Cloud Native and Sustainability - Current state of Green System Architecture and Software

Cloud Native Linz,
January 24th, 2024

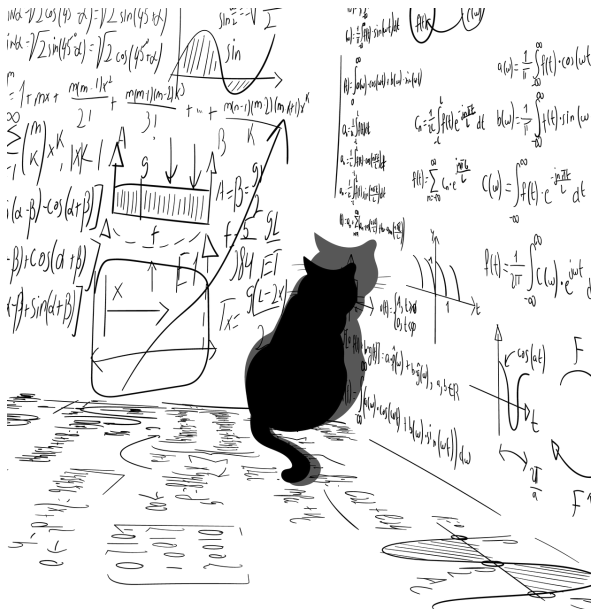
Erik Auer
DevOps Enthusiast, Founder of WhizUs

DevOps. Cloud Native. Kubernetes. Do it WhizUs!

whizus

Some words about me ...

how it all began



DevOps Enthusiast

WhizUs Founder

Community Contributor

Agenda

- CO2 equivalent
- Energy Market
- Climate Change Monitoring & Regulations
- Green Software & Principles
- CO2 Measurement
- DEMO: Cloud Native Ways of Green Software Principles

Carbon dioxide equivalent

Carbon dioxide equivalent

- Measurement of Greenhouse Gases
- environmental impact of 1 tone greenhouse gases in comparison to the impact of 1 tone CO_2
- Abbreviation: CO_2e, CO_2eq

Reference: https://climatepolicyinfohub.eu/glossary/co2eq

Energy Market

Market

Futures
- long term
- fixed prices
- ensures energy delivery continuity

Spot Market
- Short term (days/hours)
- for unexpected energy needs

OTC - Trading
- trading volumes and pricing are reached individually

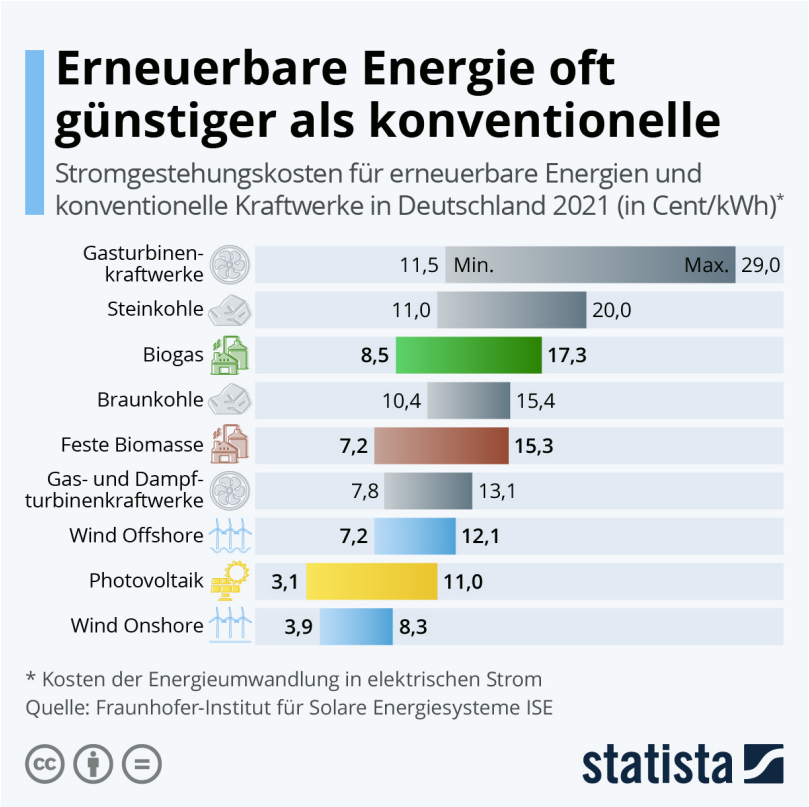
Power Plants

Energy Supplier

Consumer

https://www.wienenergie.at/blog/wie-funktioniert-der-energiemarkt/

Cost of electricity generation

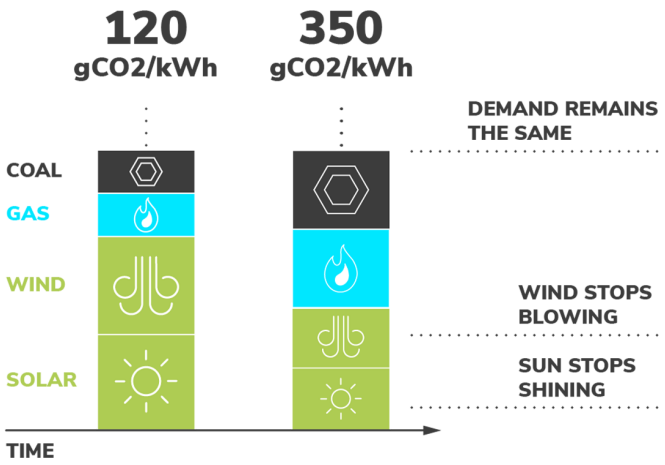


Reference: https://de.statista.com/infografik/26886/stromgestehungskosten-fuer-erneuerbare-energien-und-konventionelle-kraftwerke-in-deutschland/

