Onko vihreää ICT:tä ?

Green ICT -ekosysteemitapaaminen 26.2.2026

Jukka Manner

Professori, FT

ELEC-D7020 - Elements of Sustainable ICT

ELEC-D7020 - Elements of Sustainable ICT D, Lecture, 7.1.2026-17.4.2026
Department of Information and Communications Engineering

ELEC-D7020 - Elements of Sustainable ICT D, Lecture, 7.1.2025-8.4.2025
Department of Information and Communications Engineering

ELEC-D7020 - Elements of Sustainable ICT, Lecture, 9.1.2024-9.4.2024
Department of Information and Communications Engineering

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Aalto-universitetet
Aalto University

Sisältö

- **Miten laskenta on kehittynyt ?**

- **Miten ohjelmointi on kehittynyt ?**

- **Miten laitteet ovat kehittyneet ?**

- **Onko vihreää koodausta ja ICT:tä ?**

Vihreästä näkökulmasta

Sisältö

- **Miten laskenta on kehittynyt ?**
- Miten ohjelmointi on kehittynyt ?
- Miten laitteet ovat kehittyneet ?
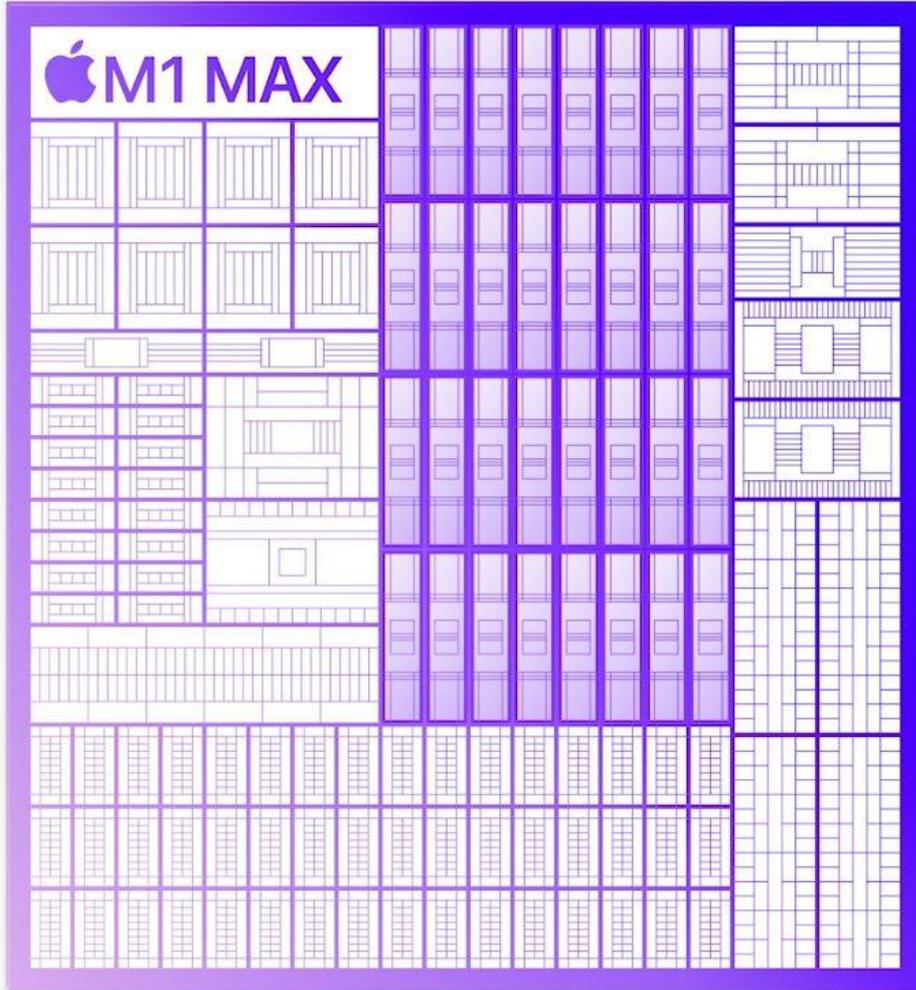- Onko vihreää koodausta ja ICT:tä ?

ASCI White (2000)
4900 GFLOPS

Samsung Galaxy S23 Ultra
3681 GFLOPS

https://en.wikipedia.org/wiki/ASCI_White

M1 MAX

32-core GPU

4096 execution units
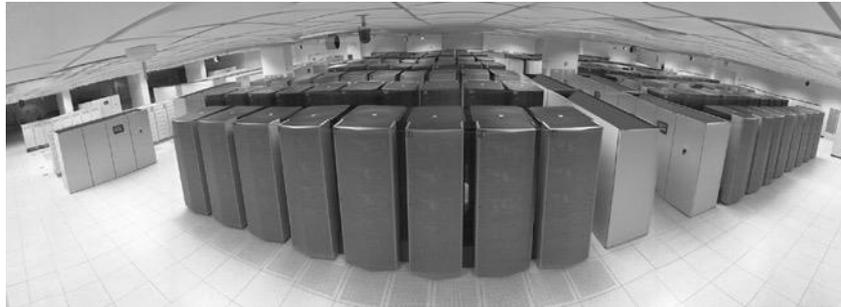
Up to 98,304 concurrent threads

10.4 teraflops

327 gigatexels/second

164 gigapixels/second

ASCI White (2000)
3MWatts laskenta +
3MWatts jäähdytys (!)

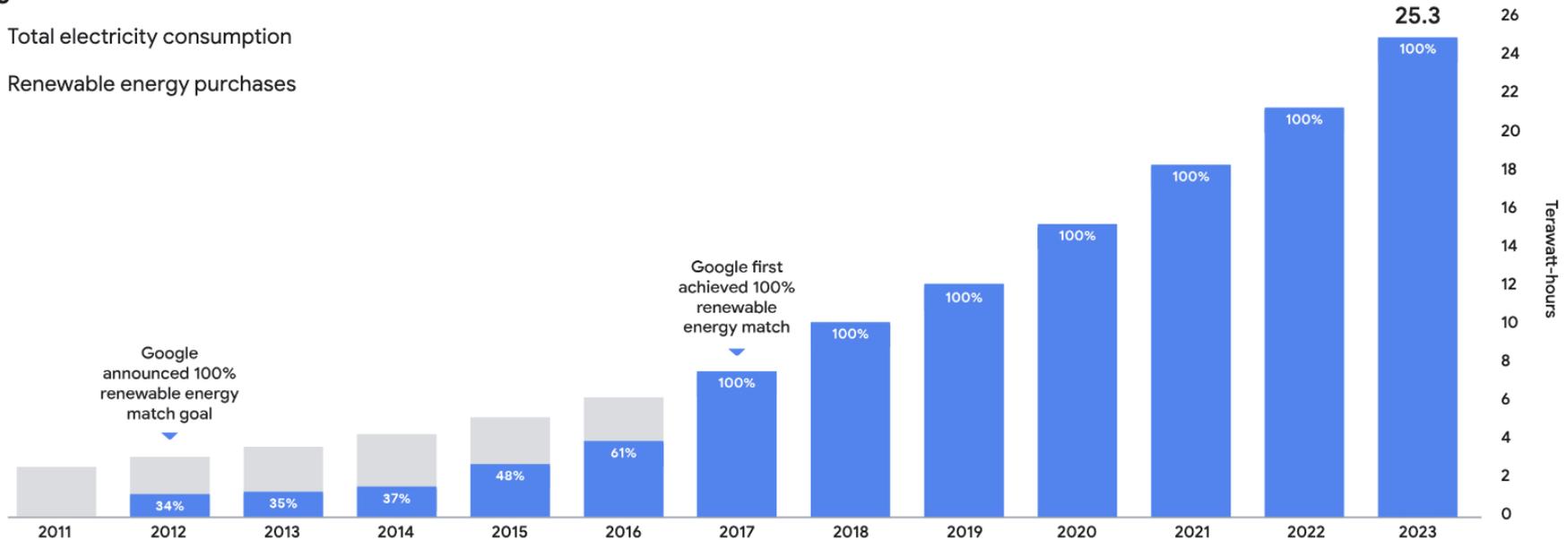Samsung Galaxy S23 Ultra
6 Wattia (näytön kanssa) ?

