Measuring Resource Efficiency of LaTeX Paper Templates

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Abstract: Scientific work is mostly communicated via scientific papers, which are often published in journals or conference proceedings, either in print or digital form. These journals and conferences usually demand that submitted papers follow a specific formatting style, for which they provide style templates. The choice of a template influences different properties of the generated document, like its file size or the number of pages that it would use in printed form, directly affecting its impact on the environment. We built a system to automatically compare different LaTeX templates with regard to different factors relevant to the environmental impact. We test our approach with seven templates used by different conferences and journals, and find that the most efficient templates have roughly one third of the file size, and require about one half of the resources for paper production of the least efficient templates.

Keywords: LaTeX template efficiency; continuous integration/continuous delivery; printing resource consumption; paper publishing process

1 Introduction

Progress in digitization has led to an increase in the use of electronic media. This is evident in the scientific community, where more and more documents are being created digitally. However, there are still many reasons to use paper and ink. For example, reading on paper is easier on the eyes than reading on a screen and also supports the understanding of what is read [Cl19]. However, it is important to consider the environment and conserve resources.

It takes 7.5 kg of wood, 125.6 L of water and 32.4 kW h to produce 500 sheets of DIN A4 paper [We22]. The amount of resources required can be reduced by using recycled paper instead. However, the number of pages and the amount of ink required to print a scientific paper can vary greatly depending on the template that is used.

There are a plethora of different LaTeX templates for scientific publications, sometimes specific to a particular publisher and sometimes specific to a particular conference or journal. The characteristics of a template, such as font size and number of columns, already give a first impression of its efficiency. For example, if you look at this document, you may notice a large white margin around the continuous text. The text would easily fit on a DIN A5 page, but the document is set to DIN A4. Even if the margin is discarded for the printed proceedings, the single-paper version is often distributed and printed too.

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This paper reviews a selection of common LaTeX templates and compares them in terms of runtime of the compilation, file size, page amount, and ink usage. For this purpose, Sect. 2 introduces related work to frame our scientific contribution. In Sect. 3 we explain our methodology and present the analysed templates. This is followed by the results in Sect. 4 and finally concluded in Sect. 5. The repository containing our files and an automated measuring pipeline is hosted on GitLab[1].

2 Related Work

In this paper we analyse the resource efficiency of documents creates with LaTeX. Thus, our contribution is very specific and related work may include work on efficient use of resources in general, the comparison of reading from screen compared to reading from paper, and the efficiency of creating a document.

The European Commission offers the “EU Ecolabel” for paper and printed products, which place strict requirements on the paper manufacturing process [Co19, Co20].

A campaign called “Think Before Printing” [tC] has been around for a while. The idea is to add a signature to every email you send to make the reader aware of the environmental impact of printing email. A very same approach might be adopted to LaTeX conference templates.

Hasan et al. [Ha13] evaluated how a team-based feedback approach may be used to reduce the individual amount of printing in a workplace setup. Over a period of two years they observed that the individual printing was reduced by 28 % after providing printing statistics to the whole team. While this work encourages to reduce printing overall, we rather try to find a template that conveys the most information on a single sheet of paper.

Clinton et al. [Cl19] performed a systematic review and meta-analysis of reports and studies to compare reading from paper and screen. They found out that reading from screen has negative effects on the reading performance. Overall, reading from paper has benefits in performance and metacognition and thus might be more efficient. We, too, see the advantages of reading printed papers and thus would like to keep printing papers efficient.

Knauff and Nejasmic [KN14] compared the efficiency of the document preparation systems Microsoft Word and LaTeX. They performed a usability study with 40 researchers in which they found out that Word users tend to be faster at producing content and also encounter less error. The authors go as far as recommending not to use LaTeX. However, LaTeX is the de facto standard for scientific documents in mathematics, physics, computer science, and more. Thus, we solely focus on scientific templates in LaTeX.

[1] https://gitlab.com/cybertier/paper-pig

Last but not least, printing ink manufacturers started to produce ink from renewable and healthier resources which has mainly been driven by new regulations and the growing environmental awareness [Ro15, AÖ20, HOAD22, Ay18].

3 Methodology

Our goal is to measure the resource efficiency of different LaTeX templates. Thus, we set up a pipeline that takes a new template and fills it with dummy content. The dummy paper is then built, and the pipeline measures the following properties of the compiled PDF document: Ink-usage split by the colours cyan, magenta, yellow and black used for printing, in percent of covering a full DIN A4 page, file size in Bytes, paper length in pages and compile time in seconds.

