SWForum.eu and HUB4CLOUD Workshop

WEGreen - Engineering Green and Sustainable Software in the Computing Continuum

HYBRID EVENT

15 September 2022

Izola, Slovenia

Co-located with the 19th International Conference on the Economics of Grids, Clouds, Systems and Services - GECON 2022

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#SWForumWorkshop

SWForum.eu

European forum of the software research community

SWForum.eu project overview for the WeGreen workshop

Juncal Alonso (TECNALIA)

European forum of the software research community - SWForum.eu project has received funding from the European Union's Horizon 2020 - Research and Innovation program - under grant agreement no. 957044.

SWForum.eu
European forum of the software research community

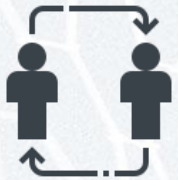
Main Objective




Raise **awareness** + Strenghthen the **competitiveness** **Of the** European Software industry

By facilitating a…

Sustainable Forum for researchers, providers, developers, operators and policy-makers



Space for engagement

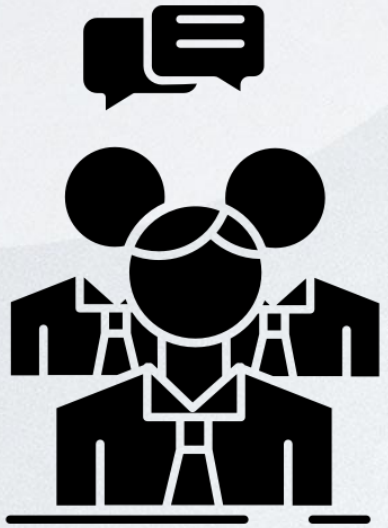
R&I Roadmaps

Policies

Assets

…

Objectives and results

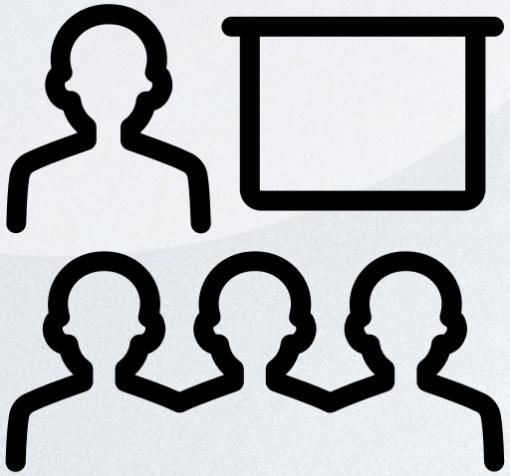


Objective 1 - Promote EU cross-fertilization between the areas of software, digital infrastructures, and cybersecurity

Key Results (KR)

Cross-fertilization workshops

Objectives and results



- **Objective 2 - Create a self-sustainable forum of researchers and practitioners in the area of software technologies and related areas.**

Key Results (KR)

Sustainable Forum and Fellowship programme

Online Platform

Research and Innovation Roadmaps

Landscape reports

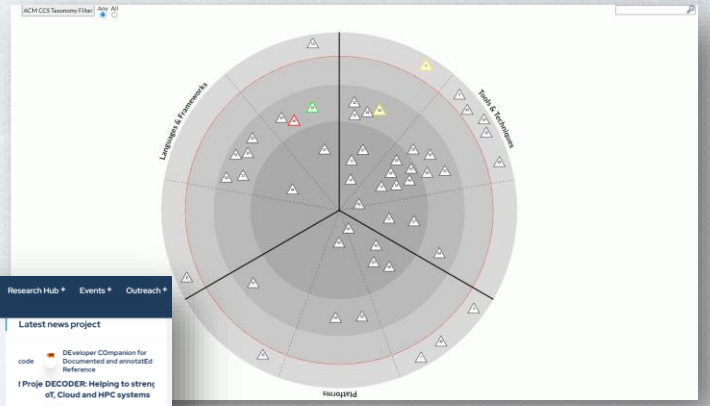
Objectives and results

Objective 3 - Enhance the visibility of European based software technology projects, digital infrastructures and cybersecurity both in the research and in the market domain at an international level.