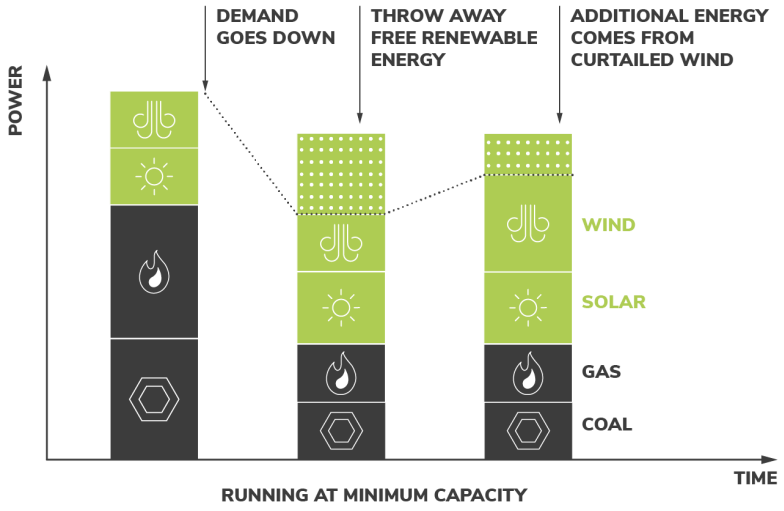
Carbon intensity

- measures how much carbon (CO_2e) is emitted per kilowatt-hour (KWh) of electricity consumed
- Standard Unit: gCO_2eq/kWh
- mix of lower- and the higher-carbon sources

Carbon intensity



Green Software Foundation
greensoftware.org



Green Software Foundation
greensoftware.org

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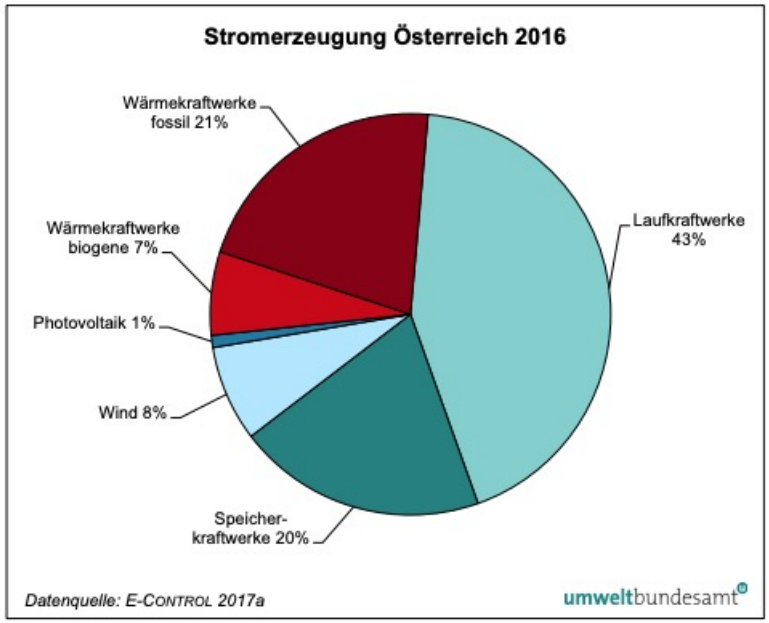
Reference: https://learn.greensoftware.foundation/carbon-awareness/

Carbon intensity

- Demand goes down: Prefer buy less energy from fossil fuel plants
- Demand goes up: Prefer buy renewable energy
- But: fossil fuel plants are more flexible

Carbon intensity

Example – Austria 2016



⇨ 21% fossil energy

⇨ 79% renewable energy

Reference: https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0654.pdf

Climate Change Monitoring & Regulations

Climate Change Monitoring

Paris Climate Agreement

Goal: keep the rise in global mean temperature to 2 degree compared to pre-industrial levels (preferred level of 1,5 degree)

United Nations Framework Convention on Climate (UNFCCC)

Preventing “dangerous” human interference with the climate system.

IPCC (Intergovernmental Panel on Climate Change)

Provide governments at all levels with scientific information that they can use to develop climate policies

Reference: https://learn.greensoftware.foundation/carbon-efficiency

EU Regulation

Rat der EU Pressemitteilung 21. Juni 2022 23:15

Neue Vorschriften für die Nachhaltigkeitsberichterstattung von Unternehmen: vorläufige politische Einigung zwischen Rat und Europäischem Parlament

Ab wann gelten die Vorschriften?

Die Anwendung der Vorschriften erfolgt in drei Stufen:

- am 1. Januar 2024 für Unternehmen, die bereits der Richtlinie über die Angabe nichtfinanzieller Informationen unterliegen;
- am 1. Januar 2025 für große Unternehmen, die derzeit nicht der Richtlinie über die Angabe nichtfinanzieller Informationen unterliegen;
- am 1. Januar 2026 für börsennotierte KMU sowie für kleine und nicht komplexe Kreditinstitute und firmeneigene Versicherungsunternehmen.

Es werden **detailliertere Berichtspflichten** eingeführt und es wird sichergestellt, dass große Unternehmen verpflichtet sind, Informationen **zu Nachhaltigkeitsfragen** wie Umweltrechten, sozialen Rechten, Menschenrechten und Governance-Faktoren zu veröffentlichen.

