

# How Kubernetes Optimization can combat climate change

Annie Talvasto

# Annie Talvasto

- Product Marketing
- CNCF Ambassador
- Azure MVP
- Kubernetes & CNCF meetup co-organizer
- Startup coach
- Co-host of Cloudgossip podcast - [cloudgossip.net](http://cloudgossip.net)



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Welcome to  
the session!

What will you  
learn?



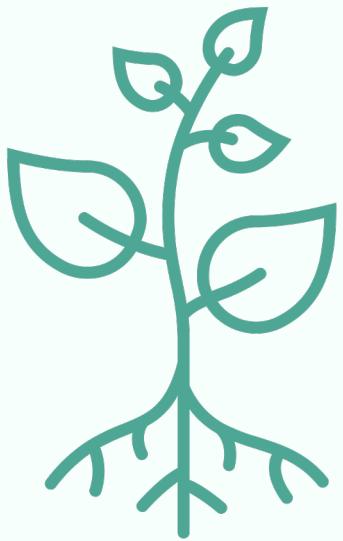
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# Agenda

- Introduction
- Principles of Green Software
- Principles in Practice: Microservices
- Open Source Projects
- Resources



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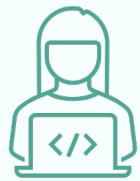


People care  
about  
**sustainability –**  
but what about  
at work?



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# Sustainability & software development



ICT industry consistently adds 2 to 6% of emissions each year since 2007 – the same as airline industry.



Modern technologies require more and more compute power.



World is going to experience irreversible changes if climate change remains unchecked.



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# KUBERNETES HAS CROSSED THE ADOPTION CHASM TO BECOME A MAINSTREAM GLOBAL TECHNOLOGY

According to CNCF's respondents, **96%** of organizations are either using or evaluating Kubernetes – a record high since our surveys began in 2016. Particularly interesting is the regional adoption of Kubernetes in production, with emerging technology hub Africa (73%) jumping ahead of

other more established tech centers including Europe (69%) and North America (55%). Additionally, 93% of respondents are currently using, or planning to use, containers in production, echoing 92% in our [2020 survey](#).

**96%** OF ORGANIZATIONS ARE EITHER USING OR EVALUATING KUBERNETES

## ARE YOU USING KUBERNETES?

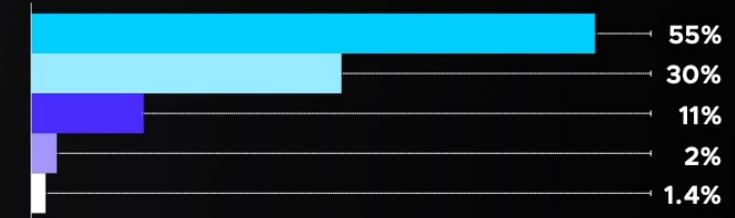
### AFRICA



### AUSTRALIA & OCENIA



### N. AMERICA



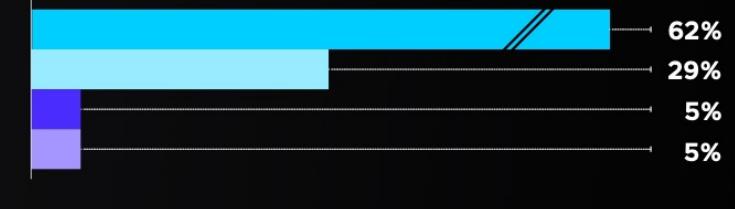
### ASIA



### EUROPE



### S. & C. AMERICA



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  - ConfigMaps
  - Secrets
  - Resource Management for Pods and Containers
  - Configuring Clusters

### Configuration Best Practices

ConfigMaps  
Secrets

Resource Management for Pods and Containers

[Kubernetes Documentation](#) / [Concepts](#) / [Configuration](#) / [Configuration Best Practices](#)

# Configuration Best Practices

This document highlights and consolidates configuration best practices that are introduced throughout the user guide, Getting Started documentation, and examples.

This is a living document. If you think of something that is not on this list but might be useful to others, please don't hesitate to file an issue or submit a PR.

## General Configuration Tips

- When defining configurations, specify the latest stable API version.
- Configuration files should be stored in version control before being pushed to the cluster. This allows you to quickly roll back a configuration change if necessary. It also aids cluster re-creation and restoration.
- Write your configuration files using YAML rather than JSON. Though these formats can be used interchangeably in almost all scenarios, YAML tends to be more user-friendly.
- Group related objects into a single file whenever it makes sense. One file is often easier to manage than several. See the [guestbook-all-in-one.yaml](#) file as an example of this syntax.
- Note also that many `kubectl` commands can be called on a directory. For example, you can call `kubectl apply` on a directory of config files.
- Don't specify default values unnecessarily; simple, minimal configuration will make errors less likely.

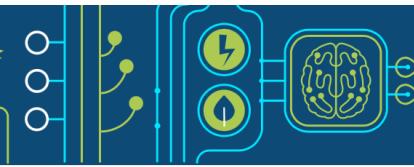
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General Configuration  
"Naked" Pods versus Deployments, and Services  
Using Labels  
Using kubectl

# Principles of Green Software



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13 Oct - 11 Nov



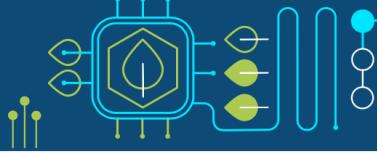
Carbon  
Hack 22

by



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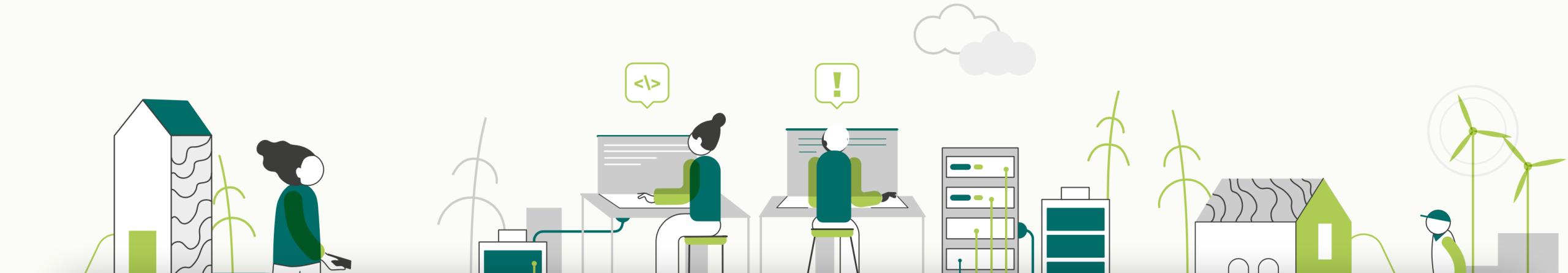
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We are building a trusted ecosystem of people,  
standards, tooling and best practices for

## GREEN SOFTWARE

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# Principles of Green software

- Carbon: Build applications that are carbon efficient.



