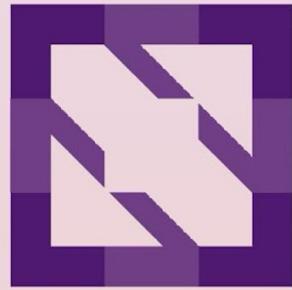


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# Building Carbon Awareness with KEDA

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*Developer Advocate*

*Microsoft*

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# Agenda

- Being energy conscious
- Green Software Principles
- Kubernetes Carbon Intensity Exporter
- Carbon Aware KEDA Operator
- Next steps

# Being Energy Conscious

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A photograph of a small, vibrant green plant with four leaves growing from a dark, textured crack in a light-colored paved surface. The background is blurred, showing a city street at sunset with warm orange and yellow light reflecting off buildings and a car. The overall theme is environmental resilience and urban greening.

# Green Software Principles

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# Green Software Principles



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Energy  
Efficiency



Hardware  
Efficiency



Carbon  
Awareness

# Types of Energy



## Clean energy



Wind



Solar



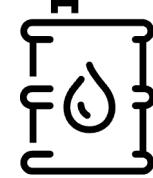
Hydroelectric



## Dirty energy



Coal



Gas

# Software Carbon Intensity (SCI)

E

Energy efficiency (E)  
Make software use less electricity

M

Hardware efficiency (M)  
Make software use fewer physical resources

I

Carbon awareness (I)  
Adapt Computation to take advantage of low carbon sources of electricity

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

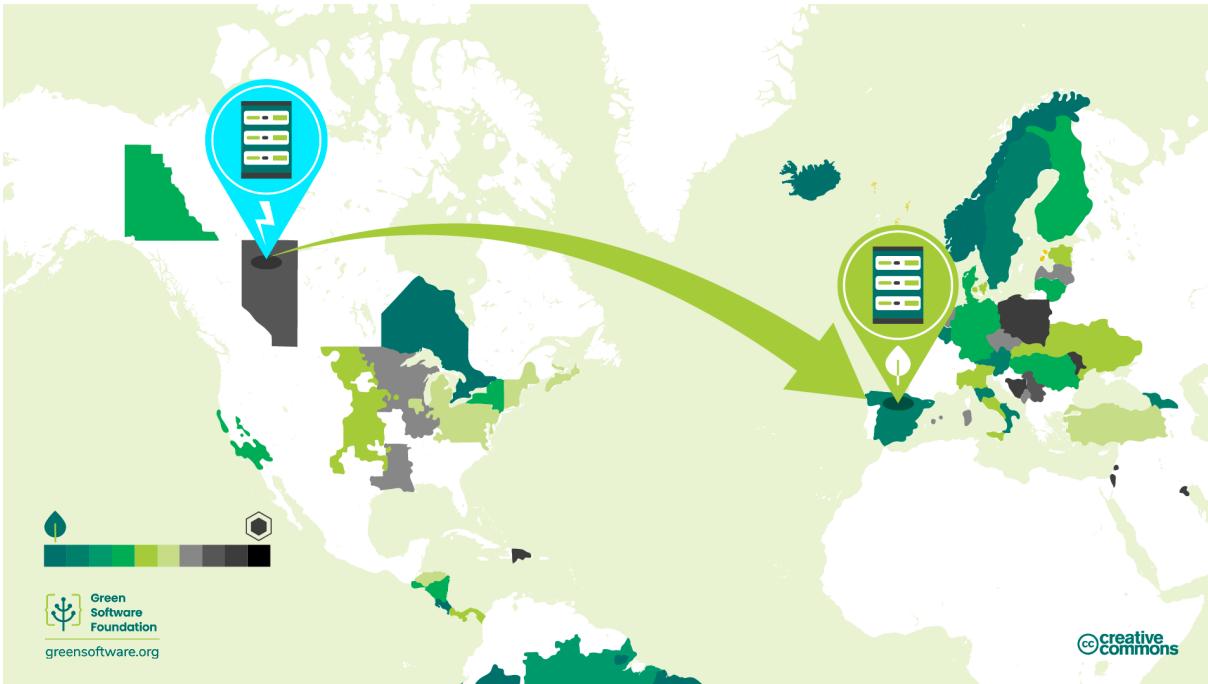
**E**=Energy consumed by software in kWh

