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Green code

– Developer perspective

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Thesis: Green in software engineering

A literature review of tools, methods and practices for reducing the environmental impacts of software use

(Mehtälä, 2023) University of Helsinki

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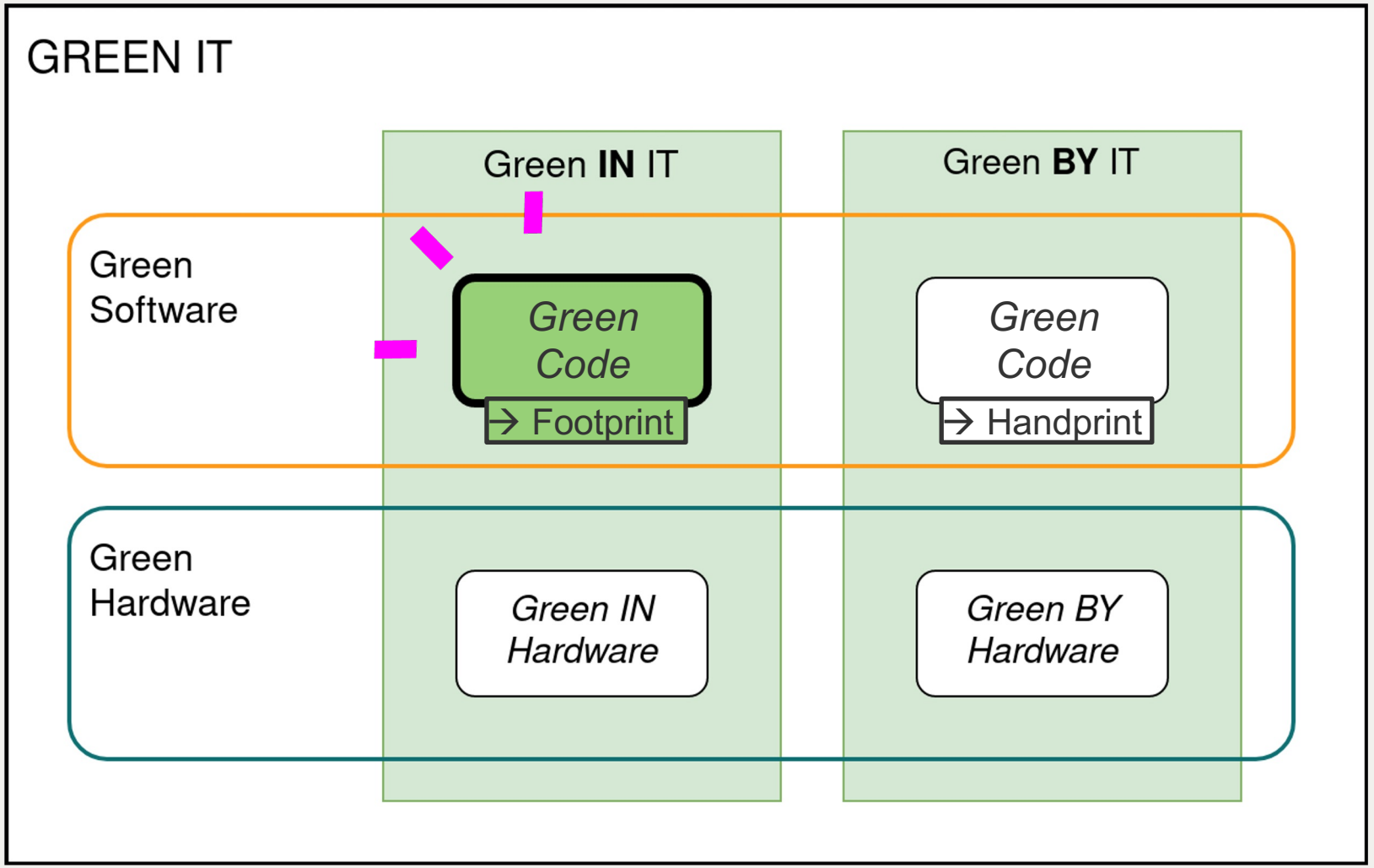
Today's topic



