

SOFTWARE ENERGY FOOTPRINT LAB

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CREATING TOMORROW



CLEANTECH ONDERZOEKSTHEMA'S

**Groene datacenters + Software
Energy Footprints**



GreenIT

*roadmapping &
demonstration*

Future Energy Systems



PV + DC grids



E-mobility



Clean mobility

**Laadinfrastructuur + zonneboot +
waterstofauto + tegenwindauto**

*innovation
management*

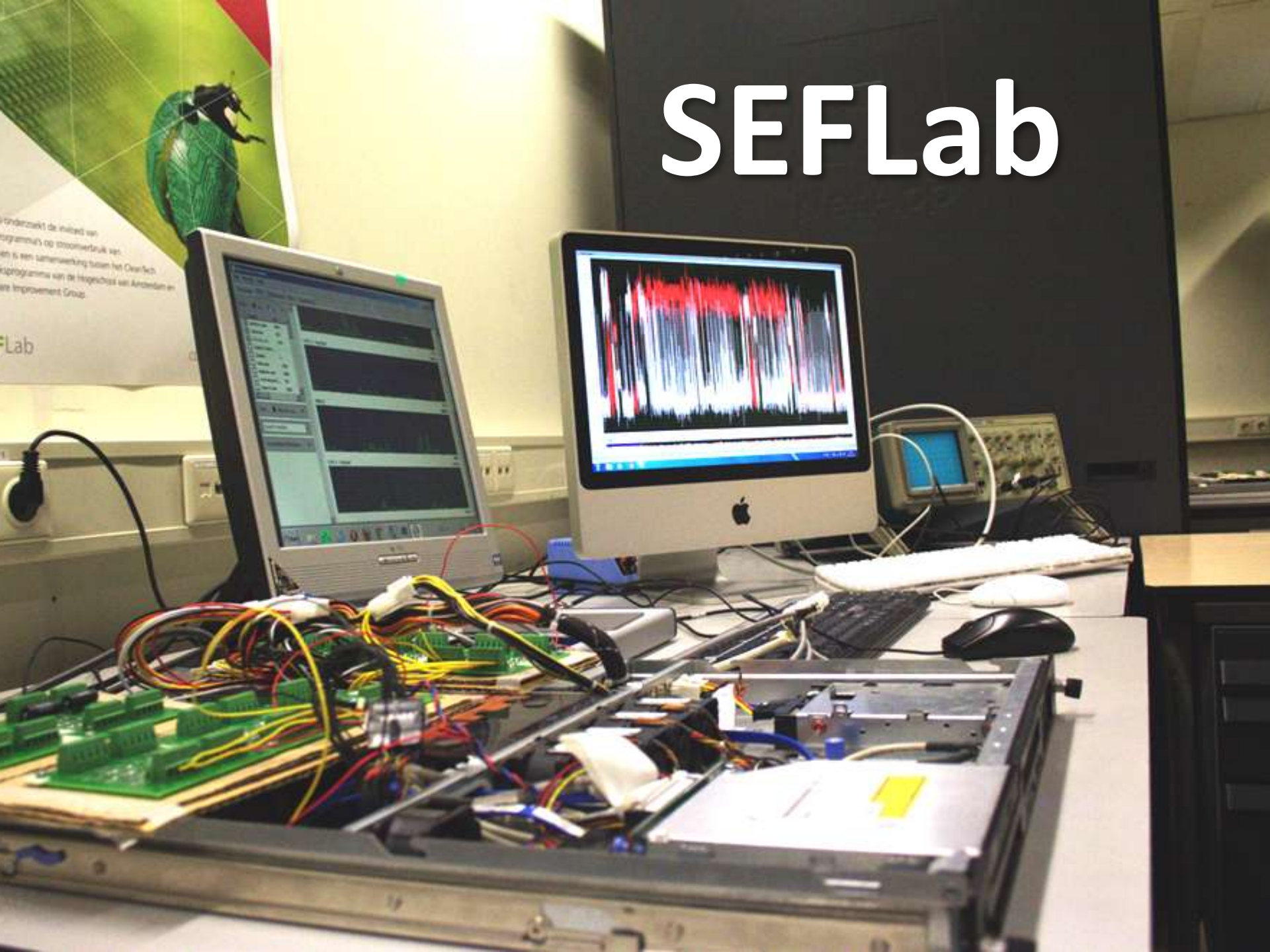
Smart & Clean Production



**Sustainable systems for food + bio
materials**

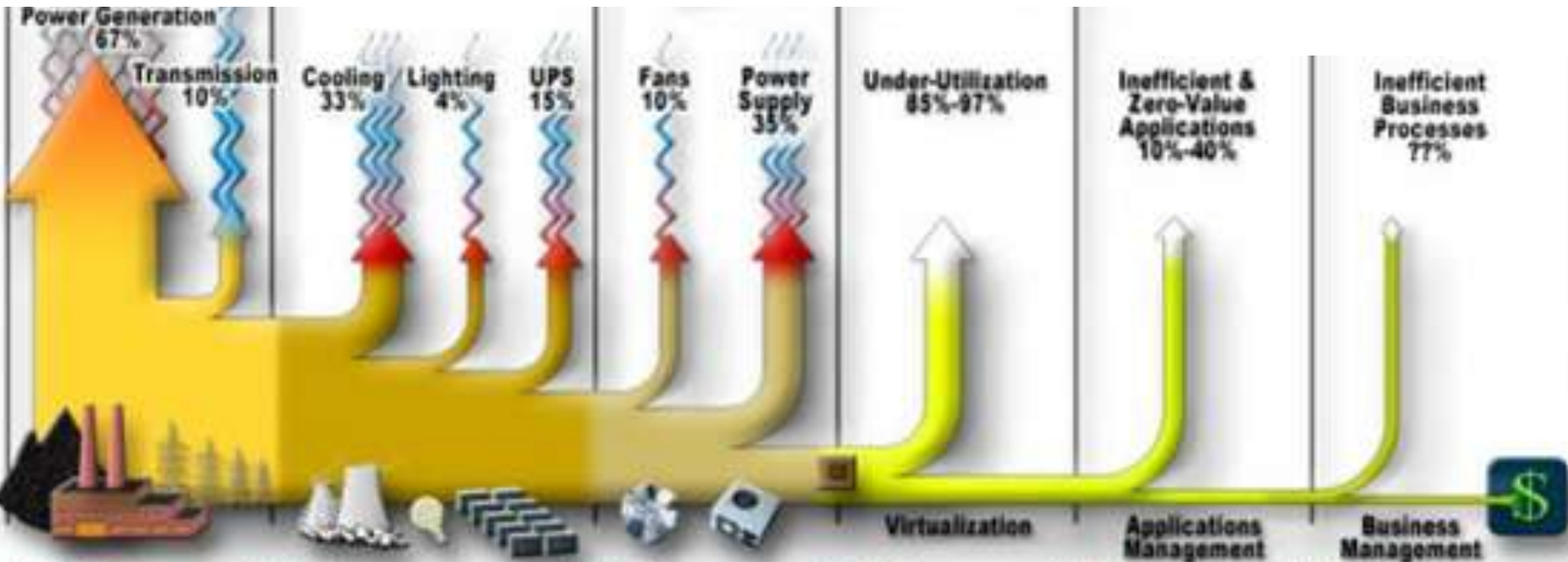
Betrokken opleidingen: E-tech, Engineering Design & Innovation, Product Design, Technische Bedrijfskunde, (Technische Informatica)

SEFLab



WAAROM SOFTWARE?

Energieverliesketen datacenter



Energiecentrale:
100 Watt

Nuttig gebruik:
<1 Watt

SOFTWARE ENERGY FOOTPRINT LAB

Onderzoeksvraag:

Wat is de invloed van software op het energieverbruik van de hardware-componenten in servers?

Doelen:

- Theorie vormen over de impact van software op het energieverbruik van computers
- Richtlijnen opstellen voor efficiënte softwareontwikkeling
- Werken naar een energielabel voor software

In samenwerking met:

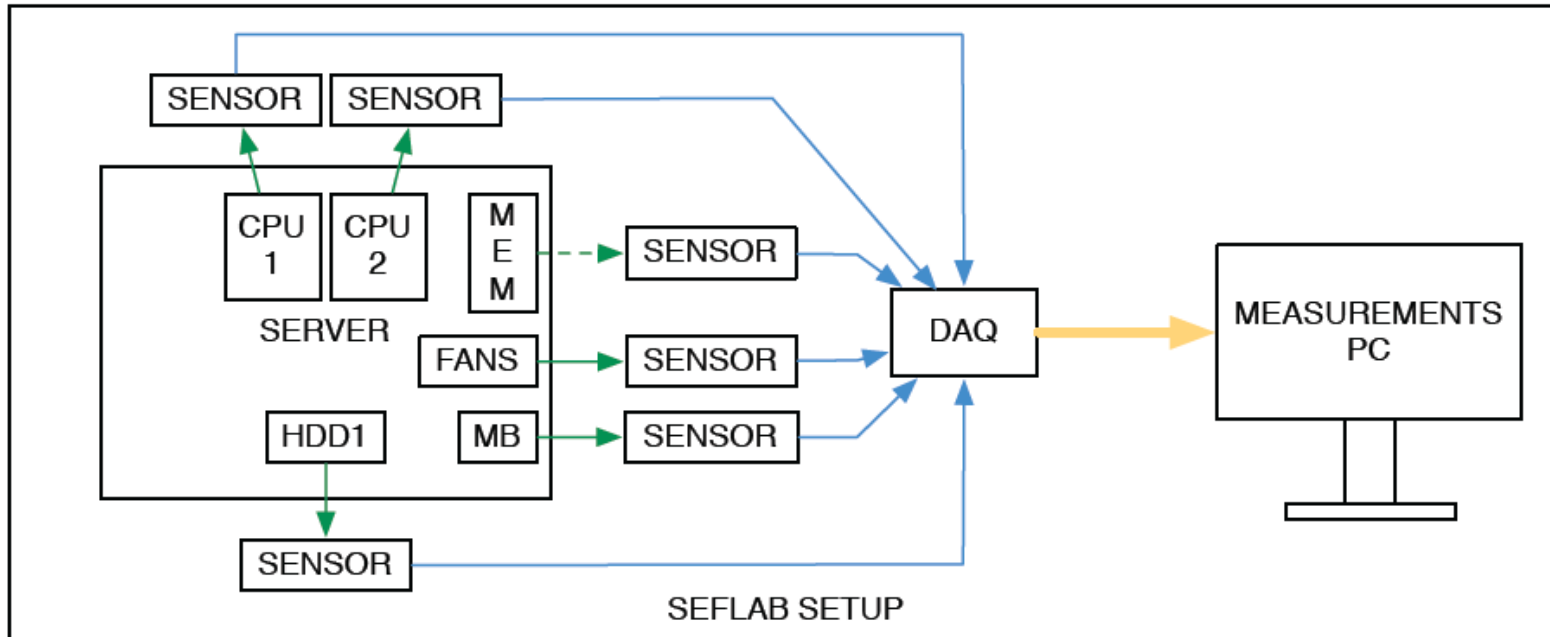
SOFTWARE ENERGY FOOTPRINT LAB

HET SEFLAB ONDERZOEKT DE INVLOED VAN SOFTWAREPROGRAMMA'S OP STROMVERBRUIK VAN HARDWARE EN IS EEN SAMENWERKING TUSSEN HET CLEANTECH ONDERZOEKSPROGRAMMA VAN DE HOGESCHOOL VAN AMSTERDAM EN DE SOFTWARE IMPROVEMENT GROUP.



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MEETMETHODE



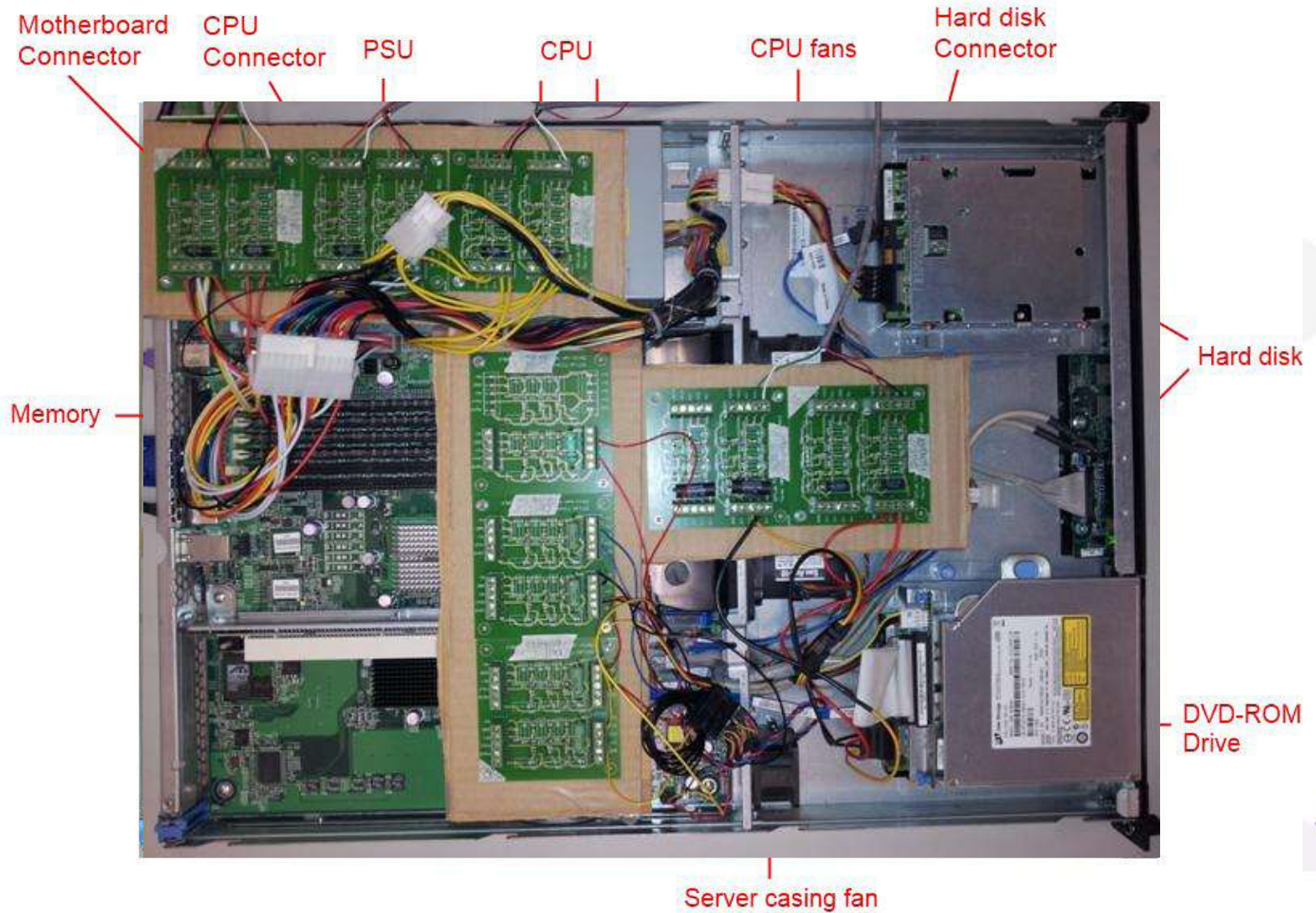
SOFTWARE



POWER CONSUMED DURING SOFTWARE EXECUTION



MEETBARE KANALEN



WELKE BROWSER IS HET ENERGIEZUINIGST?