1'000'000 X

Qualcomm Snapdragon 8 Gen 2
Thermal Design Power 6.3W (ability to
dissipate heat from microchips)

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Google Environmental Report 2024

FIGURE 17 — Renewable energy purchasing compared with total electricity

Legend
- ⬤ Total electricity consumption
- ⬤ Renewable energy purchases

25.3

Google announced 100% renewable energy match goal

Google first achieved 100% renewable energy match

2011 — 2012 (34%) — 2013 (35%) — 2014 (37%) — 2015 (48%) — 2016 (61%) — 2017 (100%) — 2018 (100%) — 2019 (100%) — 2020 (100%) — 2021 (100%) — 2022 (100%) — 2023 (100%)
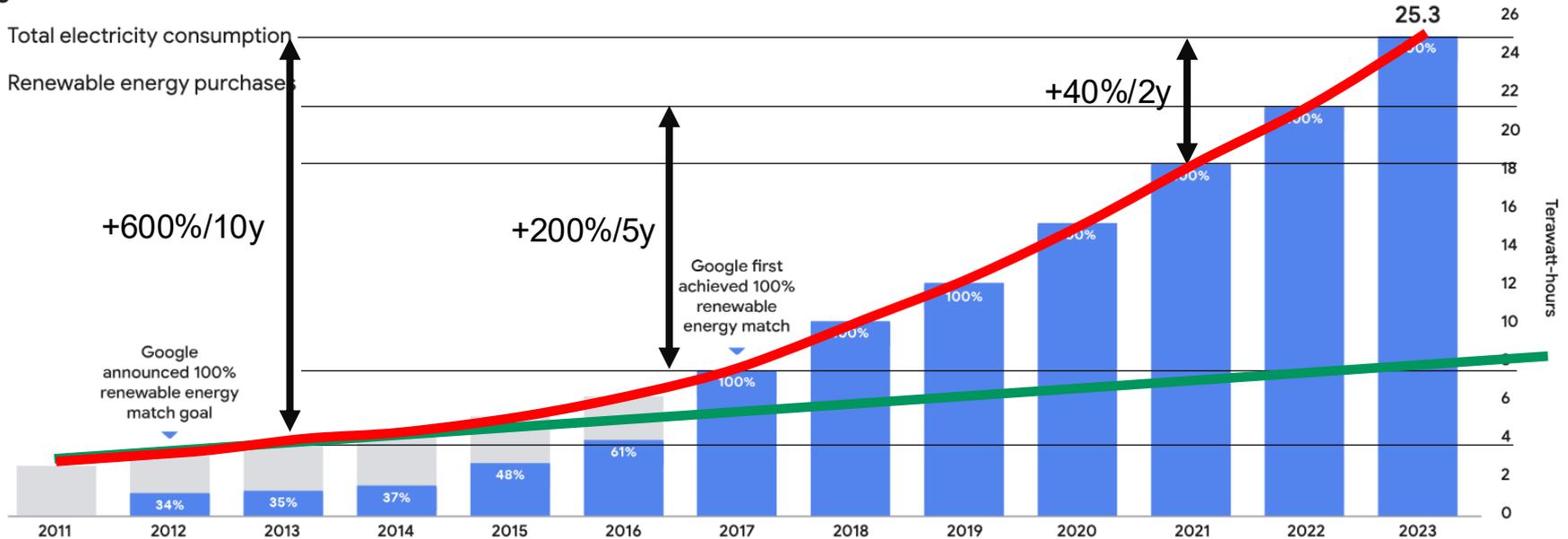
Terawatt-hours

Google Environmental Report 2024

FIGURE 17 — Renewable energy purchasing compared with total electricity

Legend
- Total electricity consumption
- Renewable energy purchases

+600%/10y

+200%/5y

+40%/2y

25.3

Google announced 100% renewable energy match goal

Google first achieved 100% renewable energy match

34% 35% 37% 48% 61% 100% 100% 100% 100% 100% 100%

2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

Terawatt-hours

Ireland's datacentres overtake electricity use of all urban homes combined

Statistics raise concerns that rise in demand for data processing driven by AI could derail climate targets

📷 Datacentres supporting tech hubs used 21% of Ireland's electricity last year, an increase 20% on 2022 – all homes used 18%. Photograph: Erik Isakson/Getty Images/Tetra images RF
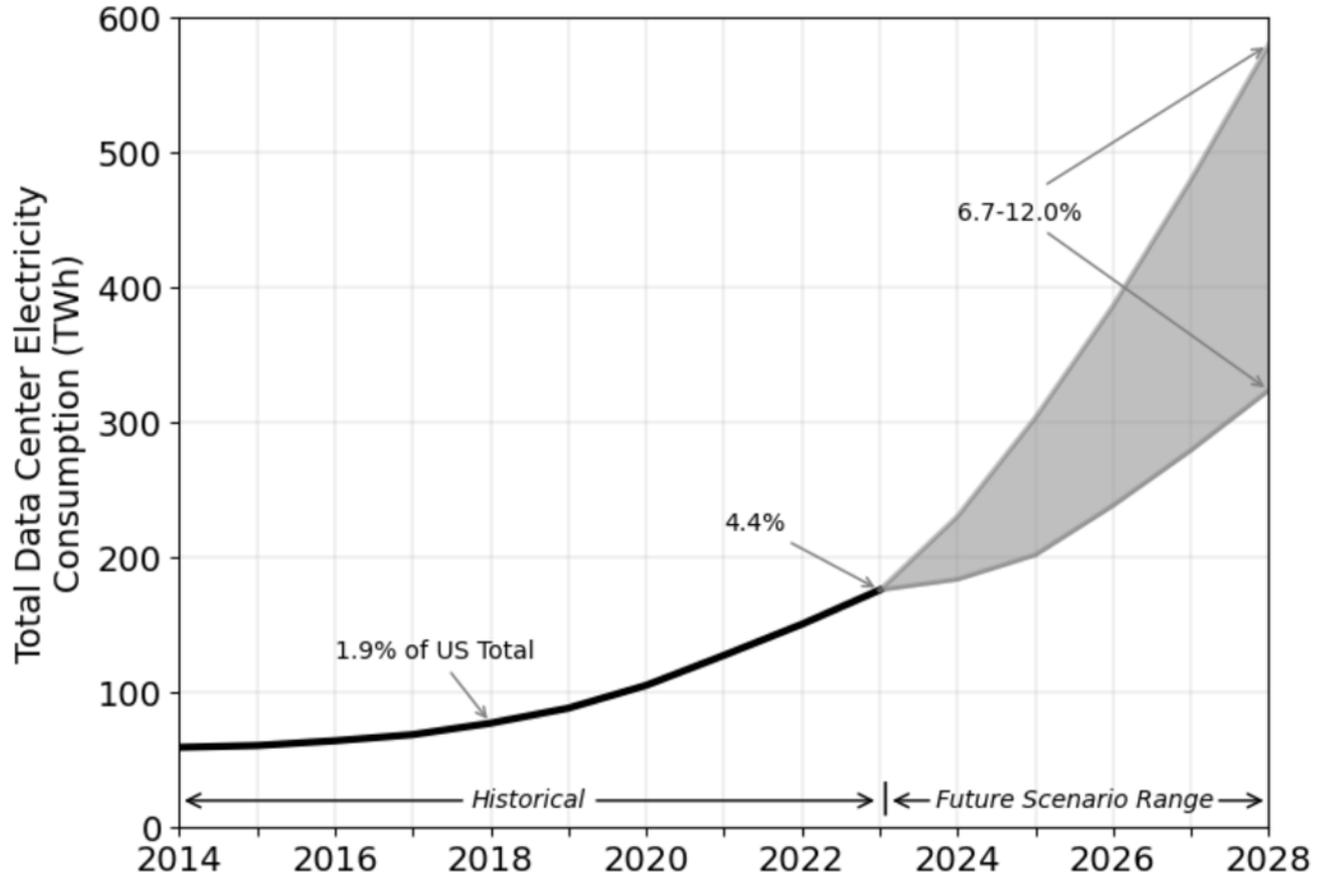
Figure ES-1. Total U.S. data center electricity use from 2014 through 2028.

https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf

Laskennan tarpeen muutos

Internet- ja pilvipalvelut

Internet- ja pilvipalvelut + AI

AI nyt

AI pian

1990 – 2023 < 3,5 kW

2023 – 2024 → 3,5 … 10 kW

3 x Gigabyte H100 – 28 kW

2025 – 2027 → 30 – 130 kW

NVIDIA NVL72 – 132 kW
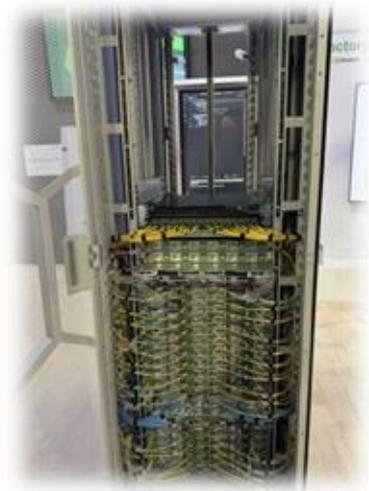
2027 → 250…1000 kW

Dell IR7000 – 480 kW

Kalvo: Matti Pärssinen

Mistä uusi energia tulee ?

Uusiutuvaa ?