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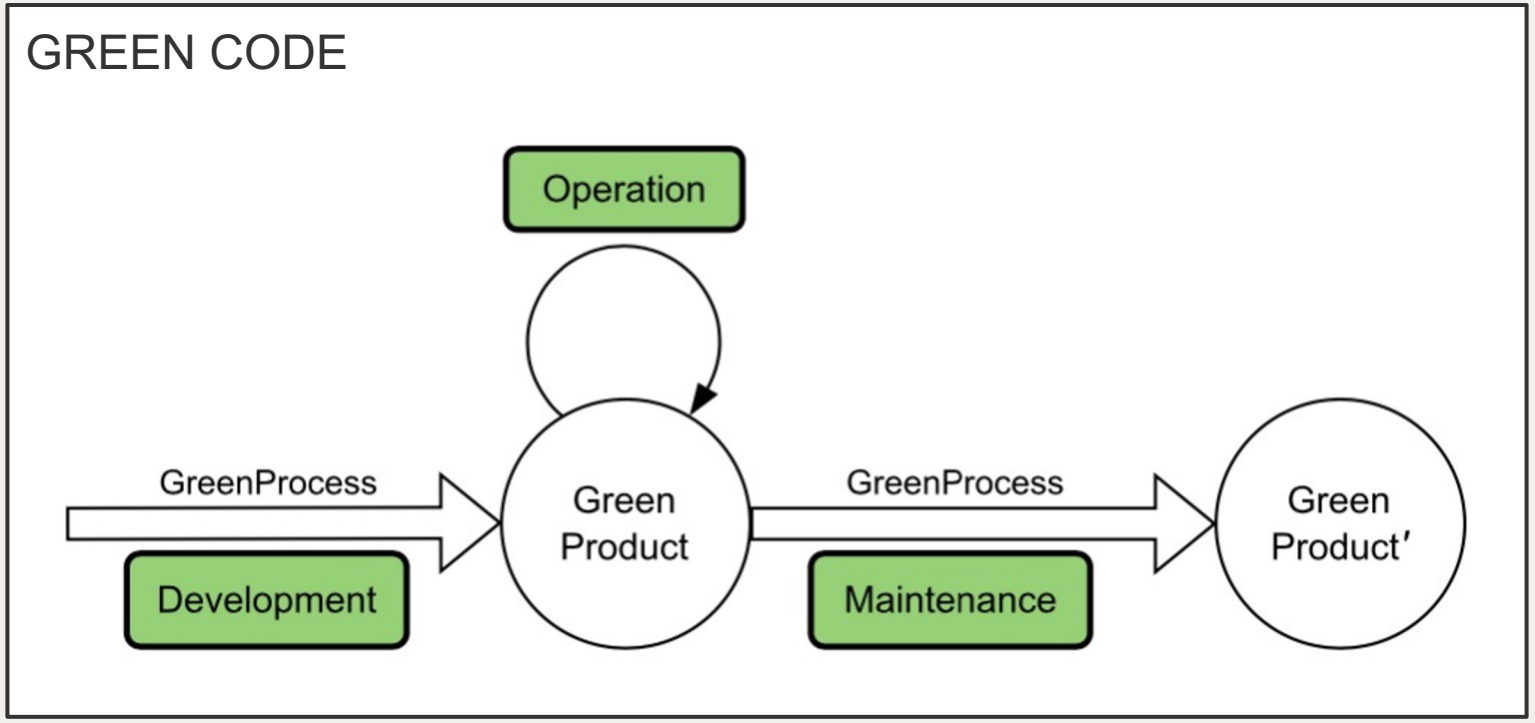
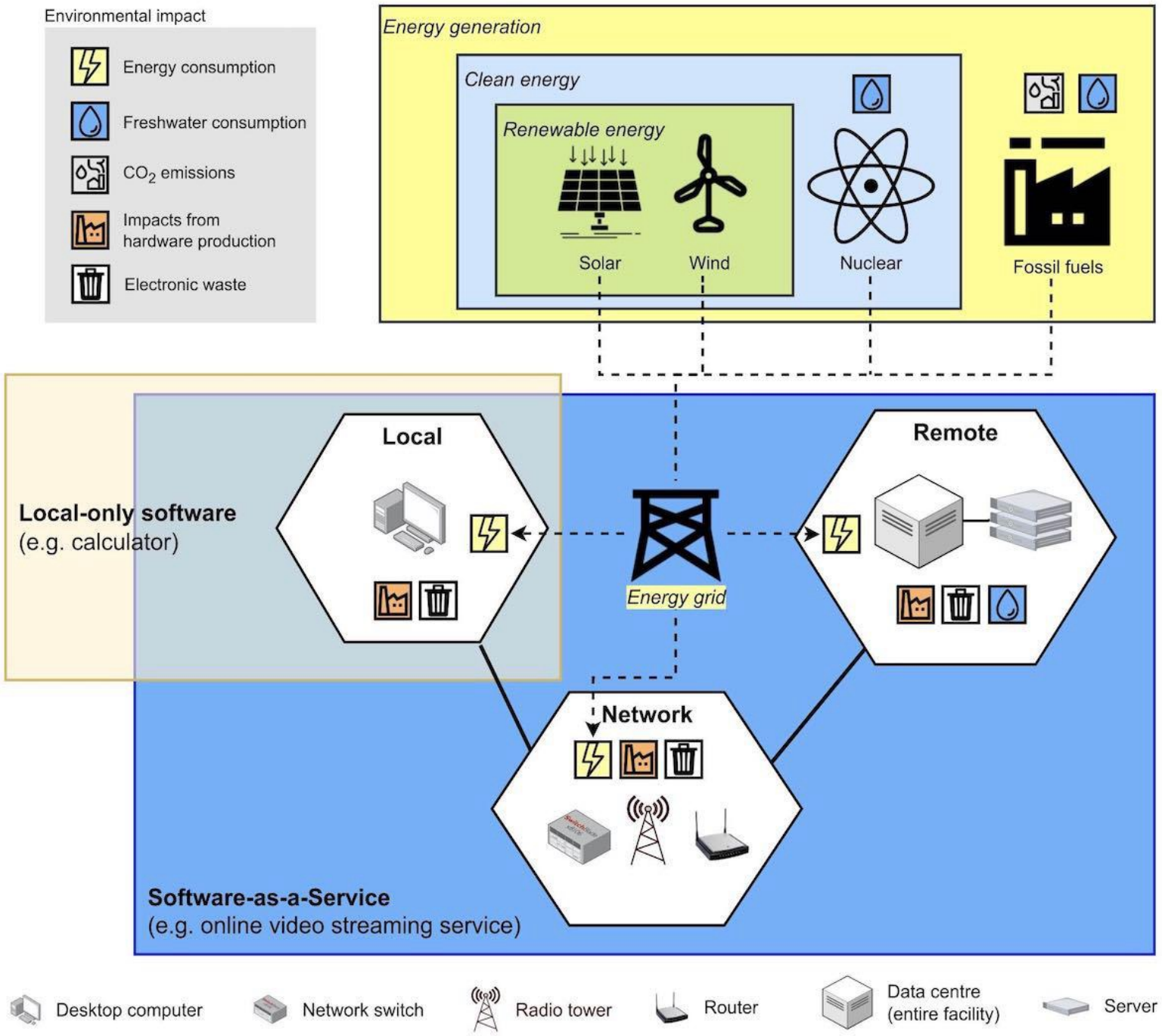
Today's topic



Actions that we can take
in the **Development**, **Operation** and **Maintenance** phases
in order to affect the environmental footprint of the product.


