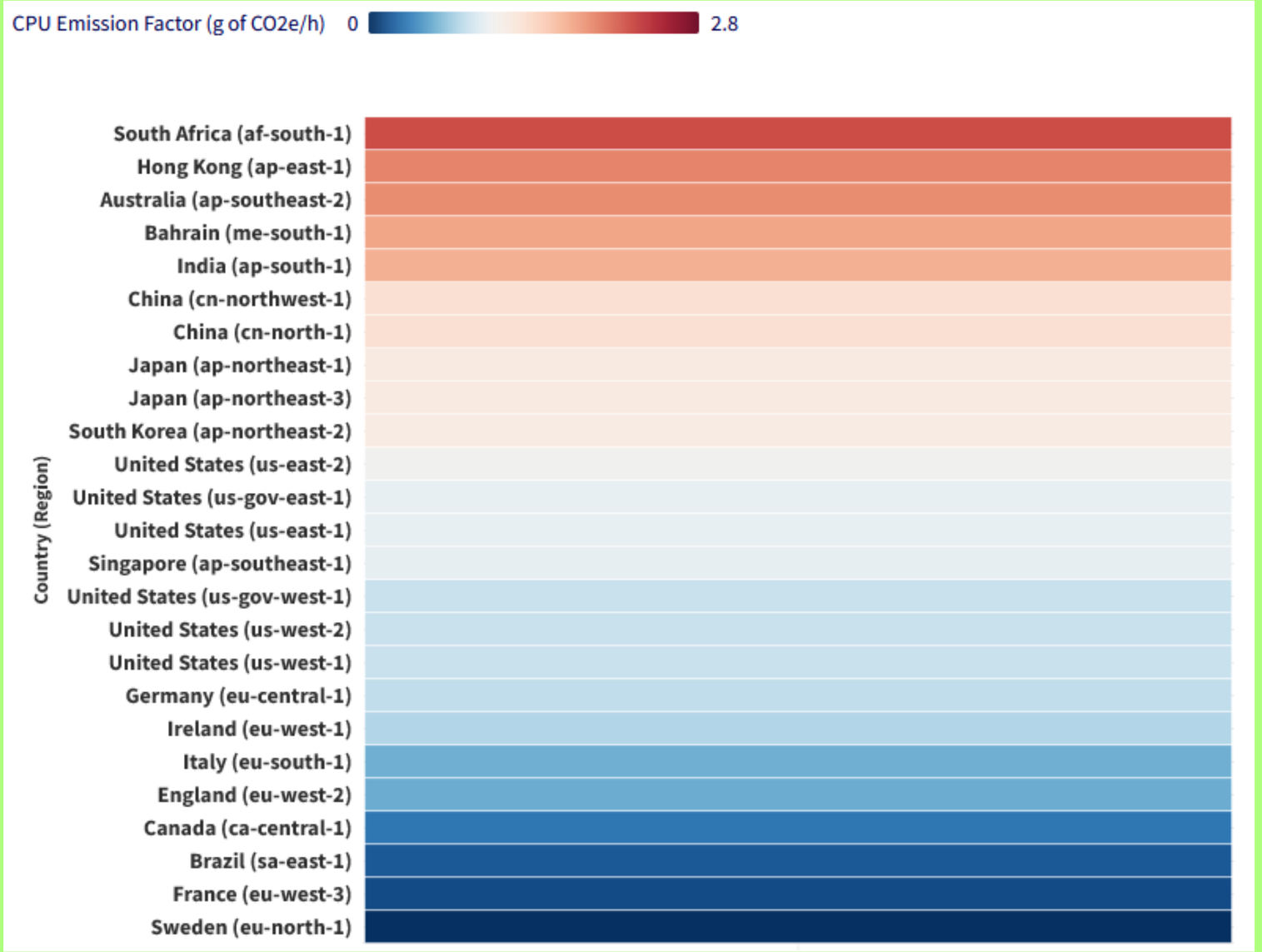
https://github.com/sustainable-computing-io/kepler/tree/main/grafana-dashboards