Firefox 18



Internet Explorer 9



Opera 12



Safari 5



Chrome 24



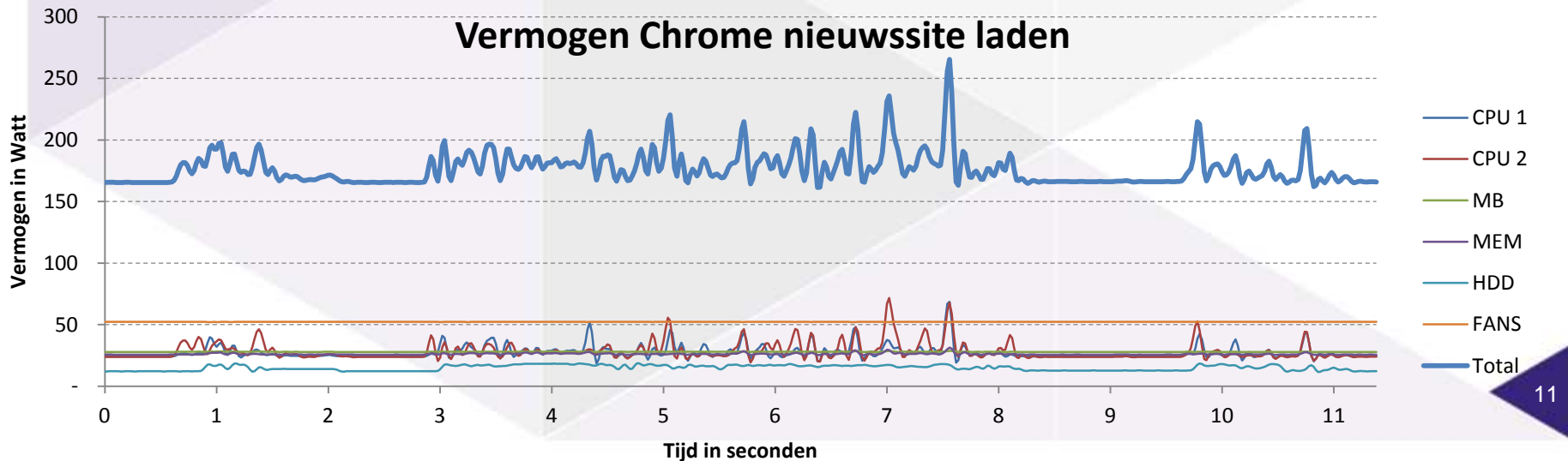
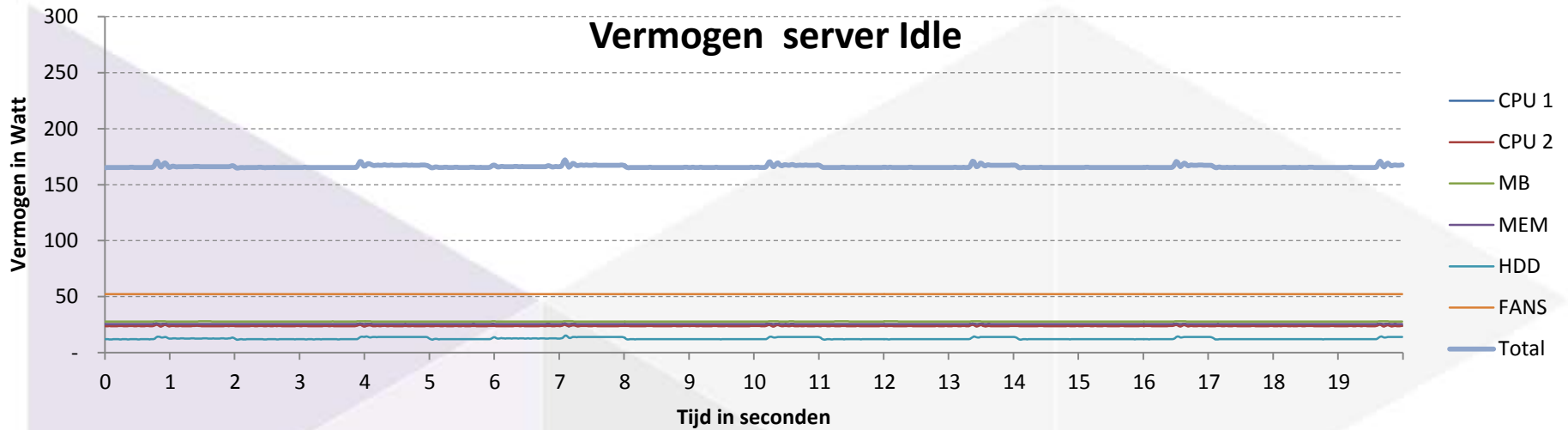
10x 10 meest bezochte websites¹ 15 sec. geladen:

1. google.nl, 2. facebook.com, 3. google.com, 4. youtube.com, 5. live.com,
6. linkedin.com, 7. wikipedia.org, 8. nu.nl, 9. yahoo.com, 10. marktplaats.nl

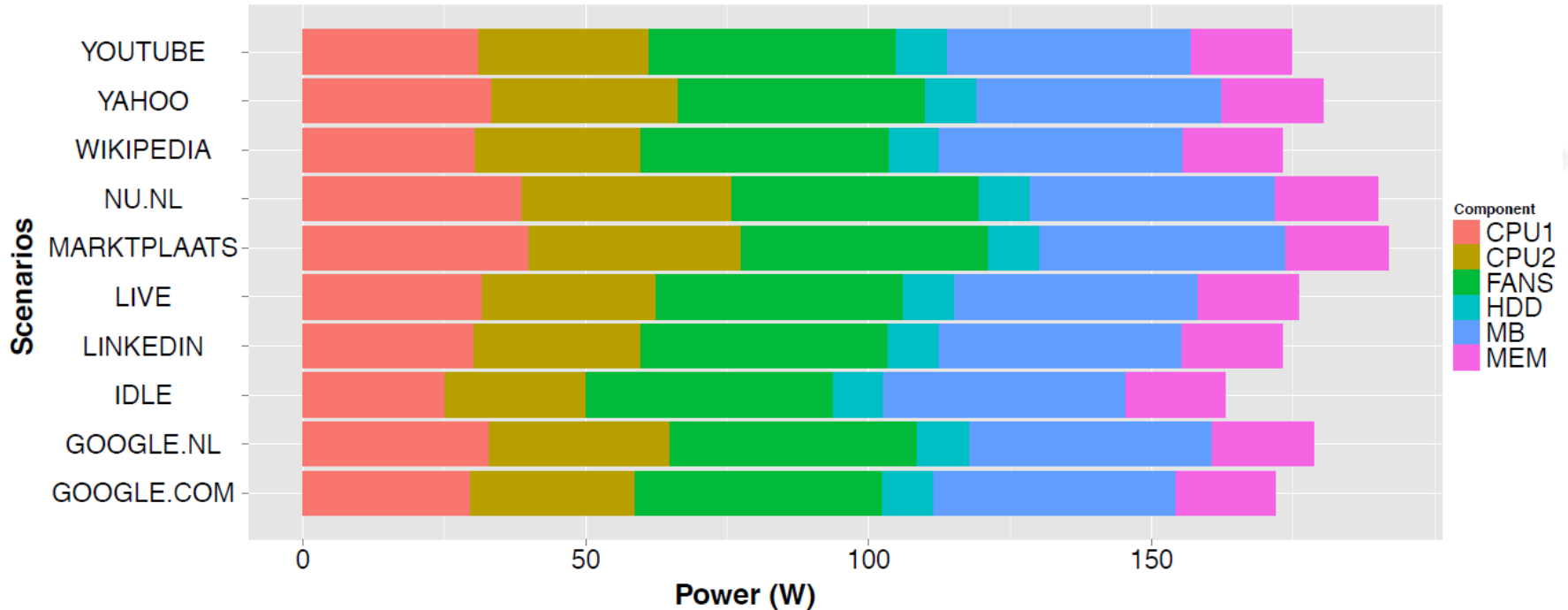
Energieverbruik: CPU 1, CPU 2, werkgeheugen, HDD , moederbord, fans

