

How Sustainable Is Your Programming language? Analyzing the impact of Power Cap on Energy Efficiency of Programming Languages

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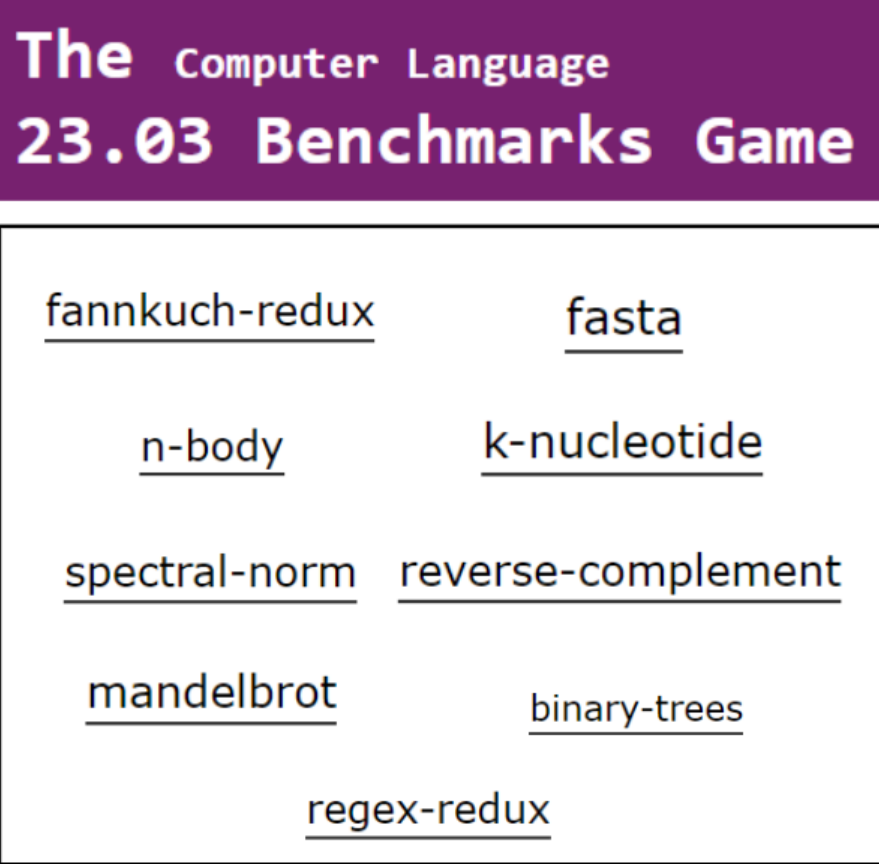
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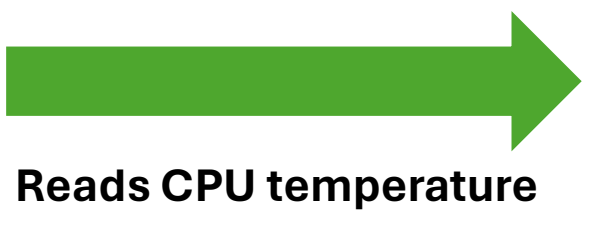
Abstract

This paper presents the outcomes of an extensive investigation centered on the assessment of the energy efficiency inherent in diverse computational algorithms implemented across twenty distinct programming languages from “The Computer Language 23.03 Benchmarks Game”. The study delves into the comprehensive analysis of the aggregate energy utilization of each computational program across varied programming languages, while scrutinizing the repercussions of CPU power constraints on language-specific performance. The discerned findings reveal that C and C++ manifest heightened efficacy concerning execution time and energy consumption, particularly when subjected to the imposition of power constraints. In contrast, Ruby and Perl exhibit suboptimal performance with regard to energy consumption, even under the constraints of PowerCap. Regarding the ramifications of employing power caps, all investigated programming languages derive benefits in terms of energy efficiency, with Python showcasing a noteworthy conservation of nearly 20% in overall energy consumption across the considered programs. In summation, this study imparts substantive insights into the energy efficiency of diverse computational problems across a spectrum of programming languages, while elucidating the consequential impact of power limitations on their respective performances.