We also estimate the usage of the following resources assuming the document is printed, once for recycled and once for new paper: Waste paper, wood, water and energy. The filesize is measured since papers are typically circulated digitally and thus causes network traffic which requires additional energy. This additional energy, however, is out of scope of our measurements. Thus, we need (1) a build environment, (2) dummy content, (3) measurement tools, (4) a selection of suitable paper templates and (5) information on the resource consumption.

Our approach is built on a git repository with gitlab-runner scripts that automatically perform the evaluation for all included templates whenever a new version is pushed. We leverage *latexmk*[2] 4.79 to easily compile the LaTeX files as well as the bibliography. Latexmk itself uses *pdfTeX* version 3.141592653 and *BibTeX* version 0.99d. Everything is run inside a *Docker* container using the *aergus/latex* image with the tag 2023-05-16.

To ensure a fair comparison between different templates, they all share the same content. For generation of text we use the `blindtext`[3] LaTeX package in version 2.0, generating text in seven sections totalling 6078 words (solely accounting the continuous text). We also include three figures from the `mwe` package in version 0.5. Two figures are included at half a page width, corresponding to the column width in a two-column layout, and one at full text width. Furthermore, we include one table, one code listing, and five equations. The bibliography comprises 22 sources.

Ink usage is measured using *Ghostscript*[4] 10.0.0 and its `ink_cov` device in coverage percentage of one page. In the words of the Ghostscript documentation: “The ***`ink_cov`*** device [. . .] considers the amount of each colourant at each rendered pixel, so the percentages in this case are what percentage of the ink is used on the page”[Ar]. For templates that use the US Letter format, we transform this percentage of a US Letter page to the percentage

[2] https://www.cantab.net/users/johncollins/latexmk/index.html
[3] https://ctan.org/pkg/blindtext
[4] https://www.ghostscript.com/

Template	Version	Options	Columns	Font size	Paper Size
acmart [AC23]	1.90a	manuscript	1	9 pt	US Letter
acmart [AC23]	1.90a	sigconf	2	9 pt	US Letter
IEEEtran [IE19]	2019	conference	2	10 pt	US Letter
LNI [GI23]	1.8	–	1	10 pt	DIN A4
NeurIPS [Ne23]	March 2023	–	2	10 pt	US Letter
Springer [Sp23]	1.3	–	1	9 pt	US Letter
Usenix [Us23]	2020-09	–	2	10 pt	US Letter

Tab. 1: Listing of all templates used in our experiment with characteristics which may influence the resource efficiency when printed.

of a DIN A4 page for comparability. File size and page amount are both gathered using *pdfinfo*[5] 22.12.0. The compile time is extracted from the latexmk build log using the `-time` flag.

While directly measuring the energy consumption of the paper compilation process would be ideal, this is usually not easy to achieve in a generic CI/CD pipeline setting like ours. However, assuming roughly constant power consumption over time during the compilation process, we can use the compile time as an easily measurable proxy value. To test our assumption, we measure the power consumption and compile time of each template on a Raspberry Pi 3 Model B[6] and calculate their correlation. Each template is compiled ten times, and the power consumption is measured at 20 samples per second.

As a proof-of-concept, we evaluate the templates listed in Tab. 1. This list is by no means complete but can easily be extended because of our pipelined build system. We plan to expand it further and include a more diverse set of templates in the future. From Tab. 1 it is visible that we evaluate seven different templates with either single or two-column layout. Most of the templates are designed for US Letter paper size except for LNI using DIN A4. The font size is either 9 pt or 10 pt. Both the amount of columns and font size directly influence the papers' lengths.

To estimate the resources consumed by a piece of printed paper, we use the same source as in the introduction. The German Environmental Agency periodically publishes an "updated life cycle assessment of graphic and tissue paper". We take the length of a sheet of paper in full pages and multiply it by the resource consumption per page. This assumes single-sided printing on DIN A4 paper. We were not able to find reliable data on the resource required to produce the consumed amount of ink and thus have no estimation other that ink usage.

[5] http://www.glyphandcog.com/XpdfInfo.html
[6] https://www.raspberrypi.com/products/raspberry-pi-3-model-b/

Template	Ink Usage	Water [L]	Wood [Kg]	Waste Paper [Kg]	Energy [kWh]
acmart-manuscript	64.52	3.25 (0.78)	0.13 (0)	0 (7.28)	0.78 (0.26)
acmart-sigconf	66.33	2.0 (0.48)	0.08 (0)	0 (4.48)	0.48 (0.16)
IEEEtran	76.40	2.0 (0.48)	0,08 (0)	0 (4.48)	0.48 (0.16)
LNI	87.56	4.75 (1.14)	0.19 (0)	0 (10.64)	1.14 (0.38)
NeurIPS	75.72	3.0 (0.72)	0.12 (0)	0 (6.72)	0.72 (0.24)
Springer	69.47	4.0 (0.96)	0.16 (0)	0 (8.96)	0.96 (0.32)
Usenix	76.01	2.25 (0.54)	0.09 (0)	0 (5.04)	0.54 (0.18)

Tab. 2: Ressource consumption per template. Values in brackets reflect ressource consumption for recycled paper. Ink usage measures the amount of ink used (as a percentage of one hypothetical DIN A4 page) for the entire document.