Environmental impact
Energy consumption
Freshwater consumption
CO_2 emissions
Impacts from hardware production
Electronic waste
Energy generation
Clean energy
Renewable energy
Solar
Wind
Nuclear
Fossil fuels
Local-only software
(e.g. calculator)
Local
Energy grid
Remote
Network
Software-as-a-Service
(e.g. online video streaming service)
Desktop computer
Network switch
Radio tower
Router
Data centre
(entire facility)
Server

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What is our current impact?

IT sector: **1.8—3.9%** of global GHG emissions

Aviation industry: 2% of global energy-related CO2 emissions

Data centres + data transmission networks: **2–3%** of global electricity use

Data centres & networks—Fuels & Technologies. IEA. Retrieved September 12, 2023, from https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

IEA. (2023). Aviation. https://www.iea.org/energy-system/transport/aviation

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*(9). https://doi.org/10.1016/j.patter.2021.100340

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Today’s focus topics

1. Hardware / OS requirements
2. Carbon-Aware Computing
3. On-demand video

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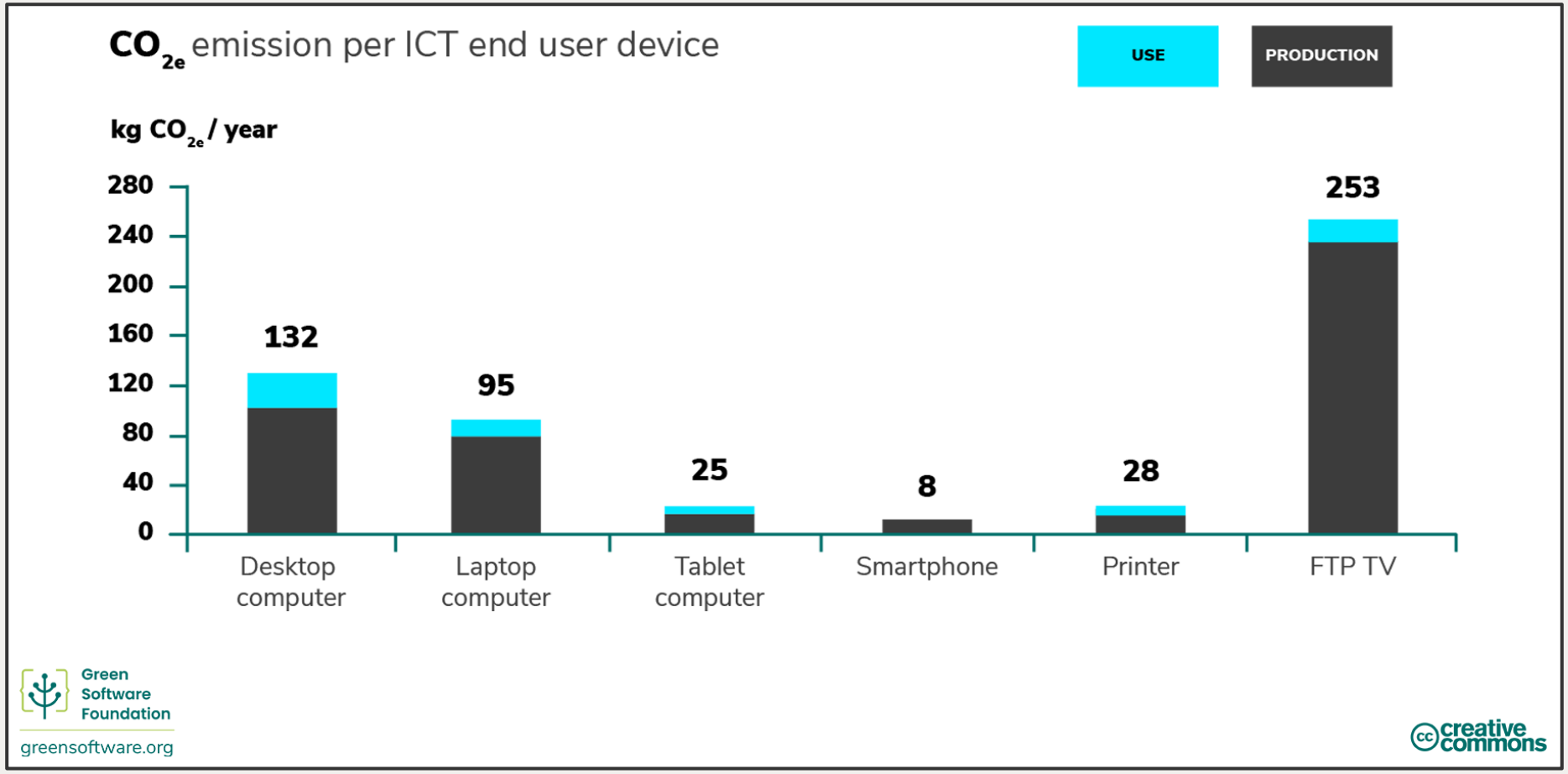
Hardware and Operating System Requirements



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Example: Android Messaging Apps

	Required Android version (checked 12.12.2023)	Works on device
Slack	10	Samsung Galaxy S9 (2018) OnePlus 5 (2017)
MS Teams	8	Samsung Galaxy S7 (2016)
Discord	7	Samsung Galaxy Note5 (2015)
WhatsApp	5	Nexus 5 (2013)

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Hardware and Operating System Requirements

1. Test your app with older hardware
   - Keep core functionalities compatible with older HW
2. Design with these in mind
   - Right to Repair (EU)
   - Used and refurbished devices