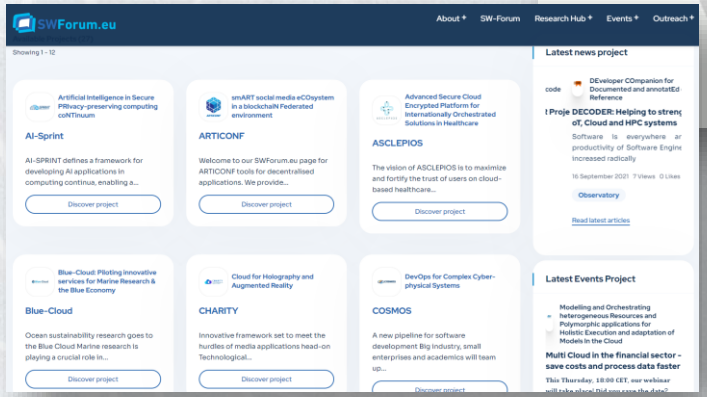
Key Results (KR)

Taxonomy

Project Radar



Hub of project mini-sites

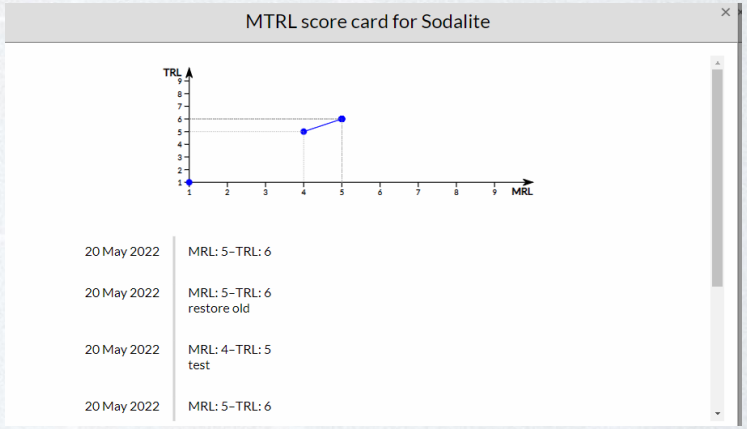


Objectives and results

- **Objective 4 - Provide guidance for increasing the competitiveness of European initiatives through the definition of a methodological approach to the improvement of their MTRL, Mentoring, Technology Transfer & Best Practices guiding towards Policy Innovation.**

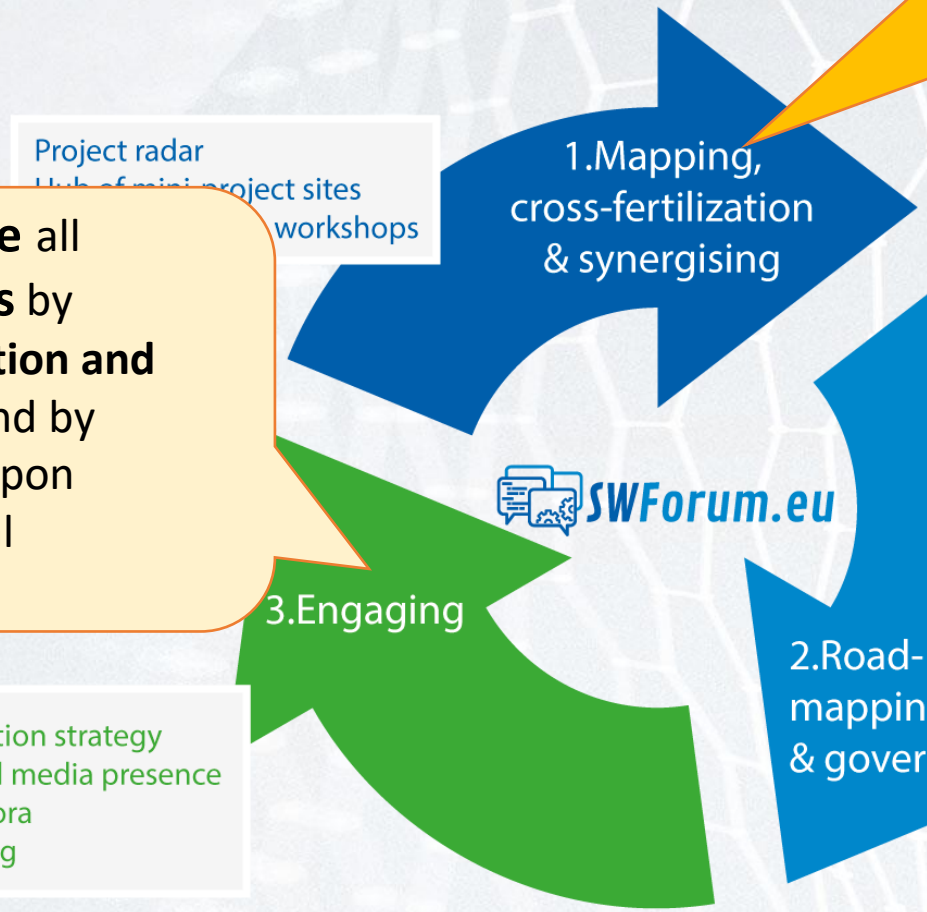
Key Result (KR)

Customized MTRL Methodology for the topics addressed in SWForum



Coordination and Su

Develop an effective way to **map R&I project topics** of software engineering, digital infrastructures, cybersecurity in Europe, **inducing collaborations** and realising synergies by proactively facilitating them through practical steps.