Energy generation

- **watttime.org** (current energy consumption per city/street, in US)
- realized by Smart Grid
- without Smart Grid you can not say how many and which kind of energy consumed in a city or area
- in Cloud Computing you don’t know exactly the location of your used computer, especially as end-user
- focus on energy generation in Germany as autonom system

https://github.com/sustainable-computing-io/kepler/tree/main/grafana-dashboards

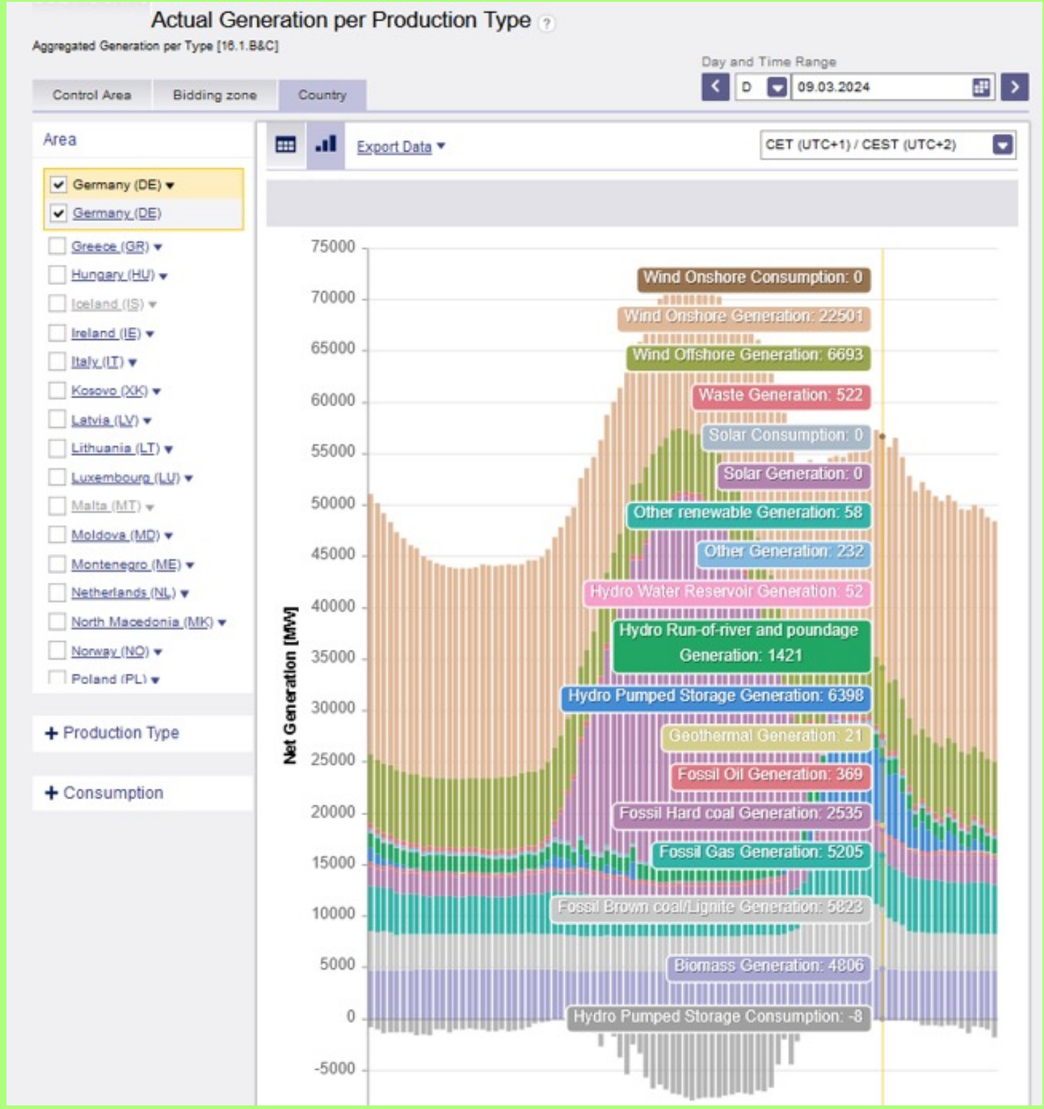
Carbon emission AWS cloud by region



(c) https://www.climatiq.io/blog/measure-greenhouse-gas-emissions-carbon-data-centres-cloud-computing

