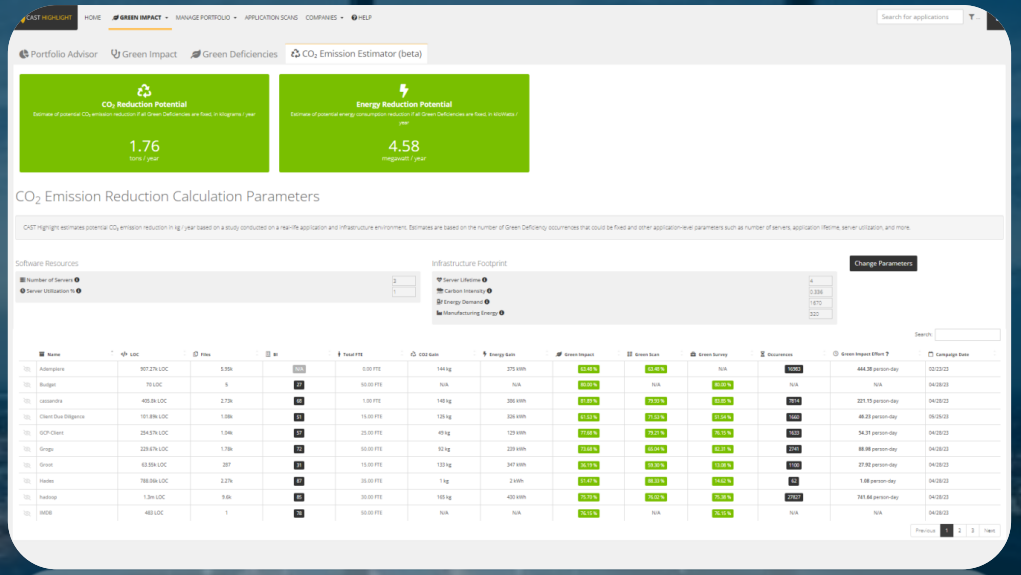
CAST

Software Intelligence for Digital Leaders



CAST Case Study

Using software intelligence and SCI to estimate CO_2 emissions

March 2024

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Overview

CAST Research Labs conducted a study to understand the impact on CO_2 emissions and energy consumption when removing green deficiencies automatically detected by CAST Highlight from the code of a custom software application.

The results of the study and the SCI formula were used to develop an initial model for estimating the potential CO_2 emissions reduction and build it into CAST Highlight.

The model is the basis of the new CAST Highlight CO_2 Emissions Estimator dashboard that was released in beta in Winter 2024.

This document includes more detail on this new capability, the underlying formula it leverages, and how it was developed.

Summary of CO_2 Emissions Reduction Study

CAST Research Labs conducted a study to understand the impact on CO_2 emissions and energy consumption when removing green deficiencies from the source code of a custom software application.

Here is an abridged summary of the steps in the study:

1. The application was analyzed by CAST Highlight to identify all green deficiencies.
2. The application was operated on the cloud and key application functions were executed thousands of times using automated tools.
3. The execution duration of the functions was measured using available diagnostic tools on the cloud platform to create a baseline.
4. A selection of ten (10) green deficiencies related to these application functions were then remediated with a more efficient coding method. The remediation process took an estimated four person days of effort.
5. The execution duration was then measured again for the “greener” version of the application and there was a ~5% improvement in the duration.
6. These results and the SCI formula were used to develop a model for estimating the potential improvements in CO_2 emissions and energy consumption that could be experienced for any application.
7. The model was then built into CAST Highlight and released in beta since it is based on a small sample size and will be refined over time when additional results are available.

Model for estimating potential CO_2 emission reduction

$$CO_2eq\ emission\ reduction = \frac{n_{GD}}{MLOC} . f . (n_{server} . ts) \left(\frac{e_{manufacturing}}{lifetime} + ed . CI \right)$$

