**CAST** Software Intelligence for Digital Leaders

 Propried
 Proprint
 Propropried
 Propried

# **CAST Case Study** Using software intelligence and SCI to estimate CO<sub>2</sub> emissions

March 2024

#### Contents

#### Overview

- Summary of the CO<sub>2</sub> emission reduction study
- Formula for estimating potential CO<sub>2</sub> emission reduction
- Formula parameters
- Formula illustration
- CO<sub>2</sub> Emission Estimator product capability
- **Current constraints**
- The path forward







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<sub>2</sub> 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<sub>2</sub> 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.

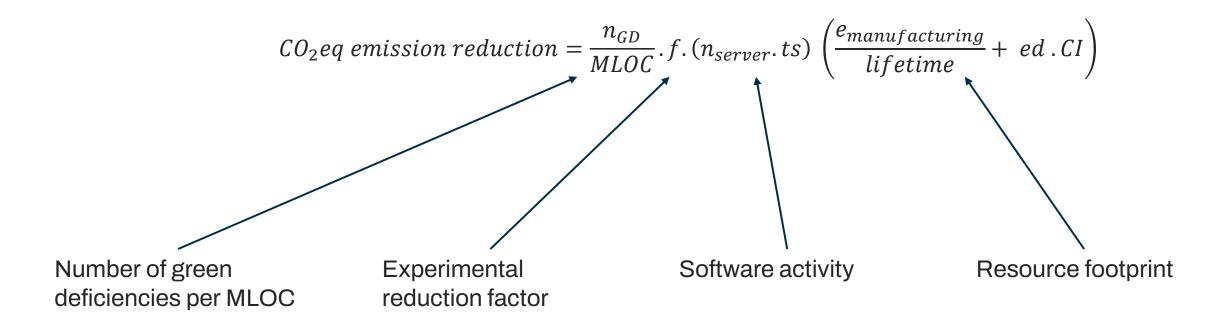
Here is an abridged summary of the steps in the study:

- 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<sub>2</sub> 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.





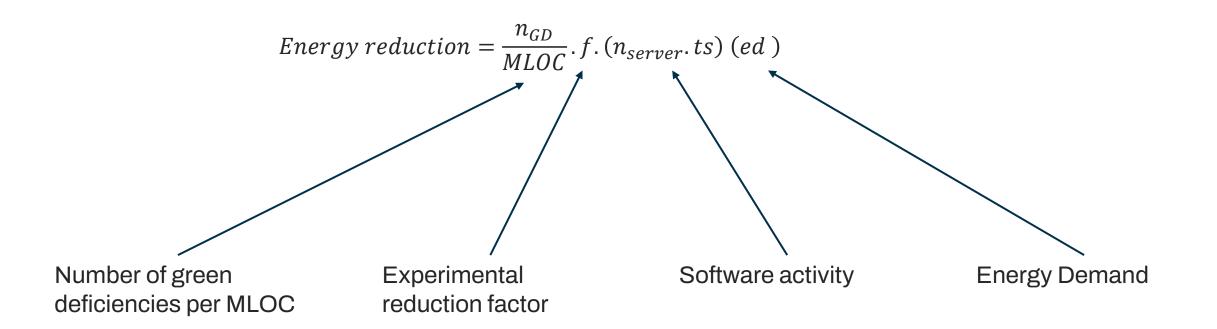
### Model for estimating potential CO<sub>2</sub> emission reduction







#### Model for estimating potential energy reduction







### **Model Parameters**

Parameter	Description	Source
n <sub>GD</sub>	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 <sub>server</sub>	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 <sub>manufacturing</sub>	The $CO_{2eq}$ emissions during manufacturing of servers	User supplied (default = 320 kgCO <sub>2eq</sub> 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 <sub>2</sub> /kWh for North America)



#### **Model Illustration**

Using results from the CAST study with the following parameters:

- $\odot$  n<sub>GD</sub> : 1676 green deficiencies
- $\odot$  CI: 0.336 kgCO<sub>2eq</sub> per server per year in North America region
- ed: 1670 kWh per year
- e<sub>manufacturing</sub>: 320 kgCO<sub>2eq</sub>
- ∃ I: 4 years
- On Server: 3 DELL PowerEdge R640 equivalent
- ອ ts: exclusive use 100%

#### Calculated results:

 $\odot$  Potential Emission Reduction: 404 kgCO<sub>2eq</sub> per year or 1.1 kgCO<sub>2eq</sub> 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
- $\mathsf{O}=(\,\mathsf{E}\,\mathsf{x}\,\mathsf{I}\,)$ 
  - E energy consumed
  - I location-based marginal carbon intensity

 $\succ$  O is represented by the n<sub>server</sub>, ts, ed, CI parameters in CAST's implementation

#### $M = TE \times TS \times RS$

- 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
- R = the entire application in the CAST implementation

M is represented by the n<sub>server</sub>, ts, e<sub>manufacturing</sub>, lifetime parameters in CAST's implementation

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





# CO<sub>2</sub> Emission Estimator (beta) available within CAST Highlight

	æ				(beta)							
CO <sub>2</sub> Reduction Potential Estimate of potential CO <sub>4</sub> emission reduction if all Green Deficiencies are fixed, in kilograms / year				Energy Reduction Potential Estimate of potential energy consumption resolution of all Oren Deficiencies are fixed, in kiloWates / yee/								
1.76 tors/year				4.58 megawatt / year								
Emission	Reduction C	alculation P	arameters									
ghlight estimates poter	ttial CO <sub>2</sub> emission reduction in kg	/year based on a study condi	ucted on a real-life application	on and infrastructure environm	rent. Estimates are based on r	he number of Green Deficien	cy occurrences that could be	fixed and other applicatio	n-level parameters such as r	umber of servers, application	n lifetime, server utilization, and more.	
Resources					Infrastructu	re Footprint					Change Parameters	
r of Servers O				3	♥ Server Life					4		-
Utilization %				1 Strengty Demand O						0.33		
					In Manufactu	ring Energy 0				320		
												Search:
		Eles	E #	Total FTE	ඩ් CO2 Gain	5 Energy Gain	Ø Green Impact	🔡 Green Scan	Green Survey	Z Occurences	Green Impact Effort ?	Campaign Date
Name	LOC				144 kg	375 kWh	63.48 %	63.48%	N/A	16983	444.38 person-day	02/23/23
	907.27k LOC	5.95k	NA	0.00 FTE							N/A	
dempiere udget	907.27k LOC 70 LOC	5	27	50.00 FTE	N/A	N/A	80.00 %	N/A	80.00 %	N/A		04/28/23
dempiere udget assandra	907.27k LOC 70 LOC 405.8k LOC	5 2.73k	27 68	50.00 FTE	N/A 148 kg	386 kWh	81.89 %	79.93 %	83.85 W	7814	221.15 person-day	04/28/23
dempiere udget assandra lient Due Diligence	907.27k LOC 70 LOC 405.8k LOC 101.89k LOC	5 2.73k 1.08k	27 68 51	50.00 FTE 1.00 FTE 15.00 FTE	N/A 148 kg 125 kg	386 kWh 326 kWh	81.89 % 61.53 %	79.93 % 71.53 %	83.85 W \$1.54 W	7814 1660	221.15 person-day 46.23 person-day	04/28/23 05/25/23