4 Results

Fig. 1 summarizes our findings regarding the PDF properties of the different templates. Page amount ranges from 8 to 19 pages, with *acmart-sigconf* and *IEEEtran-conference* both requiring only 8 pages, while *LNI* takes up 19 pages. The resulting files are between 164 kB and 493 kB in size, with *Usenix* taking up the least at 164 kB and *acmart-manuscript* taking up 493 kB. Ink usage ranges from 64 % to 87 % coverage of a full page, with *acmart-manuscript* using the least ink at 64.52 % and *LNI* using the most ink with 87.56 %.

We can see that the four templates with the lower page amounts are the four two-column templates. We do not observe a clear correlation between the font size and page amount. There is also no variable that we find to be correlating with the file size of the PDF document, or its compile time. One interesting observation is that the two PDF documents resulting from the *acmart* templates are considerably larger in file size than all the other documents. We could only find that these PDF documents contained more PDF metadata, however not to an amount that would explain the full size difference. Note that these preliminary results are just taken from a small set of templates, so they do not bear statistical significance.

As our resource usage calculation is based on the page count, it linearly scales with the amount of pages of a template's resulting PDF document. Thus, the templates with the lowest page counts, *acmart-sigconf* and *IEEEtran-conference*, both have the lowest resource consumptions, while *LNI* shows the highest resource consumption. The actual resource consumption for each template is listed in Tab. 2.

When printing on new paper, *acmart-sigconf* and *IEEEtran-conference* require 80 g of wood, 2 L of water and 0.48 kW h of energy to produce their 8 pages of DIN A4 paper. In comparison, *LNI* requires 190 g of wood, 4.75 L of water and 1.14 kW h of energy.

When printing on recycled paper, *acmart-sigconf* and *IEEEtran-conference* require 4.48 kg

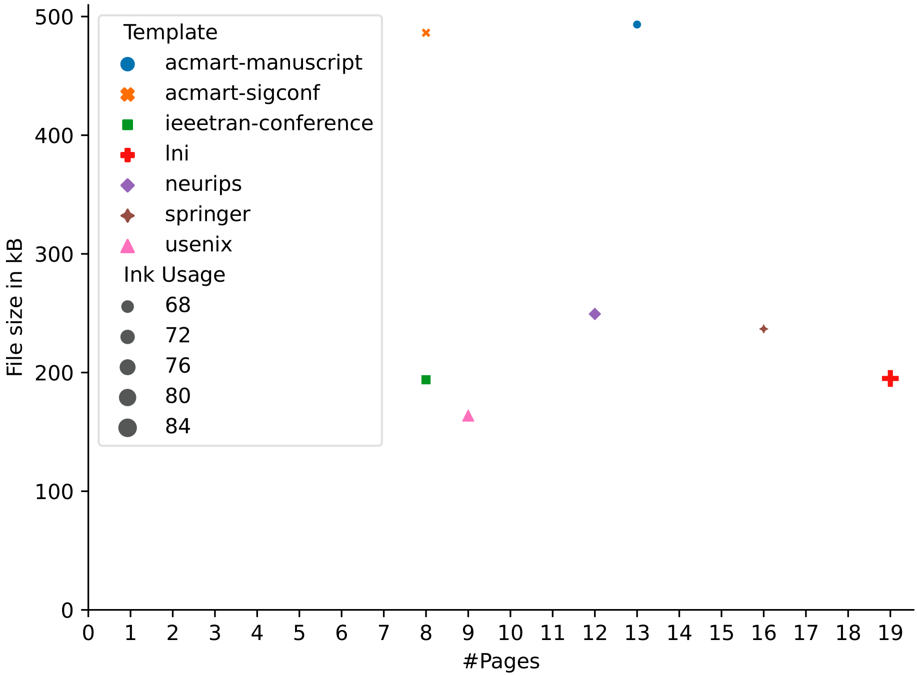

Fig. 1: PDF document properties for different templates. The x-axis represents the amount of pages of the document, while the y-axis represents the file size. Color and shape of an individual symbol correspond to one template each, while the size of the symbol reflects its ink usage, measured in percent of covering one DIN A4 page.

of waste paper, 0.48 L of water and 0.16 kW h of energy. *LNI* requires 10.64 kg of waste paper, 1.14 L of water and 0.38 kW h of energy.

