
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

# Welcome to the session!

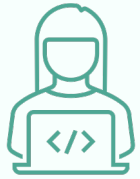
What will you learn?

# Agenda

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

People care about sustainability – but what about at work?

# 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.

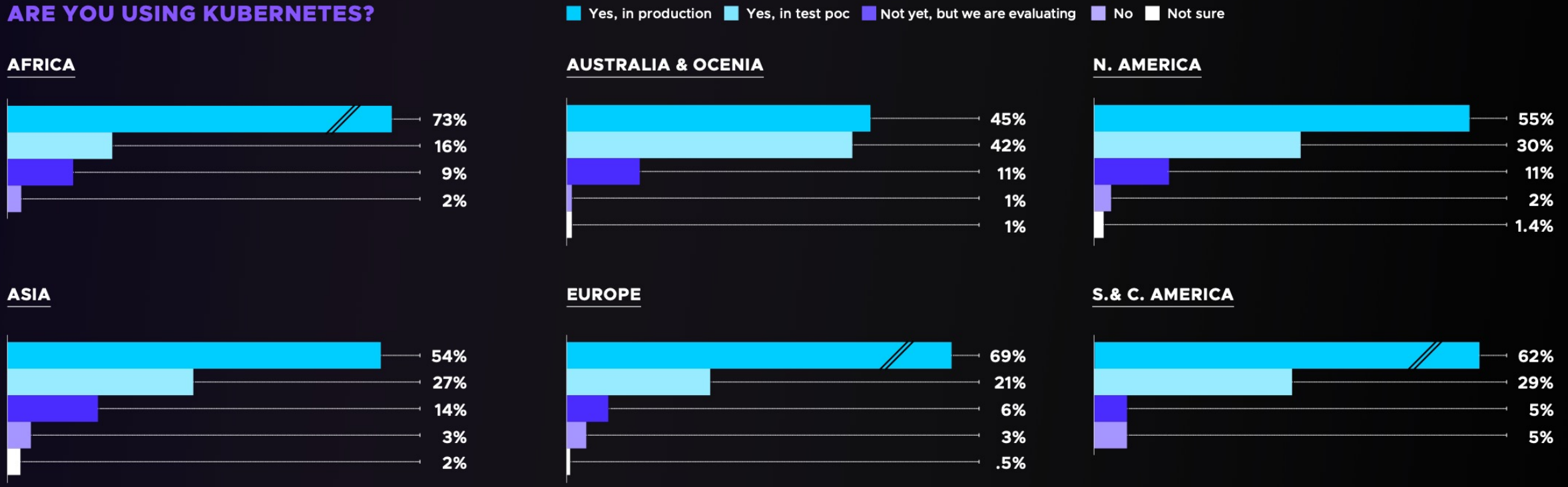
World is going to experience irreversible changes if climate change remains unchecked.

# 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?



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  - Services, Load Balancing, and Networking
  - Storage
  - Configuration
    - **Configuration Best Practices**
    - ConfigMaps
    - Secrets
    - Resource Management for Pods and Containers



# 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.

Edit this page
Create child pa
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General Configurat
"Naked" Pods versu
Deployments, and
Services
Using Labels
Using kubectl

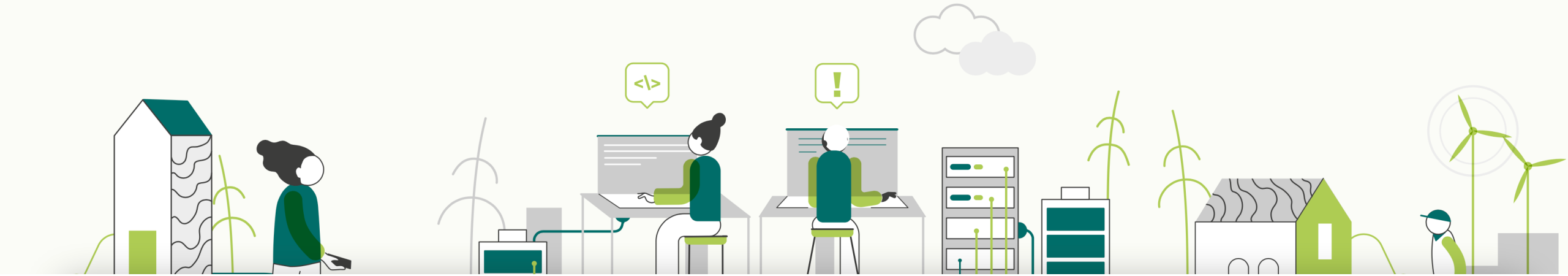
# Principles of Green Software

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

# GREEN SOFTWARE

Sign up to our newsletter...

Sign up



# Principles of Green software

- Carbon: Build applications that are carbon efficient.

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- Electricity: Build applications that are energy efficient.