Amazon buys nuclear-powered data center from Talen

Thu, Mar 7, 2024, 3:01PM | Nuclear News

Susquehanna nuclear plant in Salem Township, Penn., along with the data center in foreground. (Photo: Talen Energy)

Talen Energy announced its sale of a 960-megawatt data center campus to cloud service provider Amazon Web Services (AWS), a subsidiary of Amazon, for $650 million.

https://www.ans.org/news/article-5842/amazon-buys-nuclearpowered-data-center-from-talen/

Microsoft chooses infamous nuclear site for AI power

20 September 2024   Share ⬨ Save 🔖

Natalie Sherman
BBC News

Getty Images

America's Three Mile Island energy plant, the site of the worst nuclear accident in US history, is preparing to reopen as Microsoft looks for ways to satisfy its growing energy needs.

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August 25, 2025

# Gas utilities in the US advance data center deals as power bottlenecks persist

By **Tom DiChristopher**

Sisältö

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Top programming languages on GitHub

RANKED BY COUNT OF DISTINCT USERS CONTRIBUTING TO PROJECTS OF EACH LANGUAGE.

https://github.blog/news-insights/octoverse/octoverse-2024/
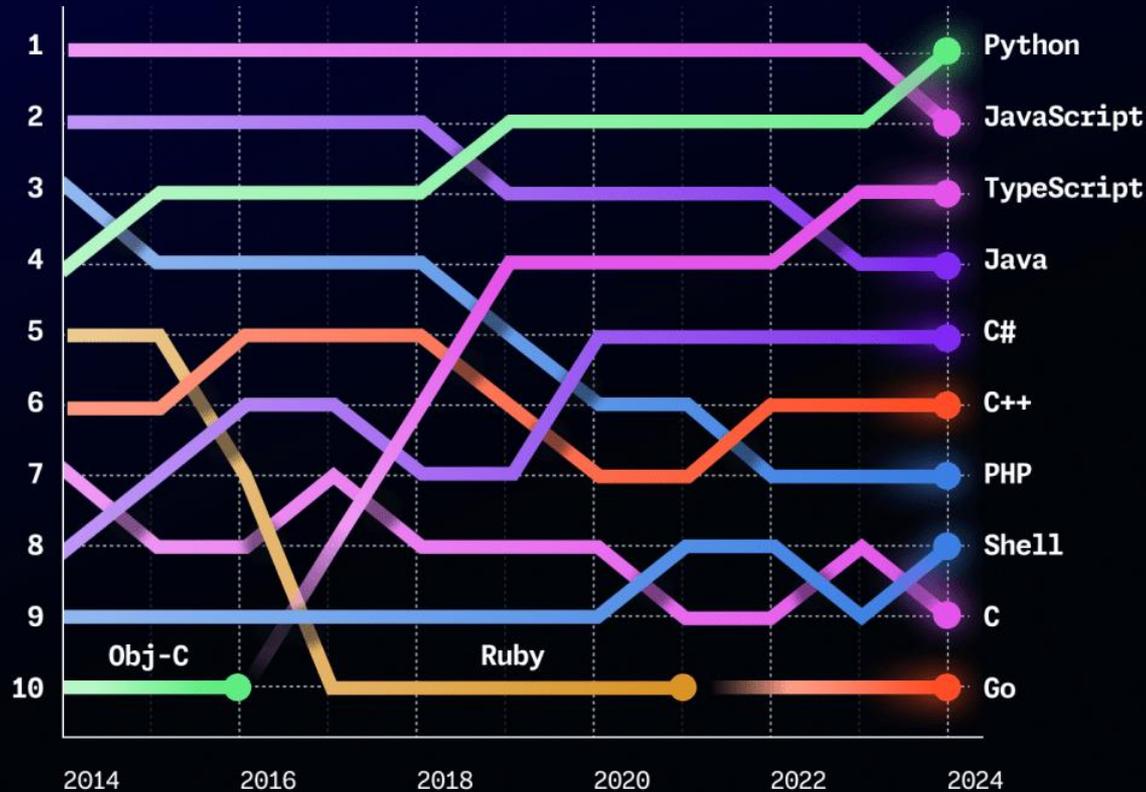
ANALYSIS | COMPUTING

The Top Programming Languages 2025 › Does AI mean the end for the Top Programming Languages?

BY STEPHEN CASS | 23 SEP 2025 | 6 MIN READ | 🔖

Stephen Cass is the special projects editor at IEEE Spectrum.

SHARE THIS STORY

✉ 🔗 X f in

TAGS

TOP PROGRAMMING LANGU...

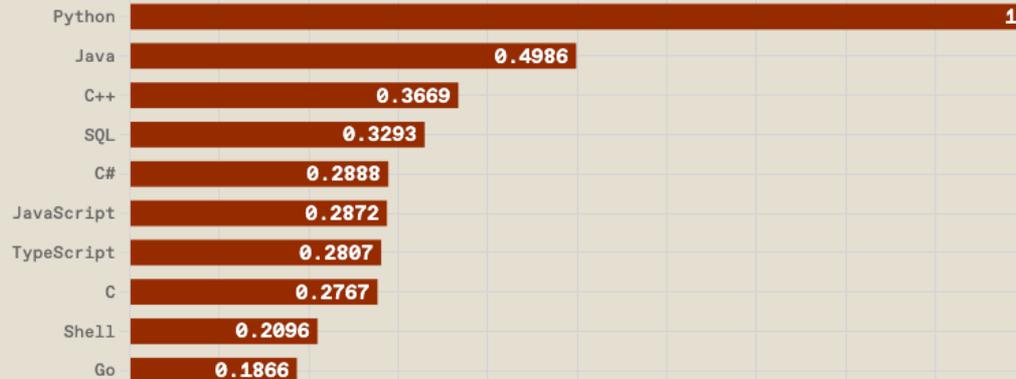PYTHON JAVASCRIPT

SQL VIBE CODING

PROGRAMMINIG

Top Programming Languages 2025

Click a button to see a differently weighted ranking

[**Spectrum**] [Trending] [Jobs]

Language	Value
Python	1
Java	0.4986
C++	0.3669
SQL	0.3293
C#	0.2888
JavaScript	0.2872
TypeScript	0.2807
C	0.2767
Shell	0.2096
Go	0.1866

Energy usage of programming languages

	Total					
	Energy		**Time**			**Mb**
(c) C	1.00	(c) C	1.00	(c) Pascal	1.00
(c) Rust	1.03	(c) Rust	1.04	(c) Go	1.05
(c) C++	1.34	(c) C++	1.56	(c) C	1.17
(c) Ada	1.70	(c) Ada	1.85	(c) Fortran	1.24
(v) Java	1.98	(v) Java	1.89	(c) C++	1.34
(c) Pascal	2.14	(c) Chapel	2.14	(c) Ada	1.47
(c) Chapel	2.18	(c) Go	2.83	(c) Rust	1.54
(v) Lisp	2.27	(c) Pascal	3.02	(v) Lisp	1.92
(c) Ocaml	2.40	(c) Ocaml	3.09	(c) Haskell	2.45
(c) Fortran	2.52	(v) C#	3.14	(i) PHP	2.57
(c) Swift	2.79	(v) Lisp	3.40	(c) Swift	2.71
(c) Haskell	3.10	(c) Haskell	3.55	(i) Python	2.80
(v) C#	3.14	(c) Swift	4.20	(c) Ocaml	2.82
(c) Go	3.23	(c) Fortran	4.20	(v) C#	2.85
(i) Dart	3.83	(v) F#	6.30	(i) Hack	3.34
(v) F#	4.13	(i) JavaScript	6.52	(v) Racket	3.52
(i) JavaScript	4.45	(i) Dart	6.67	(i) Ruby	3.97
(v) Racket	7.91	(v) Racket	11.27	(c) Chapel	4.00
(i) TypeScript	21.50	(i) Hack	26.99	(v) F#	4.25
(i) Hack	24.02	(i) PHP	27.64	(i) JavaScript	4.59
(i) PHP	29.30	(v) Erlang	36.71	(i) TypeScript	4.69
(v) Erlang	42.23	(i) Jruby	43.44	(v) Java	6.01
(i) Lua	45.98	(i) TypeScript	46.20	(i) Perl	6.62
(i) Jruby	46.54	(i) Ruby	59.34	(i) Lua	6.72
(i) Ruby	69.91	(i) Perl	65.79	(v) Erlang	7.20
(i) Python	75.88	(i) Python	71.90	(i) Dart	8.64
(i) Perl	79.58	(i) Lua	82.91	(i) Jruby	19.84

Pereira, R., Couto, M., Ribeiro, F., Cunha, J., Fernandes, J. P., & Saraiva, J. (2017). Energy Efficiency across Programming Languages. Proceedings of the 10th ACM SIGPLAN International Conference on Software Language Engineering, October 2017, Pages 256–267.