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- Carbon: Build applications that are carbon efficient.
- Electricity: Build applications that are energy efficient.



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- Carbon Intensity: Consume electricity with the lowest carbon intensity.



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- Embodied Carbon: Build applications that are hardware efficient.



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- Demand Shaping: Build carbon-aware applications.



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- Measurement & Optimization: Focus on step-by-step optimizations that increase the overall carbon efficiency.



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# Too many things? Focus on these:

- Carbon efficiency
  - Energy efficiency
  - Hardware efficiency
  - Carbon awareness



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# Energy



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# Location sifting



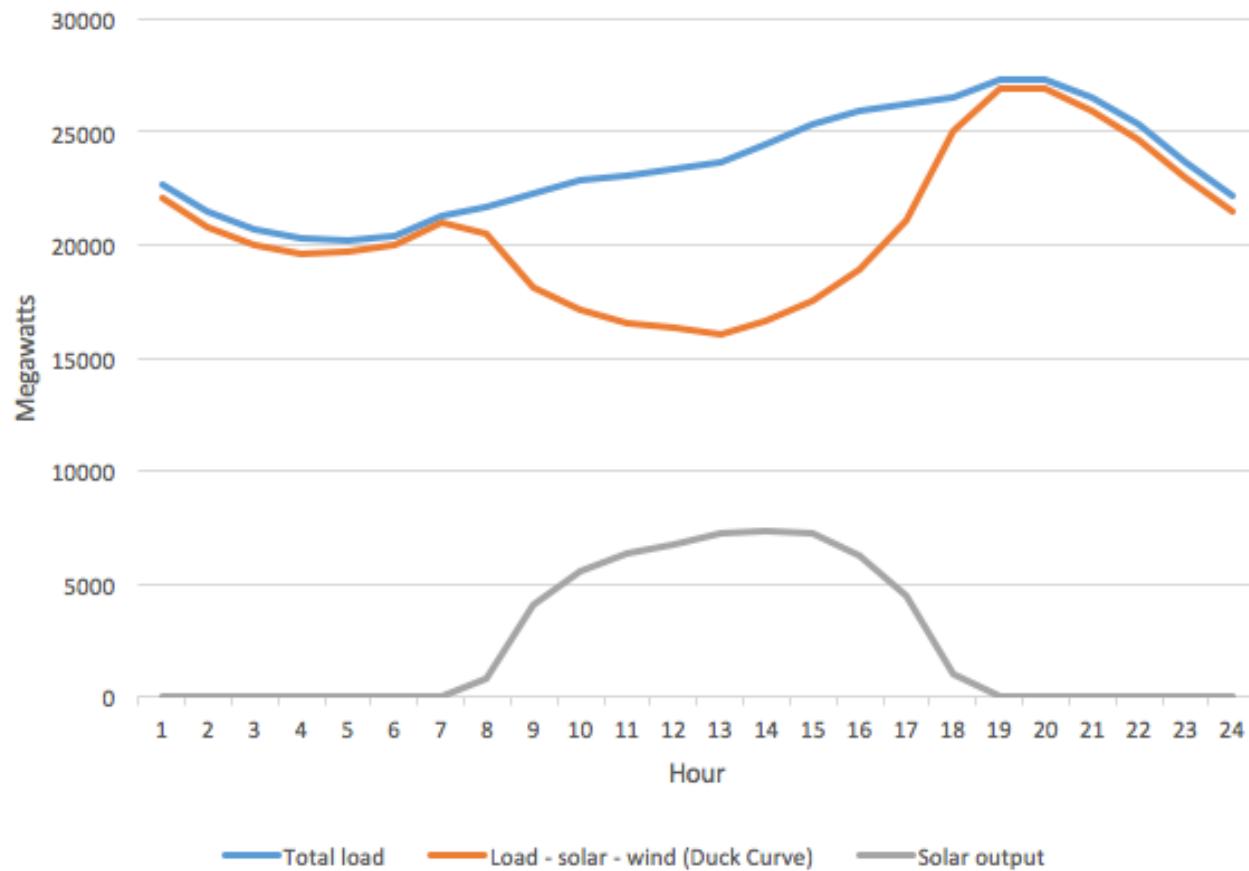
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# Varies by location