¹ bron: www.alexacom

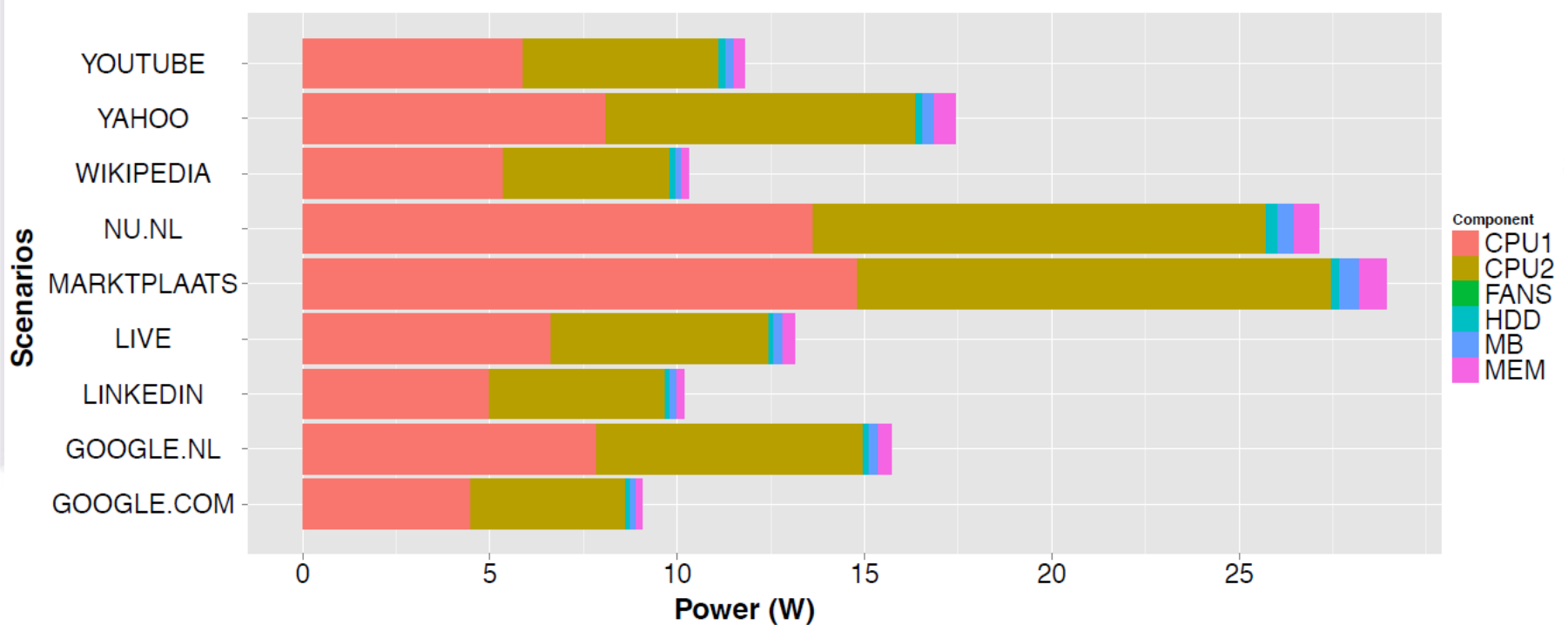
RESULTATEN: VERMOGEN IN TIJD



POWER USE SCENARIOS

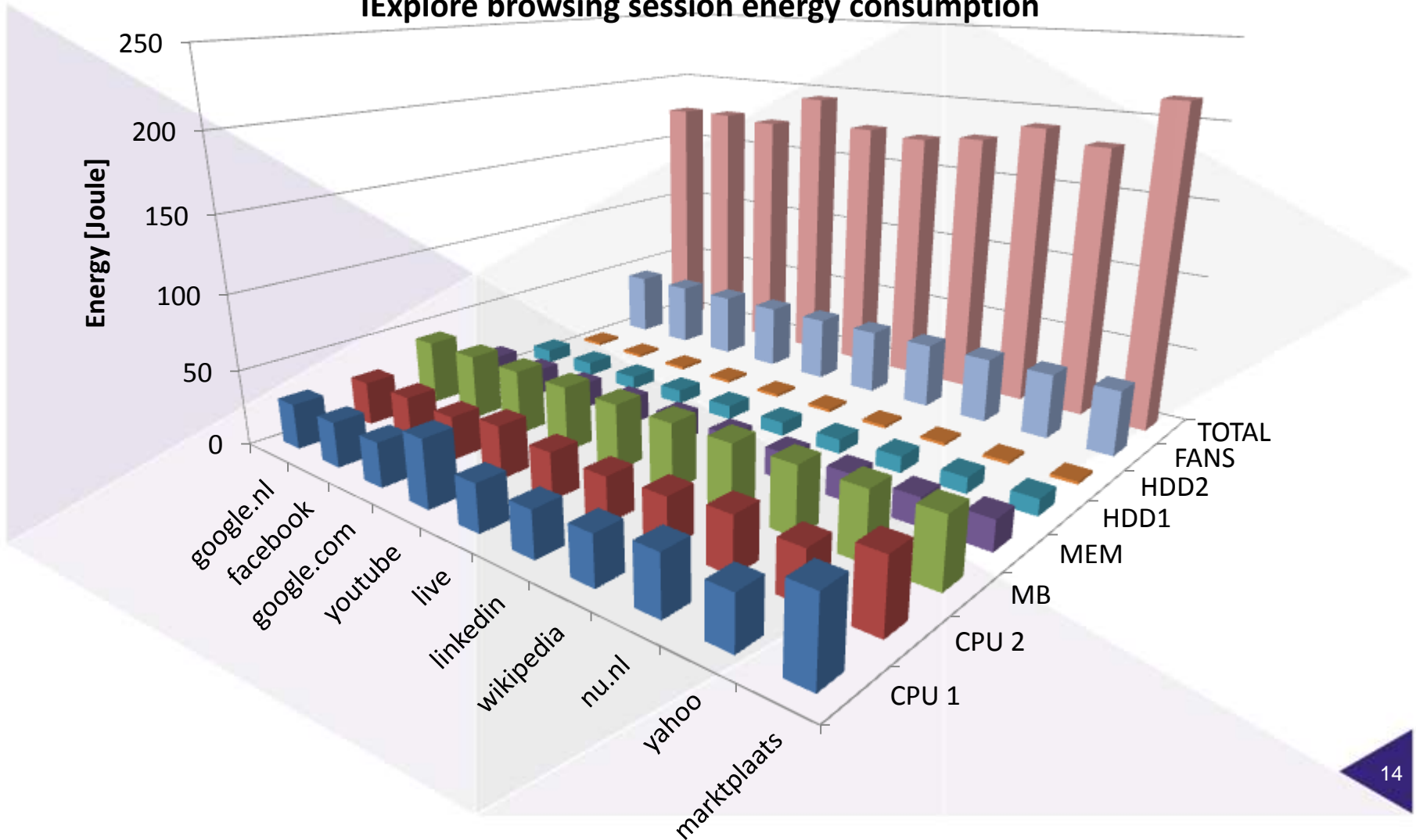


POWER USE SCENARIOS COMPARED TO IDLE