Continuously engage all relevant **stakeholders** by executing **communication and marketing activities** and by systematically acting upon pragmatic motivational mechanisms.

Provide **recommendations on policy-related issues** and the **governance structure** for the **sustainability** of the SWForum.eu community

SWForum.eu
European forum of the software research community

SWFORUM.EU

1st October 2020 – 31st March 2023

CSA H2020-ICT-2020-1 ICT-50-2020-1 Software Technologies

5 partners

CONCEPTIVITY 360 SECURITY

UNIVERSITY OF OXFORD

POLITECNICO MILANO 1863

tecnalia
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Trust-IT Services
communicating to markets

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Thank You!

Get in touch with us!

SWForum.eu

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SWForum

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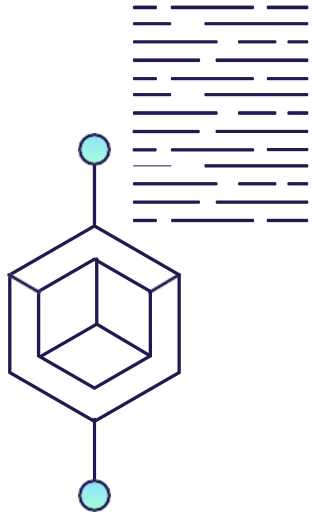
Evaluate the environmental impact of ICT

With open data, methods and tools



hubblo

PRÉSENTATION

David Ekchajzer

Research ⇒ Action

Co-founder of Hubblo.org

Contributor at Boavizta.org

HUBBLO

hubblo

Open-Source products
Integrate and automate environmental evaluation

Engineering and consulting firm
Evaluate environmental impact of ICT

Open R&D
more systemic consideration of impacts

Boavizta - evaluation of the environmental impact of IT

Working group

Organizations
Researchers
Freelancers

Themes

Data Repository
Cloud measurement
Calculation methods
Convince top-management
Open-source tools

https://boavizta.org/

The environmental impacts of digital technology

How ICT contribute to global warming ?

2020 : 2,1 to 3,9% ~= 

2025 : 6 to 8% ~= 

The impactS of ICT

%	Energy	GHG	Water	Electricity	Resources
Users	60%	63%	83%	44%	75%
Networks	23%	22%	9%	32%	16%
Datacenters informatiques	17%	15%	7%	24%	8%

Répartition des impacts du numérique mondial en 2019

Source : greenIT.fr

How to evaluate them ?