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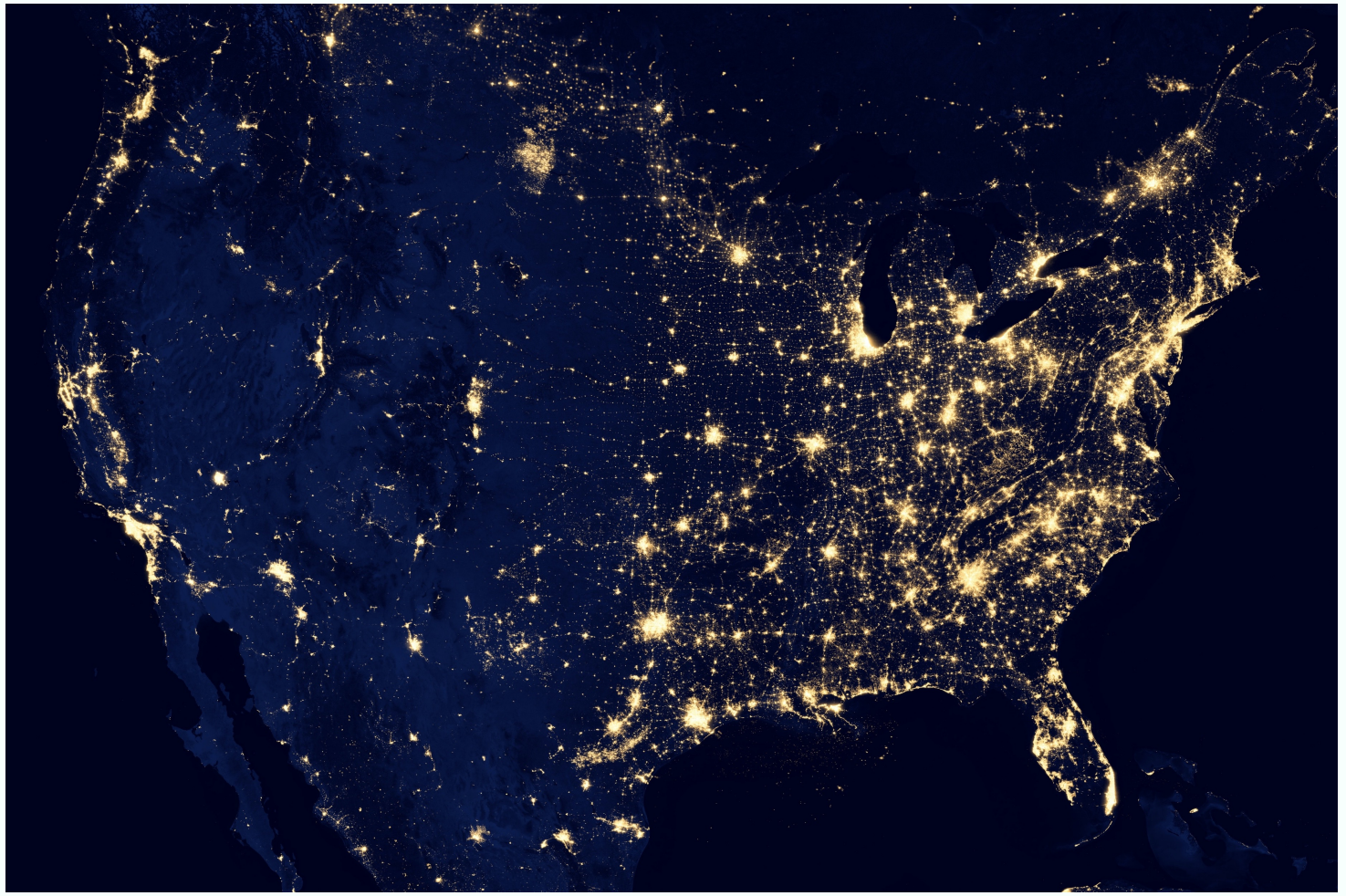
# Too many things? Focus on these:

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

# Energy

# Location sifting

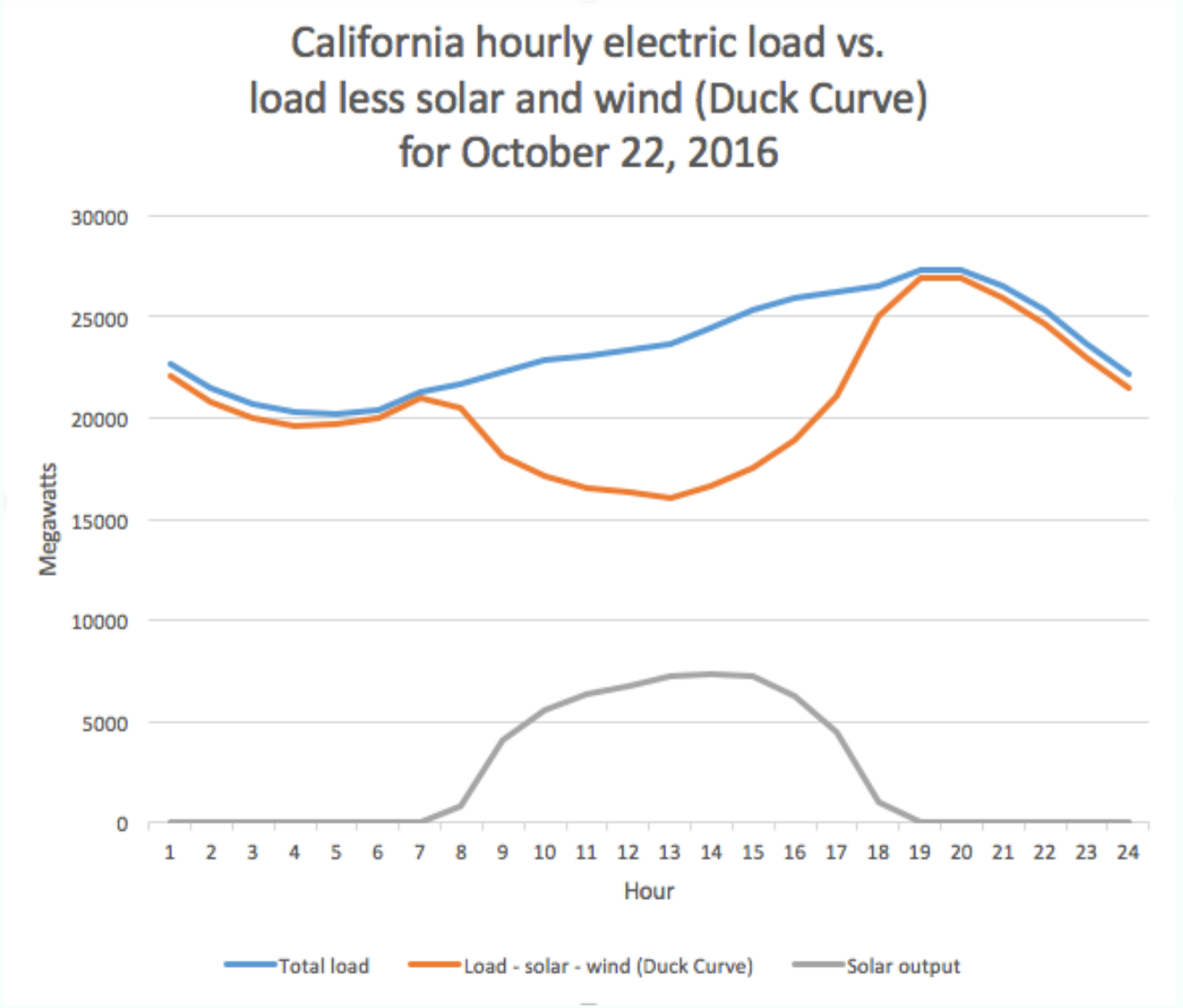


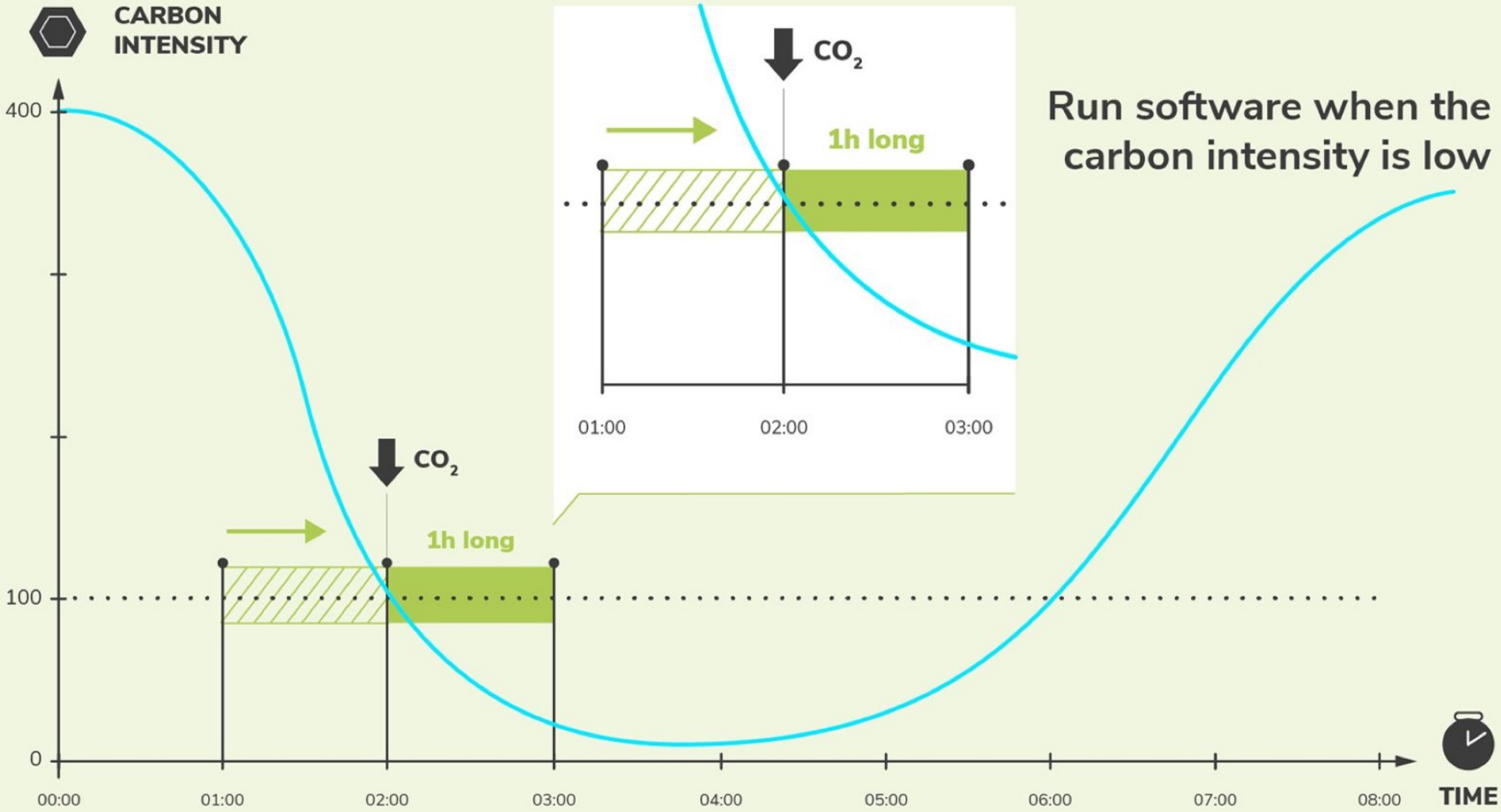
# Varies by location

Green Software Foundation

greensoftware.org

# Time sifting






## Run software when the carbon intensity is low

Green Software Foundation

greensoftware.org

# Demand shaping



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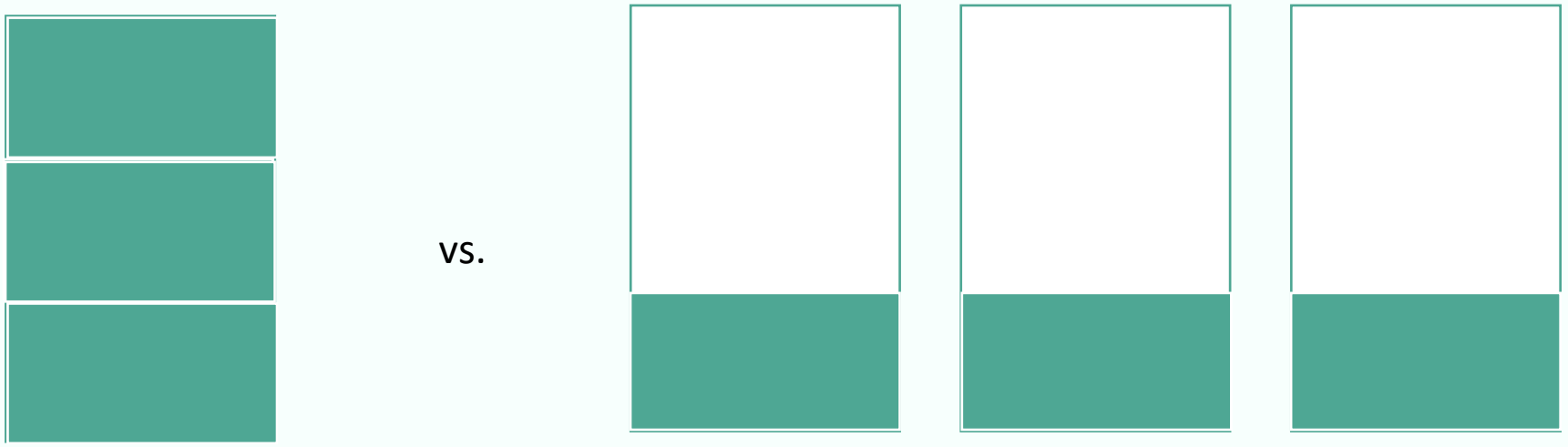
# Increasing utilization