Entso-e

- **ENTSO-E**, the European Network of Transmission System Operators for Electricity
- **TSO's** are entities operating independently from the other electricity market players and are responsible for the bulk transmission of electric power on the main high voltage electric networks.
- 40 members in 36 countries
- all data open
- has an API



(c) https://transparency.entsoe.eu/

Emission

- emissions are the sum of all substances that an energy generation system emits during operation
- usually refers to pollutants such as sulfur, tar and smoke
- climate research has focused on the greenhouse gas CO^2

- for each type of energy generation, constants can now be derived as to how many grams of CO^2 are lost per kWh of electricity
- for lignite there are currently 996, for offshore wind farms there are 4
- numbers are not that constant due the innovation of plants

coal plant Espenhain, 1980

Entso-e Python Flask

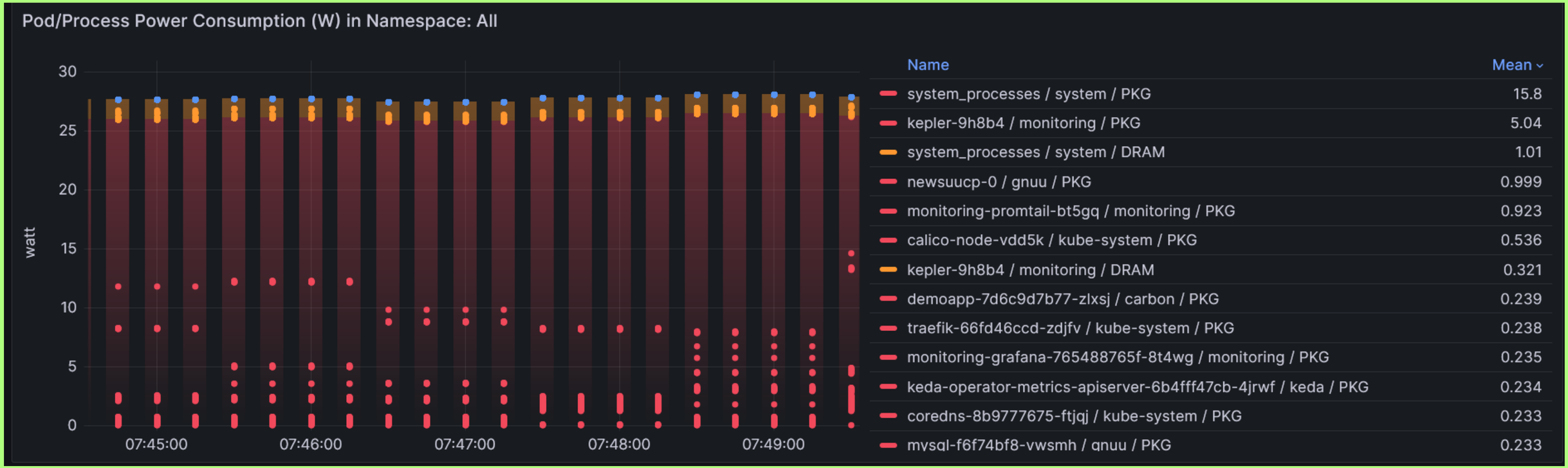
```
# HELP entsoe_factor_b01 Factor CO2g/kWh Biomass
# TYPE entsoe_factor_b01 gauge
entsoe_factor_b01 230
# HELP entsoe_factor_b02 Factor CO2g/kWh Brown Coal
# TYPE entsoe_factor_b02 gauge
entsoe_factor_b02 996
# HELP entsoe_factor_b04 Factor CO2g/kWh Gas
# TYPE entsoe_factor_b04 gauge
entsoe_factor_b04 378
# HELP entsoe_factor_b05 Factor CO2g/kWh Hard Coal
# TYPE entsoe_factor_b05 gauge
entsoe_factor_b05 880
# HELP entsoe_factor_b10 Factor CO2g/kWh Hydro Pumped Storage
# TYPE entsoe_factor_b10 gauge
entsoe_factor_b10 23
# HELP entsoe_factor_b11 Factor CO2g/kWh Hydro Run River
# TYPE entsoe_factor_b11 gauge
entsoe_factor_b11 23
```

