Was wir nicht messen können, können wir nicht verbessern

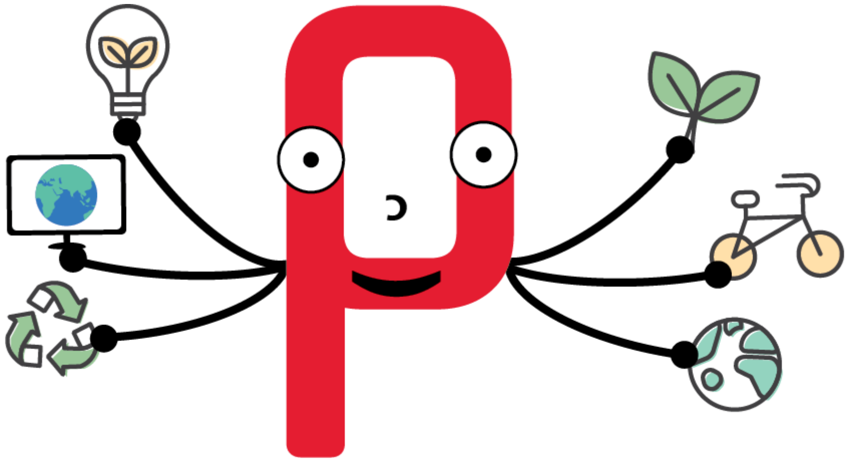
Unsere Learnings aus der Messung des Umwelteinflusses von Software mit dem Impact Framework und dem SCI

Sophia Resch

Sophia Resch

Software Engineer @ pentacor

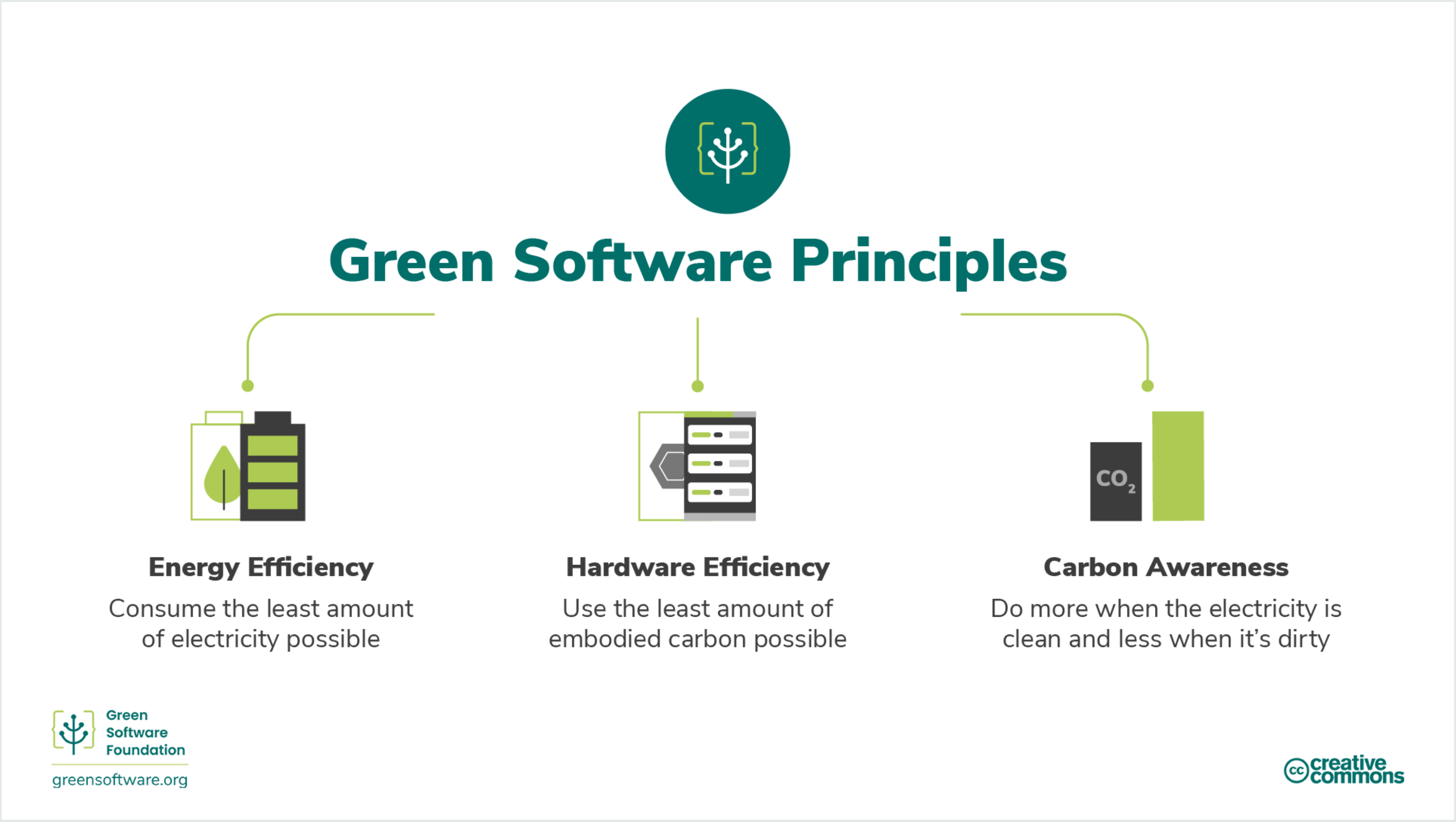
GreenIT Gruppe @ pentacor



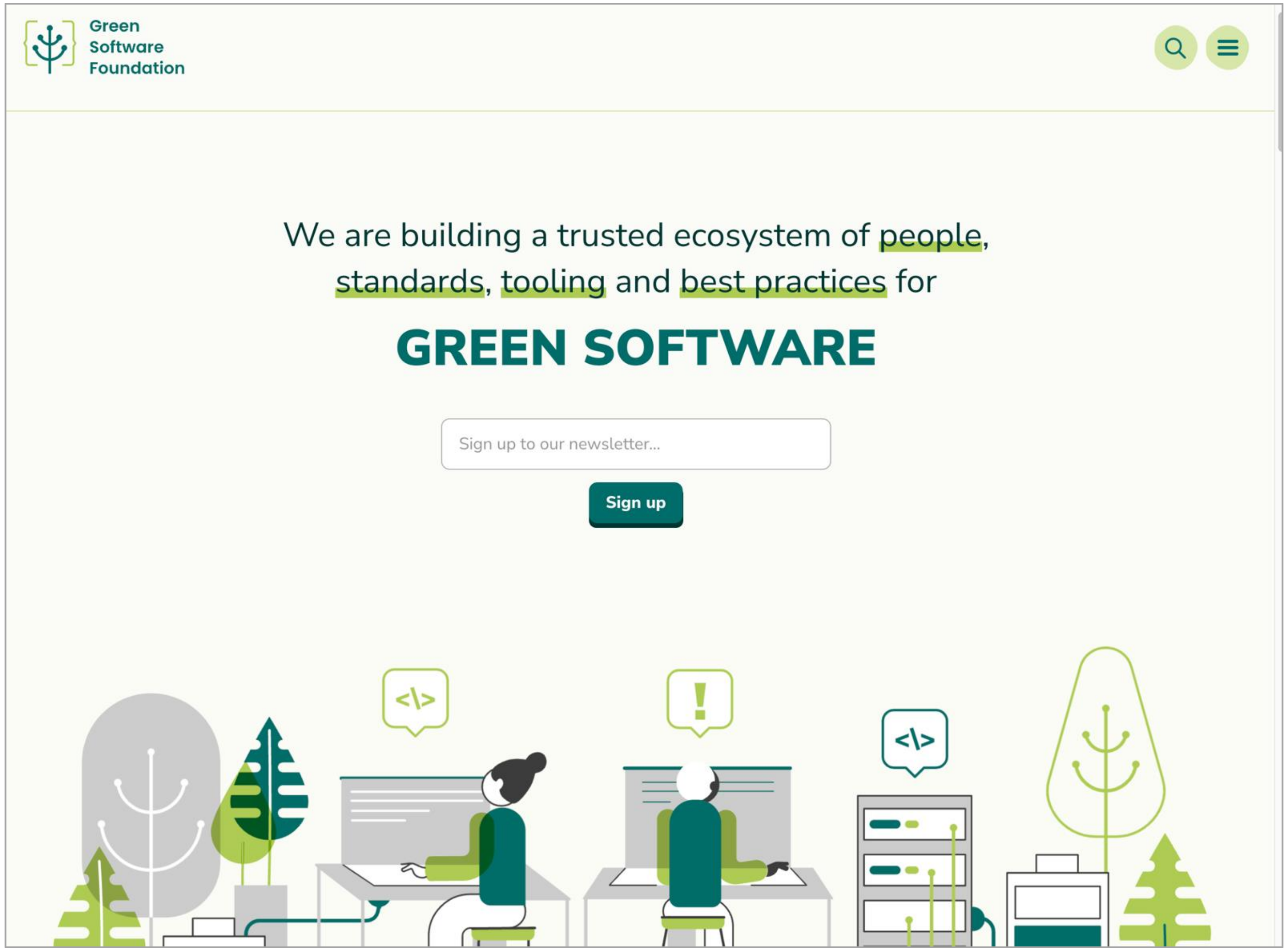
Warum GreenIT?