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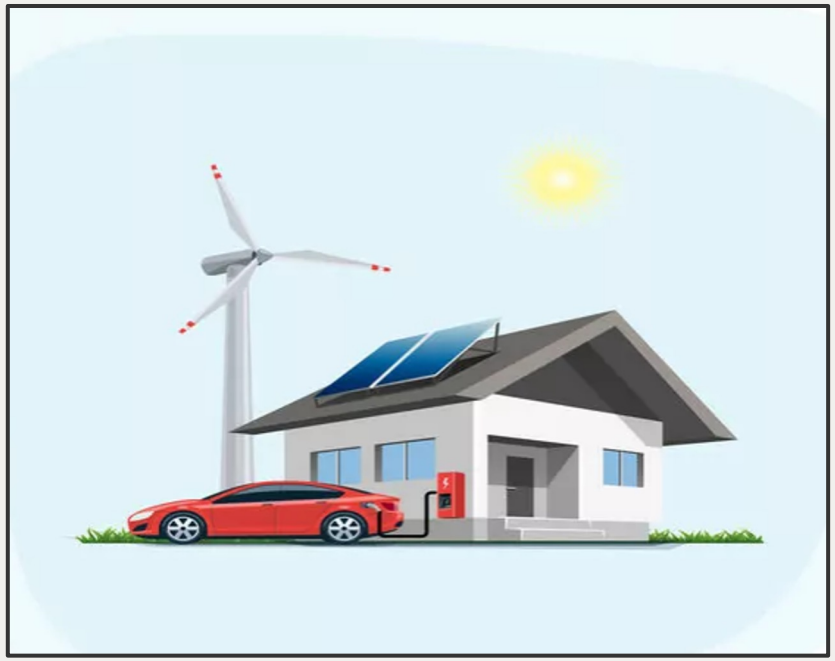
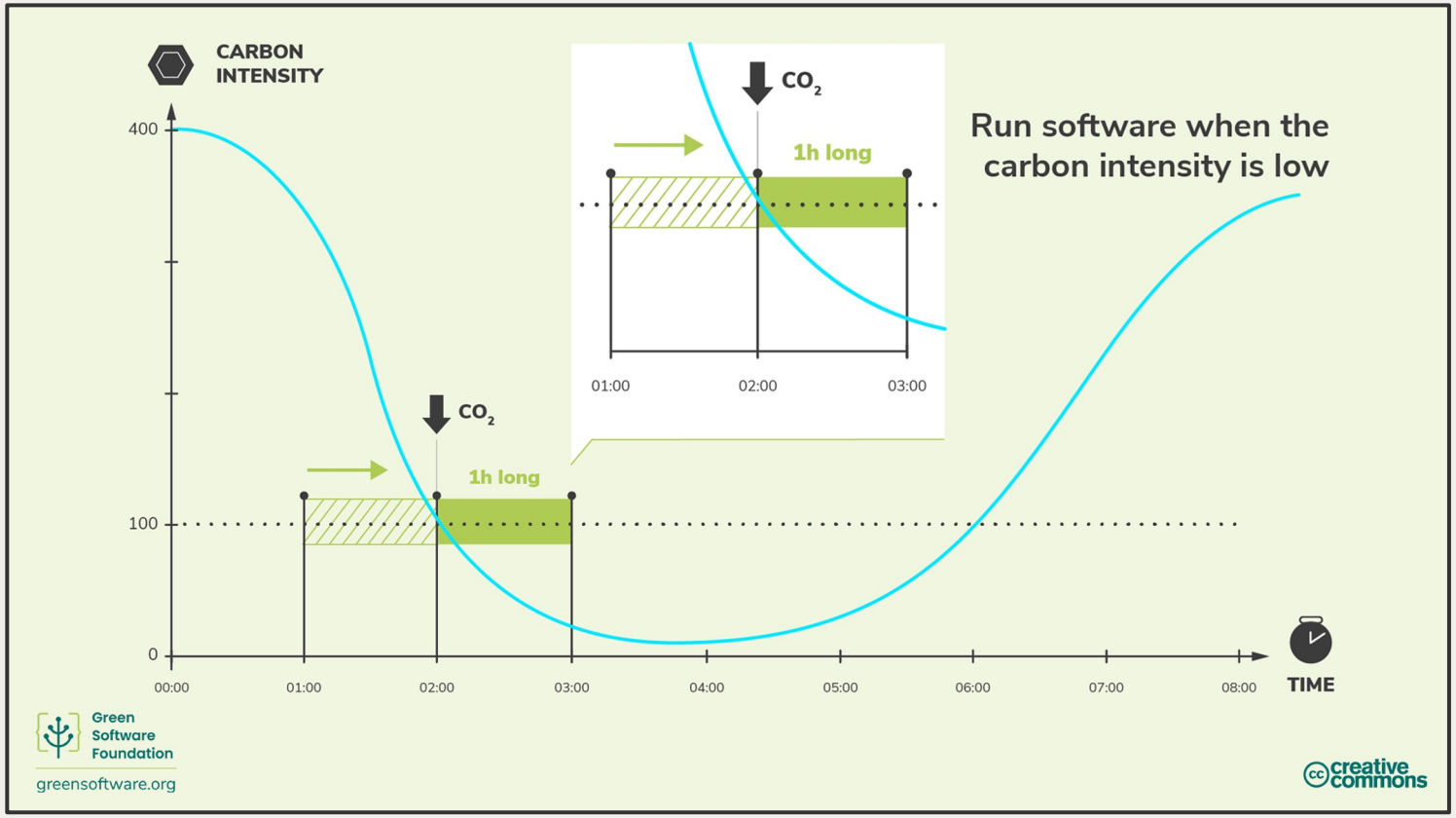
Carbon awareness