# Time sifting

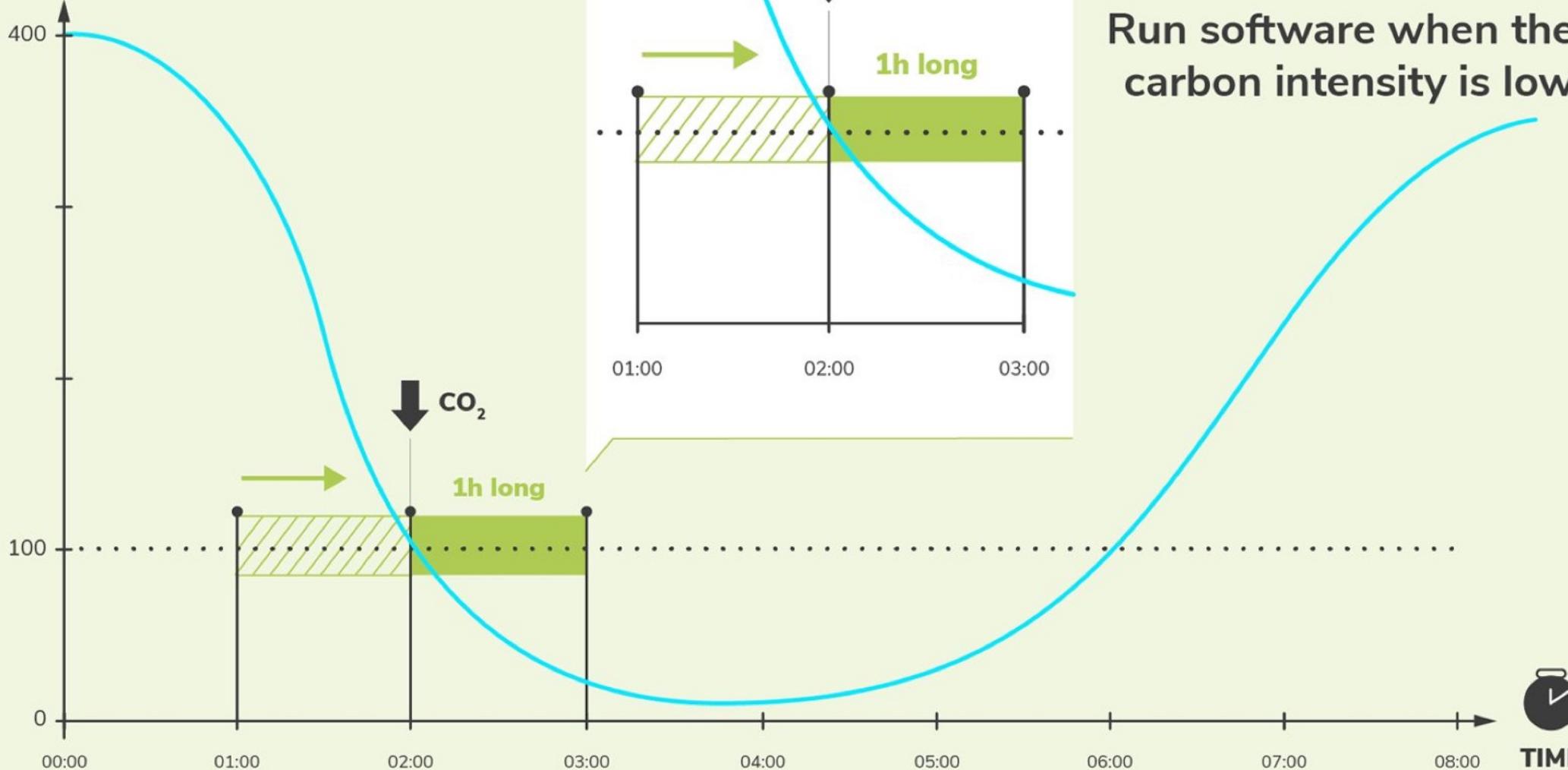
California hourly electric load vs.  
load less solar and wind (Duck Curve)  
for October 22, 2016



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## CARBON INTENSITY



Run software when the carbon intensity is low



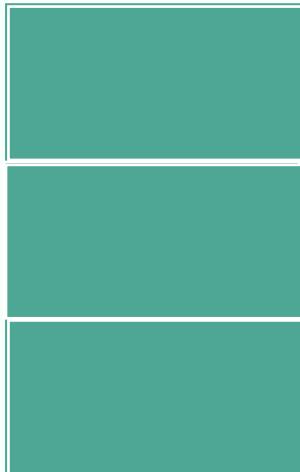
TIME

# Demand shaping



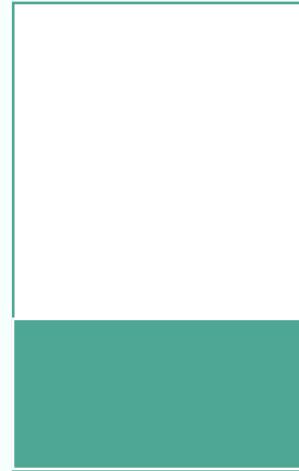
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# Increasing utilization

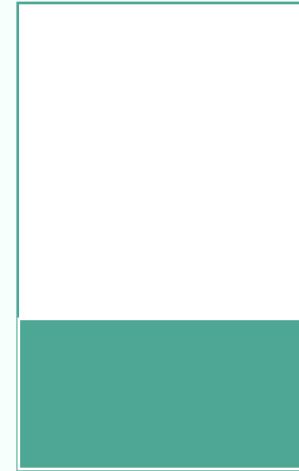


100%.

vs.



30%



30%

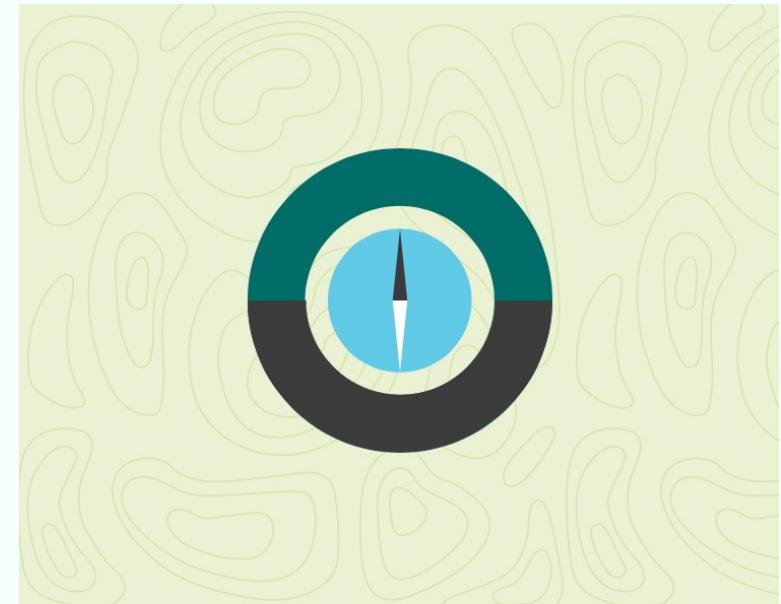


30%



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# Software Carbon Intensity – SCI



## **Software Carbon Intensity (SCI) Specification**

The Software Carbon Intensity (SCI) Specification defines a methodology for calculating the rate of carbon emissions for a software system. The purpose is to help users and developers make informed choices about which tools, approaches, architectures, and services they use in the future. It is a score rather than a total; lower numbers are better than higher numbers, and reaching 0 is impossible.