Analysis of programming languages' performance when running various CLBG problems.

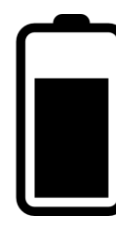
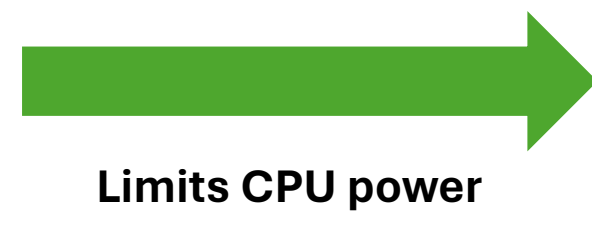


Temperature sensors



Guarantee that all programs execute at the same (CPU) temperature

PowerCap

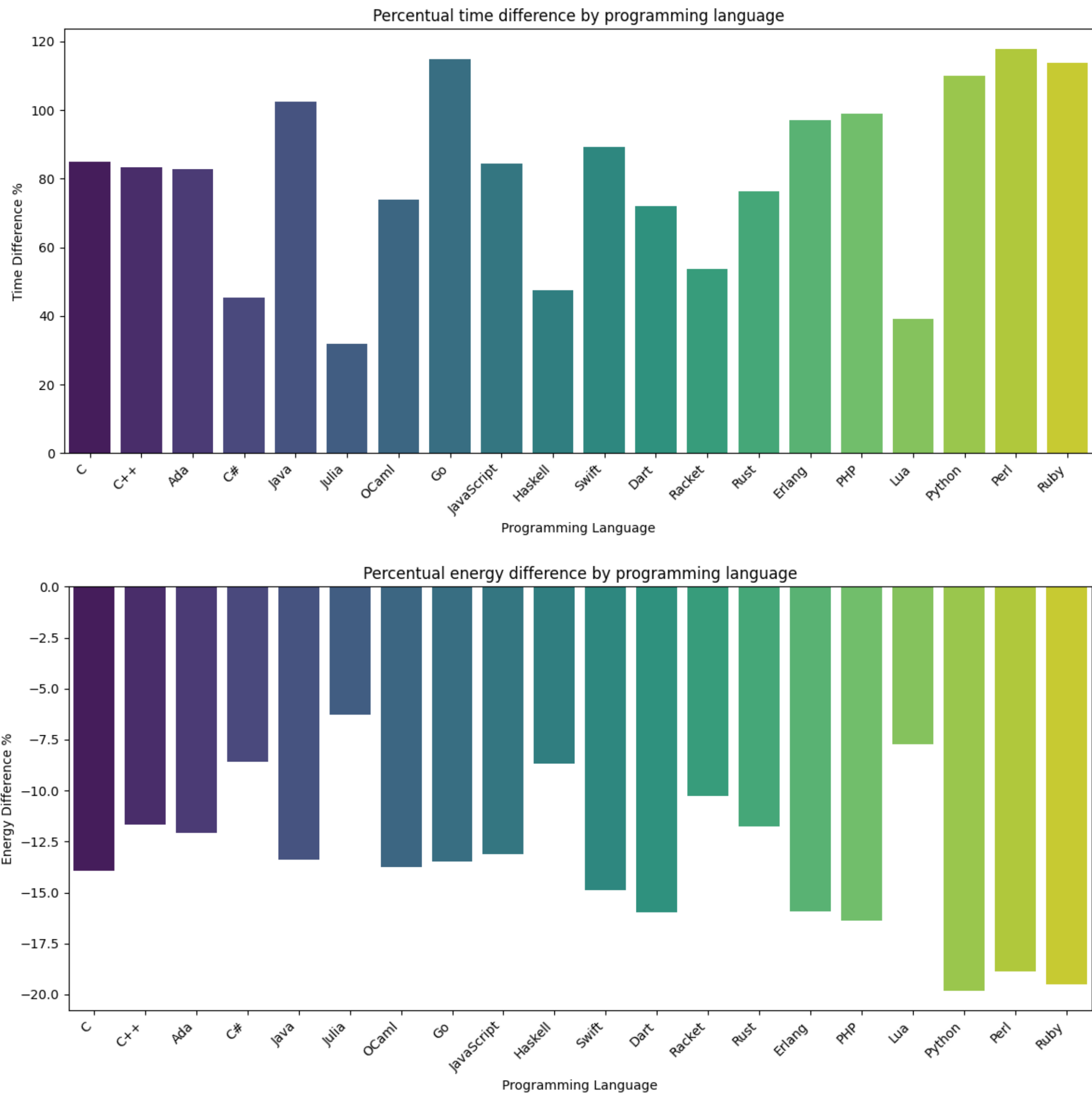


Consumes less energy



Longer execution time

Results



Language	Energy (J)	Time (ms)
C++	363.094875	1.168700e+04
C	367.654096	1.143043e+04
C#	946.813529	4.256171e+04
Ada	965.524166	3.106829e+04
Java	1144.926470	3.275579e+04
Julia	1272.131326	6.048914e+04
OCaml	1471.454647	4.877514e+04
Go	1524.454882	4.108843e+04
JavaScript	1598.456948	5.035793e+04
Haskell	1613.701765	6.692579e+04
Swift	1900.869982	5.720171e+04
Dart	1963.051426	6.418557e+04
Racket	3251.534768	1.269501e+05
Rust	7940.146240	2.658580e+05
Erlang	10772.138960	3.076343e+05
PHP	14175.292663	3.985887e+05
Lua	17869.156595	7.927677e+05
Python	35128.879512	8.975287e+05
Perl	40807.887094	1.016867e+06
Ruby	42299.772261	1.066239e+06

Without PowerCap

Language	Energy (J)	Time (ms)	Position Changes	Energy Difference (J)	Time Difference (ms)
C	316.371634	2.114607e+04	-1	-51.282462	9.715643e+03
C++	320.768877	2.144114e+04	1	-42.325997	9.754143e+03
Ada	848.854514	5.679750e+04	-1	-116.669652	2.572921e+04
