

# **Forschungsvorhaben SoftAWERE – Energieeffizienz von Software anwendungsnah messen und bewerten**

Energieeffizienz-Kennwerte von Komponenten und Werkzeugen der Softwareentwicklung und Vorarbeiten zur Etablierung einer Kennzeichnung für energieeffiziente Software.

**Software consumes resources.**

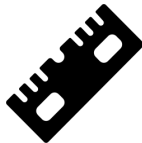
# Software also consumes resources.



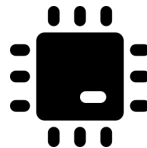
Network Bandwidth



Storage Capacity



Memory Capacity

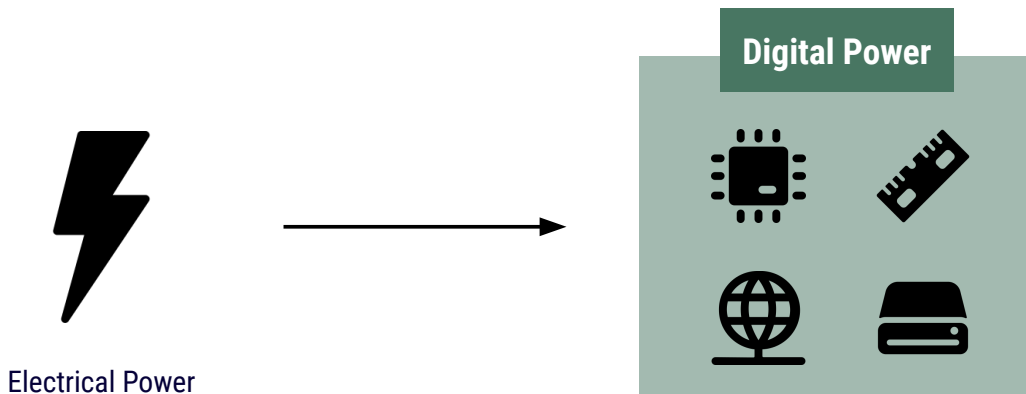


CPU Time



**Digital Power**

**Digital power is created by converting electricity into bits**  
**- for processing, storage or transport.**



# The "conversion machines" can be small-scale or large-scale.



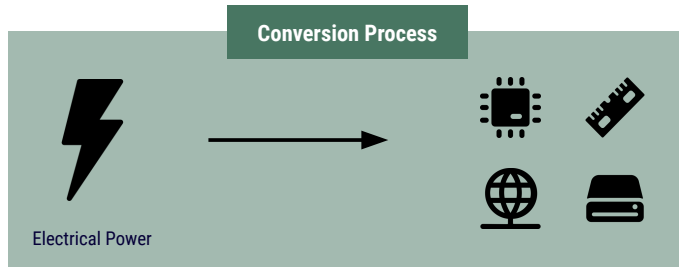
Smartphone



Laptop



Server



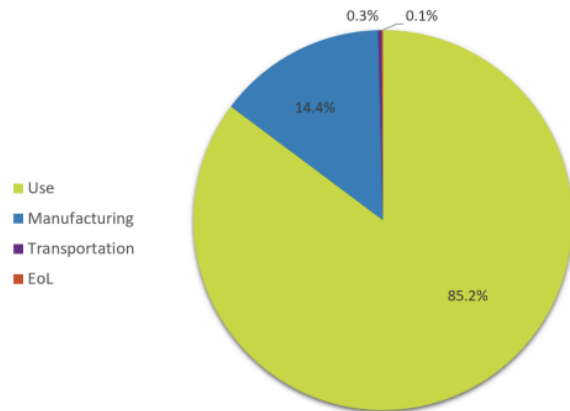
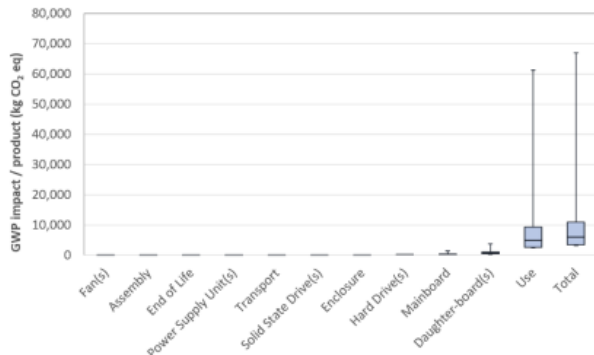
# Its conversion machines which are creating the footprint for software - resource and electricity use.