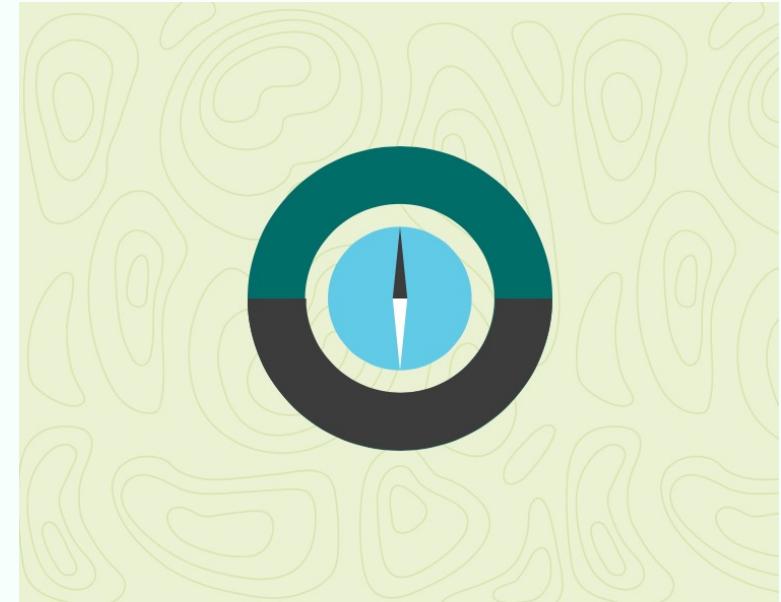


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# Software Carbon Intensity – SCI

Deep dive in GSF GH:

[https://github.com/Green-Software-Foundation/software\\_carbon\\_intensity/blob/main/Software\\_Carbon\\_Intensity/Software\\_Carbon\\_Intensity\\_Specification.md](https://github.com/Green-Software-Foundation/software_carbon_intensity/blob/main/Software_Carbon_Intensity/Software_Carbon_Intensity_Specification.md)



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# Principles of Green Software in Practice: Microservices



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# Microservices example (or Web Queue Worker)

- Optimize network traffic
- Increase your compute utilization
- Reduce your number of Microservices
- Optimize your database
- Understand your latency limitations



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# Optimize Your Network Traffic

- Traffic & architecture
- Caching headers
- CDN (Content delivery network)
- Reduce the size and optimize your bundles and static assets.
- Compression and decompression for data



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# Increase Your Compute Utilization

- Update workload distribution and compute resources - use less resources at a higher utilization.
- Smaller virtual machines
- PaaS
- Auto-scaling or burst capabilities
- Physical tiers & logical layers



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# Reduce the Number of Microservices

- Microservices architecture
- Combining services
- If two or more microservices are highly coupled, consider co-locating to reduce network congestion and latency
- Use Regions with a lower carbon intensity
- Use languages and technology stacks that optimize the efficiency of a specific microservices function.



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# Energy Efficiency across Programming Languages

## Energy Efficiency across Programming Languages

How Do Energy, Time, and Memory Relate?

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João Saraiva  
HASLab/INESC TEC  
Universidade do Minho, Portugal  
[saraiva@di.uminho.pt](mailto:saraiva@di.uminho.pt)

	Energy		Mb
(c) C	1.00	(c) Pascal	1.00
(c) Rust	1.03	(c) Go	1.05
(c) C++	1.34	(c) C	1.17
(c) Ada	1.70	(c) Fortran	1.24
(v) Java	1.98	(c) C++	1.34
(c) Pascal	2.14	(c) Ada	1.47
(c) Chapel	2.18	(c) Rust	1.54
(v) Lisp	2.27	(v) Lisp	1.92
(c) Ocaml	2.40	(c) Haskell	2.45
(c) Fortran	2.52	(i) PHP	2.57
(c) Swift	2.79	(c) Swift	2.71
(c) Haskell	3.10	(i) Python	2.80
(v) C#	3.14	(c) Ocaml	2.82
(c) Go	3.23	(v) C#	2.85
(i) Dart	3.83	(i) Hack	3.34
(v) F#	4.13	(v) Racket	3.52
(i) JavaScript	4.45	(i) Ruby	3.97
(v) Racket	7.91	(c) Chapel	4.00
(i) TypeScript	21.50	(v) F#	4.25
(i) Hack	24.02	(i) JavaScript	4.59
(i) PHP	29.30	(i) TypeScript	4.69
(v) Erlang	42.23	(v) Java	6.01
(i) Lua	45.98	(i) Perl	6.62
(i) JRuby	46.54	(i) Lua	6.72
(i) Ruby	69.91	(v) Erlang	7.20
(i) Python	75.88	(i) Dart	8.64
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(i) Perl	79.58	(i) JRuby	19.84



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# Optimize your Database

- Choose your database well
- Ensure you are using the best database for interacting with your data set
  - If no easy solution - redundant copies
- Index
- Evaluate and optimize your queries
- Database cache



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# Understand your latency limits

- Think about what you actually need for your application
- Request/response cycle
- Worker processes vs web processes
- Worker processes in a region with lower carbon intensity.
- Delay worker process to run when the carbon intensity is the lowest

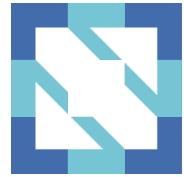


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CNCF Open  
source  
projects to  
compliment  
Kubernetes