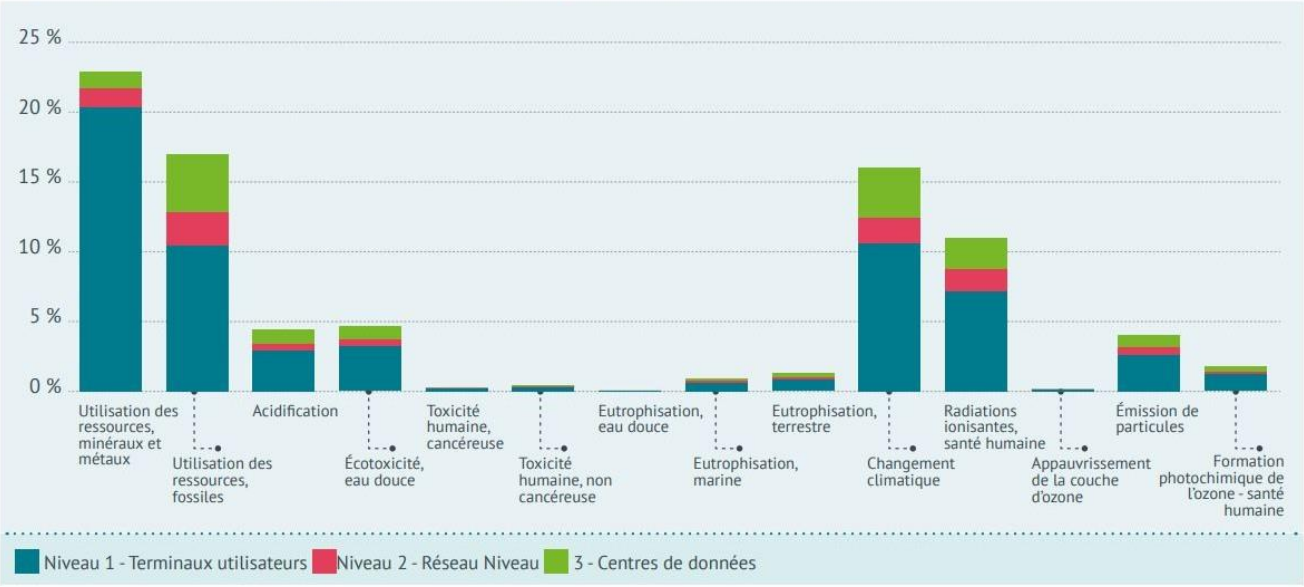
Perimeter

Multi-perimeters

Mutli-steps

Multi Criteria

Figure 1 - Distribution normalisée et pondérée de l'impact le long des 3 niveaux



The Green / EFA - Ponderation of 13 impacts criteria

EF Impact Category	EF Impact Assessment Model	EF Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2.5 equivalent	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U^{235} equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m^3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land Transformation	Soil Organic Matter (SOM) model	Kg (deficit)	Milà i Canals et al., 2007

Default EF impact [...] for PEF studies

Life cycle assessment

Life Cycle Assessment
ISO 14040
ISO 14044

Multi Criteria analysis

https://pre-sustainability.com/

Why make open evaluations ?

Because it is a democratic necessity

THE GREEN NEW DEAL FOR EUROPE

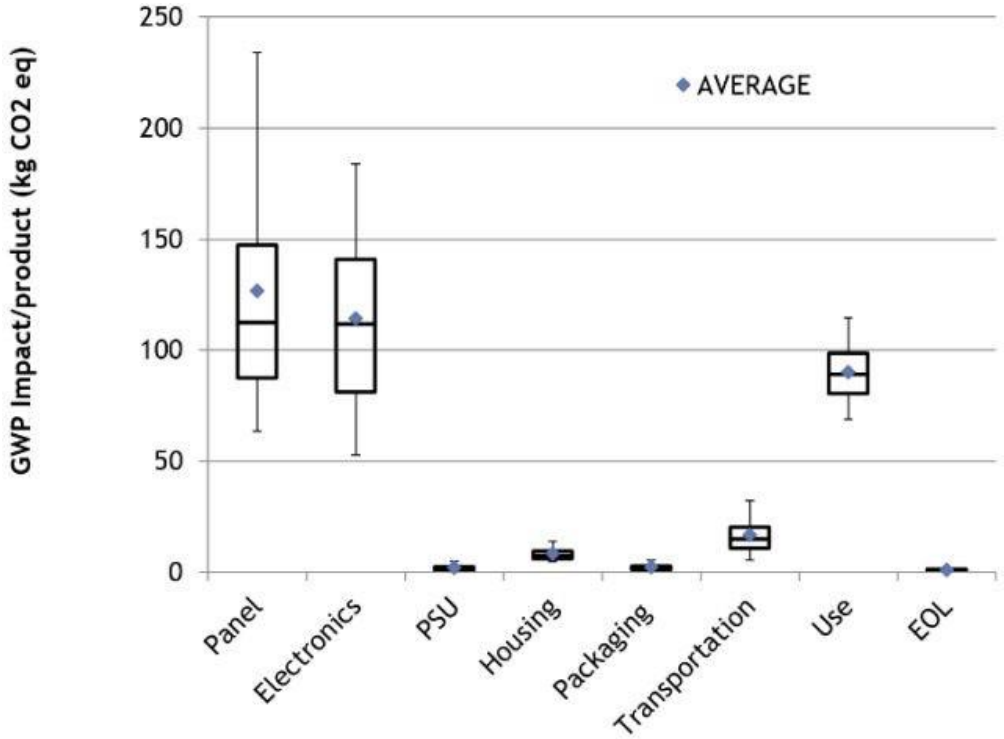
Political orientations

Environmental labeling

Because the measurements are of poor quality

Average GWP impact of screen manufacturing **(kgCO2e/inch)**	
Dell (PAIA)	11,4 to 26,7
Lenovo (PAIA)	5,7 to 24,5
HP (Other)	3,3 to 8,6
NegaOctet	2,94
Base Impacts (ADEME)	≈ 2,7

Dell E2219HN Monitor



Is it possible?