Photo by Markus Spiske on Unsplash

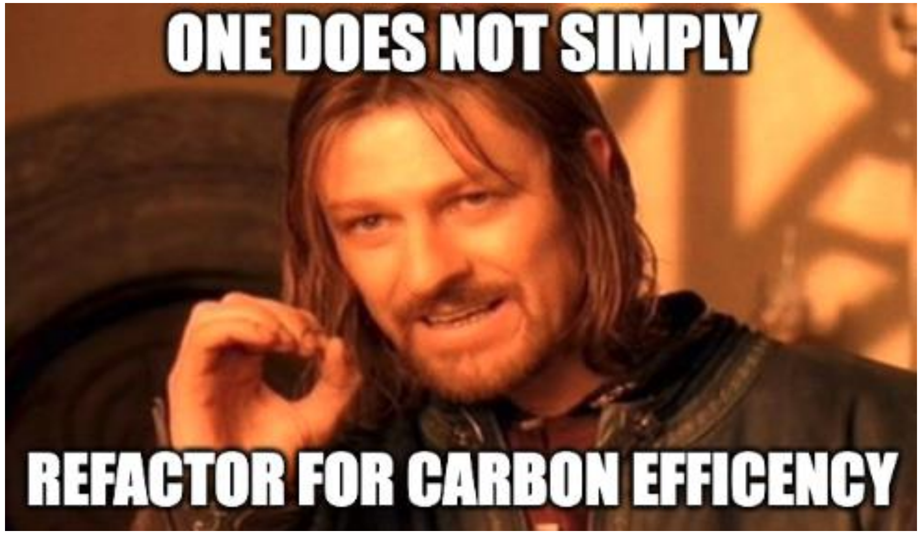
Was ist GreenIT?



Green Software Foundation



Wenn man die Auswirkungen von Änderungen nicht überwacht und misst, kann man schnell verschlimmbessern.



Messen und überwachen?

- Gefühl
- Erfahrung
- SCI
- Impact Framework

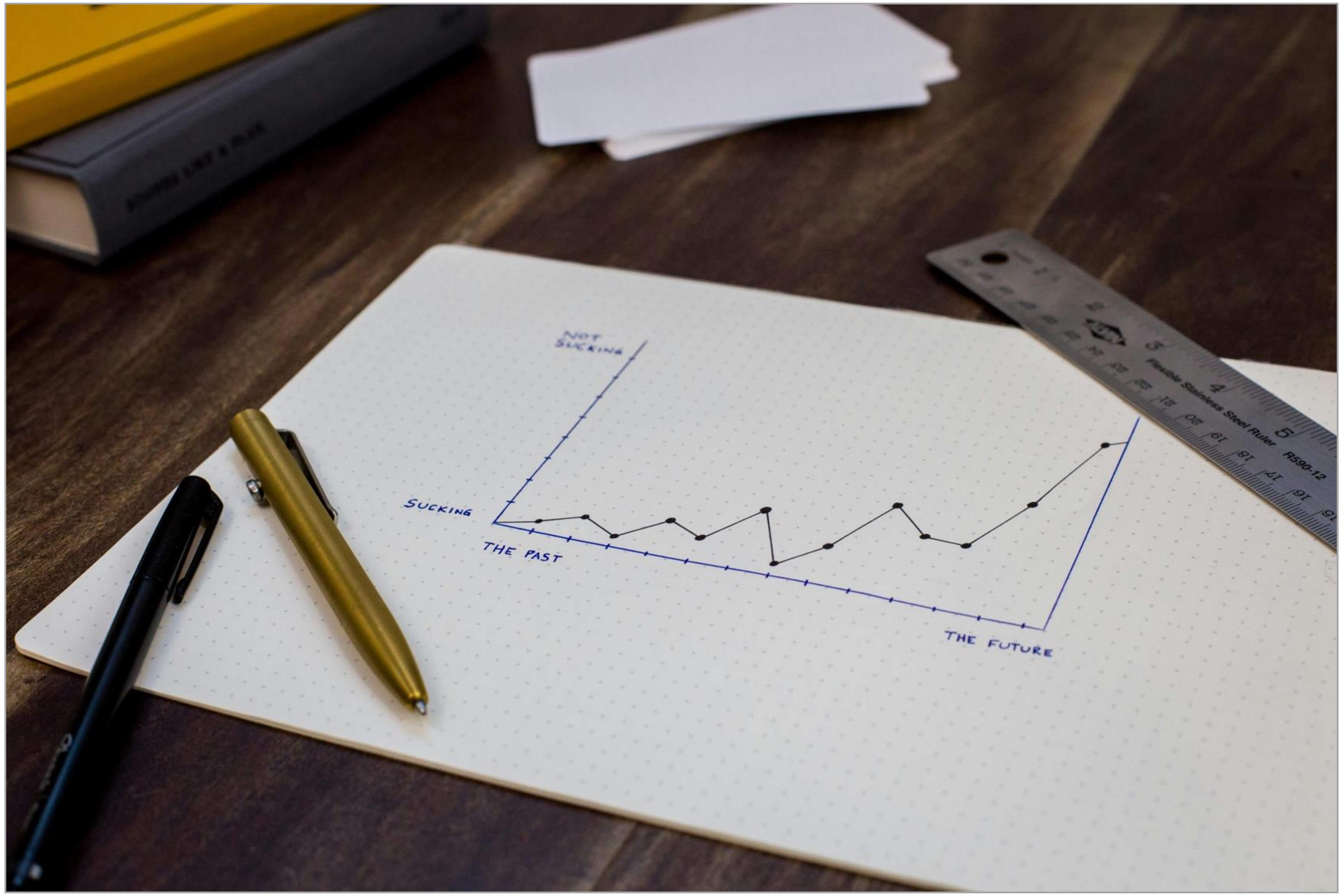
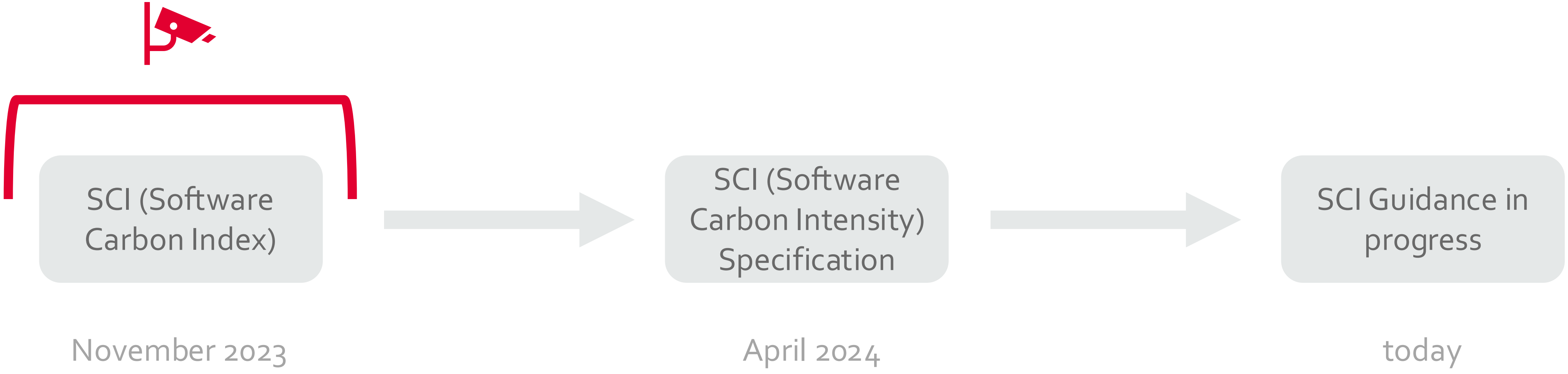