Reference: https://www.consilium.europa.eu/de/press/press-releases/2022/06/21/new-rules-on-sustainability-disclosure-provisional-agreement-between-council-and-european-parliament/

Green Software

Green Software

discipline at the intersection of climate science, software design, electricity markets, hardware, and data center design

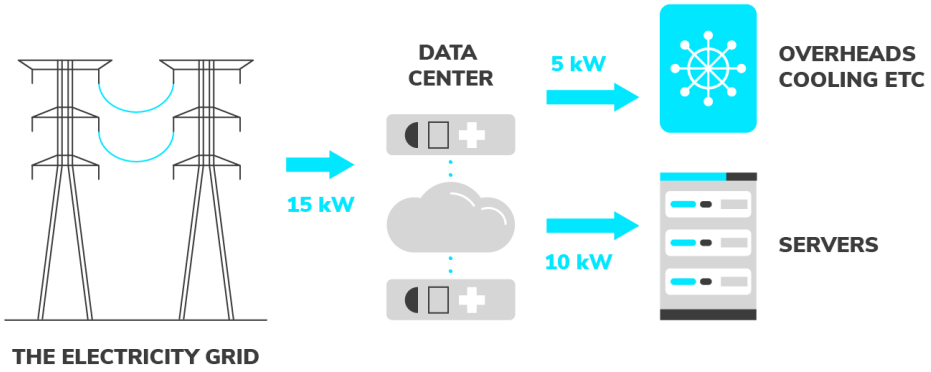
carbon-efficient software, meaning it emits the least carbon possible

Principles: Energy Efficiency, Carbon Awarness, Hardware Efficiency

Principles

Energy Efficiency

Power usage effectiveness – computing energy vs. overhead supporting energy



15 kw / 10 kw = PUE 1.5

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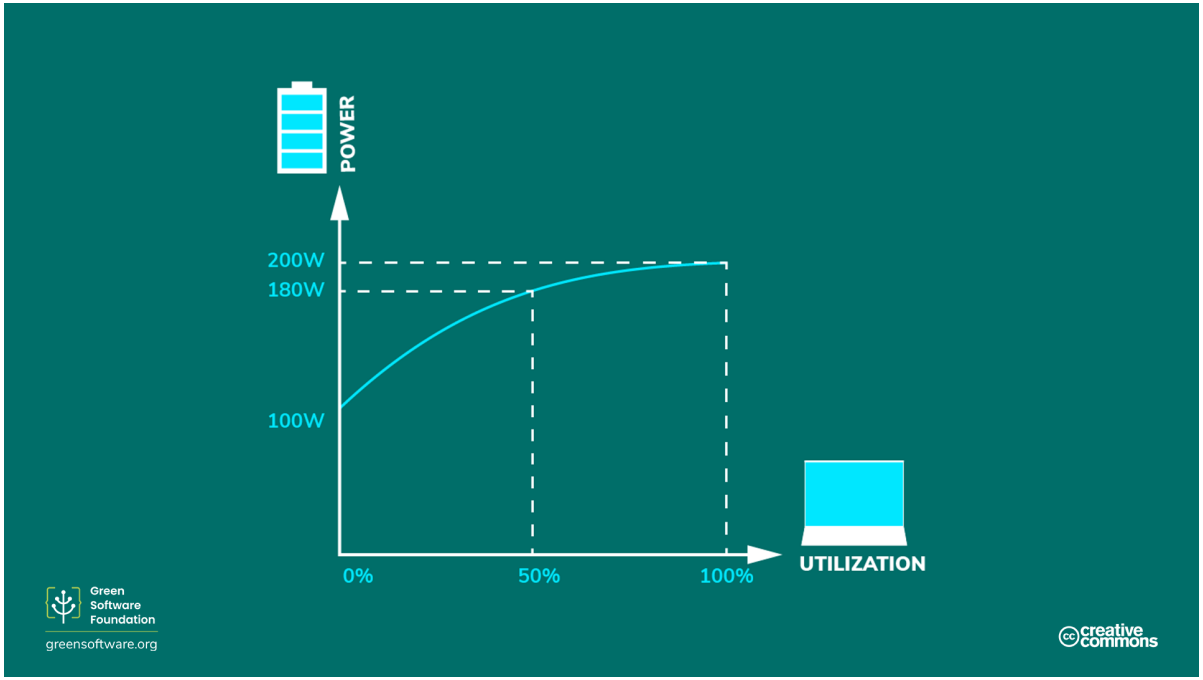
Reference: https://learn.greensoftware.foundation/energy-efficiency

Energy Efficiency

Energy Proportionality – relationship between power and utilization



Reference: https://learn.greensoftware.foundation/energy-efficiency

Carbon Awareness

Shift to Renewables caused by economic reasons

Accelerate by making renewable plants more profitable

Use more electricity when carbon intensity is lower

Carbon Awareness

DEMAND SHIFTING

Spatial Shifting

Moving computation to physical locations with lower carbon intensity.

Temporal Shifting

Shift to another time, when carbon intensity is lower.

DEMAND SHAPING

Low Carbon Intensity

increase the demand; do more in your applications.