Spoiler : Hardly

The allies

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

SDIA

THE SHIFT PROJECT
THE CARBON TRANSITION THINK TANK

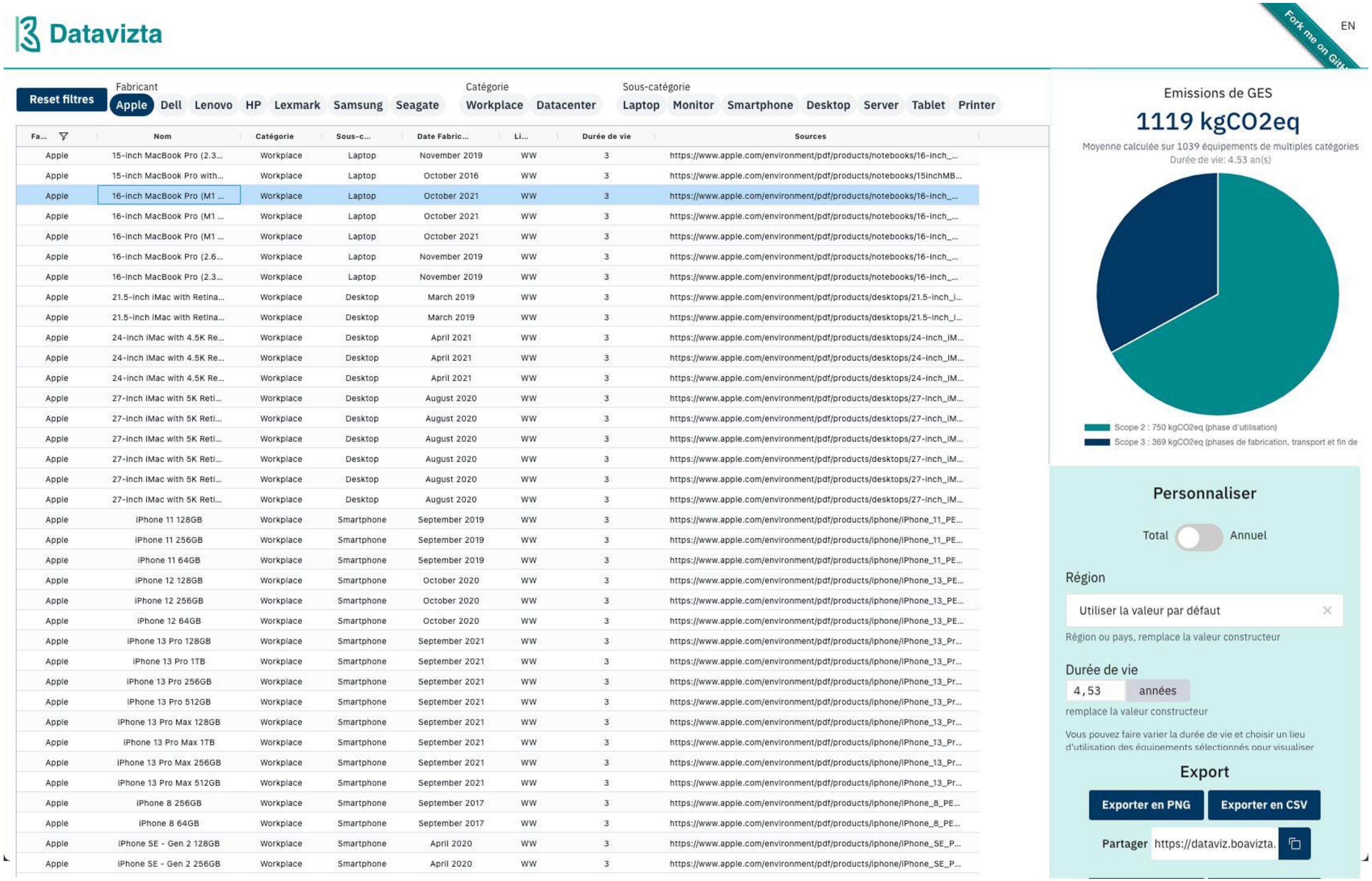
Green Software Foundation

Measuring the impact of user terminals

Perimeter

	 *End-user equipments*	*Network*	 *On-prem infra*	 *Cloud (As a service)*
 *Manufacture*				
 *Transport*				
 *Use*				
 *Waste*				