Photo by Isaac Smith on Unsplash

SCI


SCI (Software Carbon Index)
November 2023
SCI (Software Carbon Intensity) Specification
April 2024
SCI Guidance in progress
today

SCI (Software Carbon Intensity)

- Spezifikation der GSF
- Methodik zur Berechnung des CO_2-Ausstoßes von Software

$$SCI = \frac{(E * I) + M}{R}$$

E	Energieverbrauch
I	Emissionsfaktor (Kohlenstoffintensität der Energie)
M	Graue Energie (CO_2-Emissionen bei Herstellung, Transport, …)
R	Funktionale Einheit

SCI Berechnung

Vorgehen

1. Subsystem definieren und Komponenten bestimmen
2. Daten sammeln pro Term und Komponente
3. Werte berechnen pro Komponente und pro Term aggregieren
4. Zwischenergebnisse in Gleichung einsetzen und Endergebnis berechnen

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SCI Guidance

- Getting Started
- Quick Guide
- Energy (E)
- Energy Carbon Intensity (I)
- Embodied (M)
  - Datasets
  - Embodied Calculations
  - Manual Embodied Lookup process
- Functional Unit (R)
- Case Study Submissions
- Review Process
- index

Embodied (M)

Embodied (M)

Embodied carbon (also known as embedded carbon) is the amount of carbon emitted during the creation and disposal of a hardware device.

When software runs on a device, a fraction of the total embodied emissions of the device is allocated to the software. This is the value of M that you need to calculate in the SCI equation.

What are the different techniques that can be used for getting the embodied carbon for your hardware resources running the software application?

Here are some of the techniques that can be used to get the embodied carbon value:

1) Lookup Embodied Database

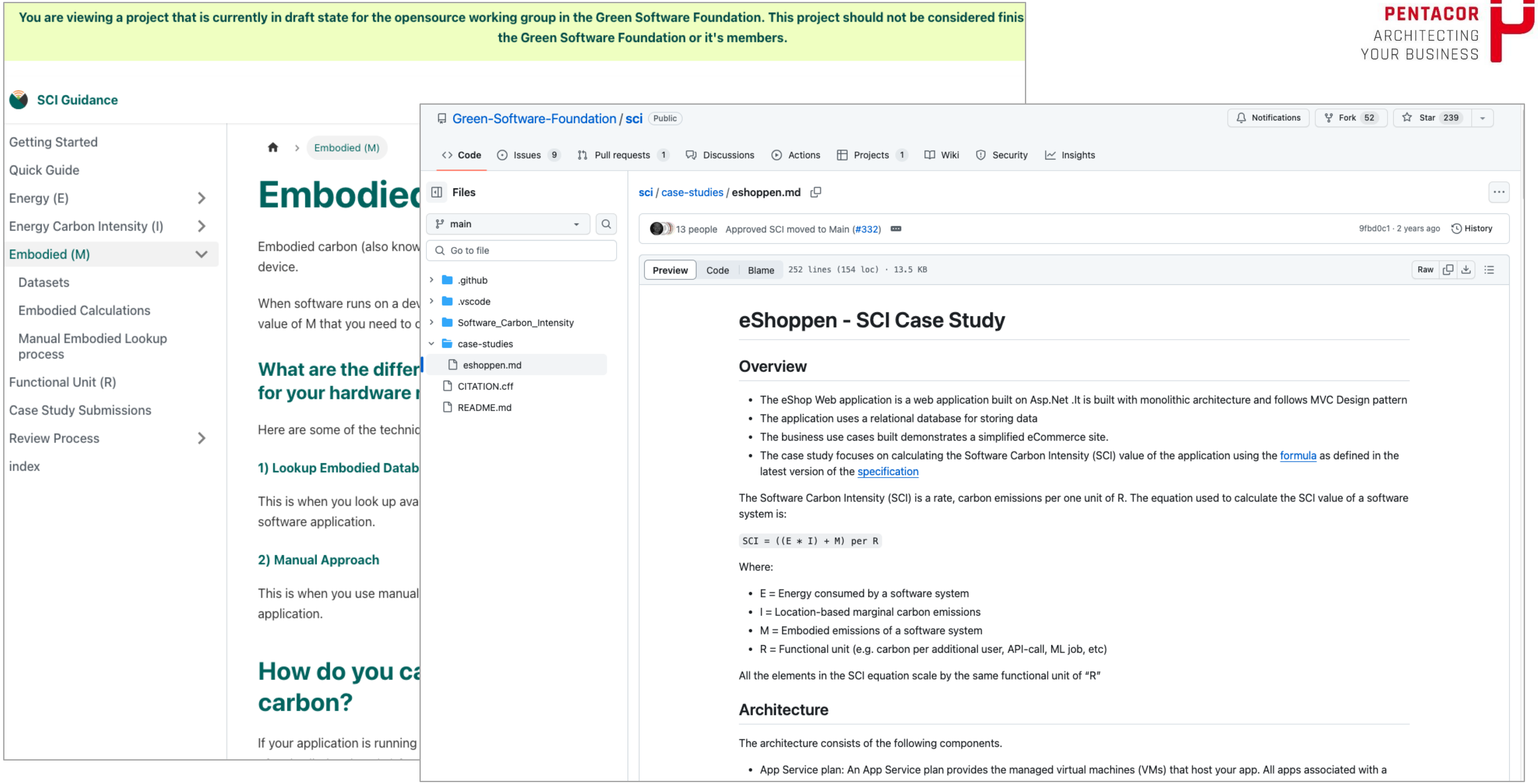
This is when you look up available database/sources to get embodied carbon for the server/hardware resources used by the software application.

2) Manual Approach

This is when you use manual processes to get the embodied carbon for the server/hardware resources used by the software application.

How do you calculate your application's share of embodied carbon?