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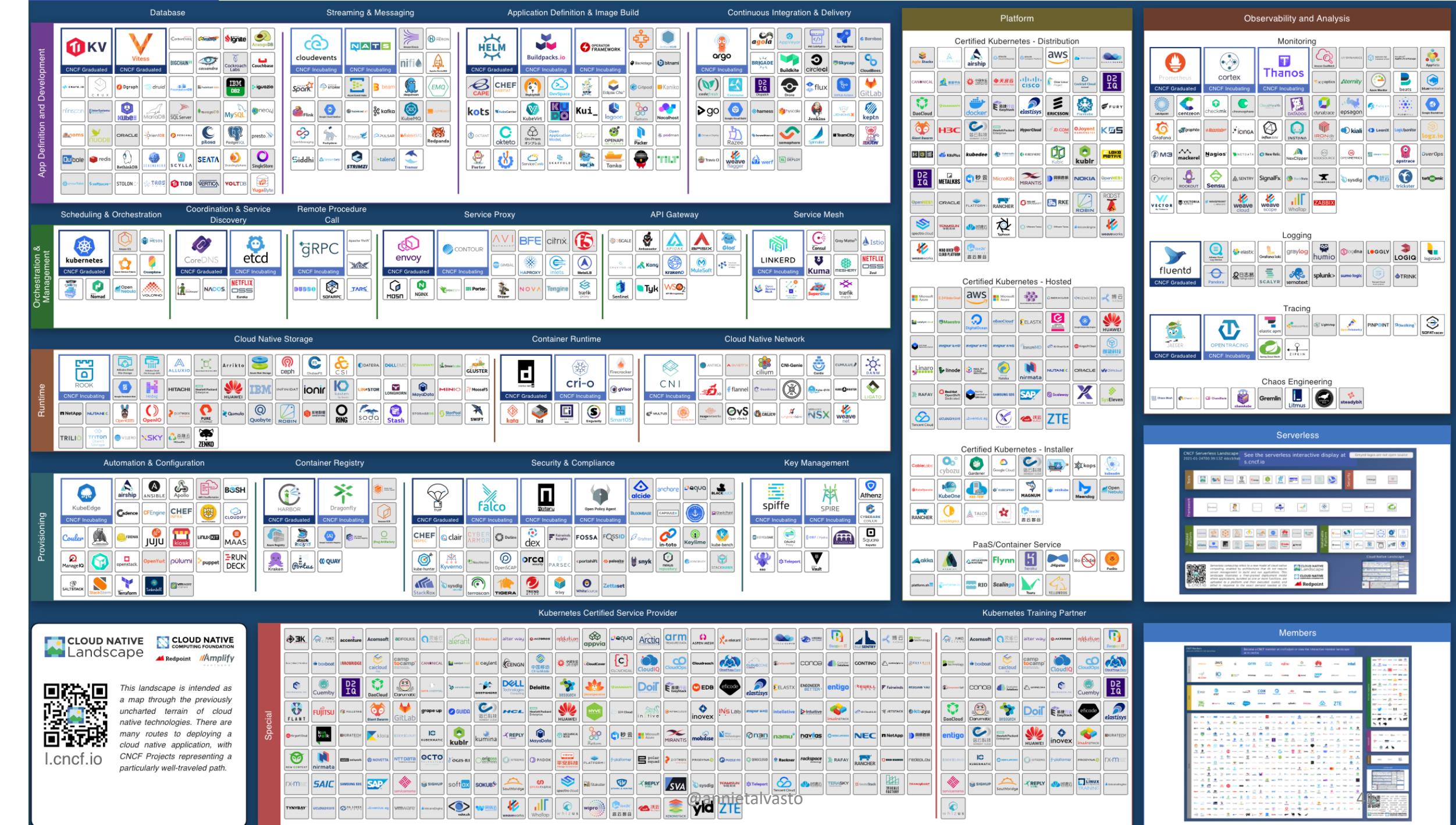
**CLOUD NATIVE  
COMPUTING FOUNDATION**

## **Building sustainable ecosystems for cloud native software**

The Cloud Native Computing Foundation (CNCF) hosts critical components of the global technology infrastructure. CNCF brings together the world's top developers, end users, and vendors and runs the largest open source developer conferences. CNCF is part of the nonprofit Linux Foundation.



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BLOG / COMMUNITY POST

# CNCF WG Environmental Sustainability

By **Max Körbächer + Leonard Pahlke**

May 31, 2022

*Community post by **Max Körbächer**, Co-Founder of Liquid Reply, and **Leonard Pahlke**, Consultant at Liquid Reply*

We are pleased to announce that we have established a new working group for environmental sustainability. Our mission is to promote sustainability awareness and develop a culture within the CNCF landscape to establish sustainability best practices and standards.

Environmental sustainability is a pressing issue for humanity, and with simultaneous digitization, software is playing an increasingly important role. Making software ecologically sustainable is becoming more and more vital.

Data Centers, and therefore every compute resource accessible, are currently using 2% of the world's energy. This is conservatively expected to grow to hold 1-2% in the next couple of years, up to 12% by 2040. The growth in energy for computing is outpacing the global growth in energy production. The contributing factors include an explosion in data, the emergence of energy-intensive workloads such as AI and, the flattening of Moore's law. The energy consumption

# Autoscaling



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# What is Keda?

- Default Kubernetes Scaling is not well suited for event driven applications.
- **Keda:** Event driven scale controlling that can run inside any kubernetes cluster -> Can monitor rate of the events to pre-emptively act before CPU is affected.
- You can install it into new or existing clusters.
- Provides 30+ built-in scalers, but you can build your own
  - Support for external scaler, external push or Metrics API