Do *more* when the electricity is *cleaner*

Do *less* when the electricity is *dirtier*





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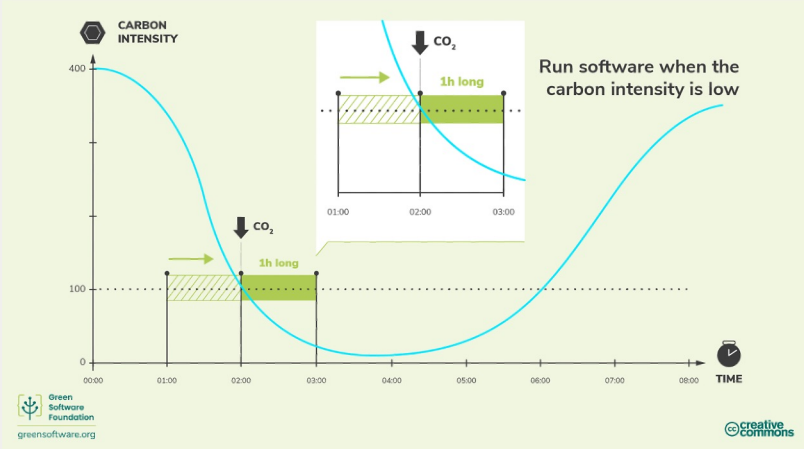
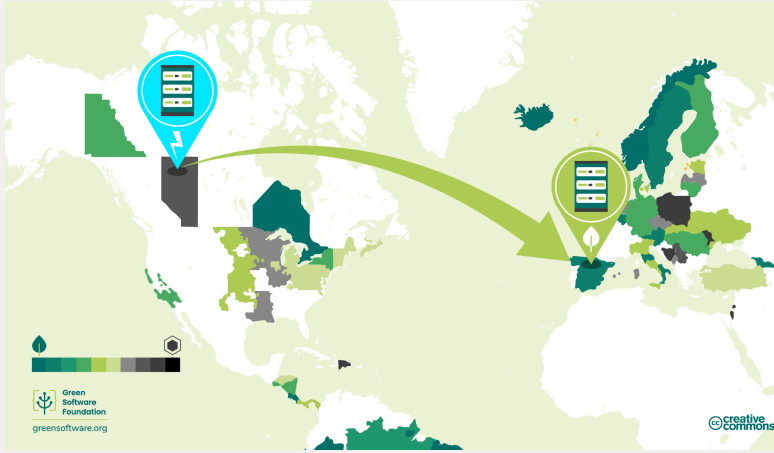
Carbon Awareness

- Demand <u>shifting</u>
  - Job types:
    - Batch job, DB indexing
    - ML trainings
    - Video encoding

Time shifting

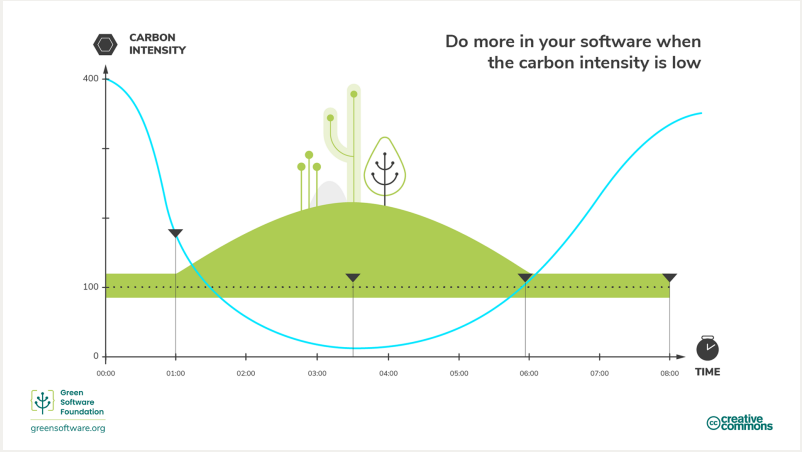


Location shifting



- Demand <u>shaping</u>
  - ”Eco mode” for software
  - Ask user consent?

Demand shaping



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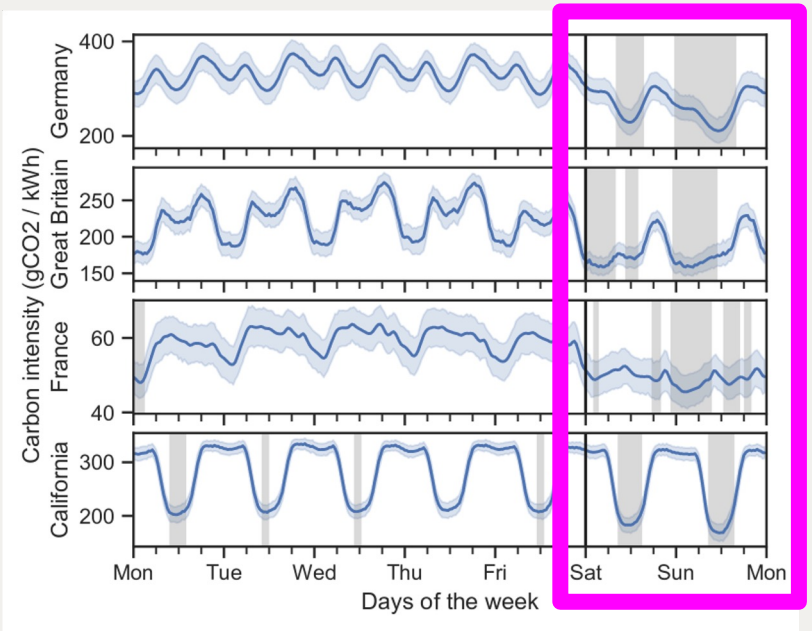
Carbon Awareness

Where to get electricity grid carbon data?