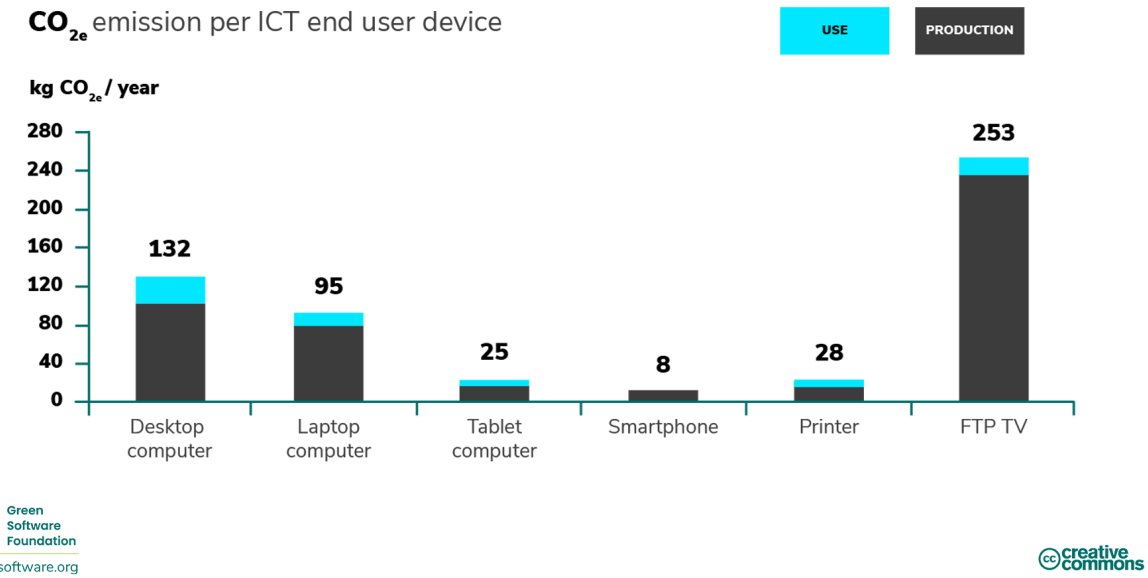
High carbon Intensity

decrease demand; do less in your applications.

Reference: https://learn.greensoftware.foundation/carbon-awareness

Hardware Efficiency

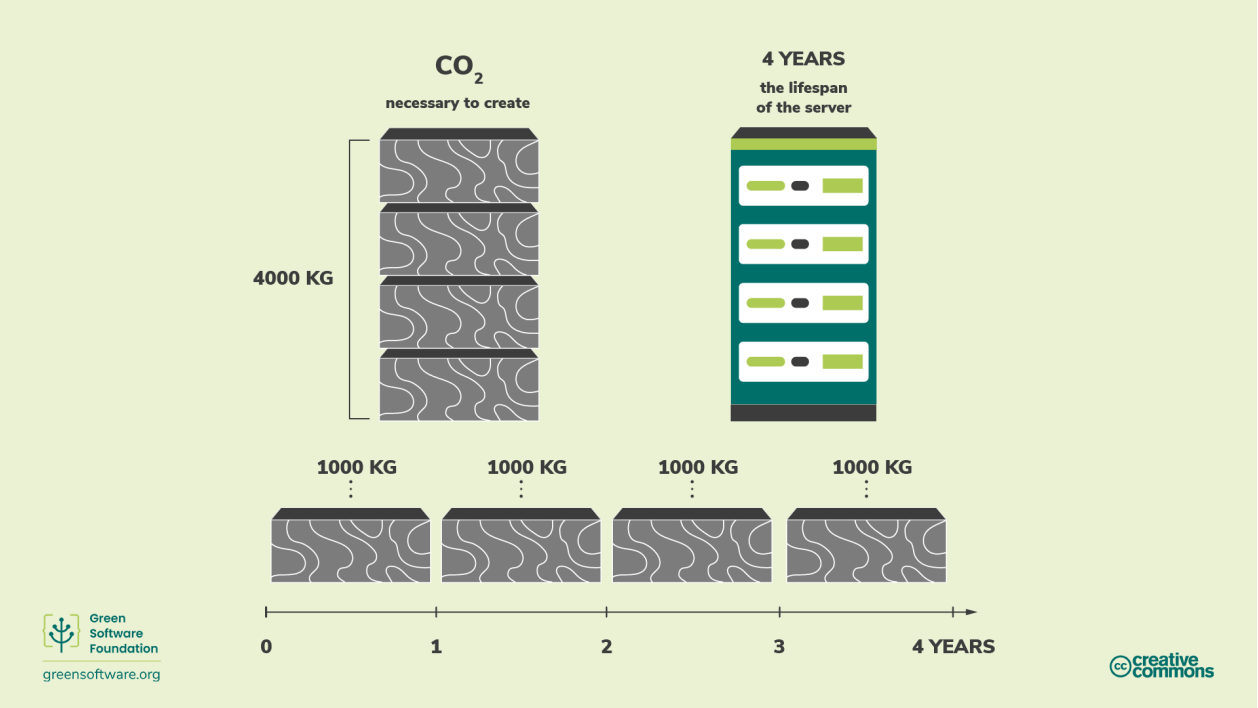
Embodied Carbon – carbon that is used during manufacturing and disposing hardware



