Environmental benefits of server lifetime extension: Identifying the sensitive parameters in the context of carbon footprinting

SUSTAINABLE ENGINEERING

BACKGROUND

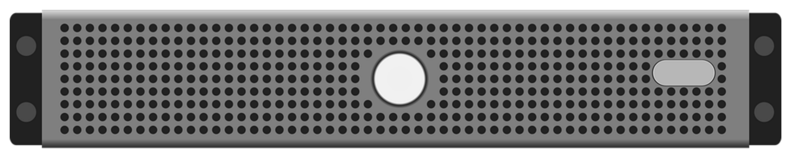
- ICT accounts for 2-4 % of global greenhouse gas emissions and emissions could rise.[1]
- <u>An important ICT product group is servers, whose carbon footprint has often been largely attributed to the use phase.</u>[2,3]
- This is an argument in favor of common business models that call for a quick replacement of servers with a next-generation device.
- However, recent work using more detailed manufacturing inventories has found that use and production are equally important.[4]
- In addition, in the context of enterprise servers for small and medium-sized enterprises (SMEs), it is unclear whether the common assumption of relatively high average CPU loads of 20 % to 70 % in previous studies [e.g. 5,6] reflects real-world conditions.

GOAL FORMULATION

- <u>Analyze whether server lifecycle extension makes sense from a carbon footprint perspective, considering key sensitive parameters.</u>
  - The focus was on analyzing the carbon emissions of the use vs. the manufacturing phase of the hardware life cycle for a typical SME rack server (config.: 2 x Intel Xeon 140 W CPUs, 12 x 32 GB DIMMs, 1 x 400 GB SSD, 8 x 3.84 TB SSDs, 2 x 1100 W PSUs, 6 fans) in the German-Austrian context.

METHOD

- Based on a literature review [e.g. 2-6], sensitive study parameters were identified and <u>a screening carbon footprint tool in Excel format was developed.</u>

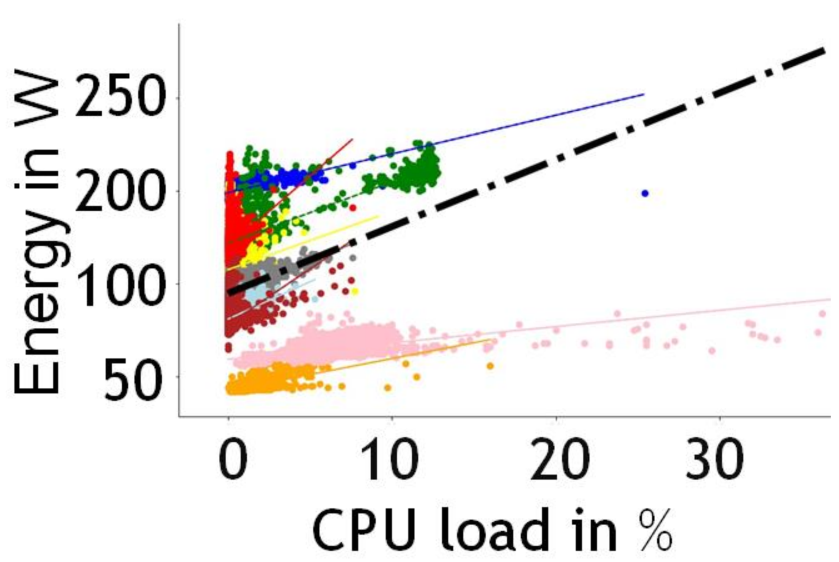


- This included, among others:
  - Existing production and end-of-life data from a thinkstep Life Cycle Assessment (LCA) of a Dell R740 rack server[4], the most detailed study to date, and a separate modeling of the use and transportation phases in the LCA FE (GaBi).
  - Analysis of real-world data on server use (CPU loads and energy consumption over time) from 9 German-Austrian SMEs

MAIN RESULTS

- <u>CPU loads for SMEs averaged only 1 % to 2 %, with maximum loads rarely exceeding 10 %.</u>
  - These figures reflect the general experience of our project partner and other IT service providers.
  - Besides, data analysis revealed slightly less power consumed relative to CPU load than assumed in comparative work[4].