- ElectricityMaps & WattTime (paid)
  - Real-time electricity grid CO2 emissions
- FinnGrid API
  - Wind electricity generation forecasts
  - https://data.fingrid.fi/en/pages/apis
- Green Web Foundation
  - CO2.js
  - Grid Intensity CLI

Wiesner, P. et al. (2021). Let's wait awhile: How temporal workload shifting can reduce carbon emissions in the cloud. Proceedings of the 22nd International Middleware Conference, 260–272. https://doi.org/10.1145/3464298.3493399



When you can't use real-time data:

- **Weekends** are typically a less carbon-intensive choice.
- Check historical data for patterns:
  - ElectricityMaps OpenData Portal
  - You will consume less carbon on average

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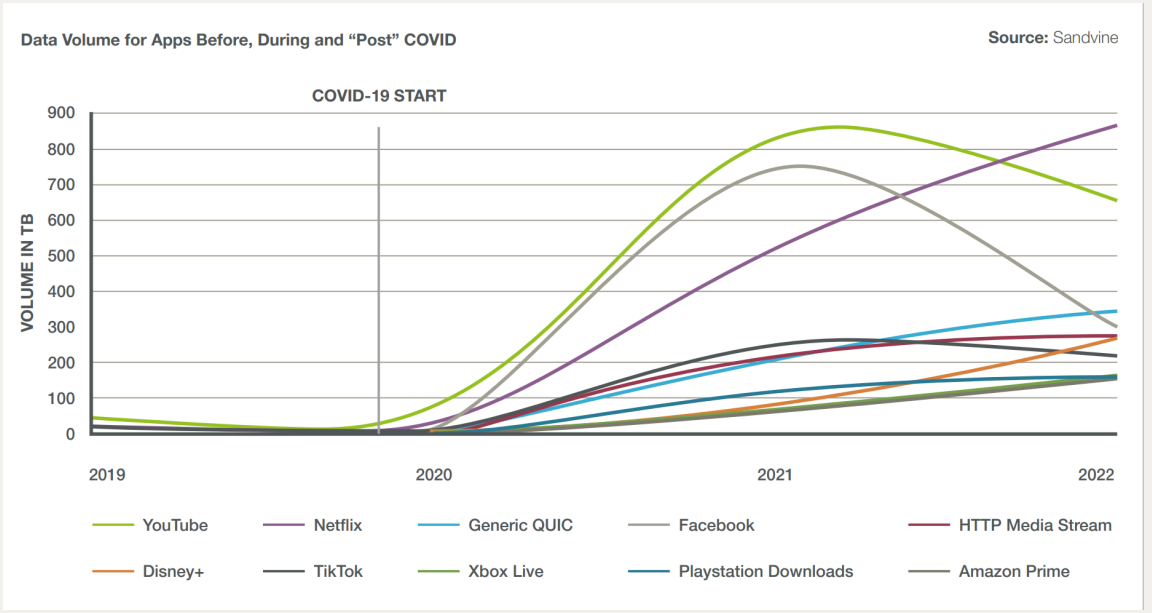
On-demand video

- Estimates: between 65—80% of all internet traffic is video
  - 4K streaming is on the increase
- Avoid using video content, if possible
- Optimise video file size
  - Compression
  - Use lower definitions



https://www.digitalinformationworld.com/2023/01/video-accounts-for-65-of-all-internet.html

https://theshiftproject.org/en/article/unsustainable-use-online-video/

https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html#Trends

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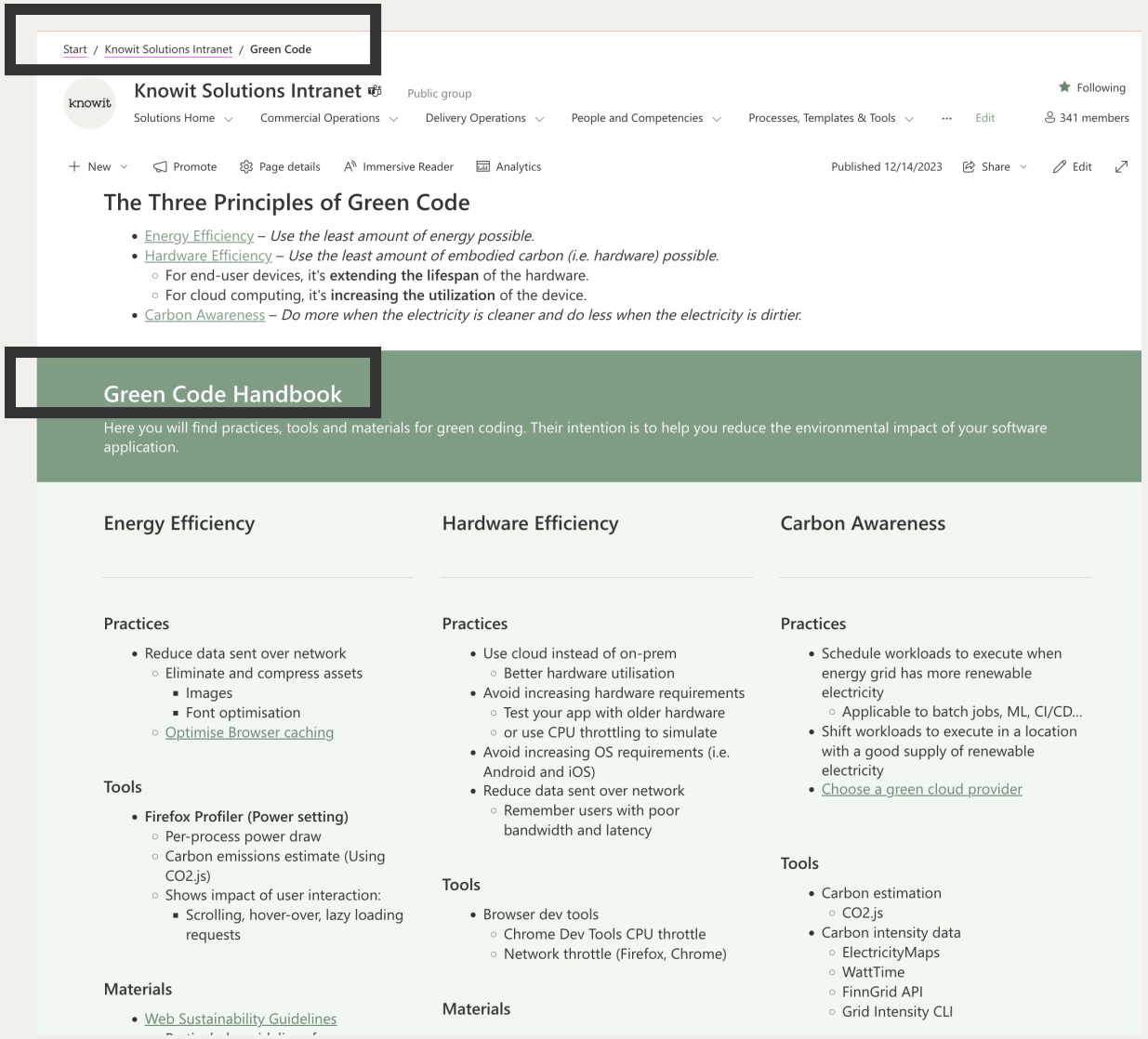
Green Code (Shareit)