Electricity



Resources



9180 kgCO<sub>2</sub>e

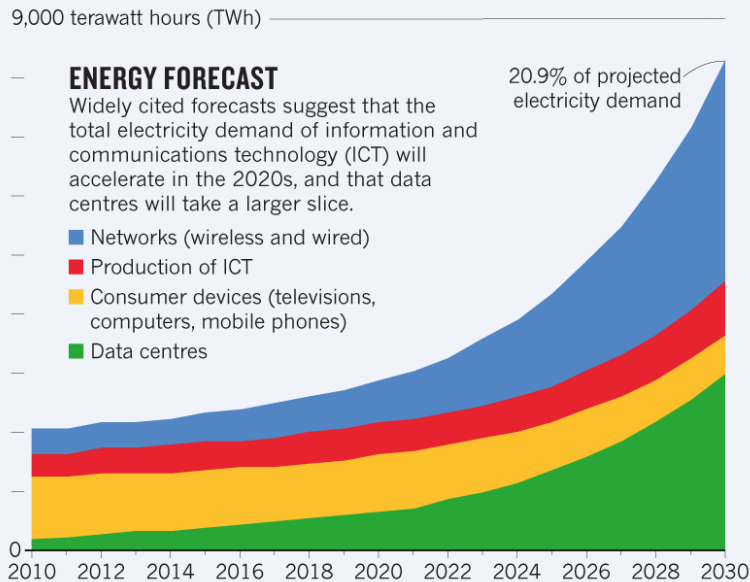
# Its conversion machines which are creating the footprint for software - resource and electricity use.



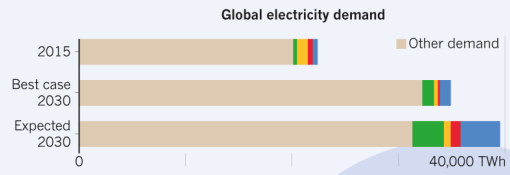
Electricity



Resources



The chart above is an 'expected case' projection from Anders Andrae, a specialist in sustainable ICT. In his 'best case' scenario, ICT grows to only 8% of total electricity demand by 2030, rather than to 21%.



# Software has an environmental footprint, based on electricity & resource consumption of the digital power conversion machines



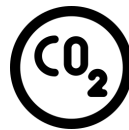
Environmental  
Footprint of Software



Electricity



Resources



Embedded CO2-eq

**Digital Power**



**Enabling IT developers & architects to understand, measure and improve this footprint, therefore is of critical importance to society and businesses addressing their environmental impact.**

# Introducing SoftAWARE - Tools to determine the electrical power consumption of software components & IDEs; towards a label for energy efficient software.



Bundesministerium  
für Wirtschaft  
und Klimaschutz

Umwelt  
Bundesamt



Öko-Institut e.V.  
Institut für angewandte Ökologie  
Institute for Applied Ecology

Ein Forschungsvorhaben des Umweltbundesamts (UBA) finanziert durch das Bundesministerium für Wirtschaft und Energie (BMWK) durchgeführt von der SDIA und dem Öko Institut

# Majority of software today is build by assembling open source libraries and components.



90% of IT leaders are using enterprise open source today.

U.S.=91%, EMEA=88%, APAC=92%, LATAM=91%

Top ways enterprise open source is being used

1. IT infrastructure modernization **64%**
2. Application development **54%**
3. Digital transformation **53%**



**Red Hat**

[The State of Enterprise Open Source](#)