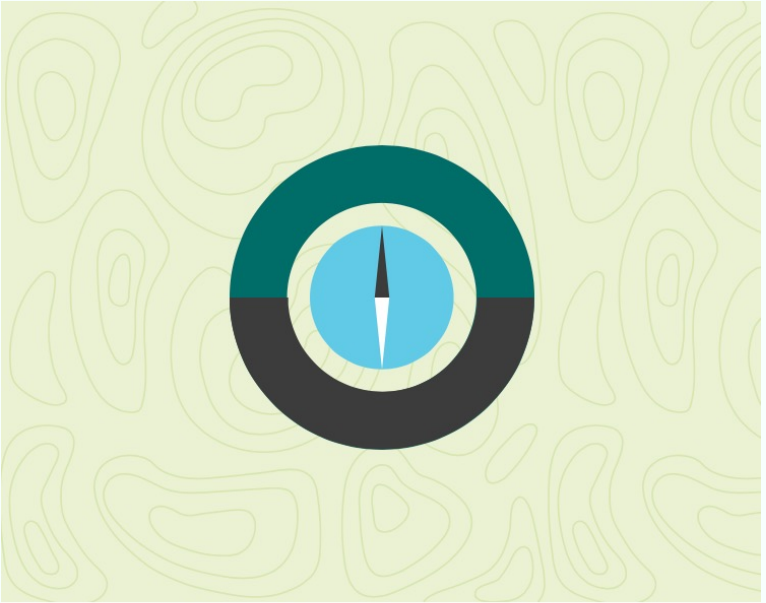

100%.

30%

30%

30%

# Software Carbon Intensity – SCI

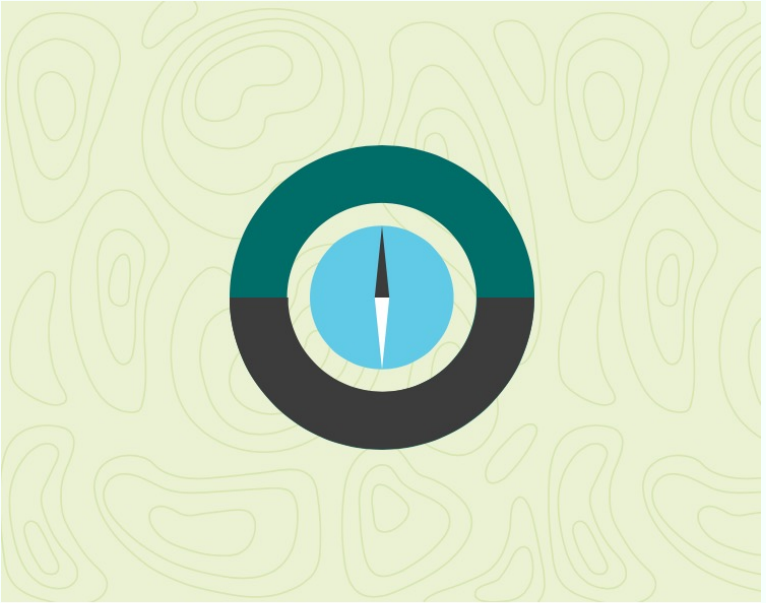


## Software Carbon Intensity (SCI) Specification

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.

# 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



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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

# 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

# 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

# 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.

# Energy Efficiency across Programming Languages

**Energy Efficiency across Programming Languages**

How Do Energy, Time, and Memory Relate?


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| | Energy |
|---|---|
| (c) C | 1.00 |
| (c) Rust | 1.03 |
| (c) C++ | 1.34 |
| (c) Ada | 1.70 |
| (v) Java | 1.98 |
| (c) Pascal | 2.14 |
| (c) Chapel | 2.18 |
| (v) Lisp | 2.27 |
| (c) Ocaml | 2.40 |
| (c) Fortran | 2.52 |
| (c) Swift | 2.79 |
| (c) Haskell | 3.10 |
| (v) C# | 3.14 |
| (c) Go | 3.23 |
| (i) Dart | 3.83 |
| (v) F# | 4.13 |
| (i) JavaScript | 4.45 |
| (v) Racket | 7.91 |
| (i) TypeScript | 21.50 |
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| (v) Erlang | 42.23 |
| (i) Lua | 45.98 |
| (i) Jruby | 46.54 |
| (i) Ruby | 69.91 |
| (i) Python | 75.88 |
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| (c) Swift | 2.71 |
| (i) Python | 2.80 |
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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 - reduntant copies
- Index
- Evaluate and optimize your queries
- Database cache

# 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

CNCF Open source projects to compliment Kubernetes

# 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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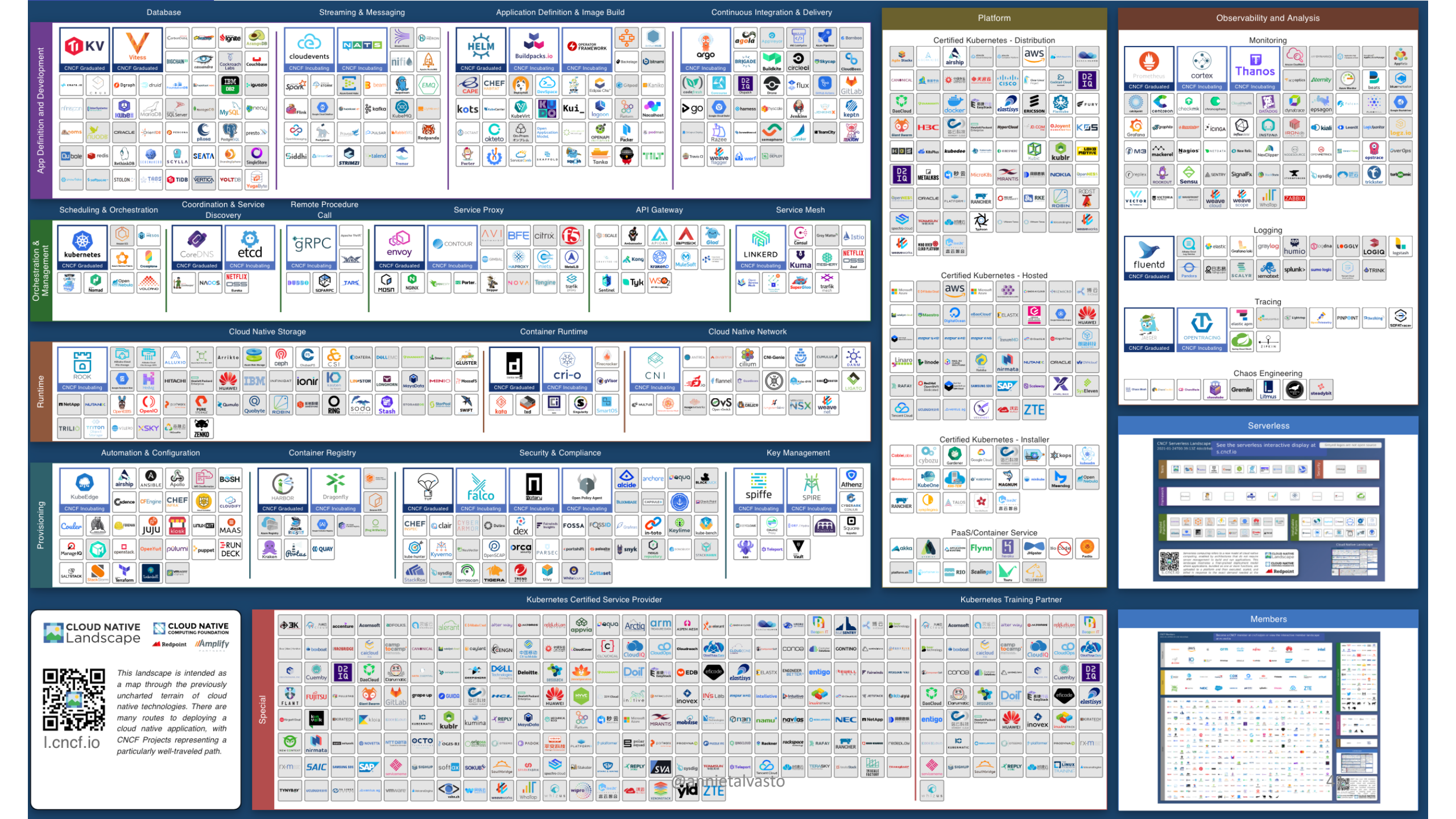