If your application is running on the cloud, the hardware resources would be shared by multiple applications. To calculate the share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When software runs on a dev
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This is when you look up ava
software application.
2) Manual Approach
This is when you use manual
application.
How do you ca
carbon?
If your application is running
Green-Software-Foundation / sci Public
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Go to file
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case-studies
eshoppen.md
CITATION.cff
README.md
sci / case-studies / eshoppen.md
13 people Approved SCI moved to Main (#332)
9fbd0c1 · 2 years ago
History
Preview
Code
Blame
252 lines (154 loc) · 13.5 KB
Raw
eShoppen - SCI Case Study
Overview
The eShop Web application is a web application built on Asp.Net .It is built with monolithic architecture and follows MVC Design pattern
The application uses a relational database for storing data
The business use cases built demonstrates a simplified eCommerce site.
The case study focuses on calculating the Software Carbon Intensity (SCI) value of the application using the formula as defined in the latest version of the specification
The Software Carbon Intensity (SCI) is a rate, carbon emissions per one unit of R. The equation used to calculate the SCI value of a software system is:
SCI = ((E * I) + M) per R
Where:
E = Energy consumed by a software system
I = Location-based marginal carbon emissions
M = Embodied emissions of a software system
R = Functional unit (e.g. carbon per additional user, API-call, ML job, etc)
All the elements in the SCI equation scale by the same functional unit of "R"
Architecture
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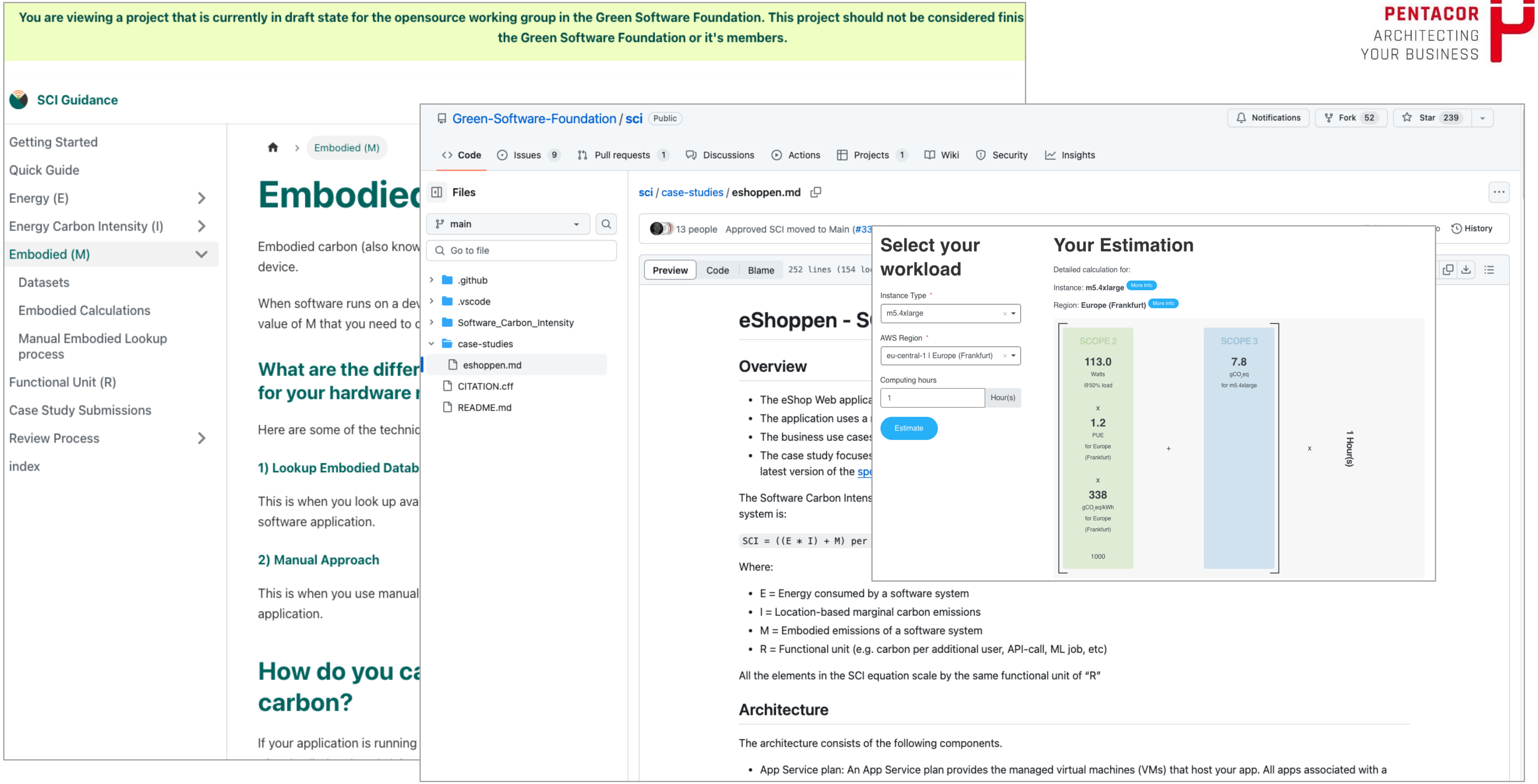
App Service plan: An App Service plan provides the managed virtual machines (VMs) that host your app. All apps associated with a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Select your workload
Instance Type
m5.4xlarge
AWS Region
eu-central-1 | Europe (Frankfurt)
Computing hours
1
Hour(s)
Estimate
Your Estimation
Detailed calculation for:
Instance: m5.4xlarge
Region: Europe (Frankfurt)
SCOPE 2
113.0
Watts
@50% load
x
1.2
PUE
for Europe (Frankfurt)
x
338
gCO2eq/kWh
for Europe (Frankfurt)
1000
+
SCOPE 3
7.8
gCO2eq
for m5.4xlarge
x
1 Hour(s)

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If your application is running

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Files

main

Go to file

- .github
- .vscode
- Software_Carbon_Intensity
- case-studies
  - eshoppen.md
- CITATION.cff

sci / case-studies / eshoppen.md

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eShoppen - S

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Select your workload

Instance Type *
m5.4xlarge

AWS Region *
eu-central-1 | Europe (Frankfurt)

Computing hours

Your Estimation

Detailed calculation for:

Instance: m5.4xlarge More Info

Region: Europe (Frankfurt) More Info

SCOPE 2
113.0
Watts
@50% load

SCOPE 3
7.8
gCO2eq
for m5.4xlarge

SPEC

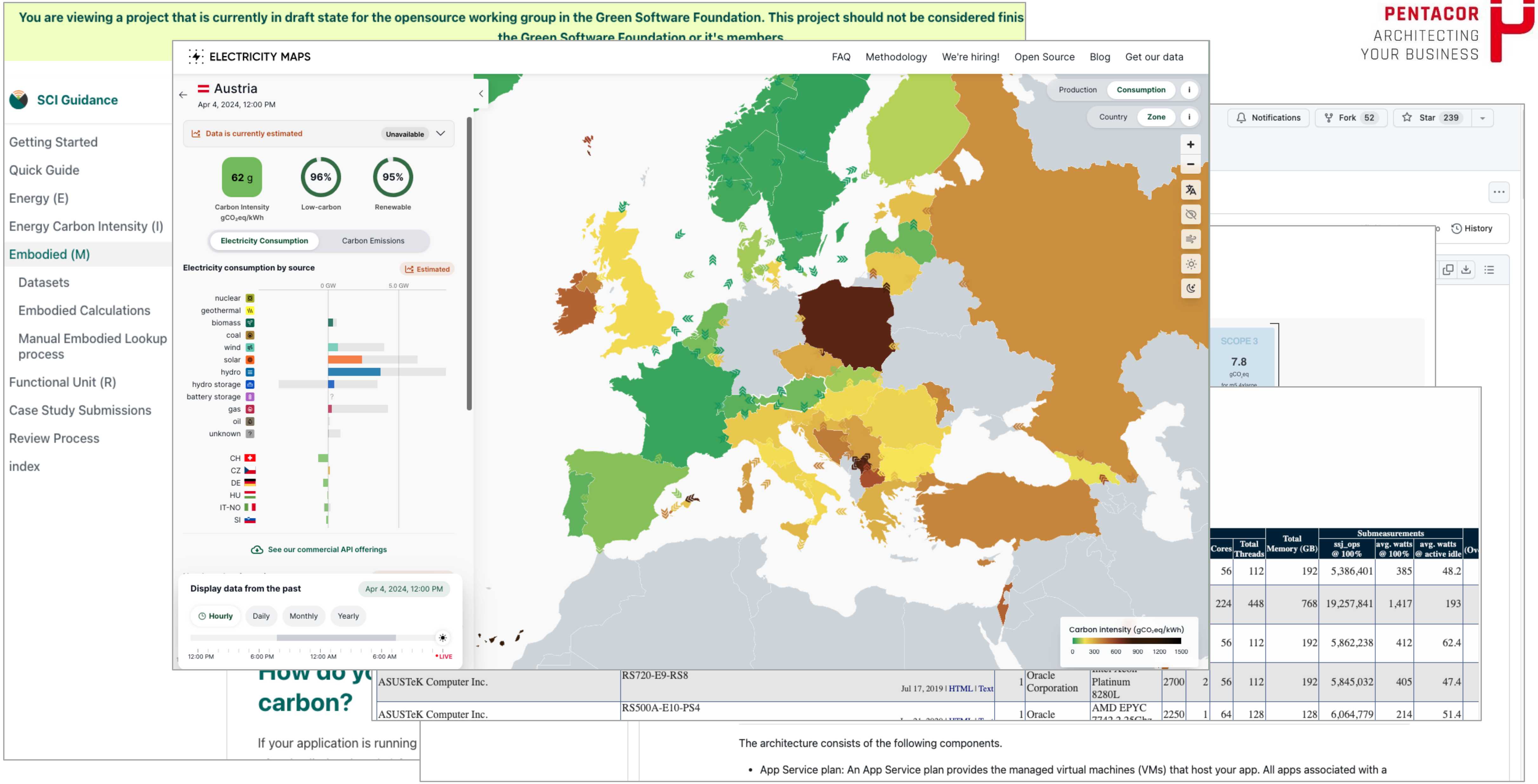
All Published SPECpower_ssj2008 Results

These results have been submitted to SPEC; see the disclaimer before studying any results.