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(c) Rust	1.03	(c) Rust	1.04	(c) Go	1.05
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(c) Ada	1.70	(c) Ada	1.85	(c) Fortran	1.24
(v) Java	1.98	(v) Java	1.89	(c) C++	1.34
(c) Pascal	2.14	(c) Chapel	2.14	(c) Ada	1.47
(c) Chapel	2.18	(c) Go	2.83	(c) Rust	1.54
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(i) Perl	79.58	(i) Lua	82.91	(i) Jruby	19.84

#3 (v) Java — Energy 1.98

#2 (i) JavaScript — Energy 4.45

#1 (i) Python — Energy 75.88

Pereira, R., Couto, M., Ribeiro, F., Cunha, J., Fernandes, J. P., & Saraiva, J. (2017). Energy Efficiency across Programming Languages. Proceedings of the 10th ACM SIGPLAN International Conference on Software Language Engineering, October 2017, Pages 256–267.

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Computer Language Benchmark Game – benchmark game 7

https://benchmarksgame-team.pages.debian.net/benchmarksgame/box-plot-summary-charts.html
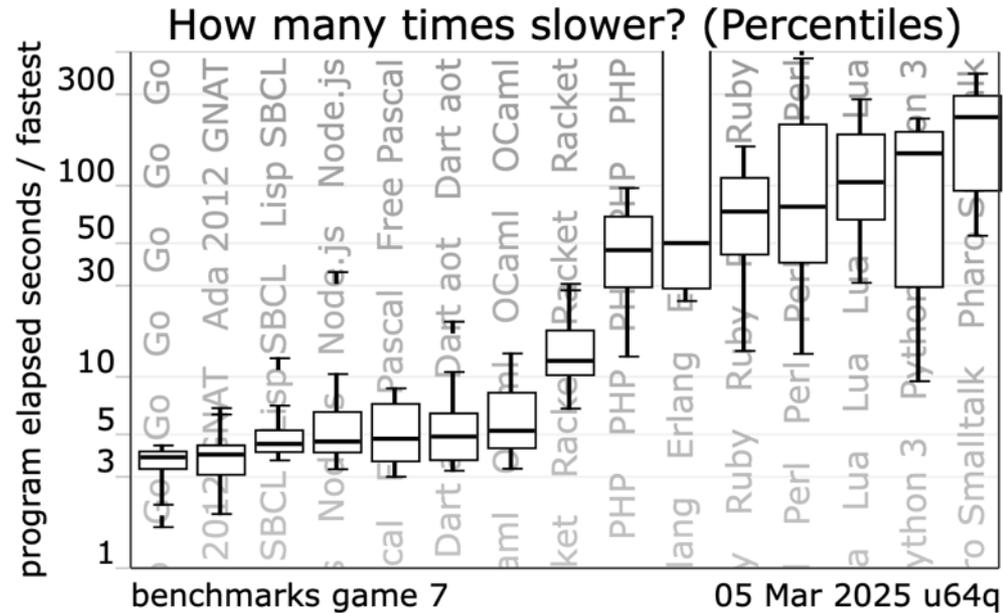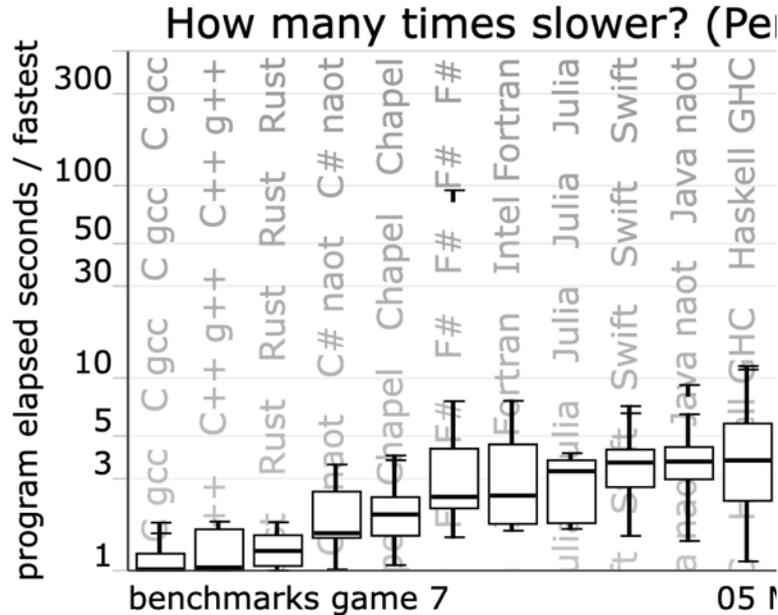
Computer Language Benchmark Game – fannkuck-redux

×	source	secs
1.0	* **C** gcc #6	**2.14**
1.0	* **C#** naot #5	**2.16**
1.6	* **C++**g++ #6	**3.33**
1.8	* **Rust** #6	**3.81**
3.2	Rust #4	6.94
3.4	C gcc #5	7.28
3.5	Rust #5	7.41
3.7	C++ g++ #5	7.86
3.8	* C# naot #9	8.11
3.8	* **Swift** #3	**8.20**

225	Pharo **Smalltalk**	**8 min**
277	PHP	9 min
283	**Lua**	**10 min**
397	PHP #8	14 min
442	Python 3 #6	15 min
597	Perl #3	21 min
673	Ruby	23 min
	Perl	30 min
	Ruby #8	34 min
	Python 3 #8	40 min

Computer Language Benchmark Game - mandelbrot

×	source	secs
1.0	* **C++**g++ #4	**0.89**
1.0	* C++ g++	0.90
1.1	**Rust** #4	**0.95**
1.1	* C++ g++ #6	0.98
1.2	Rust #6	1.08
1.2	Rust #7	1.10
1.2	Rust #2	1.10
1.3	Rust #5	1.12
1.3	Rust #3	1.15
1.3	**Chapel** #3	**1.18**

475	PHP #8	7 min
546	Lua #3	8 min
554	**Perl**	**8 min**
561	Lua	8 min
586	Lua #2	8 min
649	Ruby #4	9 min
	Python 3 #3	14 min
	Ruby #8	15 min
	Python 3 #8	26 min
	Ruby #3	29 min

https://benchmarksgame-team.pages.debian.net/benchmarksgame/performance/mandelbrot.html

Pitää olla supertietokone taskussa

Adobe Flash, anyone ?

MEDIAN DESKTOP
2123.6 KB
▲309.3%

MEDIAN MOBILE
1917.4 KB
▲1224.2%

Timeseries of Total Kilobytes
Source: httparchive.org

Zoom 1m 3m 6m YTD 1y 3y All

May 16, 2011 → May 1, 2021
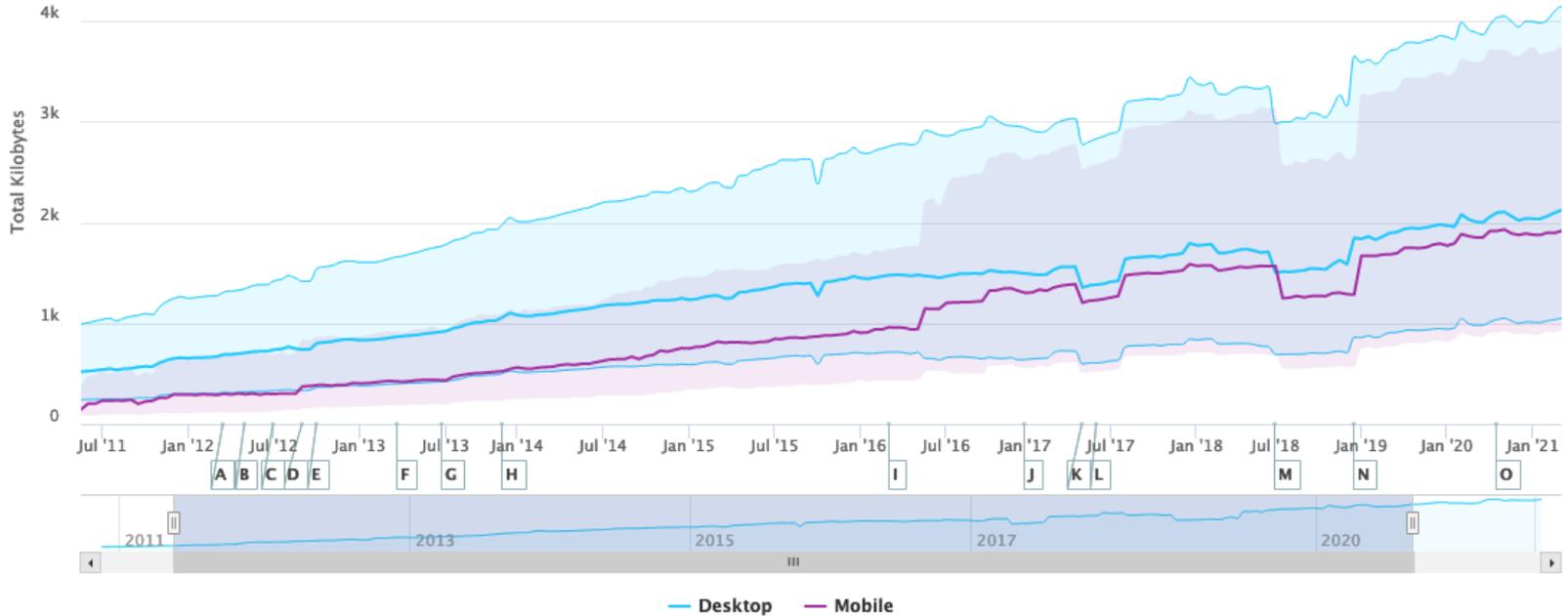
Total Kilobytes

— Desktop — Mobile

Sisältö

- Miten laskenta on kehittynyt ?