Database
Streaming & Messaging
Application Definition & Image Build
Continuous Integration & Delivery
App Definition and Development
Scheduling & Orchestration
Coordination & Service Discovery
Remote Procedure Call
Service Proxy
API Gateway
Service Mesh
Orchestration & Management
Cloud Native Storage
Container Runtime
Cloud Native Network
Runtime
Automation & Configuration
Container Registry
Security & Compliance
Key Management
Provisioning
Platform
Certified Kubernetes - Distribution
Certified Kubernetes - Hosted
Certified Kubernetes - Installer
PaaS/Container Service
Observability and Analysis
Monitoring
Logging
Tracing
Chaos Engineering
Serverless
Kubernetes Certified Service Provider
Kubernetes Training Partner
Special
Members
CLOUD NATIVE Landscape
CLOUD NATIVE COMPUTING FOUNDATION
Redpoint
Amplify
l.cncf.io
This landscape is intended as a map through the previously uncharted terrain of cloud native technologies. There are many routes to deploying a cloud native application, with CNCF Projects representing a particularly well-traveled path.
@annietalvasto

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

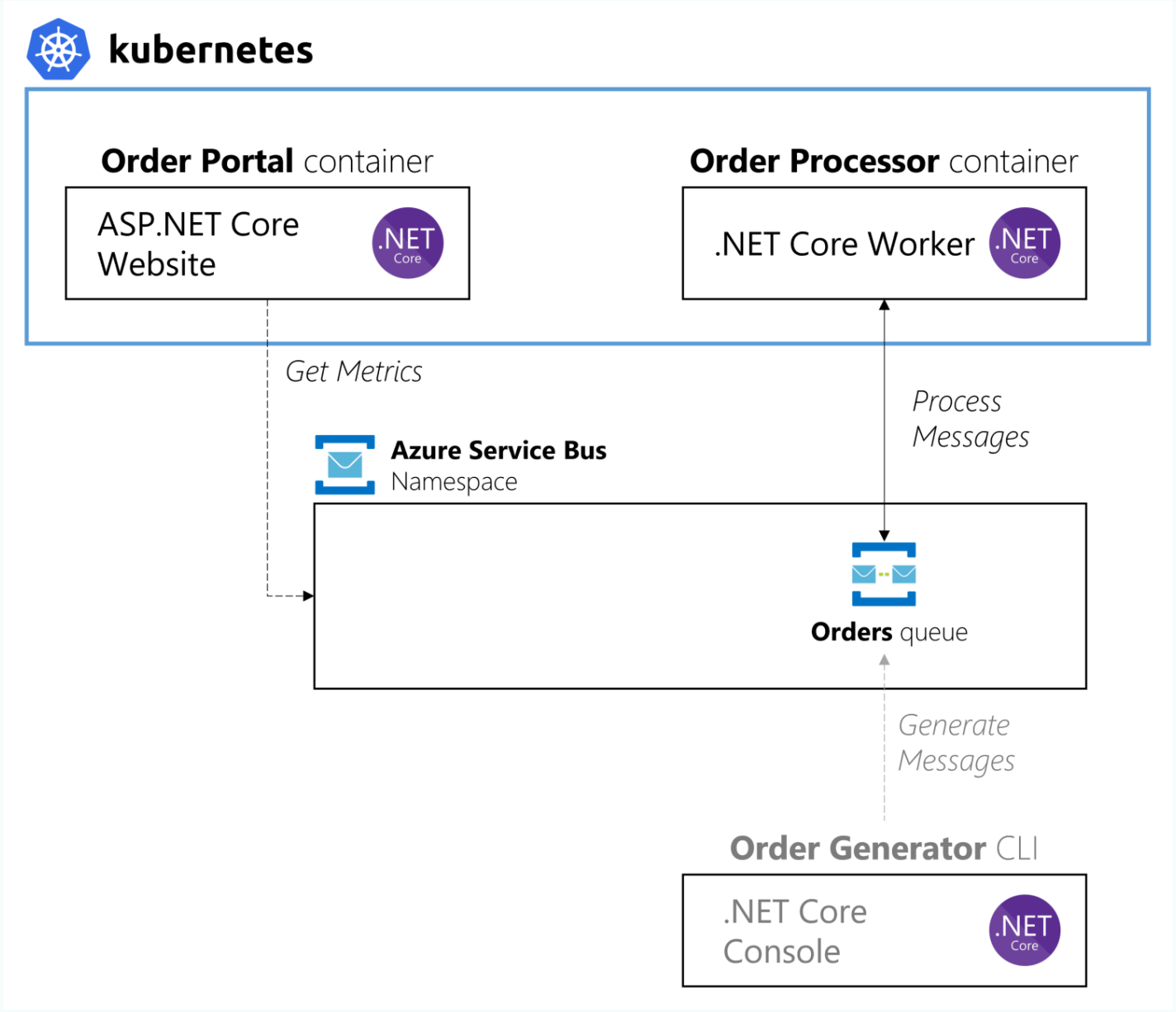
# Autoscaling

# 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


kubernetes
Order Portal container
ASP.NET Core Website
.NET Core
Order Processor container
.NET Core Worker
.NET Core
Get Metrics
Process Messages
Azure Service Bus
Namespace
Orders queue
Generate Messages
Order Generator CLI
.NET Core Console
.NET Core