Last update: *Tuesday, 26 March 2024, 16:27*

Published Results (984):

Hardware Vendor / Test Sponsor	System / Enclosure (if applicable)	Nodes	JVM Vendor	Processor: CPU Description	Processor: MHz	Processor: Chips	Processor: Cores	Processor: Total Threads	Total Memory (GB)	Submeasurements: ssj_ops @ 100%	Submeasurements: avg. watts @ 100%	Submeasurements: avg. watts @ active idle	(Ov
ASUSTeK Computer Inc.	RS720-E9/RS8 Dec 6, 2018 | HTML | Text	1	Oracle Corporation	Intel Xeon Platinum 8180	2500	2	56	112	192	5,386,401	385	48.2	
ASUSTeK Computer Inc.	RS720Q-E9-RS8 None May 10, 2019 | HTML | Text	4	Oracle Corporation	Intel Xeon Platinum 8176M	2100	8	224	448	768	19,257,841	1,417	193	
ASUSTeK Computer Inc.	RS720-E9-RS8 Jul 3, 2019 | HTML | Text	1	Oracle Corporation	Intel Xeon Platinum 8280L	2700	2	56	112	192	5,862,238	412	62.4	
ASUSTeK Computer Inc.	RS720-E9-RS8 Jul 17, 2019 | HTML | Text	1	Oracle Corporation	Intel Xeon Platinum 8280L	2700	2	56	112	192	5,845,032	405	47.4	
ASUSTeK Computer Inc.	RS500A-E10-PS4	1	Oracle	AMD EPYC	2250	1	64	128	128	6,064,779	214	51.4	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Apr 4, 2024, 12:00 PM
Data is currently estimated
Unavailable
62 g
Carbon Intensity gCO₂eq/kWh
96%
Low-carbon
95%
Renewable
Electricity Consumption
Carbon Emissions
Electricity consumption by source
Estimated
0 GW
5.0 GW
nuclear
geothermal
biomass
coal
wind
solar
hydro
hydro storage
battery storage
gas
oil
unknown
CH
CZ
DE
HU
IT-NO
SI
See our commercial API offerings
Display data from the past
Apr 4, 2024, 12:00 PM
Hourly
Daily
Monthly
Yearly
12:00 PM
6:00 PM
12:00 AM
6:00 AM
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Consumption
Country
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0
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600
900
1200
1500
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gCO₂eq
Cores
Total Threads
Total Memory (GB)
Submeasurements
ssj_ops @ 100%
avg. watts @ 100%
avg. watts @ active idle
56 112 192 5,386,401 385 48.2
224 448 768 19,257,841 1,417 193
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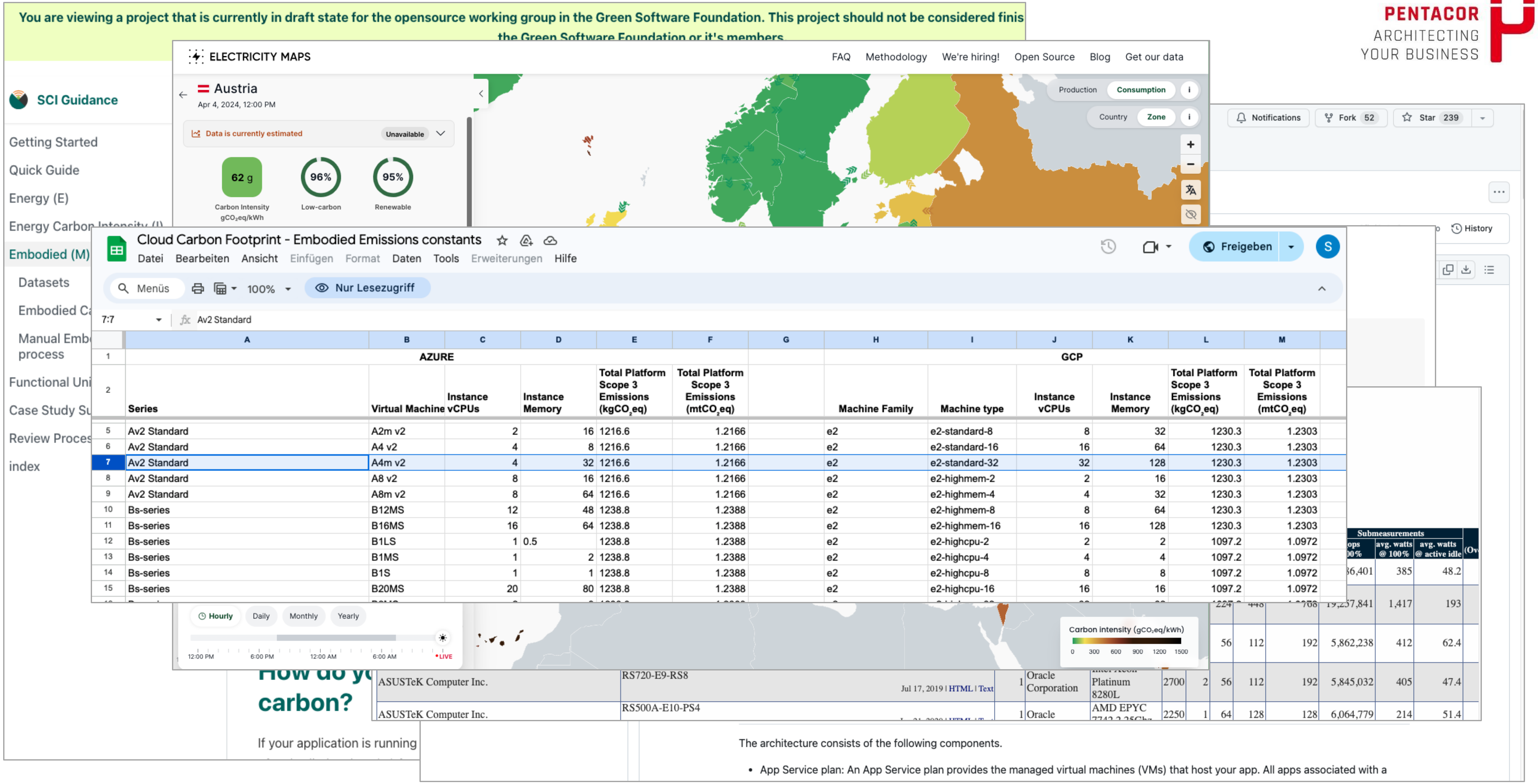
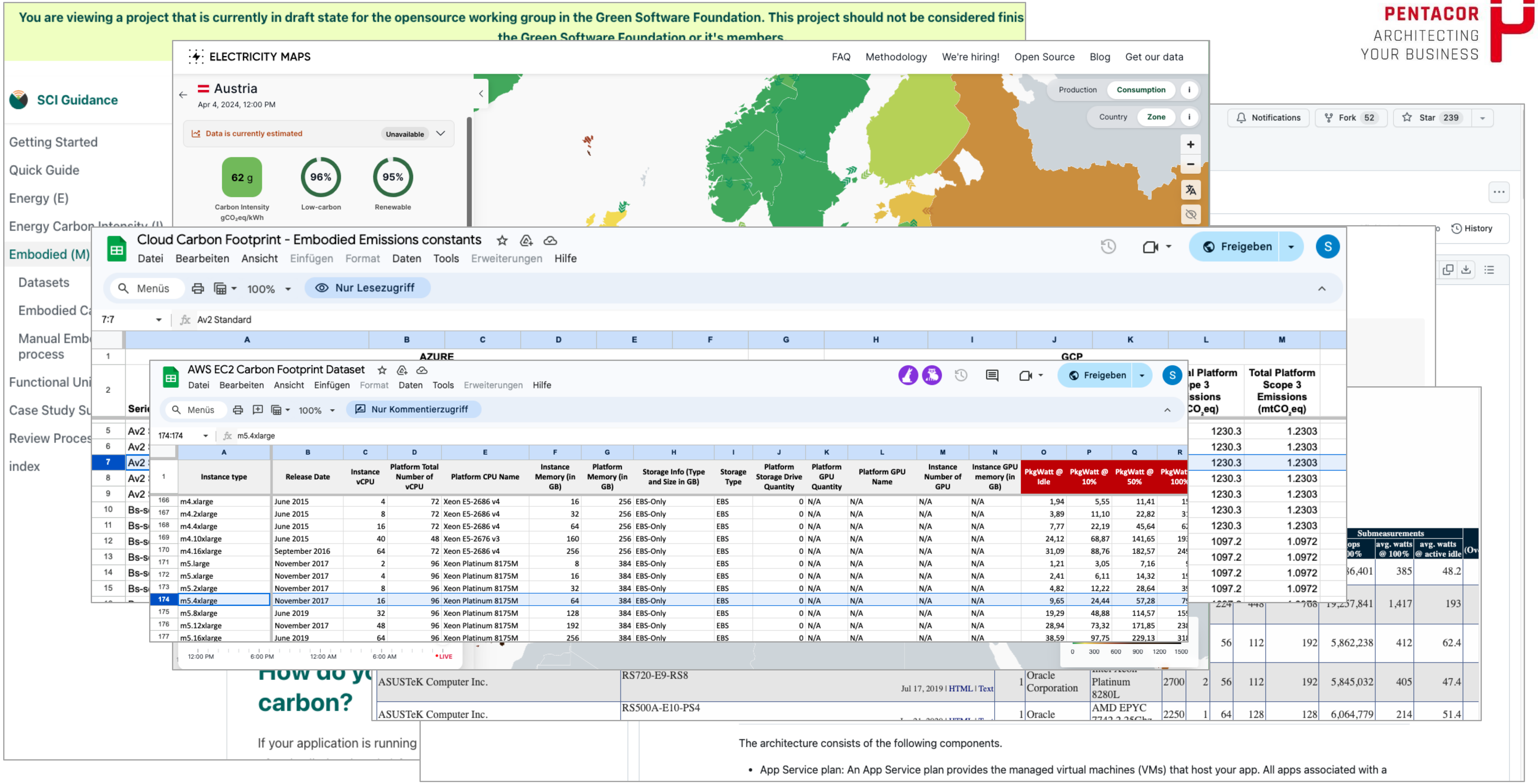