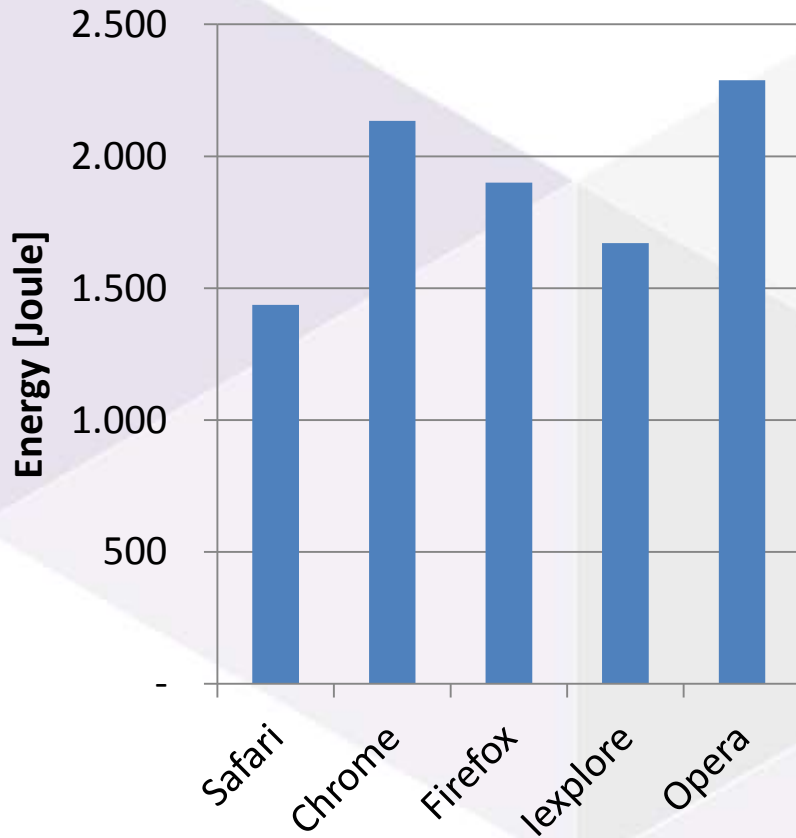
RESULTATEN: ENERGY FOOTPRINT BROWSER

Explore browsing session energy consumption

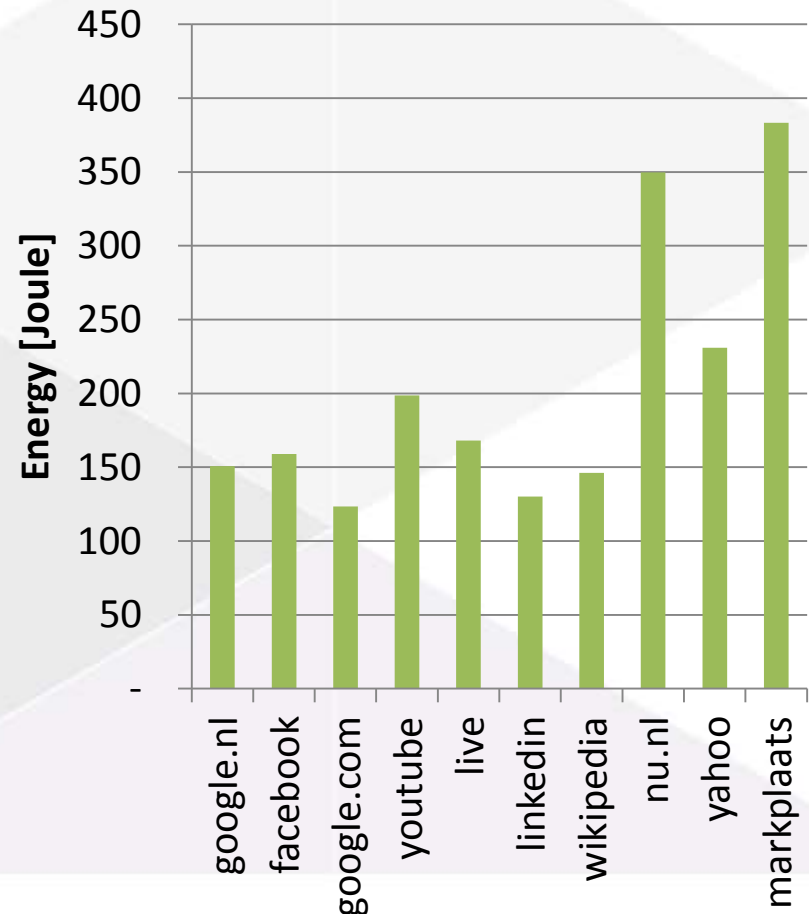


ZUINIGSTE BROWSER? VERBRUIK WEBSITES?