C#	865.582267	6.189143e+04	1	-81.231262	1.932971e+04
Java	991.363586	6.631436e+04	0	-153.562884	3.355857e+04
Julia	1192.361145	7.981214e+04	0	-79.770181	1.932300e+04
OCaml	1268.793784	8.486129e+04	0	-202.660863	3.608614e+04
Go	1319.209922	8.822679e+04	0	-205.244960	4.713836e+04
JavaScript	1388.458078	9.292921e+04	0	-209.998871	4.257129e+04
Haskell	1473.763576	9.877429e+04	0	-139.938189	3.184850e+04
Swift	1617.950413	1.082140e+05	0	-282.919569	5.101229e+04
Dart	1649.591017	1.103826e+05	0	-313.460410	4.619707e+04
Racket	2918.397461	1.952539e+05	0	-333.137307	6.830386e+04
Rust	7007.712280	4.687406e+05	0	-932.433960	2.028826e+05
Erlang	9056.255755	6.061956e+05	0	-1715.883205	2.985613e+05
PHP	11854.182338	7.929690e+05	0	-2321.110325	3.943803e+05
Lua	16490.617532	1.103063e+06	0	-1378.539063	3.102950e+05
Python	28173.105609	1.884515e+06	0	-6955.773904	9.869861e+05
Perl	33100.910880	2.214195e+06	0	-7706.976214	1.197328e+06
Ruby	34053.900064	2.277910e+06	0	-8245.872197	1.211671e+06

With PowerCap

- C and C++ are the faster and greener programming languages.
- Ruby and Perl are the slowest and least greener programming languages.
- PowerCap reduces energy consumption, while increasing runtime.
- Python reduces 19.80% its energy consumption by limiting the power of the CPU.