- Miten ohjelmointi on kehittynyt ?

- **Miten laitteet ovat kehittyneet ?**

- Onko vihreää koodausta ja ICT:tä ?

Power Mac G5 (iFixit)

Kornel
@kornel@mastodon.social

In 2003, Apple released a 64-bit dual-core 1.8Ghz system: Power Mac G5.

In 2023, Apple released a 64-bit dual-core 1.8Ghz system: Apple Watch Series 9.

The Watch is faster and has more RAM.

The G5 was too hot to put in a laptop. It'd use up S9's battery in under 2 minutes.

Dec 13, 2024, 03:56 AM · 🌐 · Web

442 boosts · **718** favorites

↩ ⇄ ☆ 🔖 ···

Sheldon Chang 🇺🇸   🌐 Dec 13, 2024 *
@sysop408@sfba.social

@kornel that's awesome, but I think you're missing the point here.

The Power Mac G5 was very difficult to wear on your wrist! I still have shoulder problems from those days.

↩ 1 ⇄ ☆ 🔖 ···

Carbon Footprint of iPhone Per Model

- **https://8billiontrees.com/carbon-offsets-credits/carbon-footprint-of-iphone/**

Apple iPhone Carbon Emissions
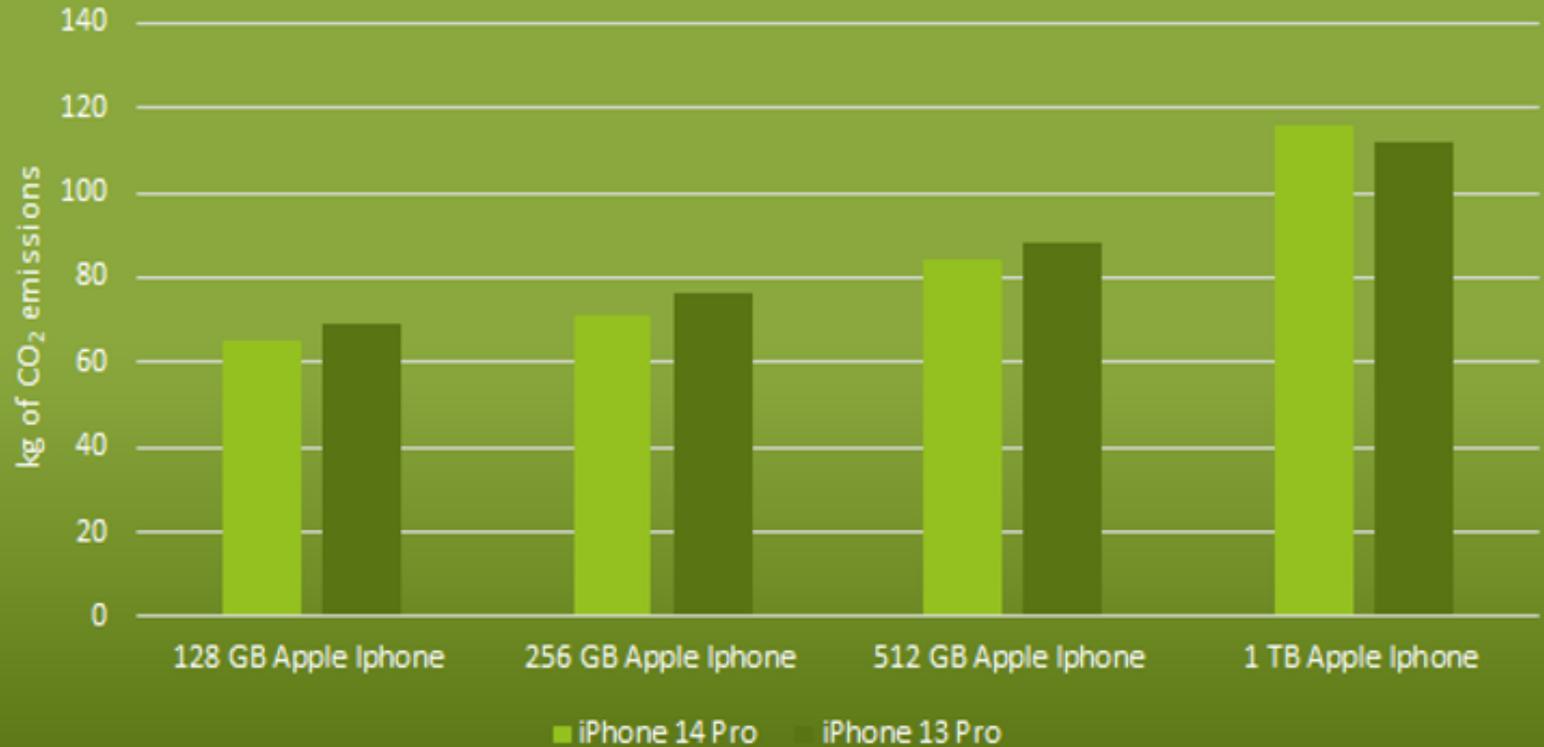
Päästöt: Dell palvelin

- Valmistus: 4283kg CO2e (R740, 2019)

- Käyttö: 201-510W, k-a 351W

- Elinaika 4 vuotta (?)

- Sähkön käytön CO^2 päästöt:
    - 3MWh/v, 12MWh/4v
    - Suomi, 32g/kWh: 394kg, **LCA osuus 8.4 %**

- **Sähköä kuluu saman verran kuin ajaisi sähköautolla 15'000km/vuosi.**

Table 4-2: Carbon footprint of main components of the Dell R740

Main Components	Global Warming Potential (GWP 100 years) [kg CO2e]
Chassis	34.1
Fans	11.1
3.84TB Solid State Drives	3373.5
400GB Solid State Drives	64.1
Mainboard	175.3
Packaging	1.9
PSU	31.3
PWB Mixed	591.8
Total	**4283.1**

Life Cycle Assessment of Dell R740

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Älypuhelimen valmistus on
99%
Elinkaaripäästöistä Suomessa