	AZURE						GCP					
Series	Virtual Machine	Instance vCPUs	Instance Memory	Total Platform Scope 3 Emissions (kgCO₂eq)	Total Platform Scope 3 Emissions (mtCO₂eq)		Machine Family	Machine type	Instance vCPUs	Instance Memory	Total Platform Scope 3 Emissions (kgCO₂eq)	Total Platform Scope 3 Emissions (mtCO₂eq)
Av2 Standard	A2m v2	2	16	1216.6	1.2166		e2	e2-standard-8	8	32	1230.3	1.2303
Av2 Standard	A4 v2	4	8	1216.6	1.2166		e2	e2-standard-16	16	64	1230.3	1.2303
Av2 Standard	A4m v2	4	32	1216.6	1.2166		e2	e2-standard-32	32	128	1230.3	1.2303
Av2 Standard	A8 v2	8	16	1216.6	1.2166		e2	e2-highmem-2	2	16	1230.3	1.2303
Av2 Standard	A8m v2	8	64	1216.6	1.2166		e2	e2-highmem-4	4	32	1230.3	1.2303
Bs-series	B12MS	12	48	1238.8	1.2388		e2	e2-highmem-8	8	64	1230.3	1.2303
Bs-series	B16MS	16	64	1238.8	1.2388		e2	e2-highmem-16	16	128	1230.3	1.2303
Bs-series	B1LS	1	0.5	1238.8	1.2388		e2	e2-highcpu-2	2	2	1097.2	1.0972
Bs-series	B1MS	1	2	1238.8	1.2388		e2	e2-highcpu-4	4	4	1097.2	1.0972
Bs-series	B1S	1	1	1238.8	1.2388		e2	e2-highcpu-8	8	8	1097.2	1.0972
Bs-series	B20MS	20	80	1238.8	1.2388		e2	e2-highcpu-16	16	16	1097.2	1.0972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Cloud Carbon Footprint - Embodied Emissions constants
Datei Bearbeiten Ansicht Einfügen Format Daten Tools Erweiterungen Hilfe
Freigeben
Nur Lesezugriff
Av2 Standard
AZURE
GCP
Total Platform Scope 3 Emissions (mtCO₂eq)
AWS EC2 Carbon Footprint Dataset
Nur Kommentierzugriff
m5.4xlarge
Instance type
Release Date
Instance vCPU
Platform Total Number of vCPU
Platform CPU Name
Instance Memory (in GB)
Platform Memory (in GB)
Storage Info (Type and Size in GB)
Storage Type
Platform Storage Drive Quantity
Platform GPU Quantity
Platform GPU Name
Instance Number of GPU
Instance GPU memory (in GB)
PkgWatt @ Idle
PkgWatt @ 10%
PkgWatt @ 50%
Submeasurements
ASUSTeK Computer Inc.
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pentacor internal / … / Green IT / SCI estimation on example of BCSO

- using 0,7% => 180 kgCO_2eq
- Embodied Calculations | SCI Guidance :

> For most cloud servers or consumer devices, the expected lifetime is 4 years.

- => 45 kgCO_2eq per year => **0,123 kgCO_2eq per day**

MongoDB

⚠ since we don't know the exact hardware the mongo DB is running on, we used values from an aws resource of the same size (a1.large).

- 1022 kgCO_2eq per instance
- cluster of 3 instances
- => 766,5 kgCO_2eq per year => **2,1 kgCO_2eq per day**

Network

There exist no reference values. We consider this out of scope following the SCI guide.

Functional Unit (R)

- **10.000** calls per day to the `steckbrief` API (derived from datadog metrics)

Calculation

SCI = (E*I+M) / R

SCI = (**1,7 kWh/day** * 0,385 kgCO_2eq/kWh + 2,223 kgCO_2eq/day) / 10.000 requests/day
= 0,000288 kgCO_2eq per request
= 0,3 gCO_2eq per request

for comparison: one Google Search Request is around 0,2 gCO_2eq (Das Google-Klima)

The architecture consists of the following components.

- App Service plan: An App Service plan provides the managed virtual machines (VMs) that host your app. All apps associated with a