Demo

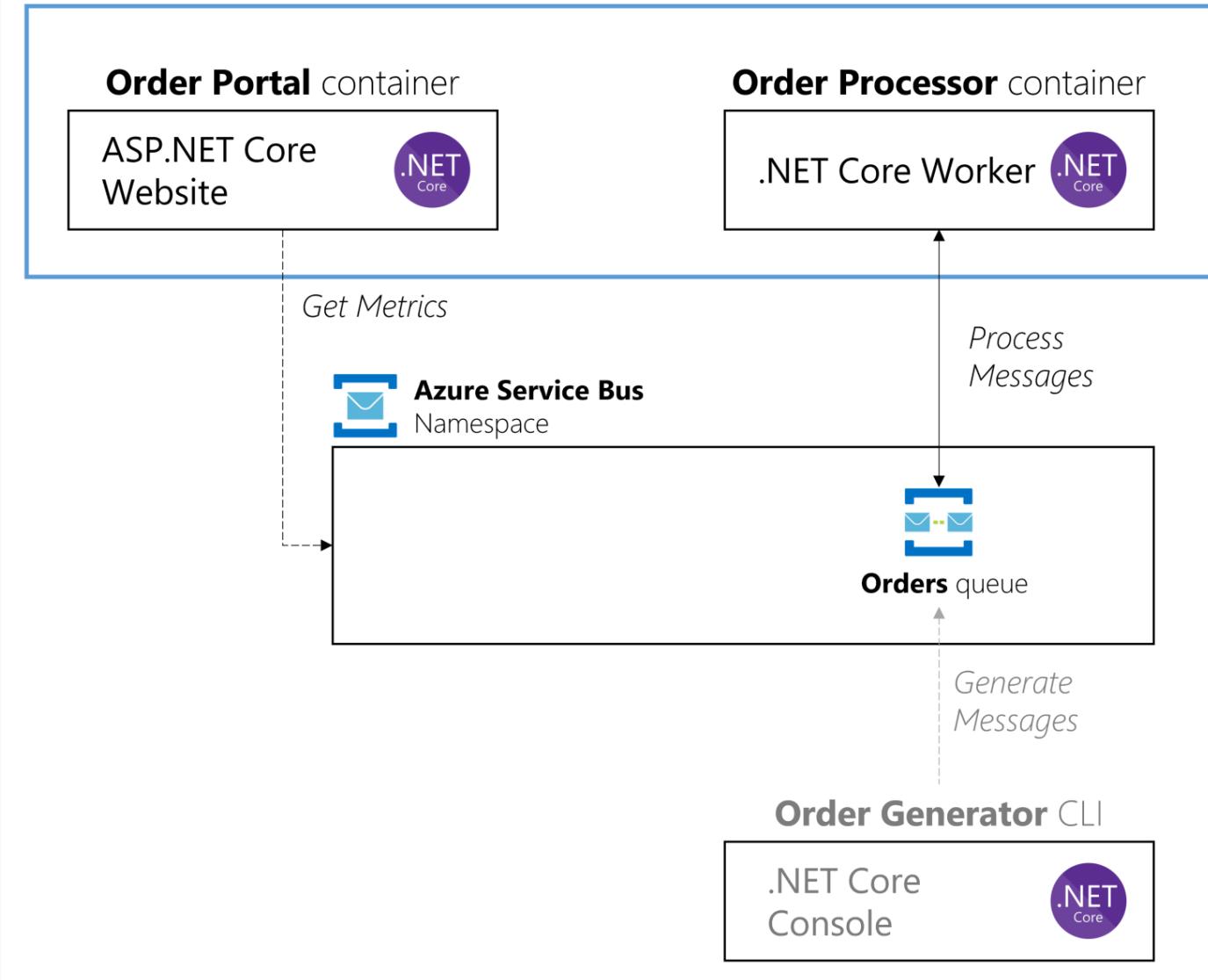
KEDA:  
Scaling .NET Core  
worker with Azure  
Service Bus



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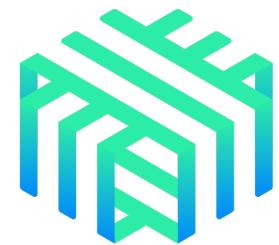


# kubernetes



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# Service Mesh



# LINKERD



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# Linkerd

- Service mesh
- Ultralight, ultrafast, security-first service mesh for Kubernetes.
- The overall goal is to reduce mental overhead of having service mesh
- What does it do?
  - Observability
  - Reliability
  - Security



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# What are the benefits of Linkerd?

- Thriving open source community
- Simple, minimalist design
- Deep Runtime Diagnostics
- Ultralight and ultra fast
- Installs in seconds with zero config
- Actionable service metrics



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# Policies



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# What is Kyverno?

- Designed for Kubernetes
- Policies managed as Kubernetes resources
  - Kubectl
  - Git
  - kustomize
- Validate, mutate and generate



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# Greenkube

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kube-green / kube-green Public

Code Issues 15 Pull requests 7 Discussions Actions Projects 1 Security Insights

main 10 branches 8 tags Go to file Code

davidebianchi Merge pull request #233 from kube-green/dependabot/github... 6cb0c3b last week 446 commits

.github chore(deps): bump azure/setup-kubectl from 3.1 to 3.2 2 weeks ago

api/v1alpha1 Merge pull request #226 from kube-green/feat/kubernetes-e2e-test 3 weeks ago

bundle upgrade tools 3 months ago

config Merge pull request #226 from kube-green/feat/kubernetes-e2e-test 3 weeks ago

controllers Merge pull request #226 from kube-green/feat/kubernetes-e2e-test 3 weeks ago

hack fix: upgrade image in bundle 3 months ago

logo update readme 3 months ago

testdata fix: change testdata last year

tests/e2e added e2e tests for cronjob suspension - part two last month

.dockerignore Initial commit 2 years ago

.gitignore Initial commit 2 years ago

CHANGELOG.md docs: CHANGELOG now links to releases 5 months ago

CONTRIBUTING.md docs: add adopters 2 months ago

Dockerfile chore(deps): bump golang from 1.19.4 to 1.19.5 2 weeks ago

LICENSE Initial commit 2 years ago

Makefile e2e tests 2 months ago

README.md

Notifications Fork 29 Star 389

About

A K8s operator to reduce CO2 footprint of your clusters

kube-green.dev

kubernetes resources k8s

cloud-native hacktoberfest downscale

green-software

Readme

MIT license

389 stars

3 watching

29 forks

Releases 5

v0.4.1 Latest on Oct 5, 2022

+ 4 releases

Packages

No packages published

Contributors



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Getting Started

How it works

Install

Configuration

Real use case >

Tutorials >

Advanced >

API Reference

FAQ

Adopters

## How many CO2 is produced by pod?

This calculations are based on the following assumptions:

- Emissions for cloud server using 100% green electricity: **160 Kg CO2eq / year and server** (from [goclimate.com](#) )
- Cluster node of 2 cpu. We approximate **1 node is 1 server**
- **15 pods per node**

With this assumption, the mean consumption of CO2 per pod in a year is  $160 / 15 = \mathbf{11 \text{ Kg CO2eq / year per pod.}}$

### CO2 Calculator

CO2 per pods per year (kg CO2eq)

Total number of pods

Total pods when kube-green active

Hour of sleep per week

### Results

Total (Kg CO2eq/week)

without kube-green: 21

**with kube-green: 5**

Difference: -16

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[« API Reference](#)

Next  
[Adopters »](#)



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I have a couple of nodes with low utilization, but they are not scaled down. Why?