dempiere udget issandra ient Due Diligence CP-Client	907.37k LOC 70 LOC 405.8k LOC 101.89k LOC 254.57k LOC	5 2.73k 1.08k 1.94k	27 68 51 57	50.00 FTE 1.00 FTE 15.00 FTE 25.00 FTE	N/A 148 kg 125 kg 49 kg	386 kWh 326 kWh 129 kWh	81.89 % 61.53 % 77.58 %	79.93% 71.53% 79.21%	82.85 % 51.54 % 76.15 %	7814 1660 1633	221.15 person-day 46.23 person-day 54.31 person-day	04/28/23 05/25/23 04/28/23
demplere udget ssandra lent Due Dillgence CP-Client rogu	907.27k.LOC 70.LOC 405.8k.LOC 101.89k.LOC 254.57k.LOC 228.67k.LOC	5 2.73k 1.09k 1.04k 1.78k	27 68 59 57 72	50.00 FTE 1.00 FTE 15.00 FTE 25.00 FTE 50.00 FTE	N/A 148 kg 125 kg 49 kg 92 kg	206 kWh 226 kWh 129 kWh 239 kWh	81.83% 61.53% 77.68% 72.68%	79.93% 71.53% 79.21% 66.04%	82.85 % 51.54 % 76.15 % 82.31 %	7814 1660 1633 2241	221.15 person-day 46.23 person-day 54.31 person-day 88.98 person-day	04/28/23 05/25/23 04/28/23 04/28/23
dempiere udget issandra ient Due Dilgence CP-Client CP-Client rogu	907.27% LOC 70 LOC 405.8% LOC 284.5% LOC 2254.5% LOC 68.35% LOC	5 2.73k 1.08k 1.04k 1.78k 287	27 68 55 57 72 10	50.00 FTE 1.00 FTE 15.00 FTE 25.00 FTE 50.00 FTE 15.00 FTE	N/A 148 kg 125 kg 49 kg 92 kg 133 kg	306 kWh 326 kWh 129 kWh 239 kWh 347 kWh	81.89% 61.53% 77.68% 72.66%	79.93 % 71.53 % 78.21 % 66.04 % 59.30 %	62.65 W 51.54 W 76.15 W 62.31 W 12.06 W	2814 1660 1633 2241 1100	221.13 person-day 46.23 person-day 54.31 person-day 84.96 person-day 27.92 person-day	04/28/23 05/25/23 04/28/23 04/28/23 04/28/23
dempiere undget saandra lent Due Difigence CP-Client cropu cropu ades	907.27% LOC 70 LOC 405.8% LOC 101.8% LOC 254.5% LOC 228.6% LOC 48.35% LOC 788.06% LOC	5 2.778 1.08k 1.04k 1.78k 2.87 2.27k	27 66 53 57 72 13 87	50.00 FTE 1.00 FTE 25.00 FTE 50.00 FTE 15.00 FTE 15.00 FTE 35.00 FTE	N/A 148 kg 125 kg 49 kg 92 kg 133 kg 1 kg	386 kWh 335 kWh 123 kWh 239 kWh 347 kWh 2 kWh	0.09% 655% 756% 7266% 7266% 7266% 7266%	79.93% 71.53% 7221% 65.04% 69.00% 88.33%	825 W 554W 7815 W 8215 W 8215 W 7800 W 1900 W	714 1960 1933 2941 1150 82	221.13 person-day 46.23 person-day 54.31 person-day 88.89 person-day 27.82 person-day 1.08 person-day	04/28/23 05/25/23 04/28/23 04/28/23 04/28/23 04/28/23
E Rame demplare assandra assandra Dient Dua Diligence CP-Client CP-Client andro reot adoop MDB	907.27% LOC 70 LOC 405.8% LOC 284.5% LOC 2254.5% LOC 68.35% LOC	5 2.73k 1.08k 1.04k 1.78k 287	27 68 55 57 72 10	50.00 FTE 1.00 FTE 15.00 FTE 25.00 FTE 50.00 FTE 15.00 FTE	N/A 148 kg 125 kg 49 kg 92 kg 133 kg	306 kWh 326 kWh 129 kWh 239 kWh 347 kWh	81.89% 61.53% 77.68% 72.66%	79.93 % 71.53 % 78.21 % 66.04 % 59.30 %	62.65 W 51.54 W 76.15 W 62.31 W 12.06 W	2814 1660 1633 2241 1100	221.13 person-day 46.23 person-day 54.31 person-day 84.96 person-day 27.92 person-day	04/28/23 05/25/23 04/28/23 04/28/23 04/28/23

- Get estimates on the potential reduction in CO<sub>2</sub> 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<sub>2</sub> 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 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