SCI Berechnung

Learnings

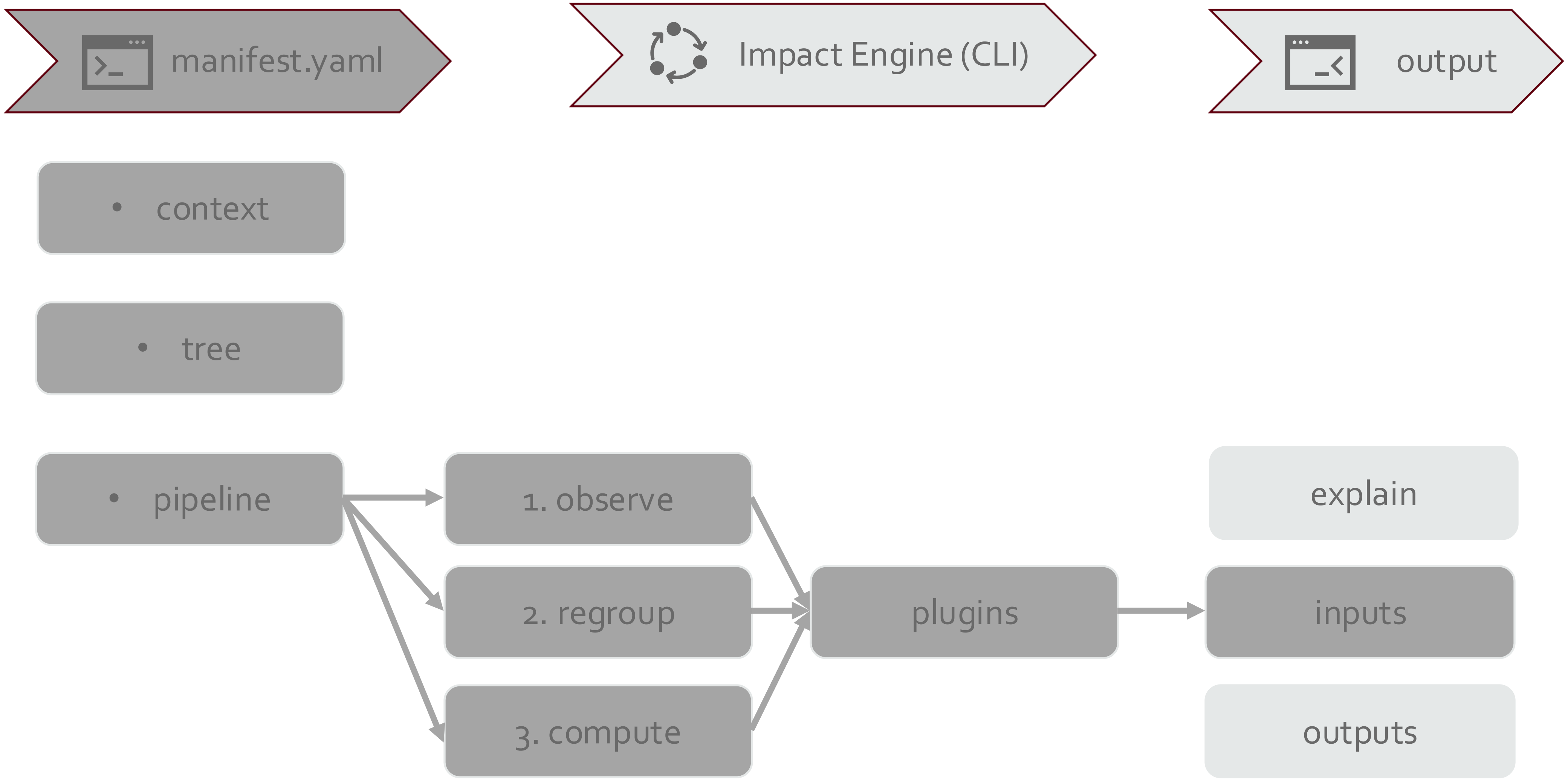
- Regt kritisches Hinterfragen der Architektur an
- Große (Daten-)Unsicherheit
- APIs und Emissionsdashboards schwer zugänglich
- Keine Automatisierung (Grundzüge eines Standards)

Impact Framework

Ziel: Umwelteinfluss von Software schnell und einfach ermitteln und teilen

- Zusammensetzbarkeit
- OpenSource
- aktuell (noch) incubation project


manifest.yaml
Impact Engine (CLI)
output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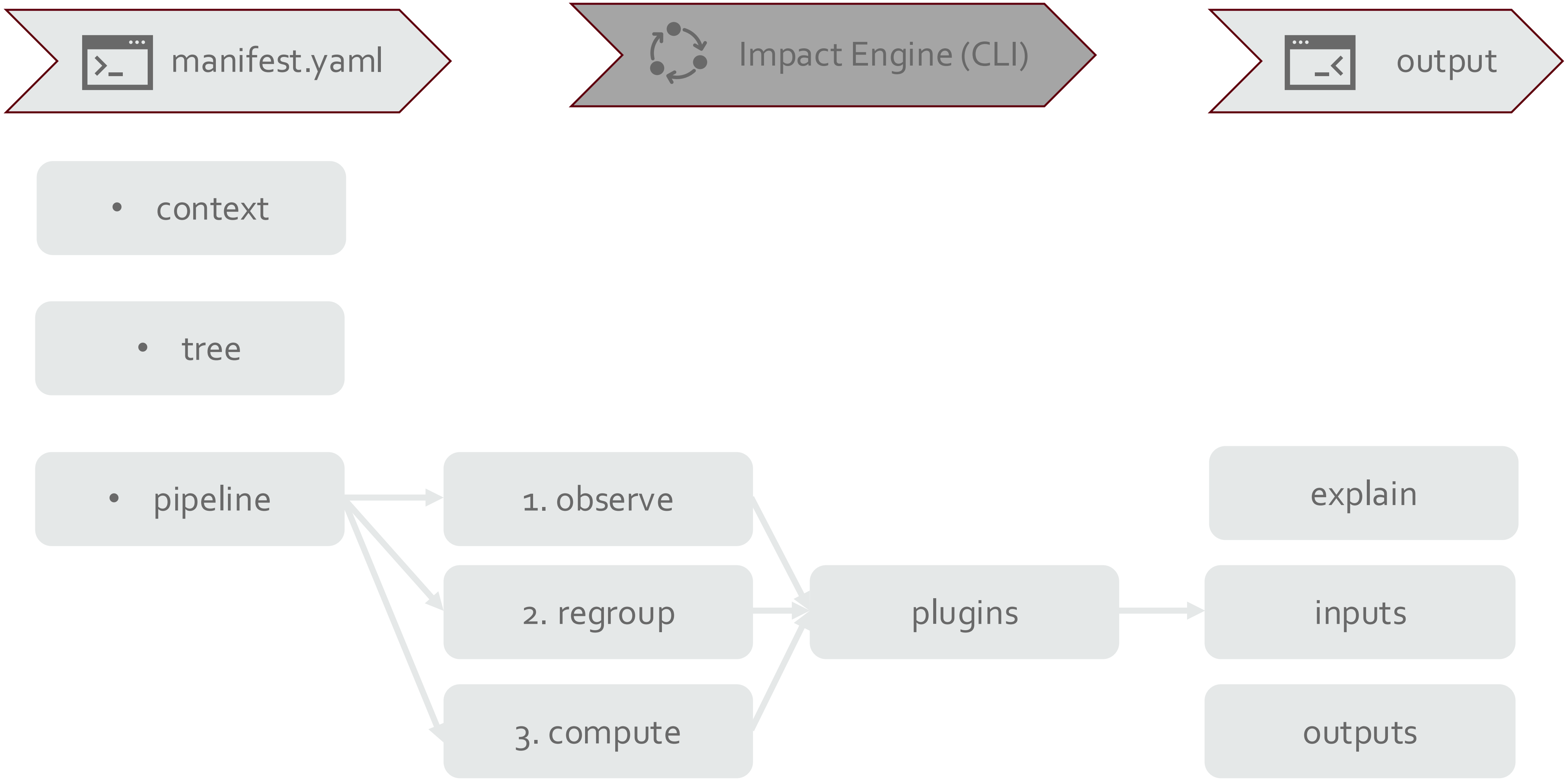
• context
• tree
• pipeline
1. observe
2. regroup
3. compute
plugins
explain
inputs
outputs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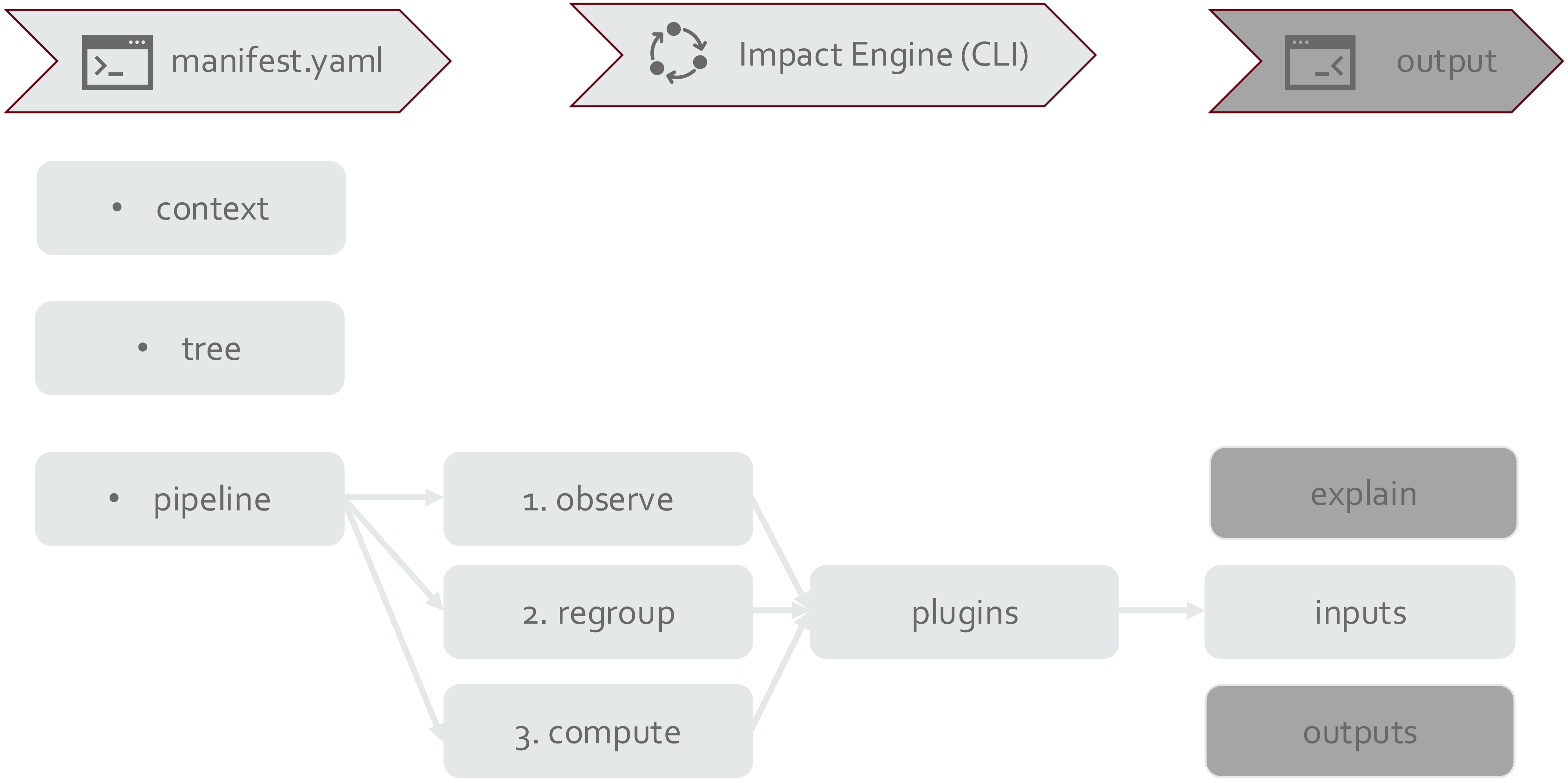