[How many CO2 is produced by pod?](#)

# More projects

The image shows two GitHub project pages side-by-side.

**sustainable-computing-io/kepler**: This project has 12 branches and 4 tags. It includes contributions from GitHub, automation/presubmit-tests, bpfseries/perf\_event, build, cmd, data, doc, e2e, enhancements, and grafana-dashboards. The repository is public and has 839 commits. The code tab is selected.

**Green-Software-Foundation/carbon-aware-sdk**: This project has 13 branches and 1 tag. It includes contributions from .devcontainer, .github, .vscode, docs, images, samples, scripts/package, src, .gitignore, CONTRIBUTING.md, GettingStarted.md, LICENSE, README.md, action.yml, and entrypoint.sh. The repository is public and has 725 commits. The code tab is selected.

The image shows a GitHub project page for sustainable-computing-io/carbon-aware-scaling-poc.

**Code**: The main branch is selected. There are 7 branches and 0 tags. The repository has 16 commits. The README.md file contains the following text:

```
∞ rootfs add youtube playlist
09ae526 on Oct 20, 2022 16 commits

carbon-intensity-exporter Carbon aware scaler operator (#14) 3 months ago
demo Carbon aware scaler operator (#14) 3 months ago
deploy Carbon aware scaler operator (#14) 3 months ago
docs Update deployment manifests (#13) 3 months ago
forecast/train_pipeline Carbon forecast (#6) 4 months ago
images CO2Signal handler for carbon intensity data (#5) 4 months ago
schemas Json schema templates (#2) 3 months ago
src Carbon aware scaler operator (#14) 3 months ago
LICENSE Create LICENSE 4 months ago
README.md add youtube playlist 3 months ago
```

**About**: No description, website, or topics provided.

**Readme**: Apache-2.0 license, 2 stars, 5 watching, 2 forks.

**Releases**: No releases published.

**Packages**: No packages published.

**Contributors**: 5 contributors shown.

**Languages**: Python 90.9%, Shell 7.5%.



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Reminder:

Use best practices  
from other fields  
creatively and as  
fits!



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# Quick tips



Observability



Optimization



Governance



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# Benefits

- Organizational improvements
- Improved performance
- Cost savings
- Sustainability goals

Saving the world !



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# Wrap up

- Introduction
- Principles of Green Software
- Principles in Practice: Microservices
- CNCF Open Source Projects
- Resources



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# Resources

## Slides & materials:

- [Github.com/annietalvasto](https://github.com/annietalvasto)



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# Resources

- **Green Software Foundation**

- <https://greensoftware.foundation>
- Youtube, Podcast, blog etc
- A lot of upcoming pro

- **CNCF Environmental Sustainability TAG**

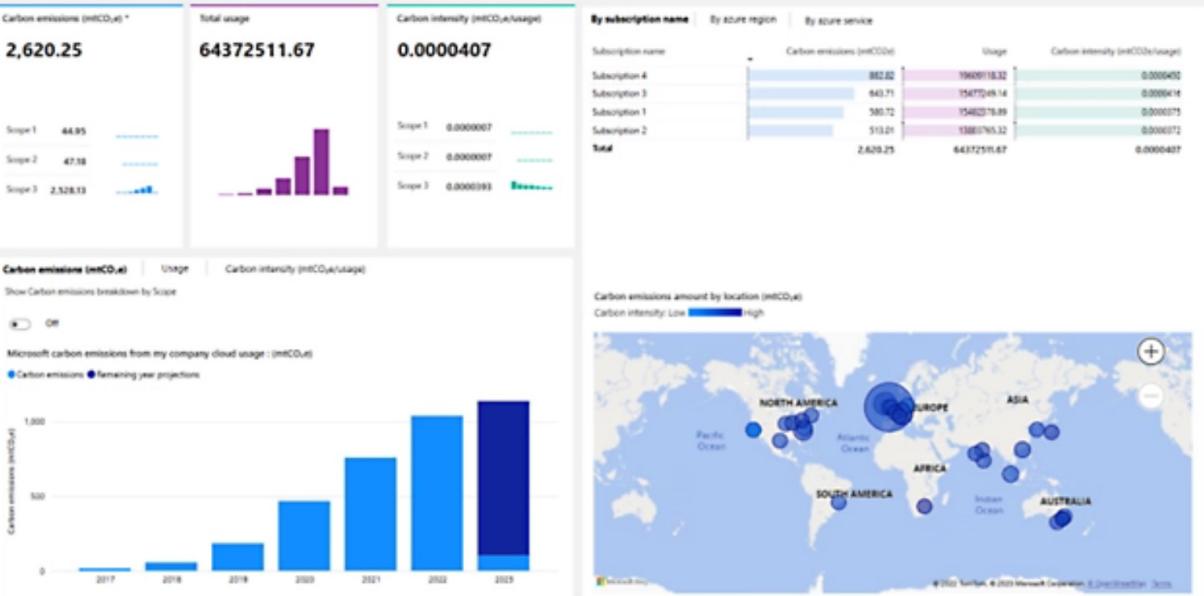
- A lot of projects upcoming: How to Get Involved in CNCF Environmental Sustainability TAG - Marlow Weston & Huamin Chen -  
<https://www.youtube.com/watch?v=XFZZ9YfOyl8>
- Slack channel (CNCF Slack): <https://cloud-native.slack.com/archives/C03F270PDU6>
- High level view: <https://github.com/orgs/cncf/projects/10/views/1>
- Best practices: <https://github.com/cncf/tag-env-sustainability/issues/54>



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# Gain transparency into the carbon impact of your cloud usage

- Track direct and indirect greenhouse gas emissions related to your cloud usage.
- Understand your emissions avoided over time through our datacenter efficiency.
- Easily share your findings, shown in CO<sub>2</sub>-equivalent metric tons, through cloud data export.
- **New!** Access your Azure emissions data with the [Microsoft Cloud for Sustainability API \(Preview\)](#).