E
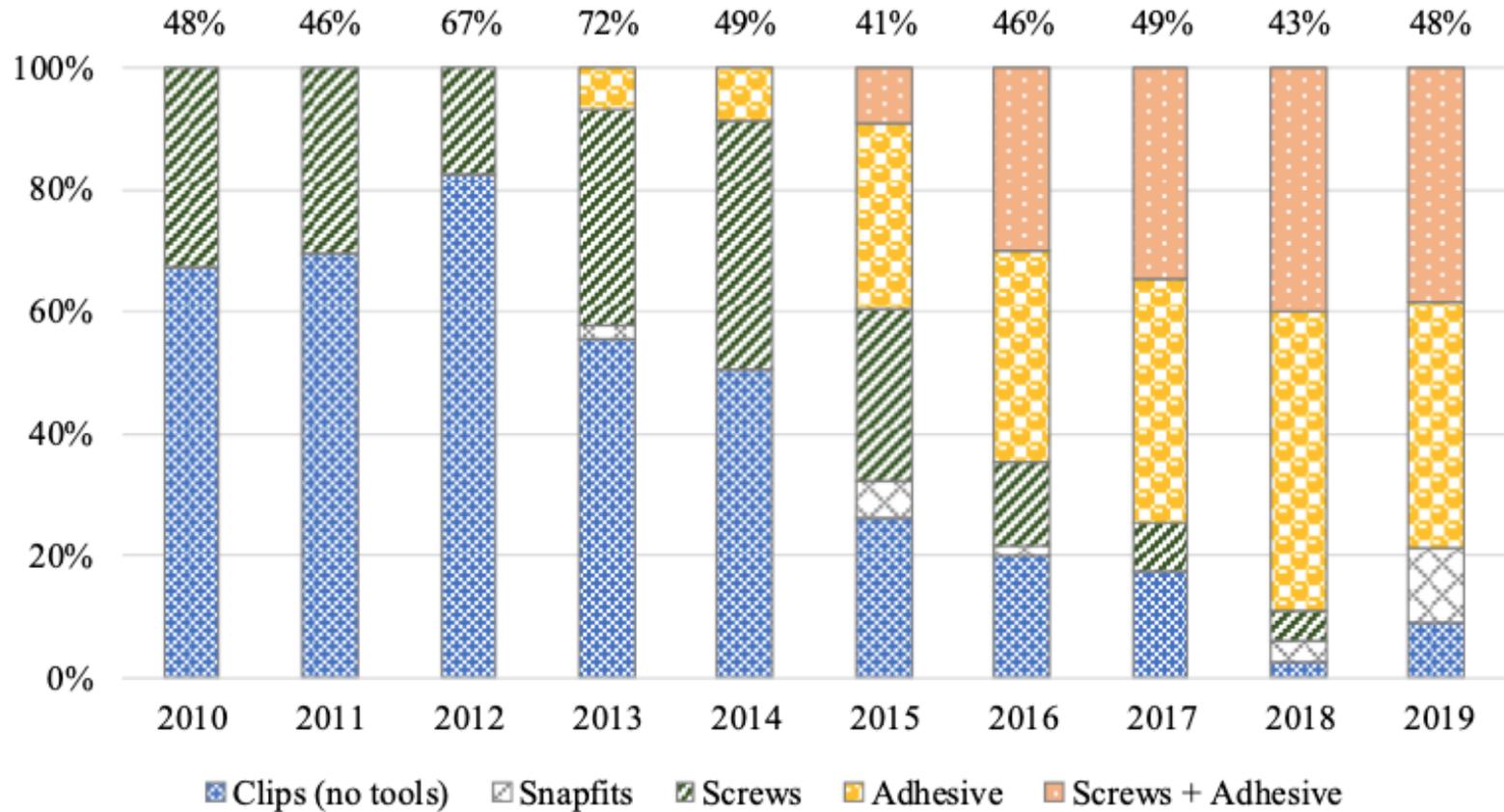
Figure 8: Evolution of smartphone case joining techniques applied to the best-selling smartphones in Europe (based on market data from Counterpoint Research; market coverage denoted on top of data columns).

- https://prompt-project.eu/wp-content/uploads/2020/07/PROMPT_20200429_Environmental-Evaluation-of-Current-and-Future-Design-Rules.pdf
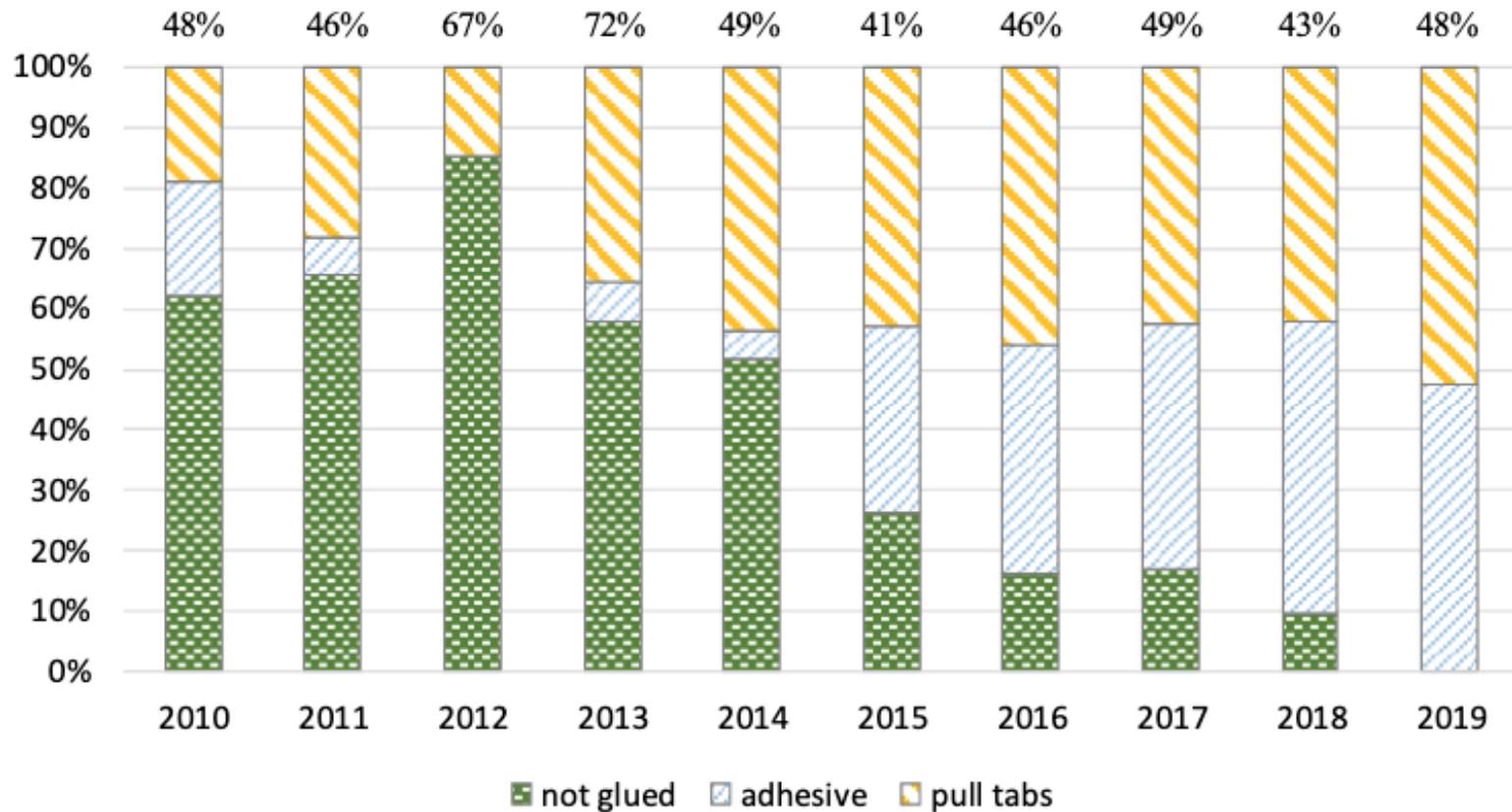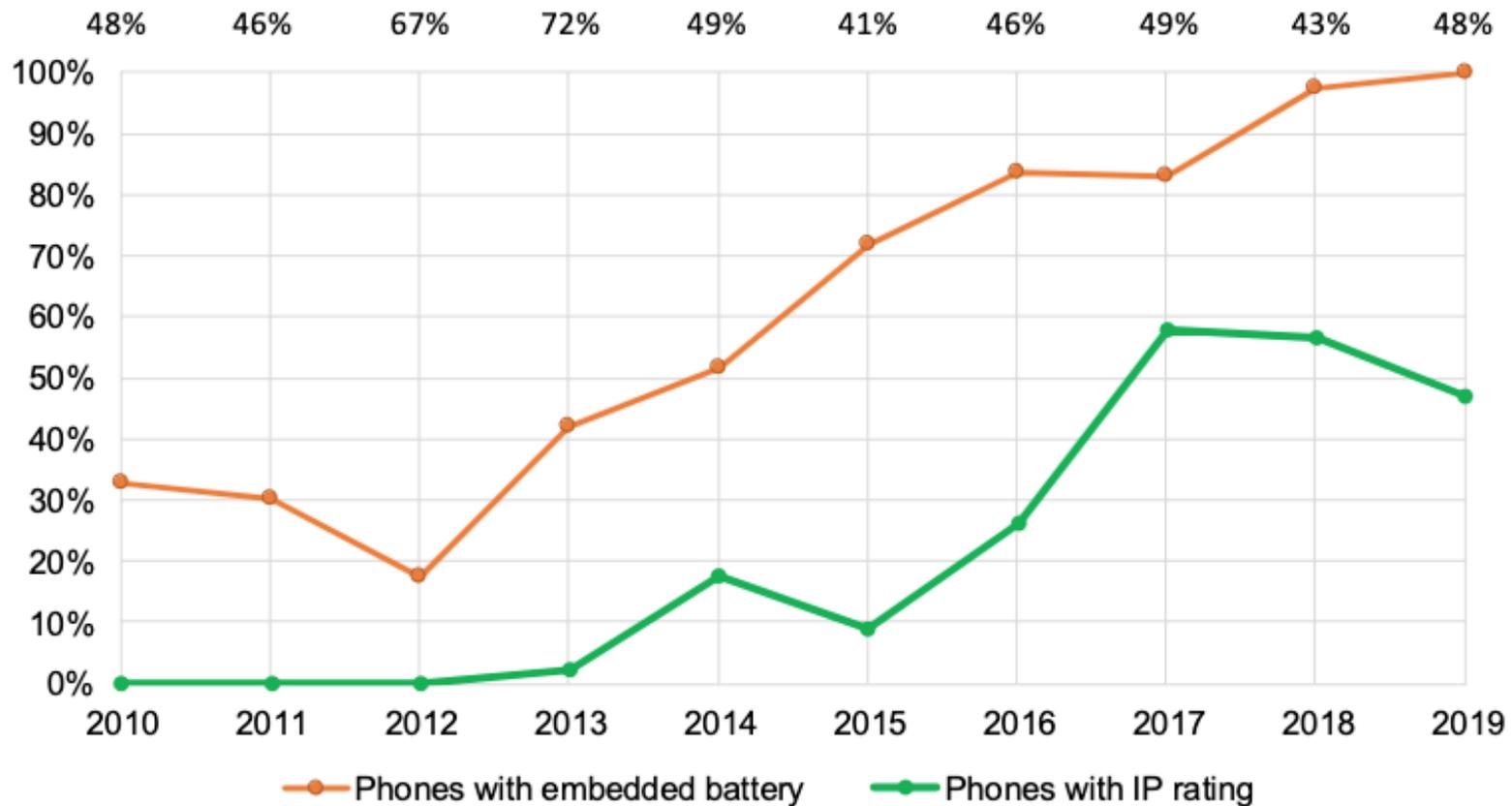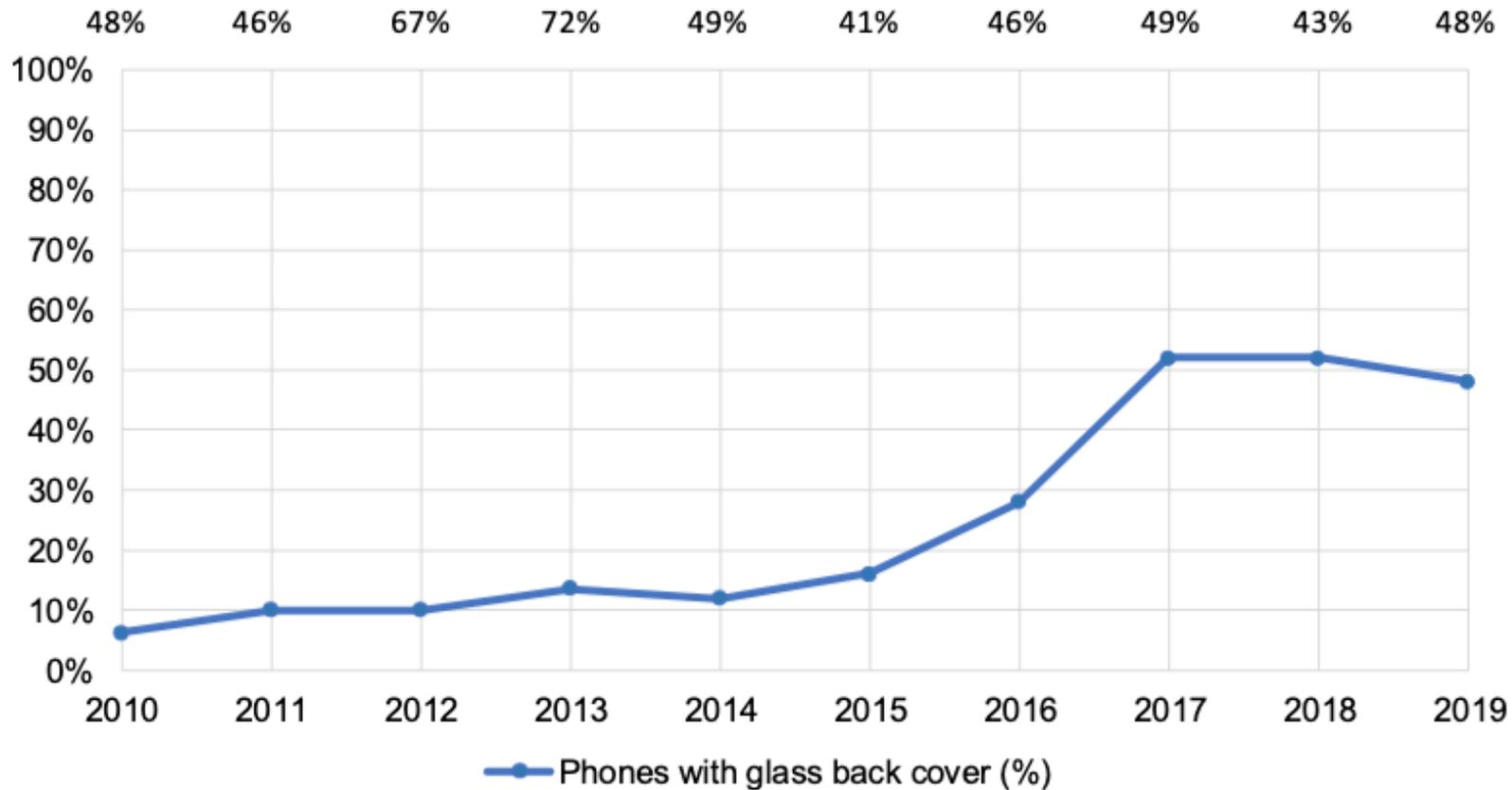
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Figure 9: Trend towards the use of adhesives to fix the battery within smartphones among the best-selling smartphones in Europe (based on market data from Counterpoint Research; market coverage denoted on top of data columns).