manifest.yaml
Impact Engine (CLI)
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pipeline
1. observe
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outputs

Design Philosophie

- Transparenz
- Überprüfbarkeit
- Flexibilität
- Modularität
- Neutralität

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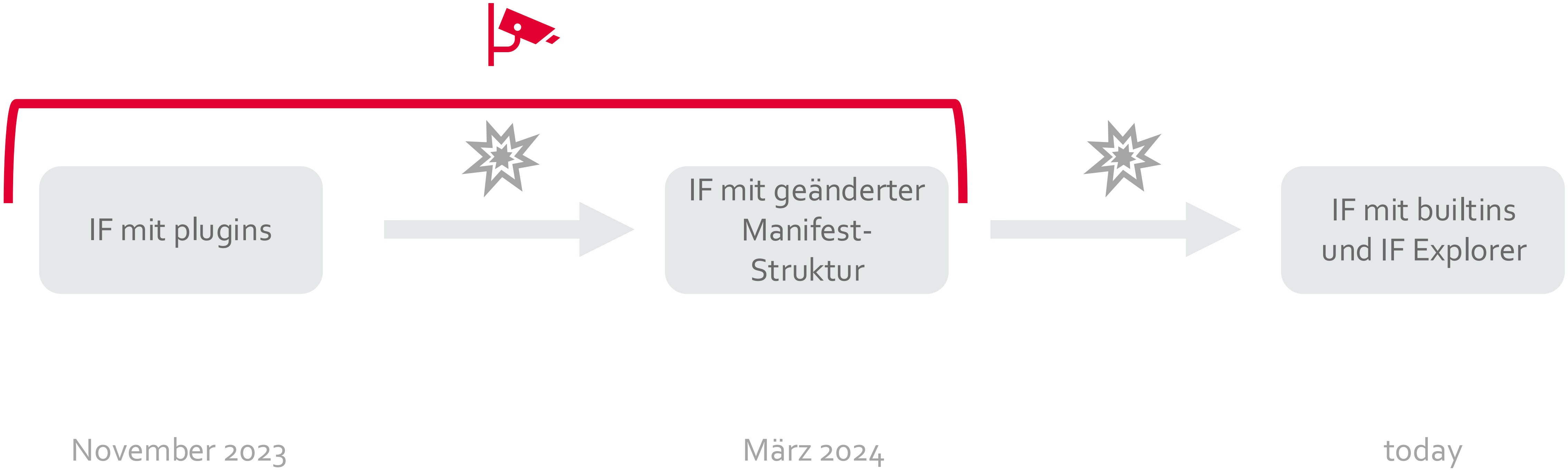
Impact Framework



Unsere Herangehens-weise

1. Beispiel aus der Doku nachstellen
2. Erneute Berechnung des Beispiels vom SCI
3. Berechnung eines komplexen Beispiels

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Erneute Berechnung des Subsystems vom SCI

- SCI-Terme mittels eigener Manifeste berechnen
- Einzelne Manifeste in ein Manifest überführen
- Ergebnisvergleich SCI und IF

2 Erneute Berechnung des Beispiels vom SCI

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SCI =

Calculation

SCI = (E*I+M) / R

SCI = (**1,7 kWh/day** * 0,385 $kgCO_2eq/kWh$ + 2,223 $kgCO_2eq/day$) / 10.000 requests/day

= 0,000288 $kgCO_2eq$ per request

= 0,288 gCO_2eq per request

for comparison: one Google Search Request is around 0,2 gCO_2eq (SZ Das Google-Klima)

IF =

```
        operational-carbon: 27.453734000000004
        carbon: 0.026050247745750 89
        sci: 0.2250741405232876 7
if-version: v0.1.9
```

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IF am komplexen Beispiel

- Beispielsystem definieren
- Manifest schreiben
- Breaking Changes fixen
- Aktuellen Stand dokumentieren
- Das IF an anderer Stelle weiter untersuchen

Impact Framework

Learnings

- Leichter Einstieg
- Flexibel und Erweiterbar
- Datengrundlage
- Incubation Status
- Keine echte Alternative bekannt

Und jetzt?

Photo by Nick Fewings on Unsplash

Das Impact Framework hat Potential sich zu einem flexiblen und mächtigen Tool zu entwickeln

Photo by mali desha on Unsplash

Wie geht es für uns weiter?

Integration IF in CI/CD-Pipeline

Entwicklung von p-lugins zur dynamischen Abfrage von Metriken

Praxistauglichkeit nachweisen

Was auch schön wäre…

- Zeit zum Reifen
- Eine aktive Community
- Mehr Plugins
- Vielleicht einen Wizard

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The End.

Fragen?

Jetzt, im Anschluss oder gern auch später.

Neugierig geworden?

Schau gern bei uns vorbei:

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1 Beispiel aus der Doku nachstellen

```yaml
name: sci-demo
description: example invoking sci model
tags:
initialize:
  outputs:
  - yaml
  plugins:
    sci:
      kind: plugin
      method: Sci
      path: "@grnsft/if-plugins"
tree:
  children:
    child:
      pipeline:
      - sci
      config:
        sci:
          functional-unit-time: 1 sec
          functional-unit: requests
      inputs:
      - timestamp: 2023-07-06T00:00
        duration: 3600
        energy: 5
        carbon-operational: 5
        carbon-embodied: 0.02
        requests: 100
```

```
┌sophiaresch@Sophias-MacBook-Pro ~/Documents/pentacor/greenit/greenit-impactframework/
└$ ie --manifest ./manifest_sci.yml --output ./output-manifest_sci.yml
```

```yaml
name: sci-demo
description: example invoking sci model
tags: null
initialize:
  plugins:
    sci:
      path: '@grnsft/if-plugins'
      method: Sci
  outputs:
    - yaml
tree:
  children:
    child:
      pipeline:
        - sci
      config:
        sci:
          functional-unit-time: 1 sec
          functional-unit: requests
      inputs:
        - timestamp: 2023-07-06T00:00
          duration: 3600
          energy: 5
          carbon-operational: 5
          carbon-embodied: 0.02
          requests: 100
      outputs:
        - timestamp: 2023-07-06T00:00
          duration: 3600
          energy: 5
          carbon-operational: 5
          carbon-embodied: 0.02
          requests: 100
          carbon: 0.0013944444444444442
          sci: 0.000013944444444444442
```