Number of green deficiencies per MLOC

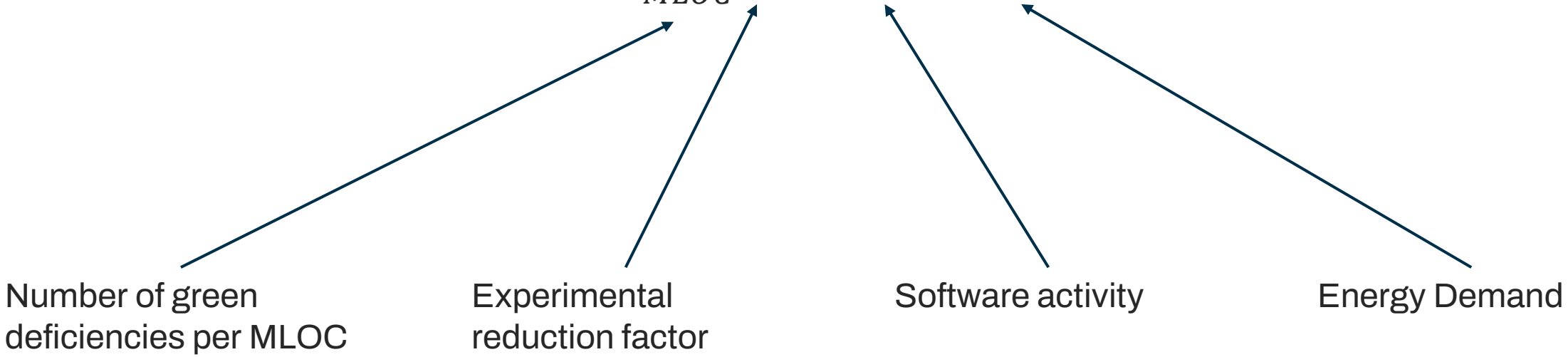
Experimental reduction factor

Software activity

Resource footprint

Model for estimating potential energy reduction

$$Energy\ reduction = \frac{n_{GD}}{MLOC}.f.(n_{server}.ts)\ (ed\ )$$



Model Parameters

Parameter	Description	Source
n_{GD}	Number of green deficiencies detected	Automatically calculated by CAST Highlight
MLOC	Millions of lines of code	Automatically calculated by CAST Highlight
f	The factor to calculate potential reductions if green deficiencies are fixed as observed in the study conducted by CAST Research Labs	Fixed value: 0.004 %.MLOC/deficiencies
n_{server}	Number of servers that the application utilizes to operate	User supplied (default = 3)
ts	The time sharing or percent utilization of the server resource capacity	User supplied (default = 100%)
$e_{manufacturing}$	The CO_{2eq} emissions during manufacturing of servers	User supplied (default = 320 $kgCO_{2eq}$ for a DELL PowerEdge R640)
lifetime	The expected lifetime of the servers in years	User supplied (default = 4)
ed	The annual energy demand for each server	User supplied (default = 1670 kWh/year for a DELL PowerEdge R640)
CI	The carbon intensity of the environment where the application is running	User supplied (default = 0.336 $kgCO_2$/kWh for North America)

Model Illustration

Using results from the CAST study with the following parameters:

- 282.42 kLOC => 0.28242 MLOC
- n_{GD} : 1676 green deficiencies
- CI: 0.336 $kgCO_{2eq}$ per server per year in North America region
- ed: 1670 kWh per year
- $e_{manufacturing}$: 320 $kgCO_{2eq}$
- l: 4 years
- n_{server}: 3 DELL PowerEdge R640 equivalent
- ts: exclusive use 100%

Calculated results:

- Potential Emission Reduction: 404 $kgCO_{2eq}$ per year or 1.1 $kgCO_{2eq}$ per day

How is the Model related to the Green Software Foundation's SCI?

CAST utilized the GSF's Software Carbon Intensity (SCI) formula as a basis for our calculations.

SCI = (O + M) / R

- O operational emissions
- M embodied emissions
- R functional unit

O = (E x I)

- E energy consumed
- I location-based marginal carbon intensity

O is represented by the n_{server}, ts, ed, CI parameters in CAST's implementation