**I**=Carbon emitted per kWh of energy, gCO<sub>2</sub>/kWh

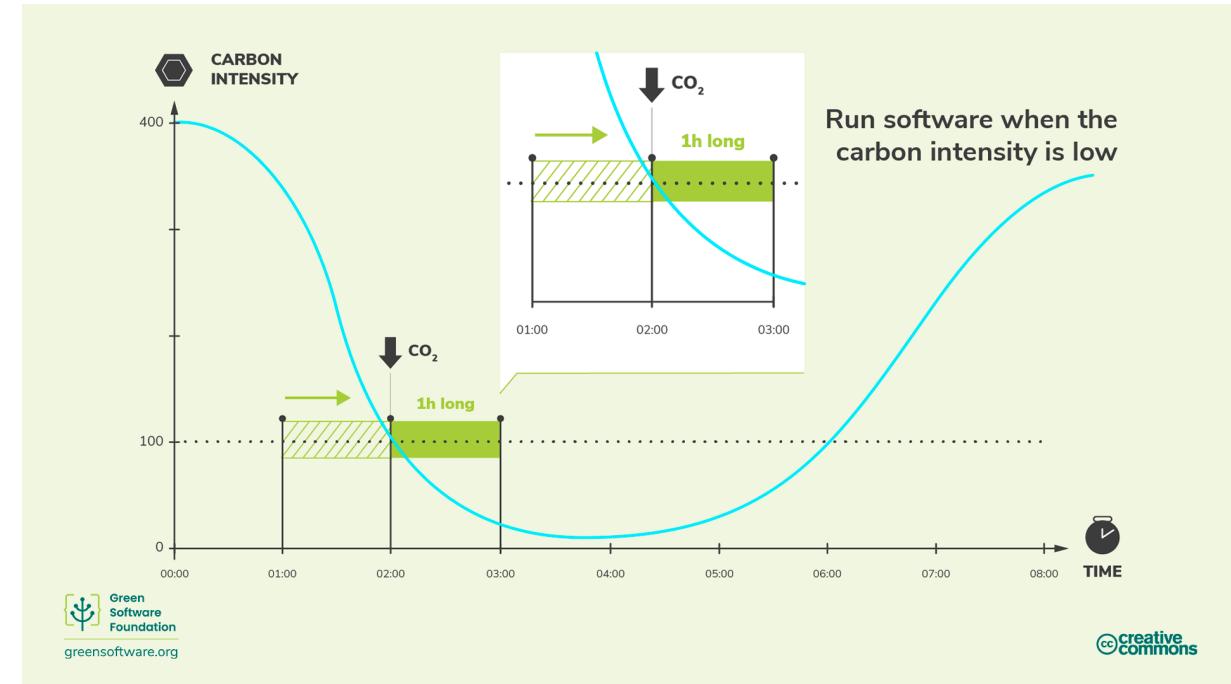
**M**=Carbon emitted through the hardware that the software is running on