Reference: https://learn.greensoftware.foundation/hardware-efficiency

Hardware Efficiency

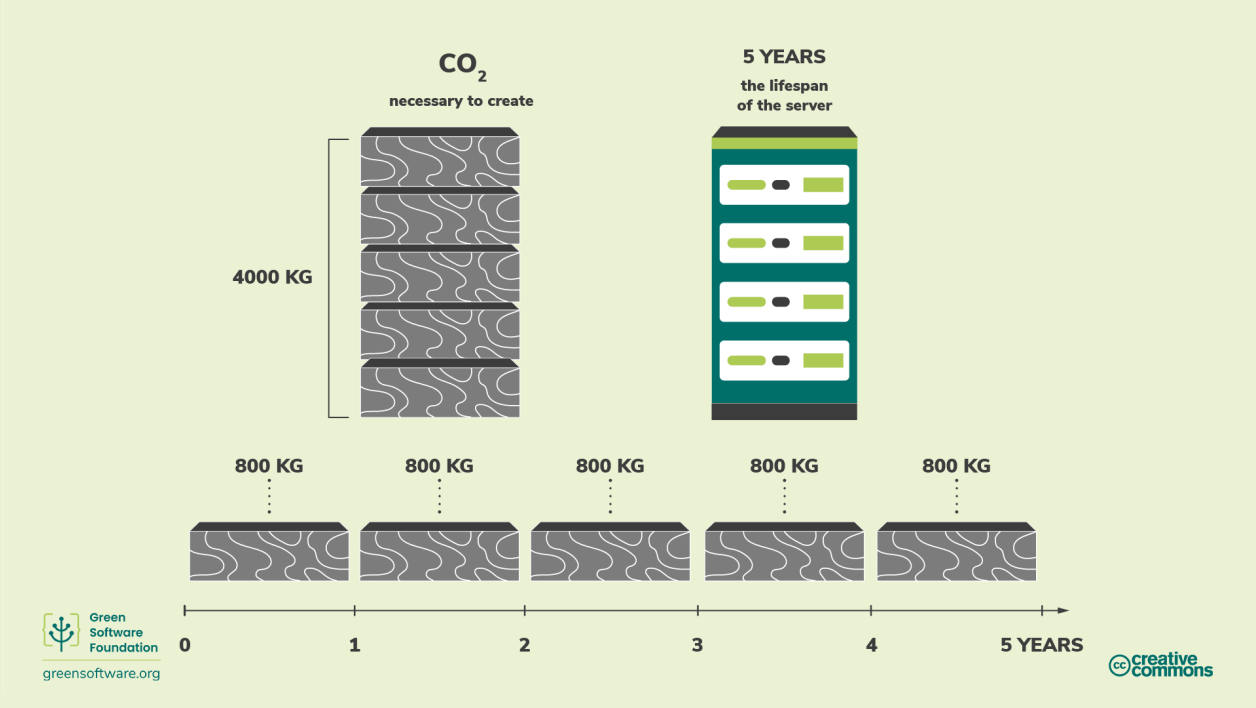
Amortization – Extending the lifespan of hardware – Example: 4 years



Reference: https://learn.greensoftware.foundation/hardware-efficiency

Hardware Efficiency

Amortization – Extending the lifespan of hardware – Example: 5 years



Reference: https://learn.greensoftware.foundation/hardware-efficiency

Hardware Efficiency

Device Utilization

Green Software Foundation
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Reference: https://learn.greensoftware.foundation/hardware-efficiency

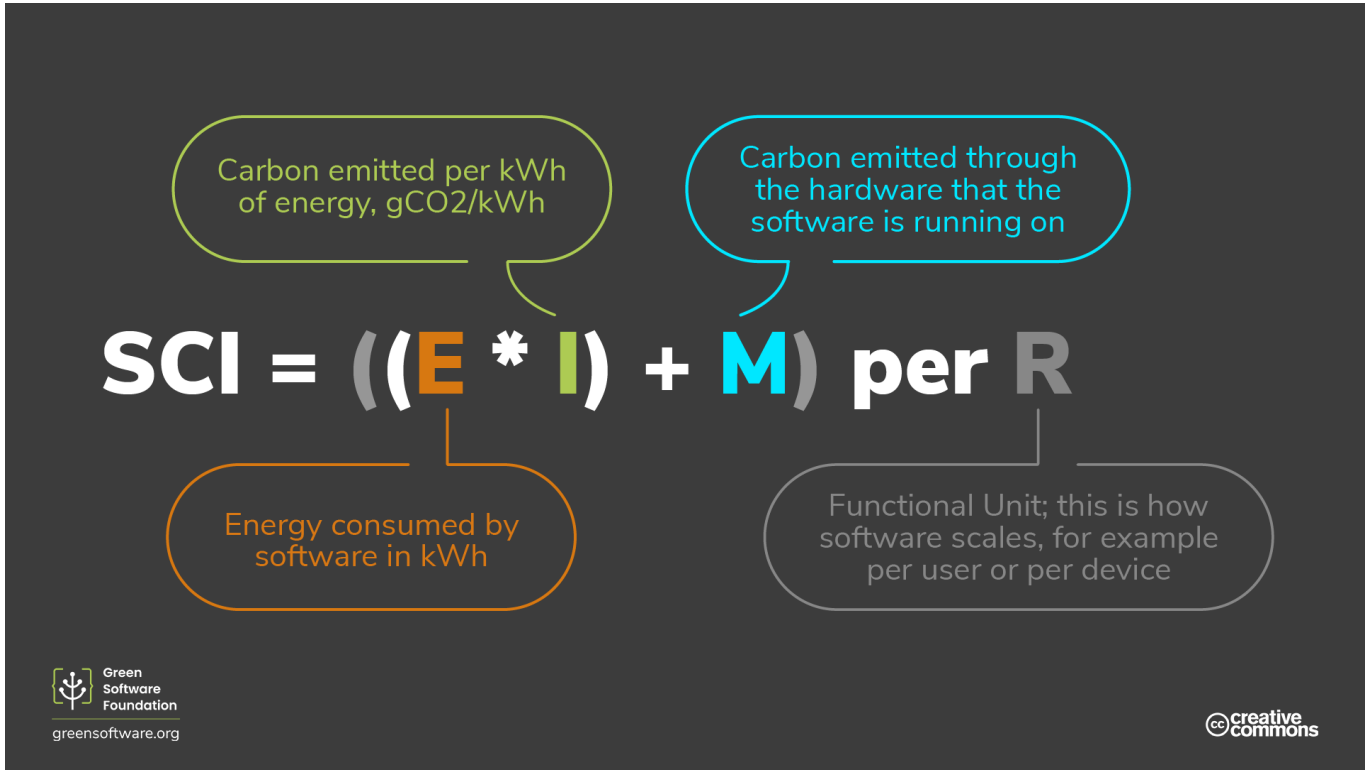
Measurement

Greenhouse Gas Protocol (GHG)