datavizta.boavizta.org



Fa...	Nom	Catégorie	Sous-c...	Date Fabric...	Li...	Durée de vie	Sources
Apple	15-inch MacBook Pro (2.3...	Workplace	Laptop	November 2019	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	15-inch MacBook Pro with...	Workplace	Laptop	October 2016	WW	3	https://www.apple.com/environment/pdf/products/notebooks/15inchMB...
Apple	16-inch MacBook Pro (M1 ...	Workplace	Laptop	October 2021	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	16-inch MacBook Pro (M1 ...	Workplace	Laptop	October 2021	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	16-inch MacBook Pro (M1 ...	Workplace	Laptop	October 2021	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	16-inch MacBook Pro (2.6...	Workplace	Laptop	November 2019	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	16-inch MacBook Pro (2.3...	Workplace	Laptop	November 2019	WW	3	https://www.apple.com/environment/pdf/products/notebooks/16-inch_...
Apple	21.5-inch iMac with Retina...	Workplace	Desktop	March 2019	WW	3	https://www.apple.com/environment/pdf/products/desktops/21.5-inch_i...
Apple	21.5-inch iMac with Retina...	Workplace	Desktop	March 2019	WW	3	https://www.apple.com/environment/pdf/products/desktops/21.5-inch_i...
Apple	24-inch iMac with 4.5K Re...	Workplace	Desktop	April 2021	WW	3	https://www.apple.com/environment/pdf/products/desktops/24-inch_iM...
Apple	24-inch iMac with 4.5K Re...	Workplace	Desktop	April 2021	WW	3	https://www.apple.com/environment/pdf/products/desktops/24-inch_iM...
Apple	24-inch iMac with 4.5K Re...	Workplace	Desktop	April 2021	WW	3	https://www.apple.com/environment/pdf/products/desktops/24-inch_iM...
Apple	27-inch iMac with 5K Reti...	Workplace	Desktop	August 2020	WW	3	https://www.apple.com/environment/pdf/products/desktops/27-inch_iM...
Apple	27-inch iMac with 5K Reti...	Workplace	Desktop	August 2020	WW	3	https://www.apple.com/environment/pdf/products/desktops/27-inch_iM...
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Apple	27-inch iMac with 5K Reti...	Workplace	Desktop	August 2020	WW	3	https://www.apple.com/environment/pdf/products/desktops/27-inch_iM...
Apple	27-inch iMac with 5K Reti...	Workplace	Desktop	August 2020	WW	3	https://www.apple.com/environment/pdf/products/desktops/27-inch_iM...
Apple	27-inch iMac with 5K Reti...	Workplace	Desktop	August 2020	WW	3	https://www.apple.com/environment/pdf/products/desktops/27-inch_iM...
Apple	iPhone 11 128GB	Workplace	Smartphone	September 2019	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PE...
Apple	iPhone 11 256GB	Workplace	Smartphone	September 2019	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PE...
Apple	iPhone 11 64GB	Workplace	Smartphone	September 2019	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PE...
Apple	iPhone 12 128GB	Workplace	Smartphone	October 2020	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_PE...
Apple	iPhone 12 256GB	Workplace	Smartphone	October 2020	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_PE...
Apple	iPhone 12 64GB	Workplace	Smartphone	October 2020	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_PE...
Apple	iPhone 13 Pro 128GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro 1TB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro 256GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro 512GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro Max 128GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro Max 1TB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro Max 256GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 13 Pro Max 512GB	Workplace	Smartphone	September 2021	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_13_Pr...
Apple	iPhone 8 256GB	Workplace	Smartphone	September 2017	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_8_PE...
Apple	iPhone 8 64GB	Workplace	Smartphone	September 2017	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_8_PE...
Apple	iPhone SE - Gen 2 128GB	Workplace	Smartphone	April 2020	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_SE_P...
Apple	iPhone SE - Gen 2 256GB	Workplace	Smartphone	April 2020	WW	3	https://www.apple.com/environment/pdf/products/iphone/iPhone_SE_P...

⚡ Measure the impacts related to usage.

Perimeter

End-user equipments

Network

On-prem infra

Cloud (As a service)