**R**=Functional Unit; this is how software scales, for example per user or per device

# Demand Shifting



Spatial



Temporal

# Demand Shaping

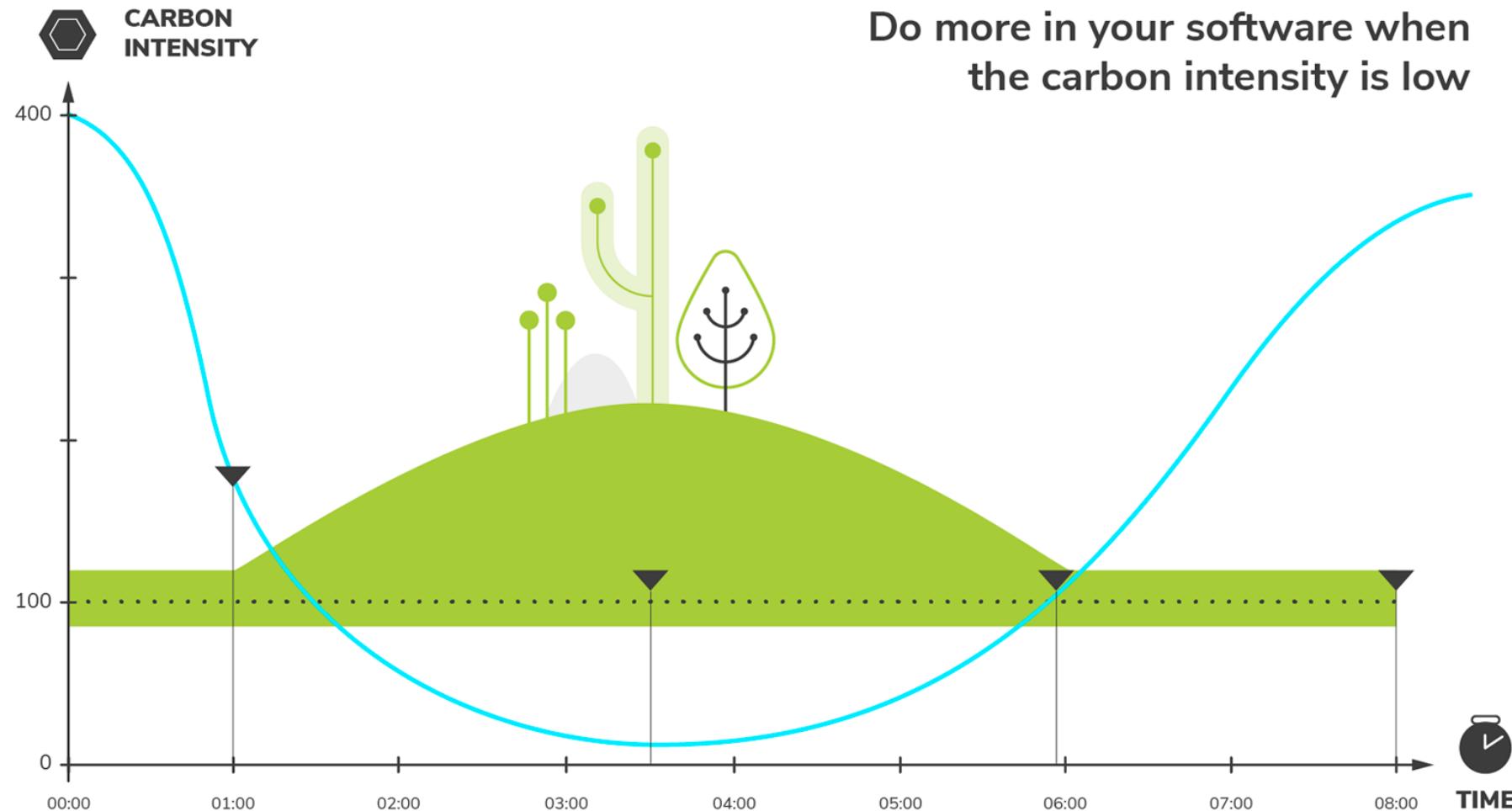


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