These preliminary results already show that depending on the type of paper that is used for printing, the template choice can save more than 2.5 L of water and more than 0.5 kW h of energy for a single paper containing around 6000 words, even when only considering the cost of printing. Given our small sample set of templates and minimal scope for resource consumption, this represents a lower bound for the resource consumption gap between the most and least efficient template choice.

The compile times and energy consumptions measured on the Raspberry Pi are visualized in Fig. 2. They range from 19.06 s for *Springer* up to 278.43 s for *LNI*, while energy consumption ranges from 5.51 J for *Springer* up to 62 J for *LNI*. While we do not observe any correlation between the templates' compile times and any of the other variables we previously discussed, there is a strong correlation between compile times and energy

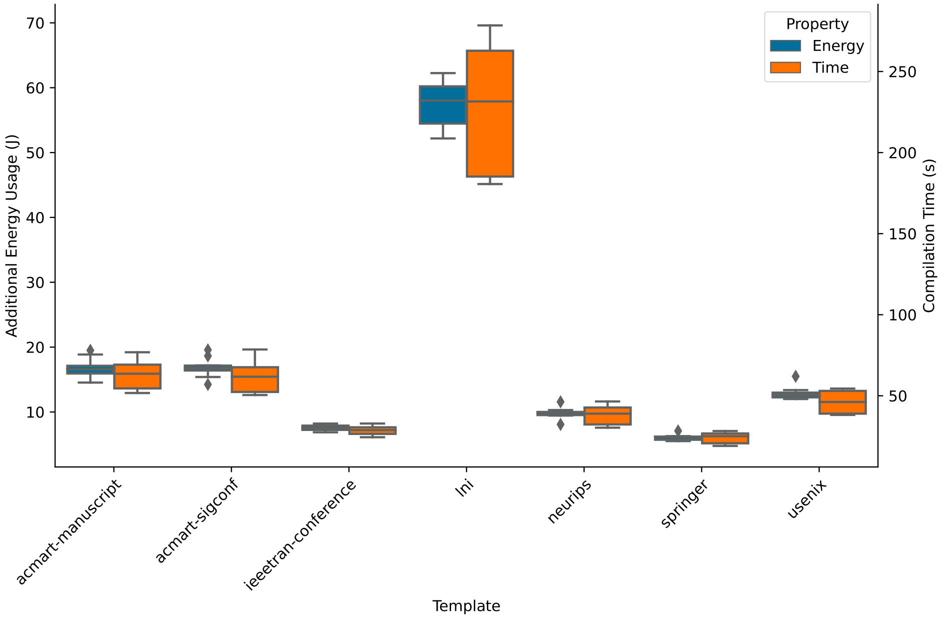

Fig. 2: Barplot representing the compile times and energy usage for all tested templates.

consumption, with a Pearson correlation coefficient of 0.96 and a p-value of 5.5×10^{-38}. It is notable that the shortest and longest documents in terms of page amount correspond to the templates with the shortest and longest compile times respectively. However, as the documents resulting from the other templates do not follow this pattern, this may just be a coincidence.

5 Conclusion

In this paper we analysed the efficiency of different LaTeX templates by measuring their compile time, file size, length, and ink usage. To this end, we set up a fully automated pipeline where new templates may easily be added. The PDF versions, statistics, and plots are generated automatically.

In our current proof of concept we analysed seven templates with either single- or two-column layout and font sizes of either 9pt or 10pt. Our main findings are that even within this small sample set, the template choice can more than double the page size and thus print-related resource consumption, and more than triple the file size of a PDF document. We find that within our sample set, all two-column layouts result in lower page amounts than single-column layouts. We do not find any correlation between print related resource consumption and the font size or compile time.

However, the experiments have some limitations. We chose dummy content which might not represent a typical paper's content. The length of the continuous text as well as the number of tables, figures, and similar might vary greatly depending on the field or even the subfield of the publication. The actual consumption of resources might differ from what we estimate and may rather be seen as motivation and to make the results tangible. We were not able to find reliable data on the resources required to produce the consumed amount of ink and thus have no estimation other that ink usage.

Overall, the actual consumption heavily depends on the way a paper is printed. We encourage the use of two-column layouts and duplex printing on recycled paper. This ensures a dense amount of information with very limited resources.

For future work we plan on extending our dataset of templates to have a more diverse set of templates for our evaluation and investigate more general causes for why individual templates produce particularly large or particularly resource intensive documents.

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