https://github.com/caas-team/caas-carbon-footprint

Carbon Footprint

https://github.com/caas-team/caas-carbon-footprint

Kepler – Power consumption per Pod



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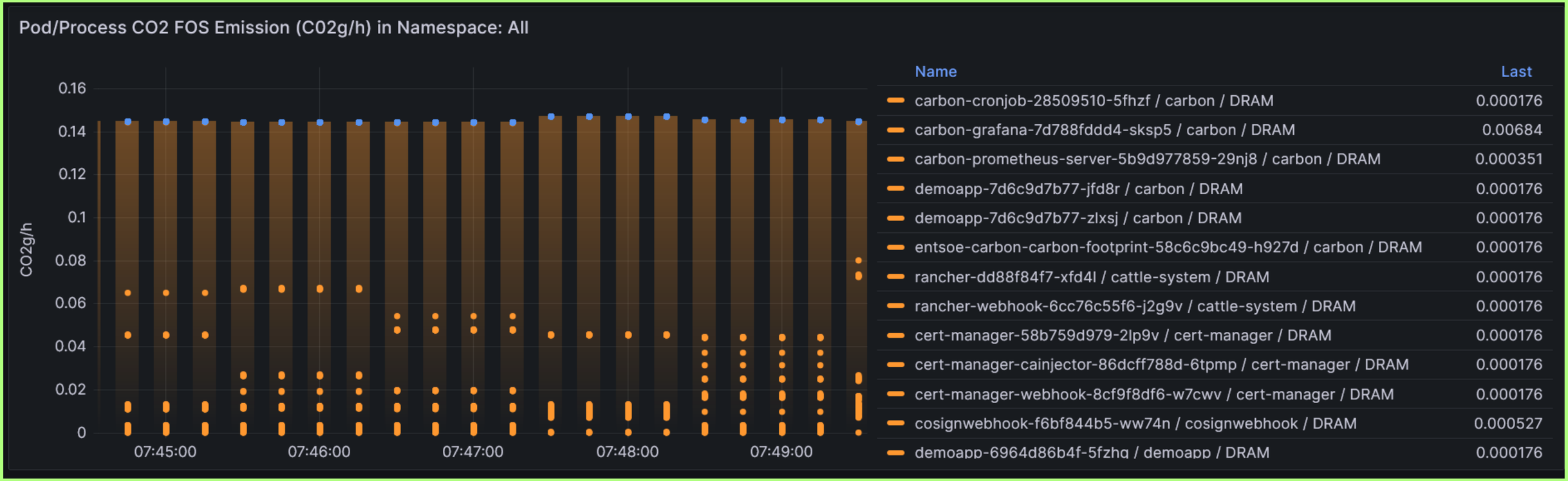
Entso-e – Carbon emission per Pod