- Green Code Handbook
  - / Materials (Internal & external)
  - / Practices
  - / Tools



Start / Knowit Solutions Intranet / Green Code

Knowit Solutions Intranet — Public group — Following

Solutions Home | Commercial Operations | Delivery Operations | People and Competencies | Processes, Templates & Tools | ... | Edit | 341 members

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The Three Principles of Green Code

- Energy Efficiency – *Use the least amount of energy possible.*
- Hardware Efficiency – *Use the least amount of embodied carbon (i.e. hardware) possible.*
  - For end-user devices, it's **extending the lifespan** of the hardware.
  - For cloud computing, it's **increasing the utilization** of the device.
- Carbon Awareness – *Do more when the electricity is cleaner and do less when the electricity is dirtier.*

Green Code Handbook

Here you will find practices, tools and materials for green coding. Their intention is to help you reduce the environmental impact of your software application.

Energy Efficiency

Practices

- Reduce data sent over network
  - Eliminate and compress assets
    - Images
    - Font optimisation
  - Optimise Browser caching

Tools

- **Firefox Profiler (Power setting)**
  - Per-process power draw
  - Carbon emissions estimate (Using CO2.js)
  - Shows impact of user interaction:
    - Scrolling, hover-over, lazy loading requests

Materials

- Web Sustainability Guidelines

Hardware Efficiency

Practices

- Use cloud instead of on-prem
  - Better hardware utilisation
- Avoid increasing hardware requirements
  - Test your app with older hardware
  - or use CPU throttling to simulate
- Avoid increasing OS requirements (i.e. Android and iOS)
- Reduce data sent over network
  - Remember users with poor bandwidth and latency

Tools

- Browser dev tools
  - Chrome Dev Tools CPU throttle
  - Network throttle (Firefox, Chrome)

Materials

Carbon Awareness

Practices

- Schedule workloads to execute when energy grid has more renewable electricity
  - Applicable to batch jobs, ML, CI/CD...
- Shift workloads to execute in a location with a good supply of renewable electricity
- Choose a green cloud provider

Tools

- Carbon estimation
  - CO2.js
- Carbon intensity data
  - ElectricityMaps
  - WattTime
  - FinnGrid API
  - Grid Intensity CLI

knowit.sharepoint.com/sites/Org-510-internal/SitePages/GreenCode.aspx

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Tools and practices

Web development

- Web Sustainability Guidelines 1.0 (draft)
  - W3C community group
- Katsaus käytännön koodioptimoinnin tekniikoihin (Recording in Finnish)
  - Tommi Sinivuo & Tommi Jalkanen, (Koodihuoneilmiö podcast)
  - Tieke Green ICT –hanke
  - Optimising DevOps pipeline (GH Actions)
  - Minimizing docker image size
  - JS frontend profiling

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Green code resources

- Keynote: Janne Kalliola (Exove) - Green Coding (slides)
  - Code Forward 30.8.2023, Technopolis Tampere
  - Environmental impact of software
  - Practices for reducing energy and resource consumption
- Green Software Practitioner Course
  training.linuxfoundation.org/training/green-software-for-practitioners-lfc131
  - Learn the basics of green code
  - Get certified
    - Course and exam take between 2 – 4 hours to complete
    - Free, unlimited exam retakes

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Environmental impact of software

- Green Coding - a sustainable web in the making (Recording)
  - Peter Solow (Knowit Experience Danmark A/S)
  - Impact of web: data storage, video, images, fonts, etc.
- Climate Impact of Software Testing (Recording in Finnish)
  - Kari Kakkonen (Knowit Solutions Finland Oy)
  - Topics:
    - Climate impact of ICT, Green ICT
    - Green Testing Techniques and Processes
      - Test environment right-sizing
      - On-demand deployments of test environments
- Learnster
  - Digital Sustainability for environmental impact
  - Digital Sustainability Developer Perspective

