

# HPC CARBON INTENSITY

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## GREENHPC

## HPC-CI specification

- The definition, application, and calculation of the HPC Carbon Intensity (HPC-CI) is heavily inspired by the Software Carbon Intensity (SCI) from the Green Software Foundation.
- HPC-CI is a methodology to calculate your emissions from HPC system use and to encourage action towards eliminating emissions.
- This is not a replacement for the GHG protocol, but an additional metric to help you understand how your HPC system use can be measured in terms of carbon emissions, and thus help you make informed decisions.
- The GHG protocol and the HPC-E calculate **total emissions**, HPC-CI is for calculating the **rate of emissions**.
- In automotive terms: GHG/HPC-E is like total carbon footprint of a car manufacturer and all the cars they produce every year, while HPC-CI is like miles per gallon.

## HPC-CI specification

- It is important to note that it is not possible to reduce your HPC-CI rate by purchasing offsets in the form of neutralisations, compensations, or by offsetting electricity in the form of renewable energy credits.
- This means any HPC system use that makes no effort toward reducing emissions but spends money on carbon credits cannot reduce the associated HPC-CI rate.
- Offsets are an essential component of any climate strategy; however offsets are not eliminations.
- If you make your HPC use more **energy efficient**, **hardware efficient**, or **carbon aware**, your HPC-CI rate will decrease. Investing time or resources into one of these three principles is the only way to reduce the HPC-CI rate.

## The HPC-CI equation

- The equation to calculate an HPC-CI rate is simple and very closely related to the calculation of total emissions (HPC-E) presented previously:

$$HPC - CI = [(E \times CI) + M] \text{ per } R$$

- $E$  = energy consumed by HPC use (in kWh)
  - $CI$  = location-based carbon intensity (in kgCO<sub>2</sub>e/kWh)
  - $M$  = embodied emissions (in kgCO<sub>2</sub>e)
  - $R$  = functional unit (e.g. iterations, simulated time, calculation cycles, research papers published, cost)
- This yields an emissions rate in carbon emissions per functional unit, such as kgCO<sub>2</sub>e / iteration.

## The HPC-CI equation

- The steps to calculate your HPC-CI score are the same as calculating your total emissions (HPC-E) described before, with additional steps to produce the rate.
  - 1. Gather your energy use
  - 2. Determine the carbon intensity at the location of the HPC system you are using
  - 3. Determine the embodied emissions associated with your use of HPC
  - 4. Compute your total HPC emissions
  - 5. Select your functional unit ( $R$ )
  - 6. Calculate your HPC-CI rate

## The HPC-CI equation – 5. Select your functional unit $R$

- The HPC-CI is a rate rather than a total and measures the intensity of emissions according to the chosen functional unit.
- The specification currently does not prescribe the functional unit; you are free to pick whichever suits the output from your use of HPC systems best.
- For example, this could be a metric from the software you use (ns simulated, number of years simulated, iterations) or a metric tied to research progress (number of compounds modelled, data points analysed, papers published).
- Imagine you are simulating the dynamics of a biomolecular system (using software such as GROMACS, Amber, or NAMD), then you might want to choose number of ns simulated as your unit.
- You can use multiple functional units to have multiple HPC-CI values, each of which may be more useful than others in different contexts.

## The HPC-CI equation – 6. Calculate HPC-CI rate

- Now you have both the total emissions for your use of HPC systems, and the number of functional units arising from the same use of HPC systems you can calculate HPC-CI by dividing the total emissions by the total number of functional units.
- Continuing the biomolecular simulation, let's say the total emissions from our HPC system use is 1500 kgCO<sub>2</sub>e, and the total number of functional units are 950 ns simulated:
  - $\text{HPC-CI} = 1500 / 950 = 1.58 \text{ kgCO}_2\text{e/ns}$
- As well as a tool to help quantify HPC system use, HPC-CI can be used to project emissions from HPC system use for future or planned projects. Many funding bodies are starting to ask for emissions estimates as part of the submission process.

## Key Points

- The GHG protocol is a metric for measuring an organisation's total carbon emissions and is used by organisations all over the world.
- The GHG protocol puts carbon emissions into three scopes. Scope 3, also known as value chain emissions, refers to the emissions from organisations that supply others in a chain. In this way, one organisation's scope 1 and 2 will sum up into another organisation's scope 3.
- You can use the GHG protocol to estimate your emissions from HPC system use but it requires access to reasonable quality information from the HPC systems you are using.
- The HPC-CI is a metric designed specifically to calculate emissions from HPC systems and is a rate rather than a total. This can be used to measure improvements in emissions efficiency and drive reductions in emissions.