# Service Mesh

LINKERD

# 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
  - Realiability
  - Security

# What are the benefits of Linkerd?

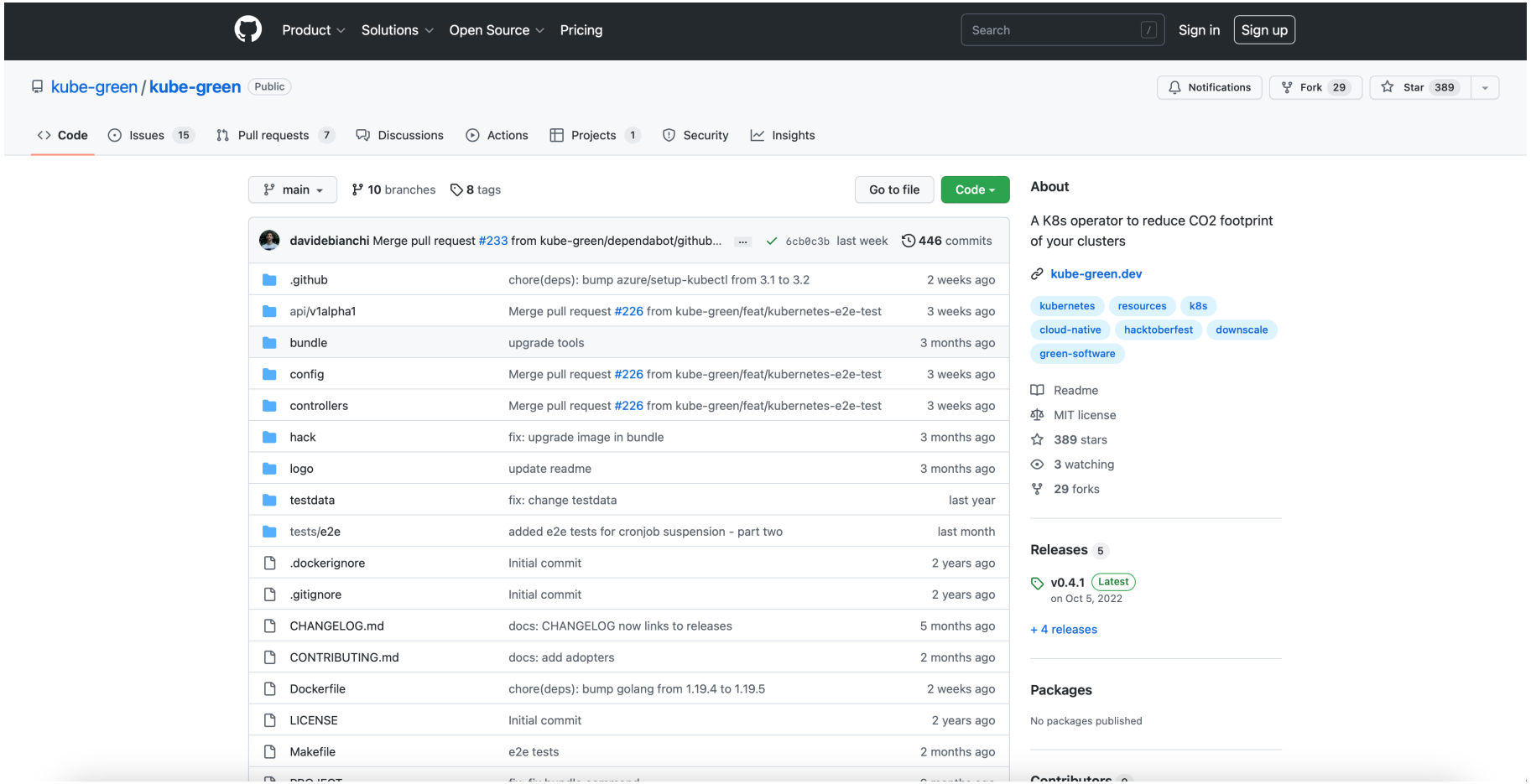
- Thriving open source community
- Simple, minimalist design
- Deep Runtime Diagnostics
- Ultralight and ultra fast
- Installs in seconds with zero config
- Actionable service metrics

# Policies

# What is Kyverno?

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

# Greenkube

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## 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 = **11 Kg CO2eq / year per pod**.

### CO2 Calculator

| | |
|---|---|
| CO2 per pods per year (kg CO2eq) | 11 |
| Total number of pods | 100 |
| Total pods when kube-green active | 100 |
| Hour of sleep per week | 128 |