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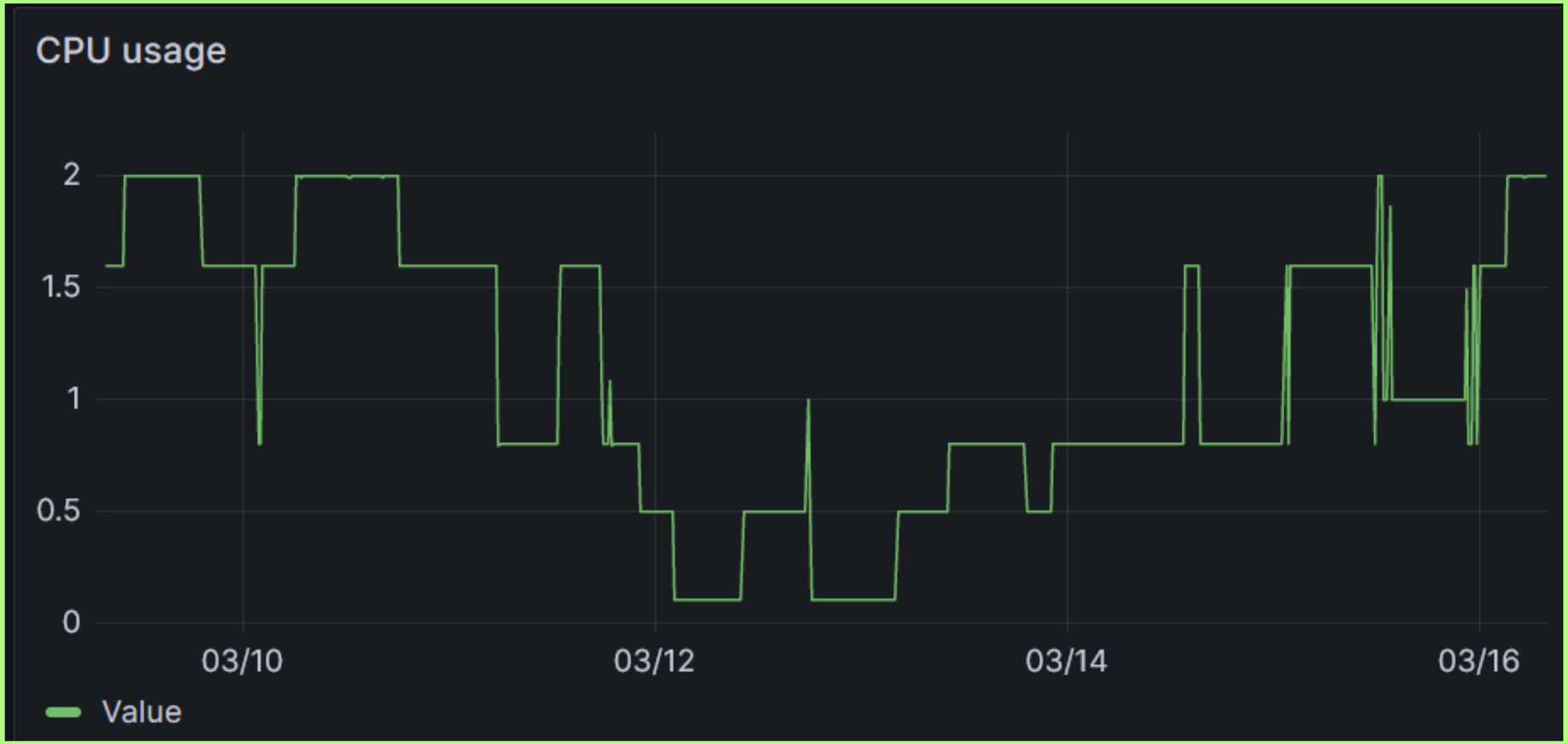
Carbon cronjob



https://github.com/caas-team/caas-carbon-footprint/blob/main/examples/resources/carbon-cronjob.yaml

Carbon Workload Adjuster

- **Cronjob** (adjust deployment scale on green energy factor)
- **HPA** (allow scale based on green energy factor)
- **Prometheus Keda** (use Prometheus to scale apps with Keda)

https://github.com/caas-team/caas-carbon-footprint/blob/main/examples/r

Starting GreenOps

- **Platform Maintenance Jobs**
  - regular OS updates (only in Green time)
  - regular build of container images (only in Green time)
  - mirror of container images (only on Green time)
  - build ML model with high resource usage
- **Job Management**
  - every kind of job workload (billing, mailings, user cleanups not only “at night” but depend on the carbon emission)
- **Platform availability** (“Sorry we close due the weather condition”)

Your thought?

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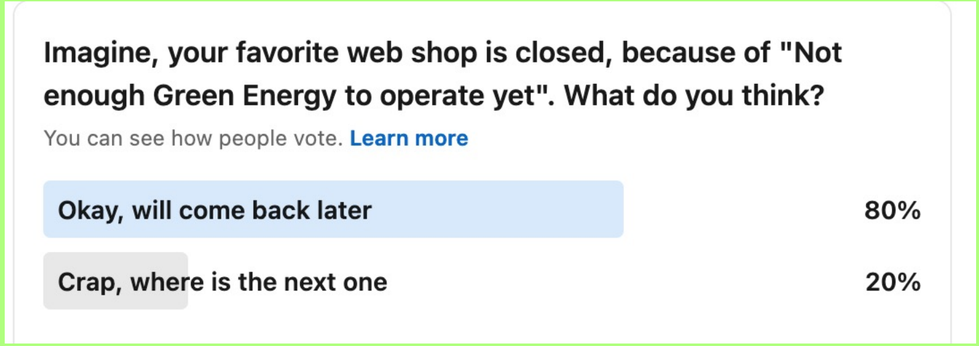
Your thought?



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