Manufacture

Transport

Use

Waste

kWh * Co2eq./kWh

kWh : Power consumption
Co2eq./kWh : Impact of a kwh of electricity

kWh : Power consumption

Open-methodology

Physics

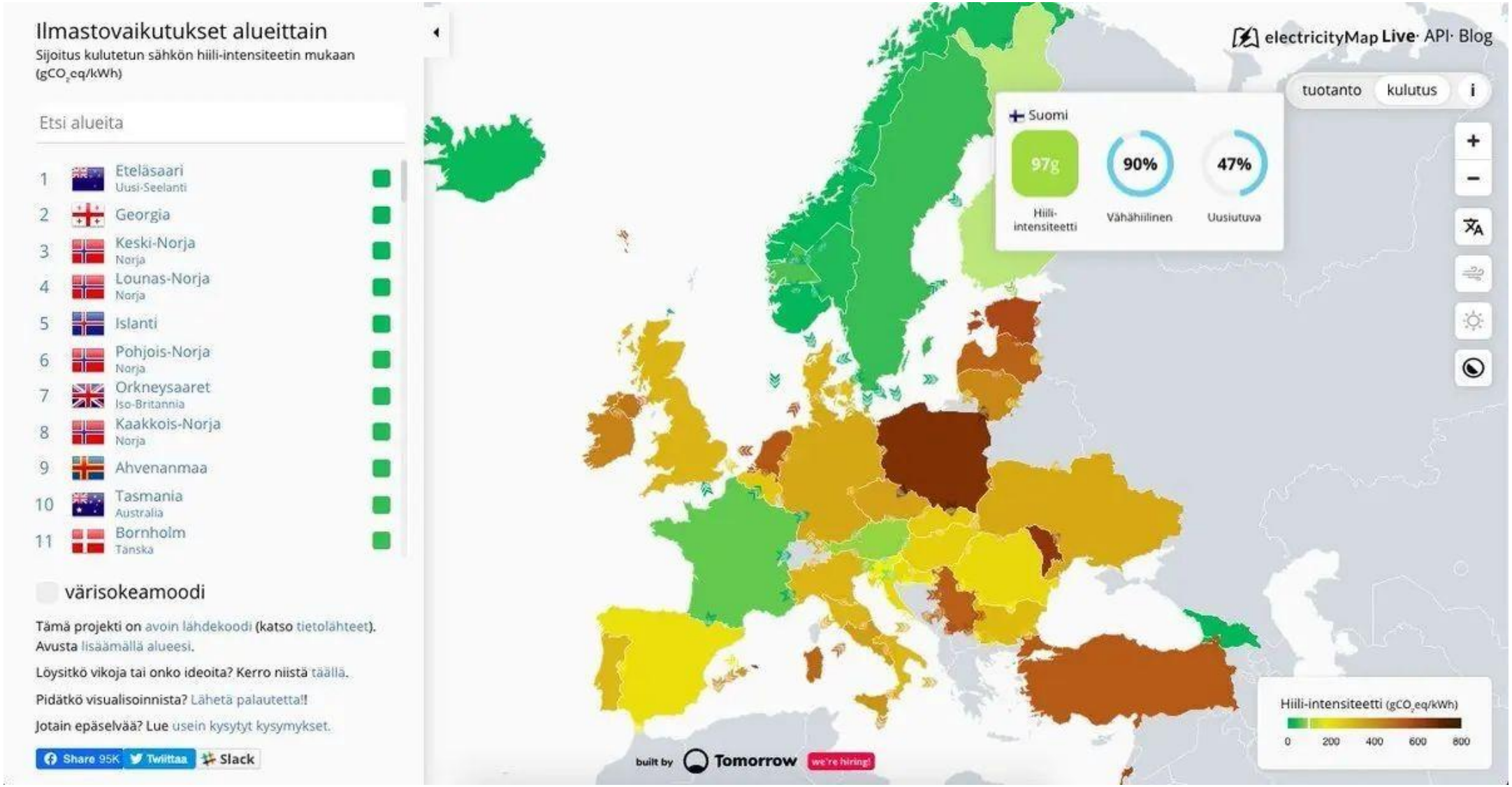
Software sensor

Open-Source

PowerAPI

Joular

Impact of a kwh of electricity : Electricity map



What about the cloud ?

Perimeter

End-user equipments

Network

On-prem infra

Cloud (As a service)