M = TE x TS x RS

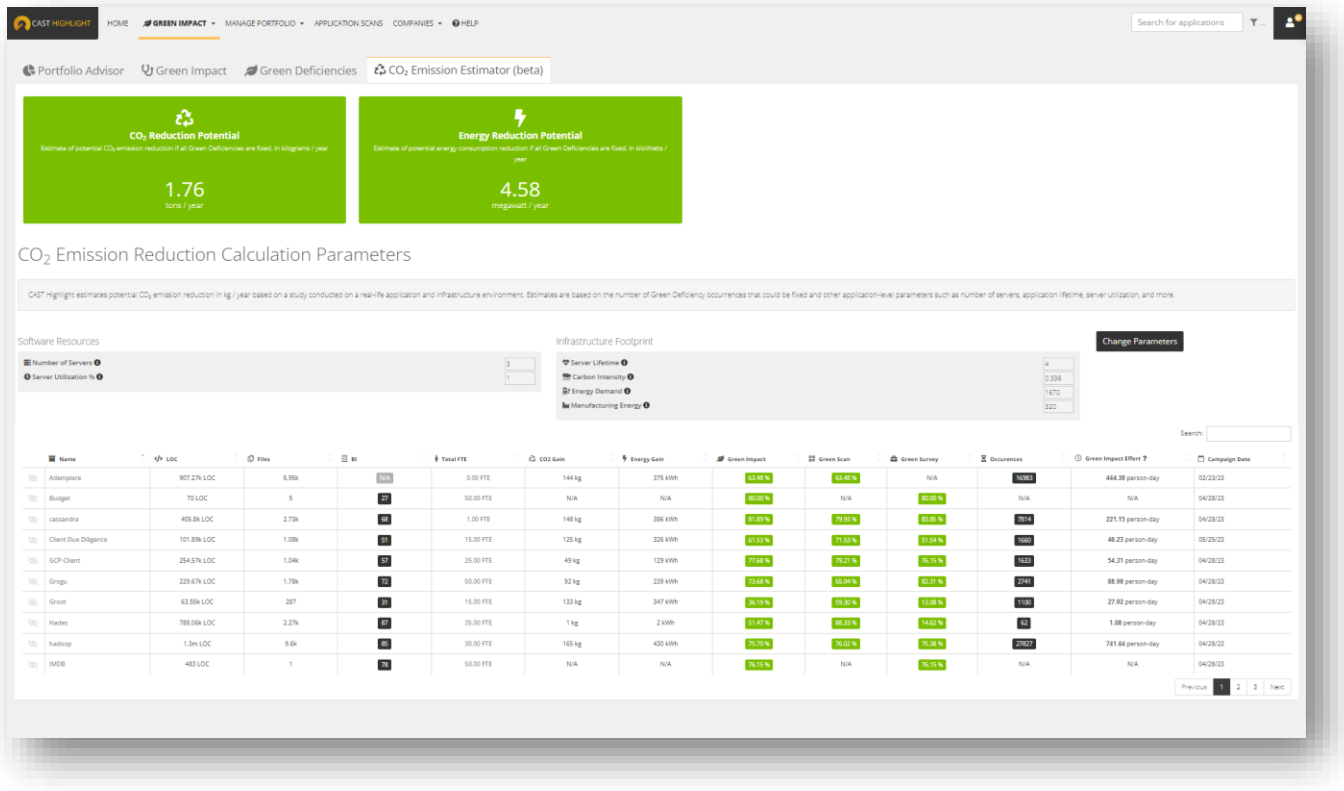
- TE total embodied emissions, across the whole lifecycle of the resource
- TS time-share, in case the resource is not allocated to the software 100% of the time
- RS resource-share, in case the resource is shared with other pieces of software

M is represented by the n_{server}, ts, $e_{manufacturing}$, lifetime parameters in CAST's implementation

R = the entire application in the CAST implementation

Note: the GSF has submitted the Software Carbon Intensity (SCI) formula to ISO with expected approval as a standard in 2024.

CO_2 Emission Estimator (beta) available within CAST Highlight



- Get estimates on the potential reduction in CO_2 emissions and energy consumption if Green Deficiencies are fixed in applications
- Initial beta release in Winter 2024 based on internal CAST study results
- Estimate calculations are based on a combination of automatically generated insights and user-configurable parameters such as the number of servers, server utilization, energy demand, and more

Current Constraints and Limitations

The CO_2 Emissions Estimator is released in beta form due to the following constraints and limitations (to name a few):

- The model is based on a single application study and one round of remediation
- All green deficiencies are weighted equally in terms of potential reduction impact
- The default values for parameters such as server choices, region, etc. could be quite different than a given organization's specific situation, so users will need to know their corresponding values for more accurate estimates
- ***The potential reduction in CO_2 emissions and energy is only realized if the newly available resources are used for some other operation or productivity***

The path forward

Gather feedback from clients and partners during the beta release to enhance the product capability

Work with partners and clients to perform additional studies for refining the model parameters

Develop real-world case studies that can be shared publicly