**Overview**

Estimate emissions already avoided by migrating to the Microsoft cloud

Currently displaying data for the following tenant: DEMO - Please connect with a valid Microsoft 365 admin profile

Select the characteristics of your on-premises alternative

Date: All

Efficiency Scale: Low, Medium, High

Renewable energy purchase: 0%

**Carbon emissions saved from on-premises alternative:** 12932.361 mTCO<sub>2</sub>e

**Carbon emissions saved from Microsoft efficiencies:** -11734.659 mTCO<sub>2</sub>e

**Carbon emissions saved from Microsoft renewable energy purchases:** -1097.803 mTCO<sub>2</sub>e

**Carbon emissions from switch to Exchange Online and SharePoint Online:** 99.899 mTCO<sub>2</sub>e

**How to select your on-premises characteristics:**

**Efficiency:**

- Low efficiency: Physical servers and direct-attached storage in a small on-premises data center (< 1,000 square feet).
- Medium efficiency: Physical and virtual servers and attached, dedicated storage in a mid-size internal data center (1,000-10,000 square feet).
- High efficiency: Virtualized servers and dedicated storage in a high-end internal data center (> 10,000 square feet).

**Renewable energy purchases:**

The estimated emissions for your switch to the Microsoft cloud include Scope 1 and Scope 2 emissions only. The figure accounts for Microsoft's renewable energy power purchases and includes energy used in transit data over the internet.

## Estimate emissions that you've avoided

Calculate the emissions your organization has already avoided by moving on-premises workloads to the Microsoft Cloud.

# Learn... *and* earn Swag in our Cloud Skills Challenge

- Complete 3 or more modules in our challenge by 26<sup>th</sup> February and then email [ukchallenge@microsoft.com](mailto:ukchallenge@microsoft.com) to claim your swag item\*. (UK addresses only)
- For Global Participants there's 50% off exam vouchers through '*30 Days to Learn It*'.
- Find out about Microsoft Reactor and discover our Microsoft UK Developer upcoming events & dev resources.

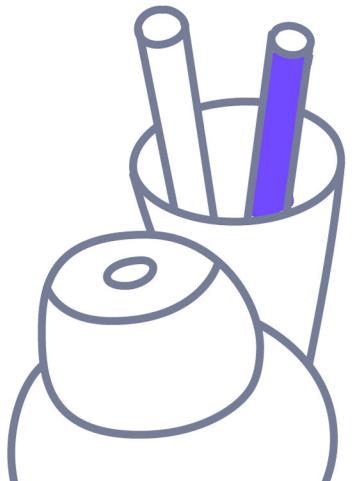


Start now at  
[aka.ms/ND\*\*C\*\*](https://aka.ms/ndc)



Microsoft

\*Full terms & conditions for the UK challenge at <https://aka.ms/challenge/ndc/terms-conditions>



# Resources

- Lightning Talk: Green(Ing) CI/CD: A Sustainability Journey with GitOps - Niki Manoledaki, Weaveworks (Kepler, Flux)
  - [https://www.youtube.com/watch?v=rgvHbG3U\\_c4&t](https://www.youtube.com/watch?v=rgvHbG3U_c4&t)
- Using kube-green with Argo CD
  - <https://akuity.io/blog/argo-cd-kube-green/>
- Carbon Aware Kubernetes article
  - <https://greensoftware.foundation/articles/carbon-aware-kubernetes>
- Green software patterns
  - <https://patterns.greensoftware.foundation/catalog/cloud/>



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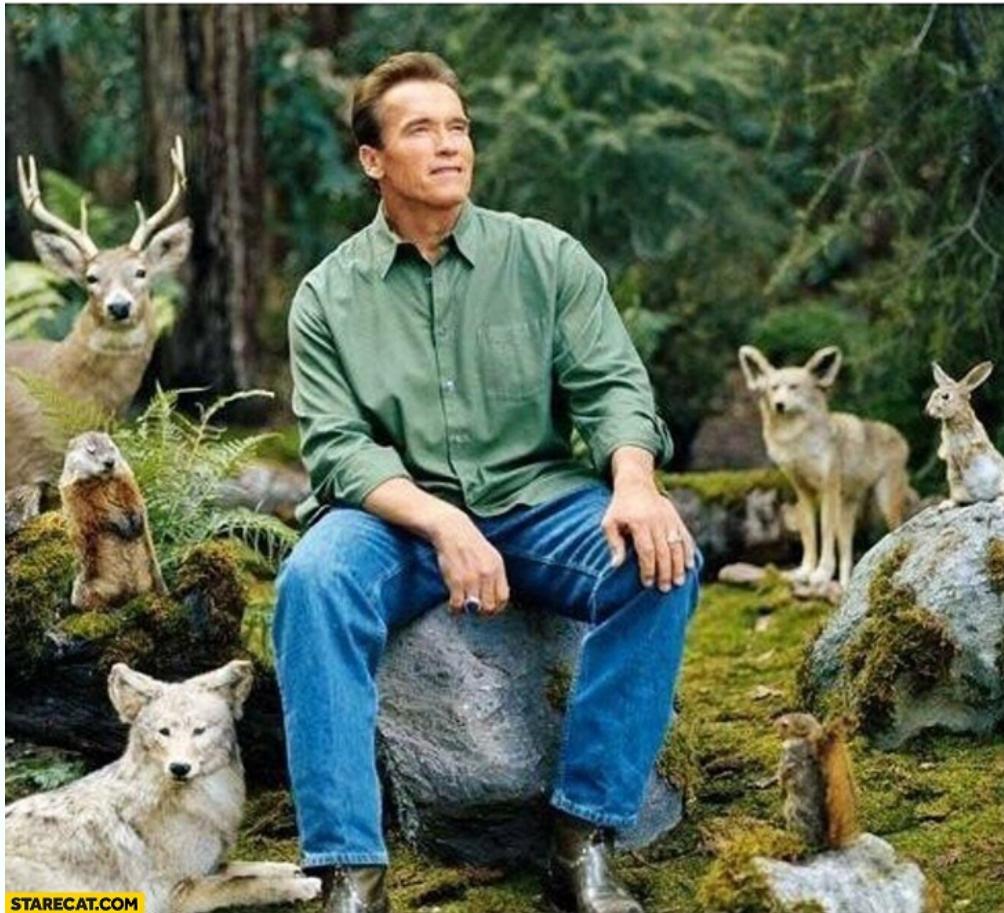
# Conclusion



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Thank you!

when you remember to bring your reusable bag to the grocery store



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