- **Scope 1**: Direct emissions from **operations** owned or controlled by the reporting organization, such as on-site fuel combustion or fleet vehicles.
- **Scope 2**: Indirect emissions related to **emission generation of purchased energy**, such as heat and electricity.
- **Scope 3**: Other indirect emissions from all the other activities you are engaged in. Including all **emissions from an organization's supply chain;** business travel for employees, and the electricity customers may consume when using your product.

Reference: https://learn.greensoftware.foundation/measurement

Software Carbon Intensity (SCI)



Reference: https://learn.greensoftware.foundation/measurement

DEMO

Using Kepler

- **Still in Alpha**
- **No support for ARM64**

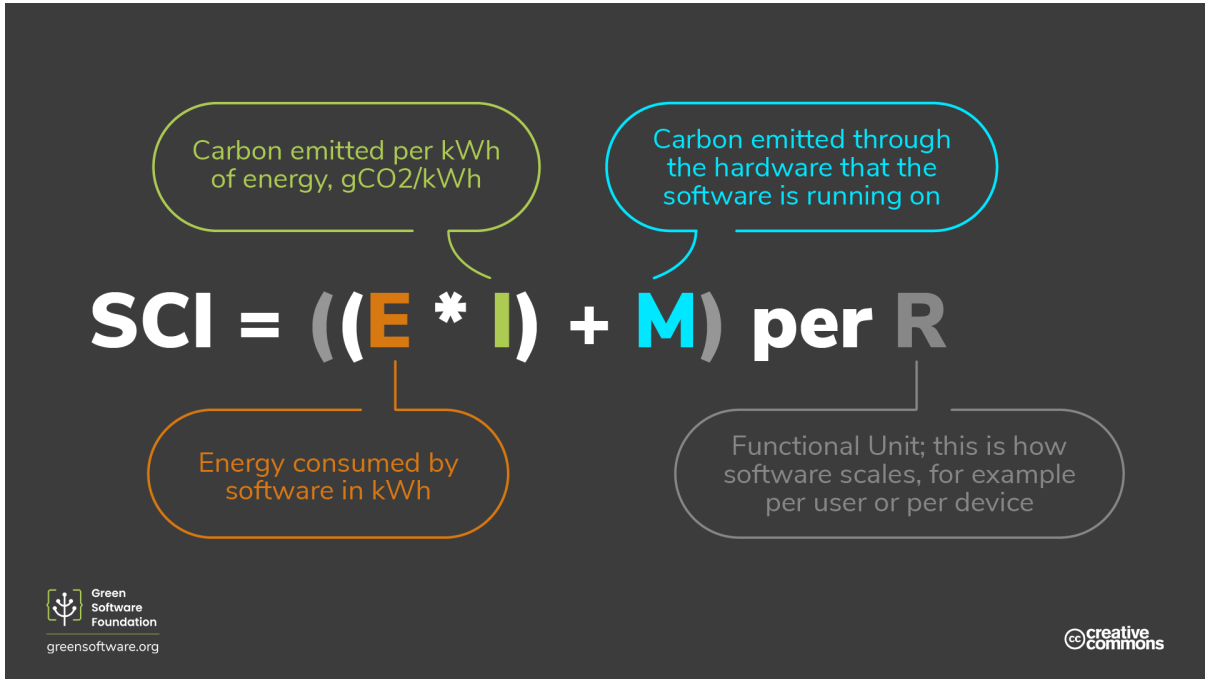
```
(⎈|kind-kind:kepler-operator)➜  tmp git:(v1alpha1) docker pull quay.io/sustainabl
e_computing_io/kepler:release-0.7.2
release-0.7.2: Pulling from sustainable_computing_io/kepler
no matching manifest for linux/arm64/v8 in the manifest list entries
```

- **Still unstable setup scripts**

```
  env:
  - name: RELATED_IMAGE_KEPLER
    value: <KEPLER_IMG>
  image: quay.io/sustainable_computing_io/kepler-operator:0.10.0
  imagePullPolicy: IfNotPresent
  livenessProbe:
    httpGet:
```

Reference: https://learn.greensoftware.foundation/measurement

SCI Calculation Example



Calculation of M:

need data for carbon emitted through the hardware;