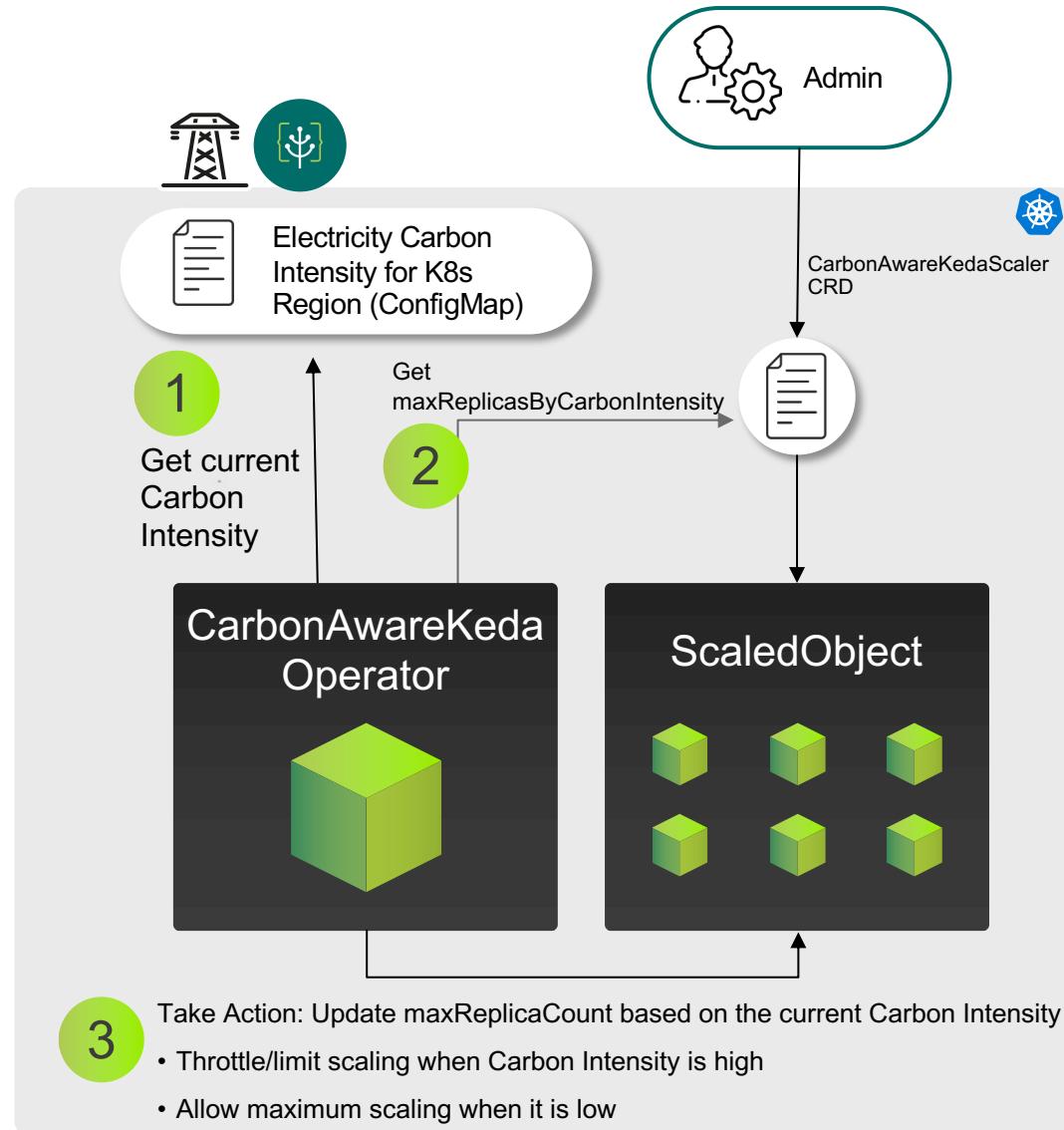


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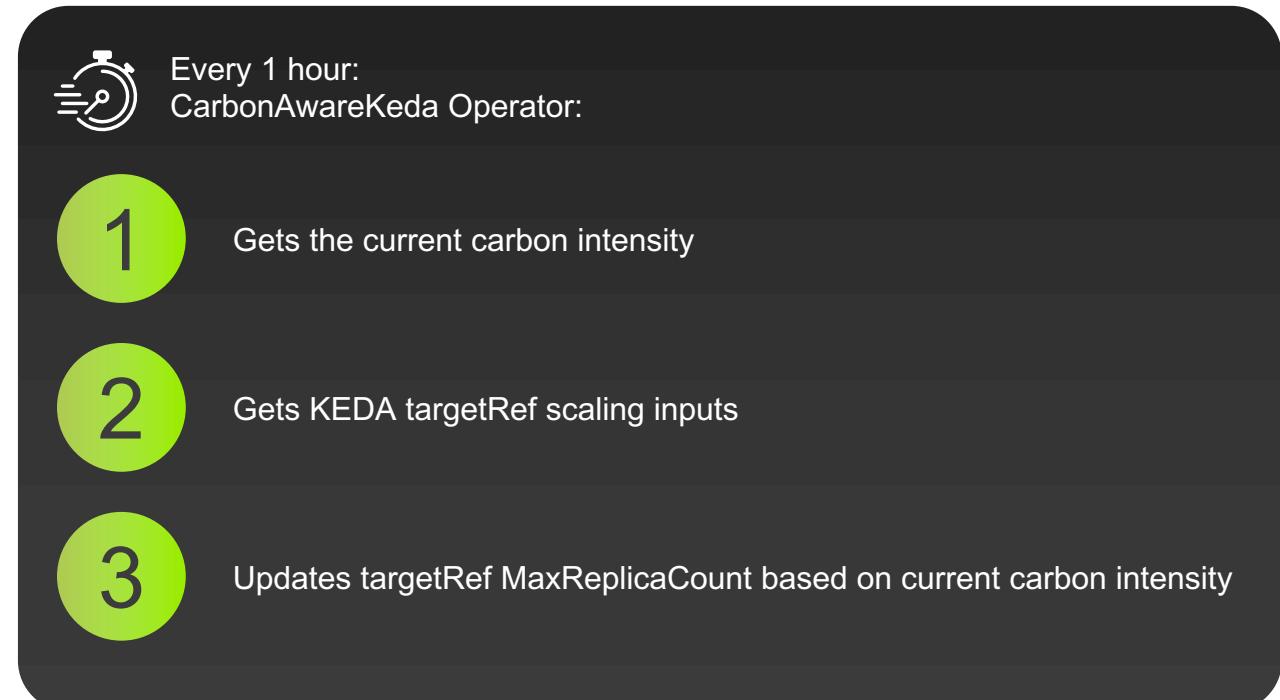
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# Carbon Aware KEDA Operator