48%   46%   67%   72%   49%   41%   46%   49%   43%   48%

Figure 10: Market share of smartphones with embedded battery and smartphones with IP rating (based on market data from Counterpoint Research; market coverage denoted on top of the diagram).

Figure 11: Market share of smartphones with a glass back cover (based on market data from Counterpoint Research; market coverage denoted on top of the diagram).

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iFixit Repairability Score

Google Pixel Fold

PROS
- Google provides a free, comprehensive service manual.
- Genuine replacement parts and software calibration tools are available for end users.

CONS
- All repairs require carefully de-gluing (and later re-gluing) the outer display and/or back cover.
- Foldable smartphone repairs in general present challenges due to the inherent complexity of the product.

2023

3

Scorecard v1.7
Learn More

Apple iPhone 15

PROS
- Great design prioritizes screen repairs while giving access to all other parts through the back glass.
- Screws and clips aid reassembly, whether you replace the adhesives or not.

CONS
- DIY repairs are hobbled by pervasive parts pairing and deterrent messaging.

2023

4
PROVISIONAL

Scorecard v1.6
Learn More

Nokia G22

PROS
- Easily pried open for repairs, with no adhesive mess.
- Battery replacements are well-prioritized.
- Nokia supplies parts and guides for at least four of the most common repairs.

CONS
- Screen repairs are do-able but not well prioritized.

2023

8

Scorecard v1.6
Learn More

Fairphone 5

PROS
- Easy to disassemble/reassemble with basic tools—no adhesive blocks the way.
- End users can replace the battery in a few seconds.
- Fairphone provides a DIY service manual and offers original replacement parts.