data from supplier, e.g. environmental report for product

Reference: https://learn.greensoftware.foundation/measurement

SCI Calculation Example

Excerpt from environmental report

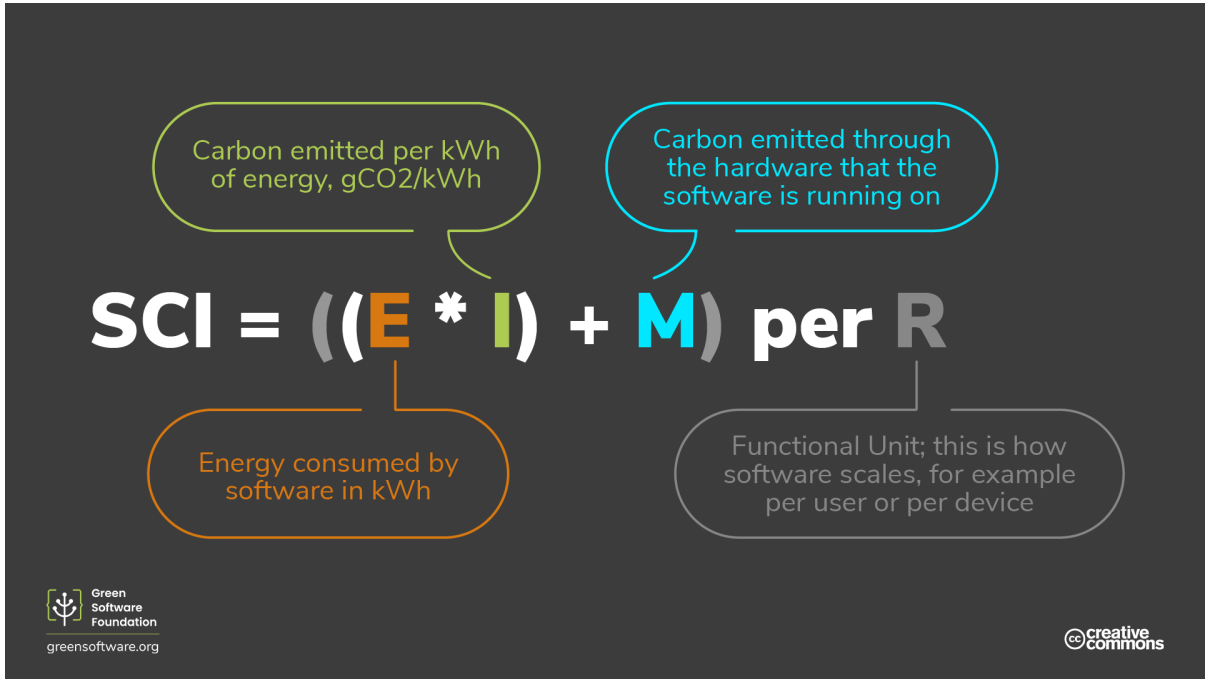
Carbon footprint			
Mac mini (M1, 2020)		**Mac mini (2018)**	
Apple M1 chip with 256GB SSD storage	172 kg CO_2e	3.6GHz quad-core Intel Core i3 with 256GB SSD storage	263 kg CO_2e
Apple M1 chip with 512GB SSD storage	197 kg CO_2e	3.0GHz 6-core Intel Core i5 with 512GB SSD storage	284 kg CO2e

Assumption – 5 year hardware life span

M = 197 kg CO2e / 5 = 39,4 kgCO2e

Reference: https://www.apple.com/environment/pdf/products/desktops/Macmini_PER_Nov2020.pdf

SCI Calculation Example



Calculation of I:

environmental papers/analysis from country/region where server is placed

data from energy supplier („Stromkennzeichnung“)

Reference: https://learn.greensoftware.foundation/measurement

SCI Calculation Example

Excerpt from “Stromkennzeichnung” of Wien Energie (Versorgermix)

Umweltauswirkungen	
CO2-Emissionen	108,00 g/kWh
radioaktiver Abfall	0,00 mg/kWh

Excerpt from statistics of Umweltbundesamt Austria

Beispiele für CO_2-Emissionen von Verbrauchern			Quelle
durchschnittlicher Jahres-Stromverbrauch – 1-Personen-Haushalt (1.927 kWh/a)	ca.	**390 kg THG**	E-Control

I = 390 / 1927 = 0,20238… kgCO2e/kWh

Reference: https://dokumente.wienenergie.at/wp-content/uploads/Vollumfassende-Stromkennzeichnung_2023_05_neue-Fusszeile.pdf
Reference: https://secure.umweltbundesamt.at/co2mon/co2mon.html

SCI Calculation Example

Excerpt from “Stromkennzeichnung” of Wien Energie (Produktmix)

Produktmix 100 % erneuerbare Energie

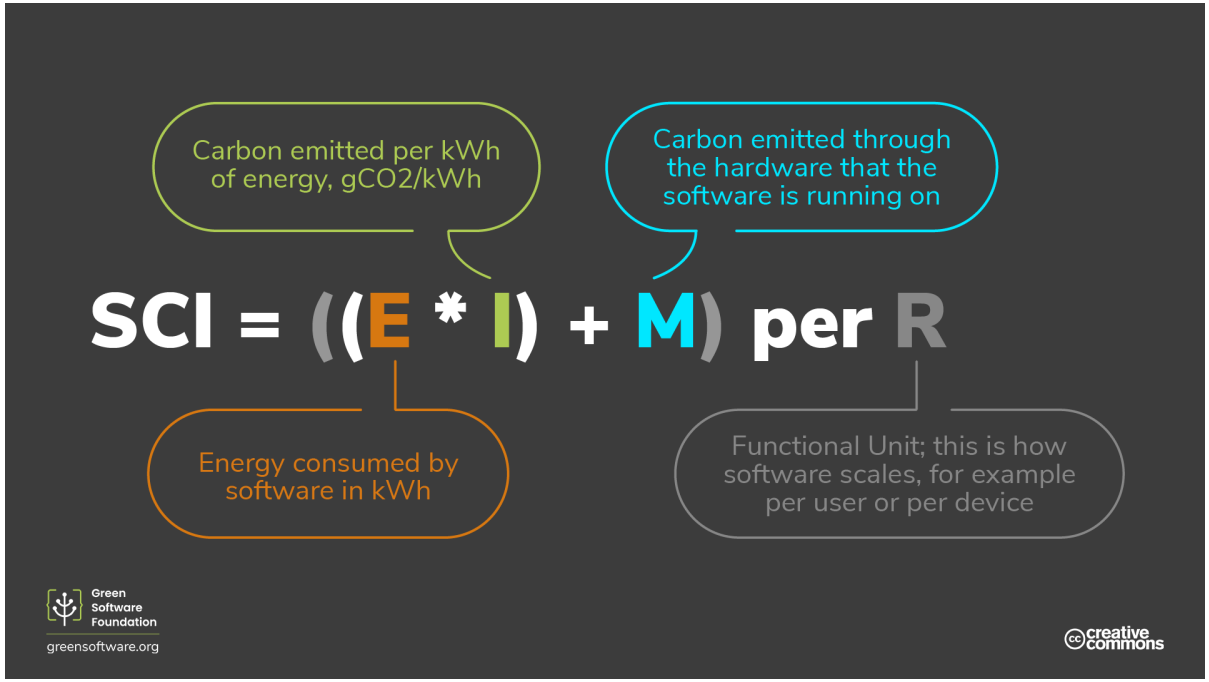
Energieträger	Anteil
Wasserkraft	77,59 %
Windenergie	12,33 %
feste oder flüssige Biomasse	5,03 %
Sonnenenergie	1,93 %
erneuerbare Gase	3,12 %
Summe	100,00 %