# So doesn't the choice of components already impact the electricity footprint of an application?

```
"require": {
    "ext-date": "*",
    "ext-dom": "*",
    "ext-filter": "*",
    "ext-gd": "*",
    "ext-hash": "*",
    "ext-json": "*",
    "ext-pcre": "*",
    "ext-PDO": "*",
    "ext-session": "*",
    "ext-SimpleXML": "*",
    "ext-SPL": "*",
    "ext-tokenizer": "*",
    "ext-xml": "*",
    "php": ">=7.3.0",
    "symfony/console": "^4.4",
    "symfony/dependency-injection": "^4.4",
    "symfony/event-dispatcher": "^4.4",
    "symfony/http-foundation": "^4.4",
    "symfony/http-kernel": "^4.4",
    "symfony/mime": "^5.4",
    "symfony/routing": "^4.4",
    "symfony/serializer": "^4.4",
    "symfony/translation": "^4.4",
    "symfony/validator": "^4.4",
    "symfony/process": "^4.4",
    "symfony/polyfill-iconv": "^1.0",
    "symfony/polyfill-php80": "^1.16",
    "symfony/yaml": "^4.4",
    "typo3/phar-stream-wrapper": "^3.1.3",
    "twig/twig": "^2.12.0",
    "doctrine/reflection": "^1.1",
    "doctrine/annotations": "^1.12",
    "guzzlehttp/guzzle": "^6.5.2",
    "symfony-cmf/routing": "^2.1",
    "laminas/laminas-feed": "^2.12",
    "stack/builder": "^1.0",
    "egulias/email-validator": "^2.1.22|^3.0",
    "masterminds/html5": "^2.1",
    "symfony/psr-http-message-bridge": "^2.0",
    "laminas/laminas-diactoros": "^2.1",
    "composer/semver": "^3.0",
    "asm89/stack-cors": "^1.1",
    "pear/archive_tar": "^1.4.14",
    "psr/log": "^1.0"
```

```
replace": {
    "drupal/action": "self.version",
    "drupal/aggregator": "self.version",
    "drupal/automated_cron": "self.version",
    "drupal/bartik": "self.version",
    "drupal/bartik": "self.version",
    "drupal/basic_auth": "self.version",
    "drupal/big_pipe": "self.version",
    "drupal/block": "self.version",
    "drupal/block_content": "self.version",
    "drupal/book": "self.version",
    "drupal/breakpoint": "self.version",
    "drupal/ckeditor": "self.version",
    "drupal/ckeditor5": "self.version",
    "drupal/claro": "self.version",
    "drupal/classy": "self.version",
    "drupal/color": "self.version",
    "drupal/comment": "self.version",
    "drupal/config": "self.version",
    "drupal/config_translation": "self.version",
    "drupal/contact": "self.version",
    "drupal/content_moderation": "self.version",
    "drupal/content_translation": "self.version",
    "drupal/contextual": "self.version",
    "drupal/core-annotation": "self.version",
    "drupal/core-assertion": "self.version",
    "drupal/core-bridge": "self.version",
    "drupal/core-class-finder": "self.version",
    "drupal/core-datetime": "self.version",
    "drupal/core-dependency-injection": "self.version",
    "drupal/core-diff": "self.version",
    "drupal/core-discovery": "self.version",
    "drupal/core-event-dispatcher": "self.version",
    "drupal/core-file-cache": "self.version",
    "drupal/core-file-security": "self.version",
    "drupal/core-file-system": "self.version",
    "drupal/core-front-matter": "self.version",
    "drupal/core-gettext": "self.version",
    "drupal/core-graph": "self.version",
    "drupal/core-http-foundation": "self.version",
    "drupal/core-php-storage": "self.version",
    "drupal/core-plugin": "self.version",
    "drupal/core-proxy-builder": "self.version",
    "drupal/core-render": "self.version",
    "drupal/core-serialization": "self.version",
    "drupal/core-translator": "self.version",
    "drupal/core-utility": "self.version",
    "drupal/core-uid": "self.version",
```

## drupal/drupal



Verbatim mirror of the git.drupal.org repository for Drupal core. Please see the <https://github.com/drupal/drupal#contributing>. PRs are not accepted on GitHub.

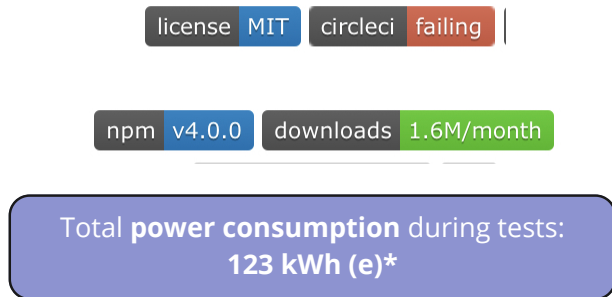
43 Contributors 444 Used by 4k Stars 2k Forks

github.com

**GitHub - drupal/drupal:** Verbatim mirror of the git.drupal.org repository for Drupal core. Please see the <https://github.com/drupal/drupal#contributing>. PRs are not accepted on GitHub.

Verbatim mirror of the git.drupal.org repository for Drupal core. Please see the <https://github.com/drupal/drupal#contributing>. PRs are not accepted on GitHub. - GitHub - drupal/drupal: Verbatim mir...

# We believe so. So the first step is to create transparency and enable choice for developers selecting components:



\* There is many ways to approach this label = we will evaluate the best approach during the project.

# But how to actually measure the energy efficiency of a software library (without applying it)?

"Software testing is the process of evaluating and verifying that a software product or application does what it is supposed to do." - [IBM](#)

"[...] unit testing is a [software testing](#) method by which individual units of [source code](#)—sets of one or more computer program [modules](#) together with associated control data, usage [procedures](#), and operating procedures—are tested to determine whether they are fit for use." - [Wikipedia](#)