Firefox Profiler: “Power” setting

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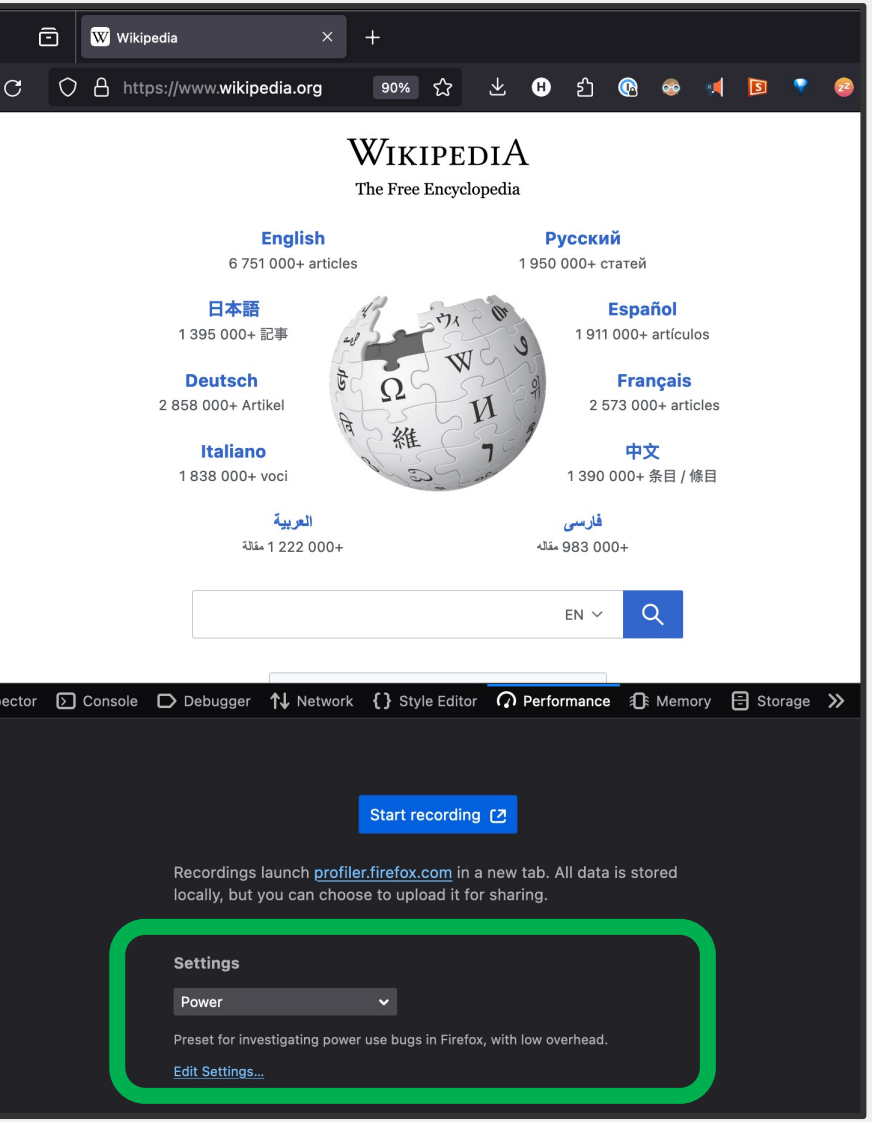

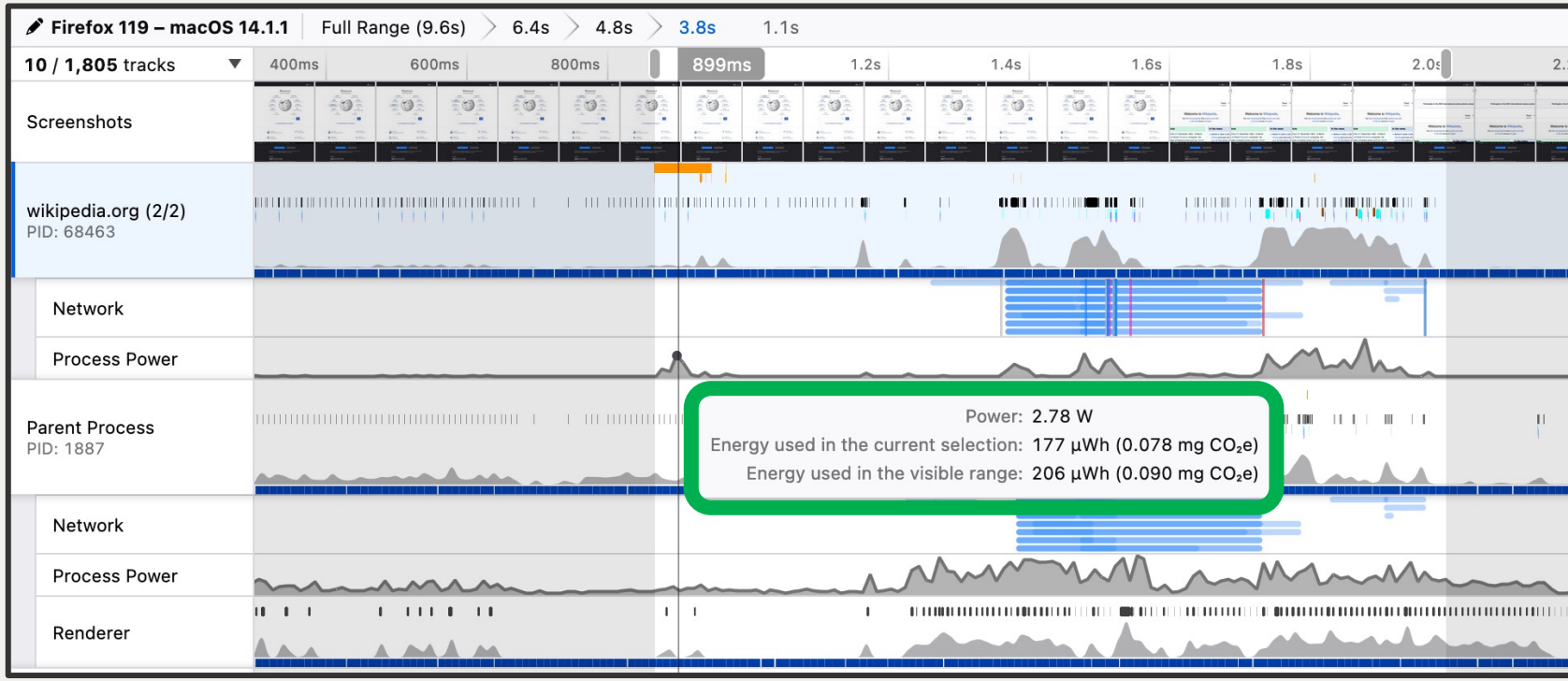

- Per-process power draw
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- Shows impact of user interaction:
  - Scrolling, hover, etc.
  - Lazy loading requests