Umweltauswirkungen	
CO2-Emissionen	0,00 g/kWh
radioaktiver Abfall	0,00 mg/kWh

Not suitable for calculation of CO2 emissions

Reference: https://dokumente.wienenergie.at/wp-content/uploads/Vollumfassende-Stromkennzeichnung_2023_05_neue-Fusszeile.pdf

SCI Calculation Example

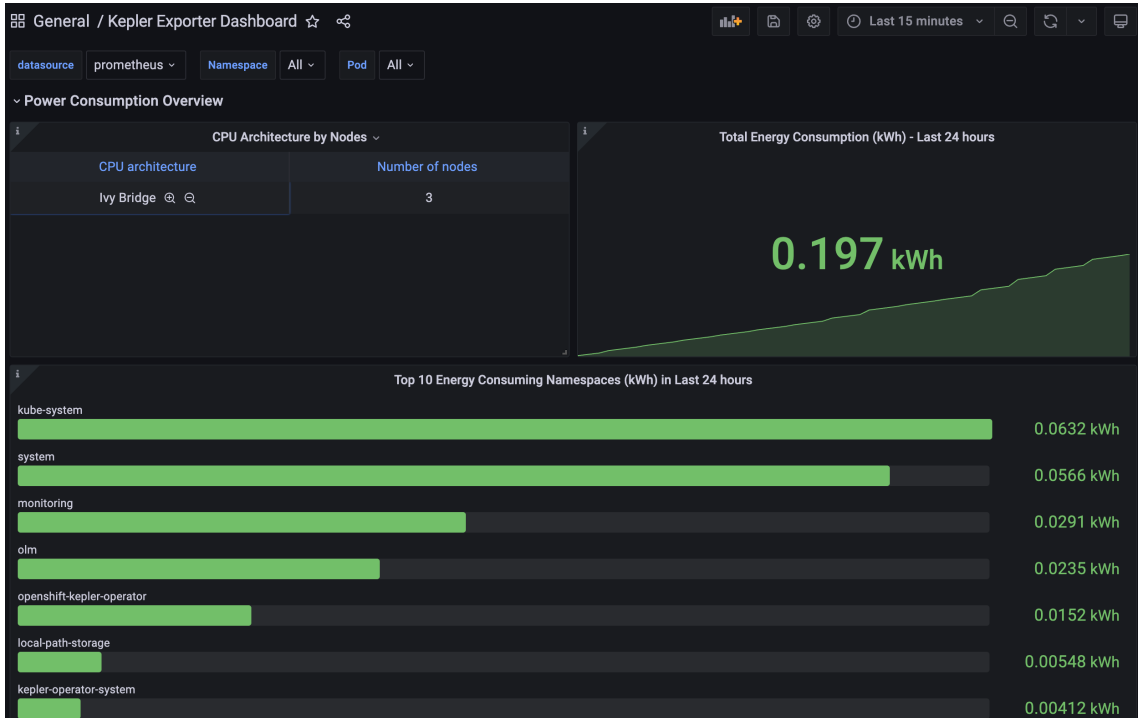


Measurement of E:

Possible with Kepler

Reference: https://learn.greensoftware.foundation/measurement

SCI Calculation Example



E = 0.197 * 365 =

= 71 kWh

SCI Calculation Example

SCI = ((E * I) + M) per R

= (71 * 0,20238...) + 39,4 per R

= 53,76... kgCO2e per R

Reference: https://learn.greensoftware.foundation/measurement

SCI Calculation Example

What is R?

R …
… per Device per year
… per user

Reference: https://learn.greensoftware.foundation/measurement

Cloud Native Technologies

Cloud Native Technologie	Description
Kepler	Support you to measure your carbon emission
Scaphandre	https://github.com/hubblo-org/scaphandre
KEDA	Autoscaling – to improve energy efficiency/hardware efficiency
CNCF Sustainability Landscape	https://tag-env-sustainability.cncf.io/landscape/

References

Description	URL
Green Software Basics	https://learn.greensoftware.foundation/
Umweltbundesamt Austria	https://www.umweltbundesamt.at/energie
Kepler	https://sustainable-computing.io/

Want more Cloud Native - Join Austrians first KCSP!

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