Mean browsing session energy consumption on top of idle



Average website energy consumption



CONCLUSIES SEFLAB

- ❖ Meetopstelling die nauwkeurig het energieverbruik per hardwarecomponent kan meten
- ❖ Om valide metingen te doen moeten meerdere hardwareconfiguraties toegevoegd worden
- ❖ Safari zuinigste browser (op een oude Dell server, 10 meest bezochte websites)
- ❖ Websites verschillen aanzienlijk in energieverbruik

EERSTE PAPER

2nd International Workshop on Green and Sustainable Software

In conjunction with ICSE 2013:



SEFLab: A Lab for Measuring Software Energy Footprints

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Abstract—Hardware dissipates energy because software tells it to. But attributing hardware energy usage to particular software functions is complicated due to distribution, resource sharing, and layering of software. To enable research on energy usage attribution, we have created the Software Energy Footprint Lab. We explain the experimental setup offered by the lab and describe some preliminary results aimed at deciphering hardware dissipation profiles for various types of servers under various forms of software stress. Finally, we provide an outlook of how energy footprint measurements can contribute to a body of knowledge on software-level energy optimization.

Index Terms—Software Engineering, Energy efficiency, Green products

accurate measurement, fine-grained server instrumentation has been put in place. In this paper, we present the setup of our energy footprint lab (Section II) and we share some initial experimental results (Section III). We also discuss related work (Section IV), remaining weaknesses (Section V), and we provide an outlook to further improvement and experimentation (Section VI). We provide a replication package for this research via the url: <http://www.sig.eu/en/seflab-paper>.

I. INTRODUCTION

The ICT sector is responsible for substantial and fast-growing energy consumption [1]. At the level of hardware, in improving efficiency and reducing energy loss, has been made sign and development of software applications remains mostly energy-agnostic. With the exception of programming for mobile devices—where battery life is a major concern—application programmers rarely optimize their software for energy consumption. As a result, gains in energy-efficiency in hardware and infrastructure could be cancelled out by inefficient resource consumption of software.

As an important step towards energy-aware software design and development the relationship must be mapped out between software operation and energy dissipation in hardware. This relationship is complicated due to the distribution of software components over multiple hardware devices, the sharing of hardware devices by multiple software components, and the layered design of modern software with frameworks, virtual machines, interpreters, and other abstraction mechanisms. We have initiated a laboratory to study the energy footprint of software. The setup of the lab includes measurement infrastructure that enables measurement at hardware and software levels and alignment of the resulting measurement streams. To allow

II. LAB SETUP

A. Infrastructure

Fig. 1 depicts a conceptual view of the SEFLab. Seen as a black-box, the SEFLab takes software products in, executes them in a server and outputs power measurements taken during the software execution.

To understand the measurements produced by the setup, one needs to analyze how it is built. The three main components of the setup are (1) the server (where the software under test is executed), (2) the data acquisition system (DAQ) (that collects all measurements and provides them in a machine readable format) and (3) the measurements PC (where all measurements are processed and recorded).

Fine-grained instrumentation is applied to the server under test. The situation in the figure is based on the server currently under test, which is a Dell PowerEdge SC1425 with the following specifications:

- 2x Intel Xeon CPUs, 3.2GHz
- 4x Infineon 1GB DDR2-333 SDRAM
- Intel E7520 chipset
- 1x Maxtor 7L250SD 250GB SATA150 HDD
- Dell power Supply Unit 450W

This server is rigged with sensor boards (green arrows) attached to the power distribution lines that go from the power supply unit (PSU) to the motherboard. This way we can obtain independent power measurements for several components. (The arrow going from the memory bank to the sensor board is

TOEKOMST SEFLAB

- ❖ Ontwikkelen **lesmodule Green Software Engineering** i.s.m. (Technische) Informatica HvA
- ❖ Start onderzoek i.h.k.v. subsidie **MRA Cluster Groene Software** i.s.m.:



UNIVERSITEIT VAN AMSTERDAM



EQUINIX



SCHUBERG PHILIS



Greenit
amsterdam region

TOEKOMST SEFLAB

- ❖ Uitbreiden met **nieuwe hardwareconfiguraties**
- ❖ Doorontwikkelen van meetopstelling voor **hoogfrequente metingen**
- ❖ Samenwerken met andere partijen t.b.v.:
 - **Hardware sponsoring** (hardwareontwikkelaars, datacenters)
 - Kennis over **softwareontwikkeling** (softwareontwikkelaars)
 - **Onderzoek** (universiteiten)
 - **Te testen software + meerwaarde** bespreken (IT-afdelingen van onderwijsinstellingen en bedrijven, softwareontwikkelaars)

VRAGEN?

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