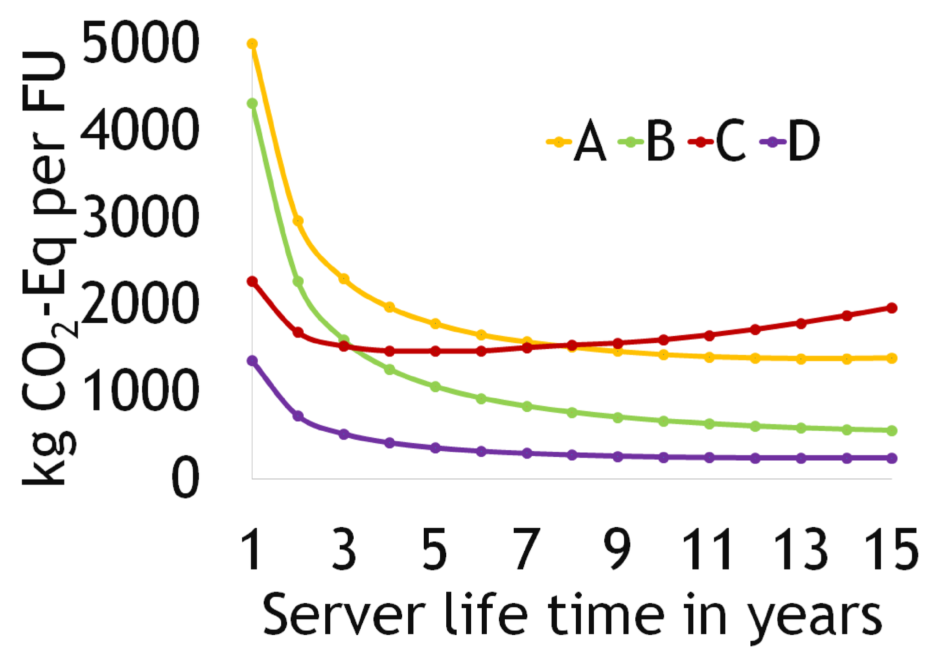
Use patterns for SMEs*



* Black dotted dashed line: average relation for energy consumed per CPU load
Colored dots: data points from different SMEs

- The Excel tool allows for scenario analysis
- Number of adjustable parameters:
  - Manufacturing (3), use phase (10), transport (2), end-of-life (6)
- Functional unit: 1 year of server use by SMEs (time horizon: 15 years from 2020)
- <u>Examples of scenarios & parameters:</u>
  - Scenario A: Scenario based on the thinkstep LCA study[4] while assuming 3 % annual energy efficiency improvement, 30 % average CPU load, and a static EU grid mix
  - Scenario B: Adjusts Scenario A with CPU loads (Ø = 2 %) that best reflect real server use patterns and the associated power consumption, as well as with a non-static grid mix based on policy targets
  - Scenario C: Rather unrealistic scenario assuming 10% annual energy efficiency improvement, 100% average CPU load, a static EU grid mix, and replacement of SSDs with HDDs
  - Scenario D: Adapting Scenario C with a 100% renewable grid mix

Scenario Analysis



- Break-even-points for scenarios
  - Scenario A (13 years), Scenario B (no break-even-point), Scenario C (6 years), Scenario D (14 years)
- Extending server life beyond a typical 4-year baseline makes environmental sense
- Case of Germany (3.2M SMEs[7])
  - ≈1.6 million tons CO_2-Eq. annual saving potential by doubling server lifetime (Scenario B)

TAKEAWAYS AND OUTLOOK

- <u>Based on scenario analysis, in most cases it makes environmental sense to significantly extend the server's life beyond an assumed baseline of 4 years.</u> This is particularly true for scenarios based on real-world data from SMEs with low CPU loads.
- The latter conclusion will be strengthened as the share of renewable energy in the grid increases.
- Beyond the use phase, future work should focus on improving life cycle inventories for the server manufacturing phase.

tu berlin

Andreas Link*, Jessica Hoffmann, and Matthias Finkbeiner
Technical University of Berlin
* andreas.link@tu-berlin.de

<u>Acknowledgements:</u>
The authors thank our project partner "hardwarewartung.com" for funding the study. In particular, we thank Mr. Yusuf Sar and his colleagues for the exchange of ideas and their assistance in contacting the SMEs. Finally, we thank all the SMEs that provided us with usage data of their servers.

<u>References:</u>

1. Freitag, C., Berners-Lee, M., Widdicks, K., Knowles, B., Blair, G.S., Friday, A., 2021. The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations. Patterns 2, 1–18. https://doi.org/10.1016/J.PATTER.2021.100340
2. Stutz, M., O'Connell, S., Pflueger, J., 2012. Carbon footprint of a dell rack server | IEEE Conference Publication | IEEE Xplore, in: 2012 Electronics Goes Green 2012+. IEEE, Berlin.
3. Stutz, M., 2013. Comparing the Carbon Footprints of 11G and 12G Rack Servers from Dell.
4. Busa, A., Hegeman, M., 2019. Life Cycle Assessment of Dell R74.
5. Berwald, A., Faninger, T., Bayramoglu, S., Benoît Tinetti, B., Shailendra Mudgal, S., Lutz Stobbe, L., Nissen, N., 2016. Ecodesign preparatory study on enterprise servers and data equipment. Publications Office of the European Union. https://doi.org/10.2873/14639
6. Peñaherrera, F., Hobohm, J., Szczepaniak, K., 2019. LCA of Energy and Material Demands in Professional Data Centers: Case Study of a Server, in: Sustainable Production, Life Cycle Engineering and Management. Springer, pp. 79-88. https://doi.org/10.1007/978-3-319-92237-9_9/FIGURES/7
7. Statistisches Bundesamt, 2024. 56 % in kleinen und mittleren Unternehmen tätig - Statistisches Bundesamt [WWW Document]. URL https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Unternehmen/Kleine-Unternehmen-Mittlere-Unternehmen/aktuell-beschaeftigte.html (accessed 5.2.24).