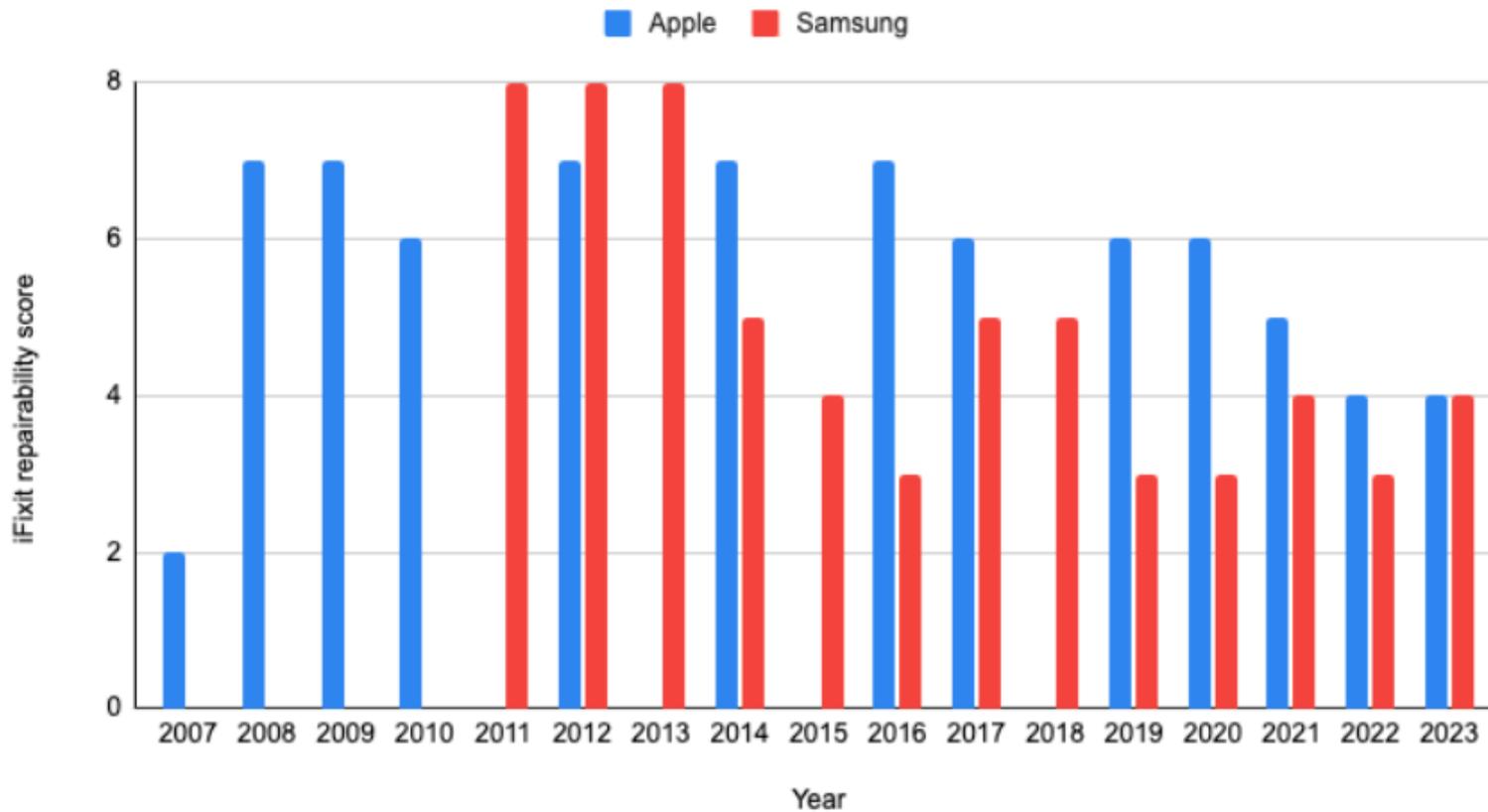2023

10

Scorecard v1.6
Learn More

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https://www.ifixit.com/repairability/smartphone-scores

Figure 4 iFixit repairability score the baseline model of Apple and Samsung S series.

Planned obsolescence

Ohjelmistopäivitykset

Sisältö
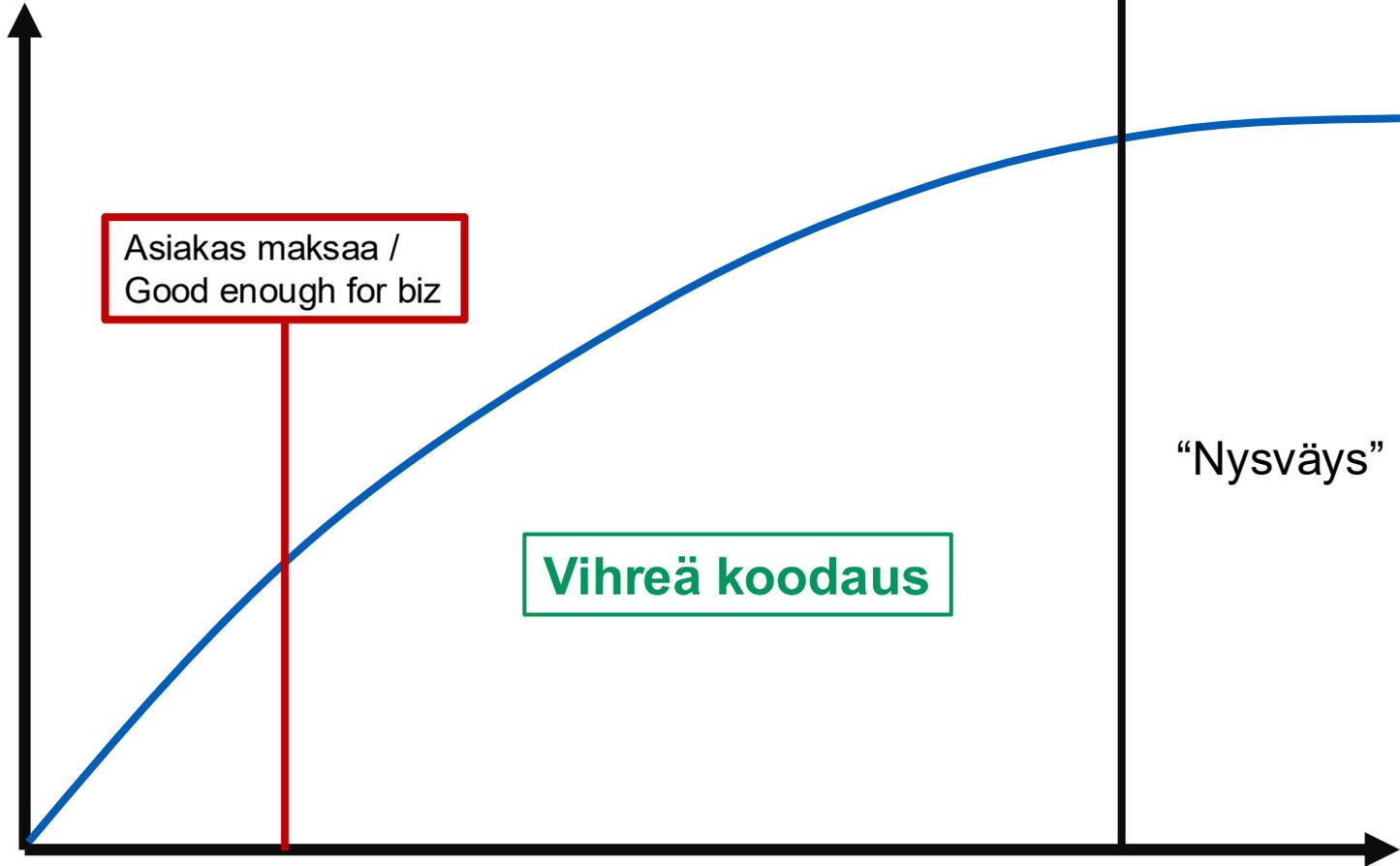
- Miten laskenta on kehittynyt ?

- Miten ohjelmointi on kehittynyt ?

- Miten laitteet ovat kehittyneet ?

- **Onko vihreää koodausta ja ICT:tä ?**

Laatu / suorituskyky

Asiakas maksaa /
Good enough for biz

Vihreä koodaus

"Nysväys"

Kehitysaika / hinta

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Vihreä on harvoin businesstä

Vihreä koodaus = laatu koodaus

Vihreä koodaus = normi koodaus

Laitteiden elinkaaripäästöt =
Valmistus + operointi

EU Energy Label

Energy labelling requirements will apply to smartphones and tablets put on the EU market from 20 June 2025 onwards.

Previous labels exit for light bulbs, home appliances, cars, tyres, etc.

Smartphones and tablets will have to display information on their

• energy efficiency,

• battery longevity,

• protection from dust and water and

• resistance to accidental drops.

This is also the first time that a product placed on the EU market will be required to display a repairability score.

This energy label will help EU consumers make more informed and sustainable purchasing choices and encourage sustainable consumption.
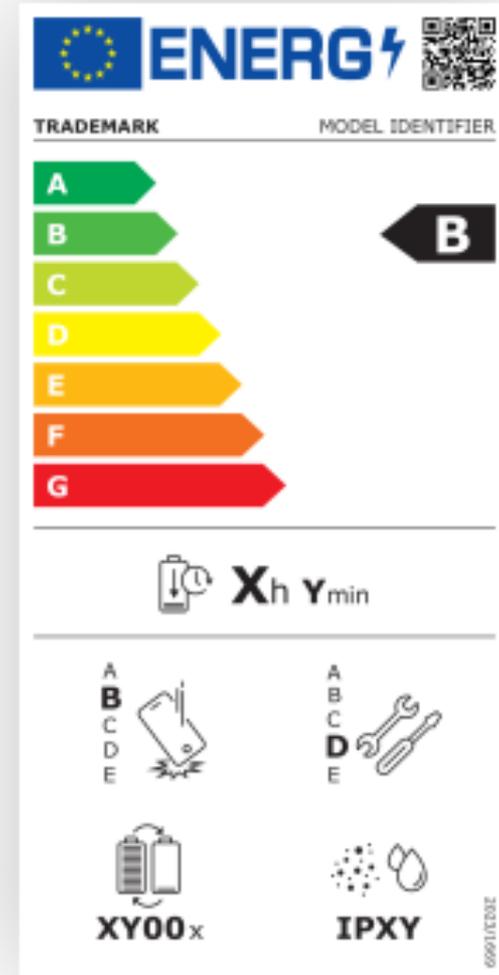
Onko vihreä ICT oikeasti vain normaalia ICT:tä ?

Ja nykyinen normaali ICT

on aika mustaa ?