**Scaphandre** [skafɑ̃dʁ] is a metrology agent dedicated to electrical [power](#) consumption metrics.












**Pipelines** Settings

Filters: web-ui All Pipelines All Branches

PIPELINE	STATUS	BRANCH	WORKFLOW	COMMIT	STARTED	DURATION
#11253	SUCCESS	renovate/runtime	build-test-and-deploy	Update Runtime dependencies	8 hours ago	8m 50s
#11252	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update dependency @types/react to v16.9.17	10 hours ago	8m 36s
#11251	SUCCESS	renovate/runtime	build-test-and-deploy	Update Runtime dependencies	14 hours ago	11m 11s
#11250	FAILED	renovate/major-runtime	build-test-and-deploy	Update Runtime dependencies	17 hours ago	15m 16s
#11249	FAILED	renovate/major-devdependencies	build-test-and-deploy	Update Development dependencies	17 hours ago	8m 10s
#11248	SUCCESS	master	build-test-and-deploy	Merge pull request #1586 from circleci	17 hours ago	12m 27s
#11247	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	17 hours ago	7m 18s
#11246	SUCCESS	master	build-test-and-deploy	Merge pull request #1589 from circleci	17 hours ago	11m 3s
#11245	SUCCESS	renovate/runtime	build-test-and-deploy	Update Runtime dependencies	17 hours ago	9m 55s
#11244	SUCCESS	change-proj-link	build-test-and-deploy	removing unused import	22 hours ago	6m 54s
#11243	CANCELED	change-proj-link	build-test-and-deploy	changing 'add new project' link to new onboarding	22 hours ago	7m 55s
#11242	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	1 day ago	10m 15s
#11241	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	2 days ago	9m 35s
#11240	CANCELED	renovate/major-runtime	build-test-and-deploy	Update Runtime dependencies	2 days ago	20m 44s
#11239	SUCCESS	renovate/runtime	build-test-and-deploy	Update Runtime dependencies	2 days ago	8m 45s
#11238	SUCCESS	renovate/runtime	build-test-and-deploy	Update Runtime dependencies	2 days ago	10m 9s
#11237	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	2 days ago	7m 52s
	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	2 days ago	9m 25s
#11236	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	2 days ago	12m 20s
#11235	SUCCESS	renovate/devdependencies	build-test-and-deploy	Update Development dependencies	2 days ago	9m 58s
#11234	SUCCESS	master	build-test-and-deploy	Merge pull request #1588 from circleci	2 days ago	11m 33s

See more

# Our approach: Record power consumption while each test is executing and report results into CI/CD flow

TRX Report - trx2html.Test, Version=1.0.0.0, Culture=...				
<a href="#">Totals</a>   <a href="#">Summary</a>   <a href="#">Detail</a>   <a href="#">Environment Information</a>				
Percent	Status	TotalTests	Pas	
42.11%		19	8	
TestClasses Summary		Percent	Status	TestsPassed TestsF
<a href="#">trx2html.Test.FailAndIgnored</a>		0%		0 2
<a href="#">trx2html.Test.AllPassed</a>		100%		3 0
<a href="#">trx2html.Test.SomeIgnored</a>		66.67%		2 0
<a href="#">trx2html.Test.AllFailed</a>		0%		0 3
<a href="#">trx2html.Test.SomeFailed</a>		33.33%		1 2
<a href="#">trx2html.Test.ResourceReaderTest</a>		100%		2 0
Test Class Detail				
trx2html.Test.FailAndIgnored				
TestMethod6		TestMethodThatIsInconclusive Assert.Inconclusive failed. Inconclusive		00:00:00.001
TestMethod5		TestMethodThatIsInconclusive		00:00:00.001

**In local development environments, physical power measuring infrastructure won't be available**

**RAPL vs. Using Constants?**



# And we will look at your IDEs themselves and how much power they consume when used:



## Programming languages:

Python, Java, C, C++, JavaScript, Go Lang

## Development environments:

Android Studio, Visual Studio, Eclipse IDE, JetBrains, Visual Studio Code /  
GitHub Atom

# Last, here is what the project will not be or do:

Benchmarking or comparison  
of libraries

Have 99.999% accuracy in all  
scenarios

Consider the complete lifecycle  
impact of the library

Be applicable for user  
interfaces & GUI

**What you can do now:**

**Are you a maintainer or fan of an open source library that we should consider first?**

E-Mail us: [community@sdialliance.org](mailto:community@sdialliance.org)

# The use of resources = environmental impact.

## Where can you use less in your code?

Turning off legacy systems?

Do we really need those new servers?

Are all those dependencies really needed?

Does this have to be solved with software?

Can this website be static instead of running on a CMS/Wordpress?

Can this run only at night (when the power grid is less stressed)?

# Join the SDIA! :-)

A not-for-profit organization (e.V.) dedicated to create sustainable digital infrastructure to enable a sustainable digital economy.

We are on measuring the footprint of the digital economy, and have created a [roadmap until 2030](#) to reduce it to zero.

Web: [sdia.io](https://sdia.io)