**Results**

**Total (Kg CO2eq/week)**

without kube-green: 21

**with kube-green: 5**

**Difference: -16**



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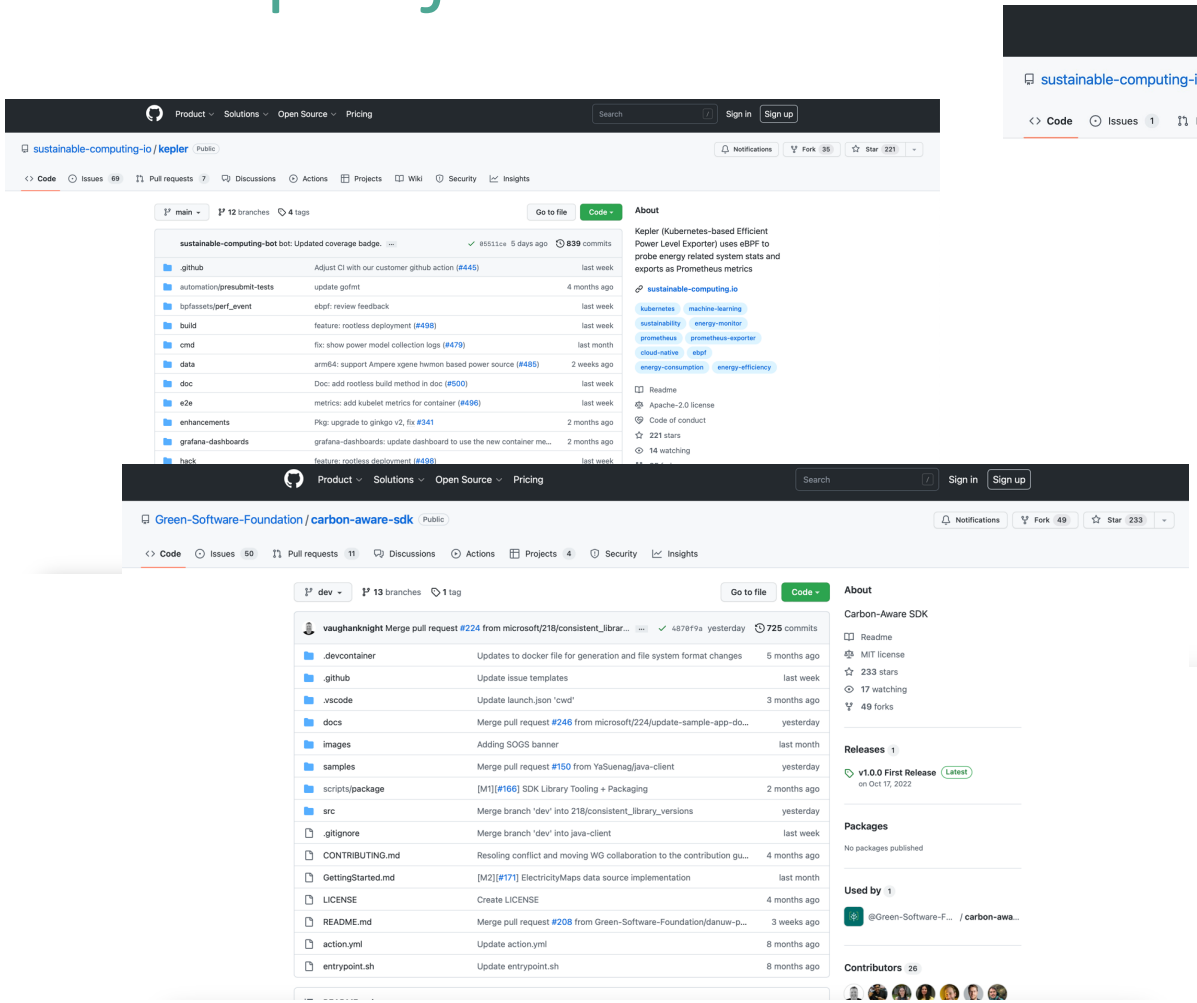
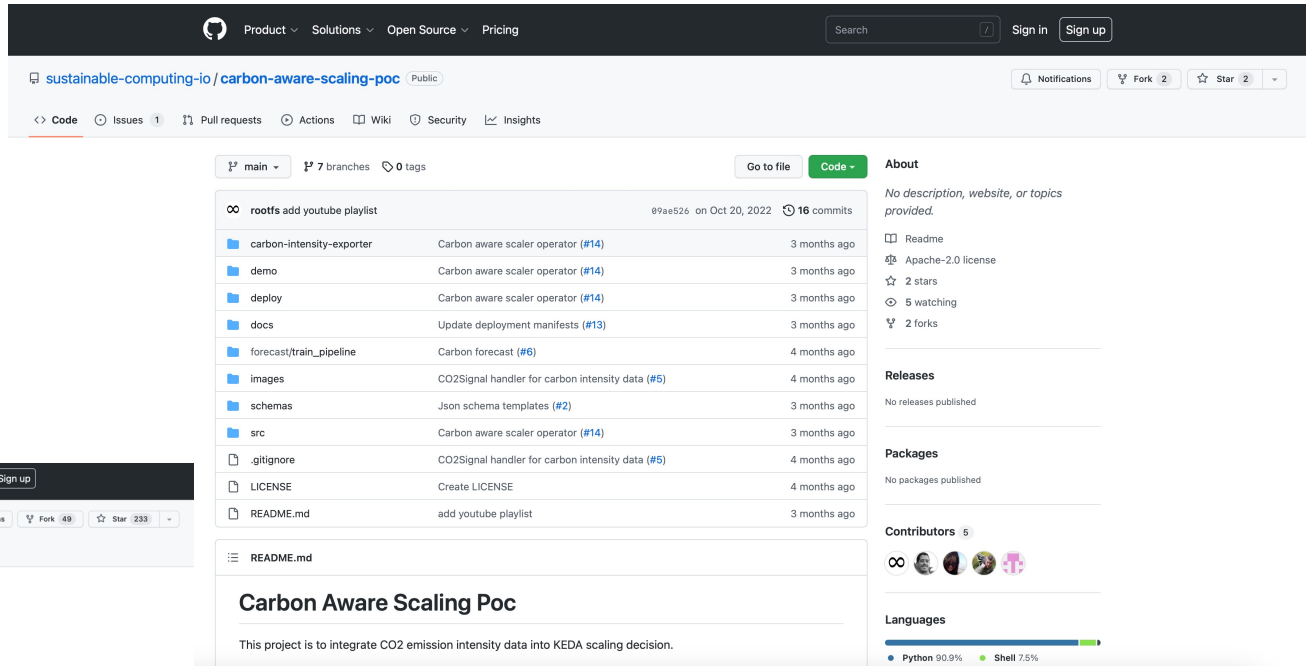
Adopters »

# More projects



## Reminder:

Use best practices from other fields creatively and as fits!

# Quick tips

Observability

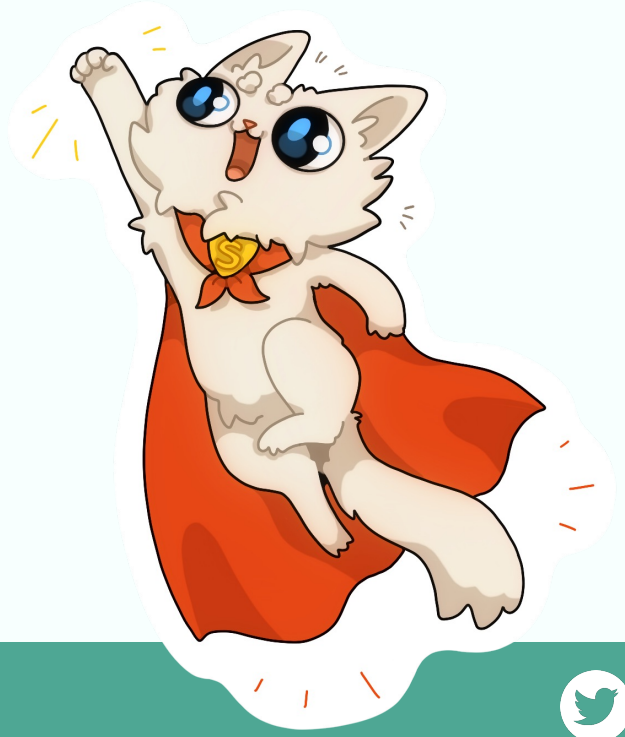
Optimization

Governance

# Benefits

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

Saving the world !