**Step 0: Admin creates CarbonAwareKedaScaler**



# Custom Resource Definition

```
type CarbonAwareKedaScalerSpec struct {
    // keda type to target (scaledObject or scaledJob)
    KedaTarget KedaTarget

    // name of the keda target
    KedaTargetRef KedaTargetRef

    // data source of carbon intensity values
    CarbonIntensityForecastDataSource CarbonIntensityForecastDataSource

    // array of carbon intensity configs
    MaxReplicasByCarbonIntensity []CarbonIntensityConfig []CarbonIntensityConfig

    // configuration to disable carbon aware scaler
    EcoModeOff EcoModeOff
}
```

# Custom Resource Definition

```
type CarbonIntensityConfig struct {
    // carbon intensity threshold to scale the number of replicas
    CarbonIntensityThreshold int32

    // maximum number of replicas to scale to
    MaxReplicas *int32
}
```

# Custom Resource Definition

```
type CarbonAwareKedaScalerSpec struct {
    // keda type to target (scaledObject or scaledJob)
    KedaTarget KedaTarget

    // name of the keda target
    KedaTargetRef KedaTargetRef

    // data source of carbon intensity values
    CarbonIntensityForecastDataSource CarbonIntensityForecastDataSource

    // array of carbon intensity configs
    MaxReplicasByCarbonIntensity []CarbonIntensityConfig

    // configuration to disable carbon aware scaler
    EcoModeOff EcoModeOff
}
```

# Custom Resource Definition

```
type EcoModeOff struct {
    // default maximum number of replicas
    MaxReplicas int32

    // start and end time periods to disable
    CustomSchedule []Schedule

    // recurring schedule in Cron format to disable
    RecurringSchedule []string

    // carbon intensity too high for too long?
    CarbonIntensityDuration CarbonIntensityDuration
}
```

# Custom Resource Definition

```
apiVersion: carbonaware.kubernetes.azure.com/v1alpha1
kind: CarbonAwareKedaScaler
spec:
  kedaTarget: scaledobjects.keda.sh
  kedaTargetRef:
    name: word-processor-scaler
    namespace: default
  carbonIntensityForecastDataSource:
    localConfigMap:
      name: carbon-intensity
      namespace: kube-system
      key: data
  maxReplicasByCarbonIntensity:
    - carbonIntensityThreshold: 358
      maxReplicas: 110
    - carbonIntensityThreshold: 436
      maxReplicas: 10
  ecoModeOff:
    maxReplicas: 100
  customSchedule:
    - startTime: "2023-11-09T17:45:00Z"
      endTime: "2023-11-09T18:00:59Z"
  recurringSchedule:
    - "* 23 * * 1-5"
```



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# Demo: Carbon Aware KEDA Operator

# Next Steps

Join the discussion

<https://github.com/kedacore/keda/issues/4463>

Decarbonize Software

<https://grnsft.org/decarb>

Green Software Practitioner

<https://learn.greensoftware.foundation/>

Sustainability with AKS

<https://aka.ms/aks/learn-sustainable-software>



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- Jorge Palma
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- Steven Murawski
- Ross Fairbanks
- Green Software Foundation
- KEDA community



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