# Wrap up

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

# Resources

- Slides & materials:
  - Github.com/annietalvasto

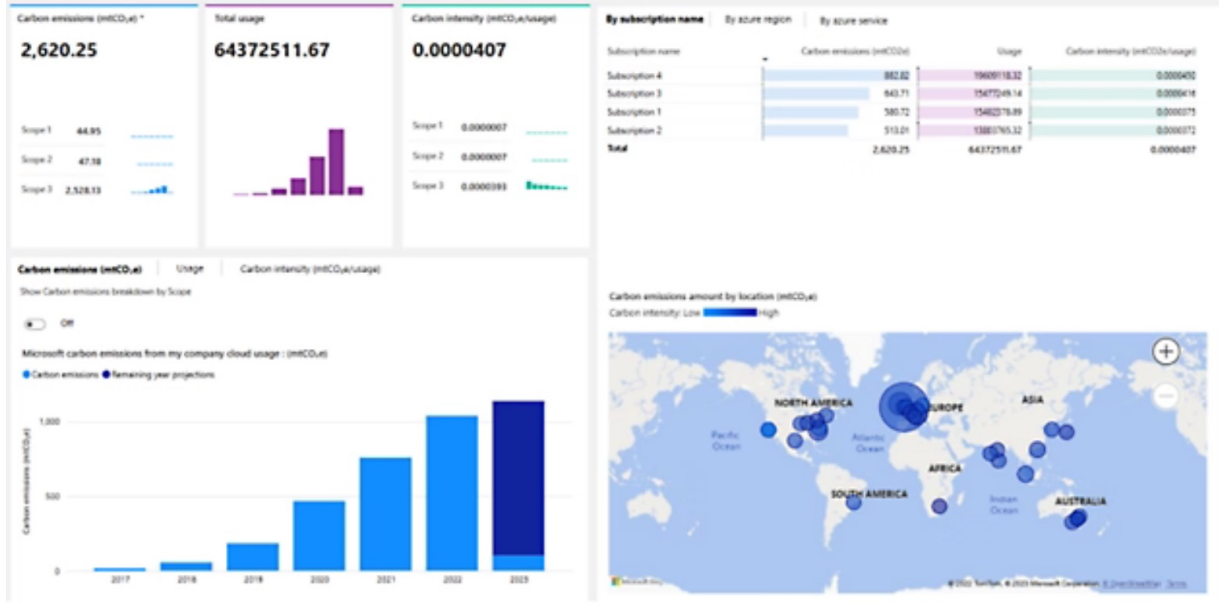
# Resources

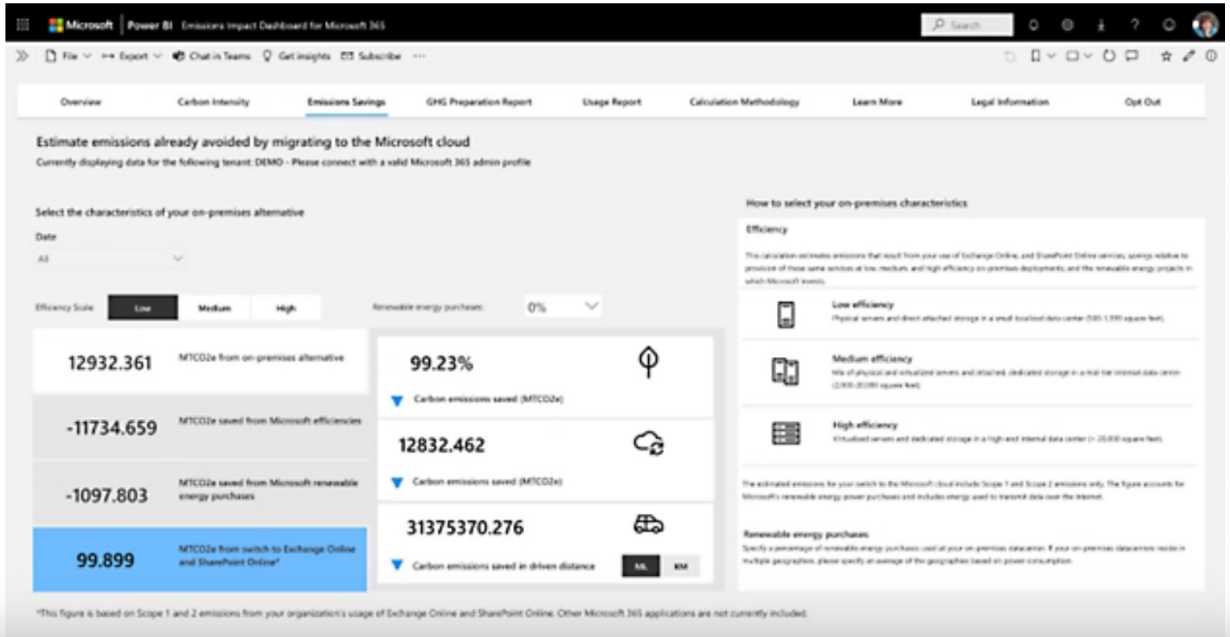
- **Green Software Foundation**
  - https://greensoftware.foundation
  - Youtube, Podcast, blog etc
  - A lot of upcoming pro

- **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=XFZZ9YfOyI8
  - 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

# 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 CO2-equivalent metric tons, through cloud data export.
- **New!** Access your Azure emissions data with the Microsoft Cloud for Sustainability API (Preview).




## 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 26th February and then email 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/NDC**

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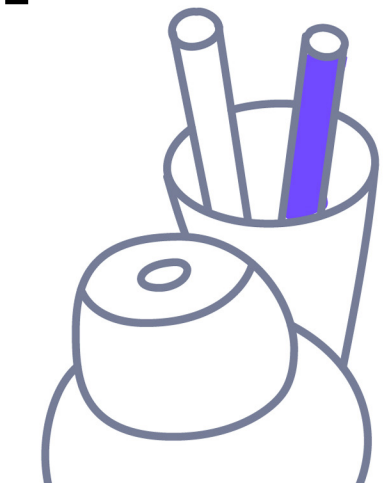

**Full terms & conditions for the UK challenge at https://aka.ms/challenge/ndc/terms-conditions*

# 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
- 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/

# Conclusion

# Thank you!


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