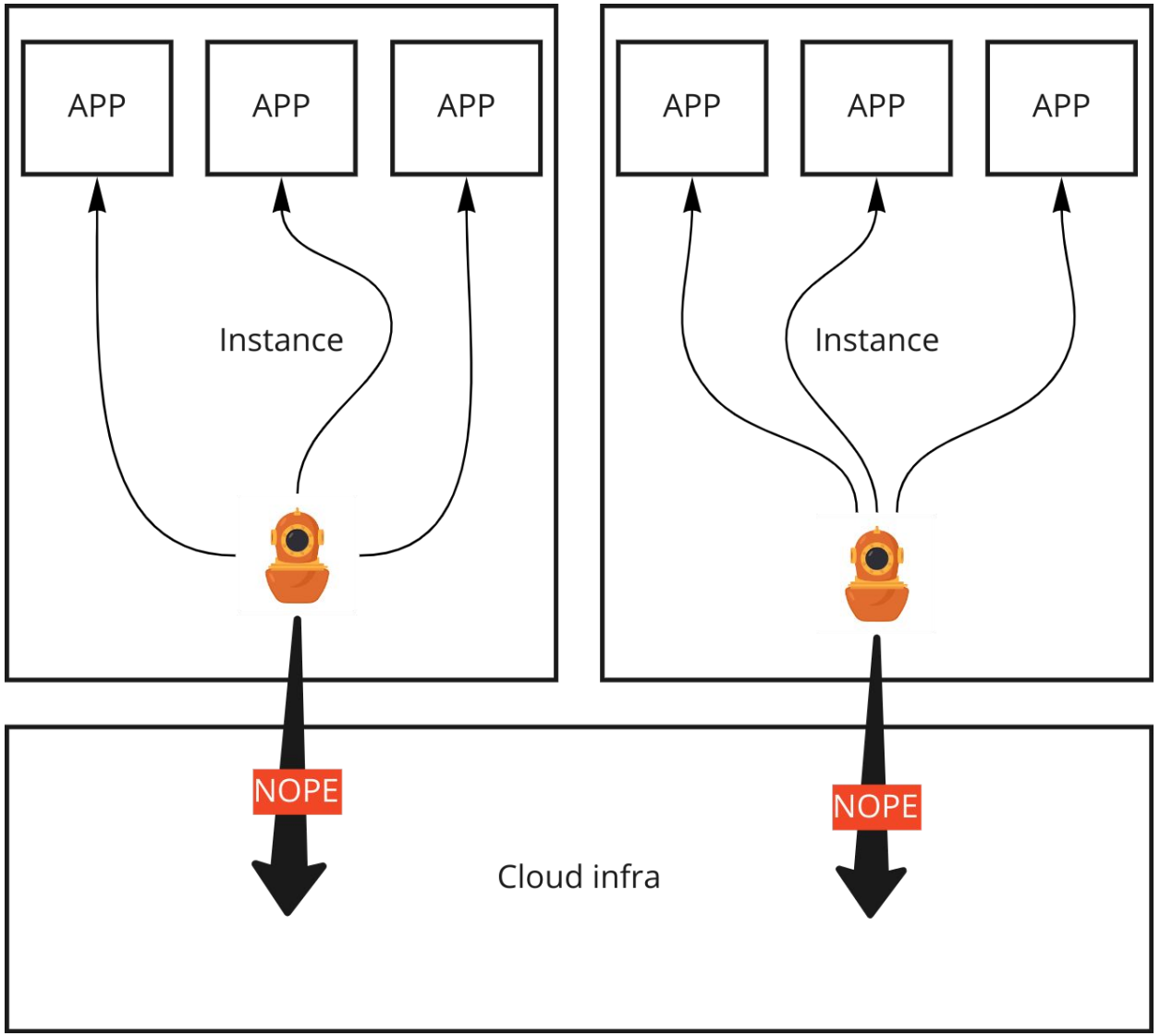
Manufacture

Transport

Use

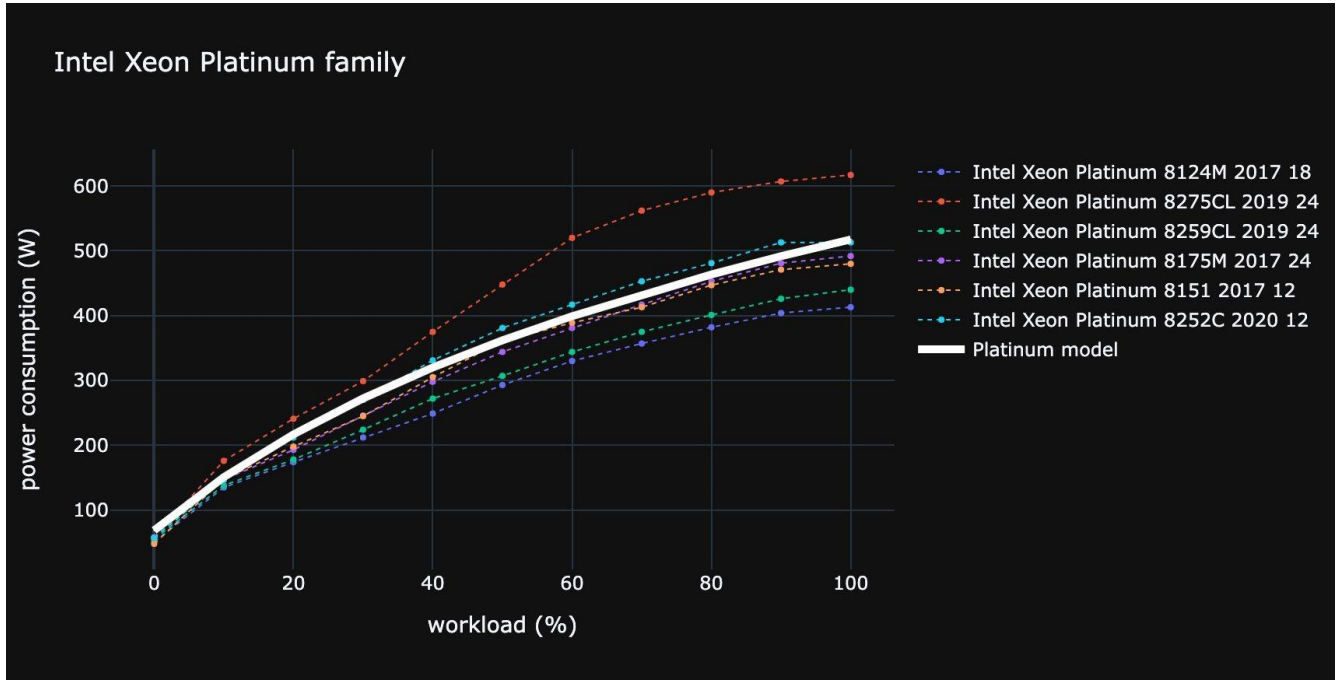
Waste

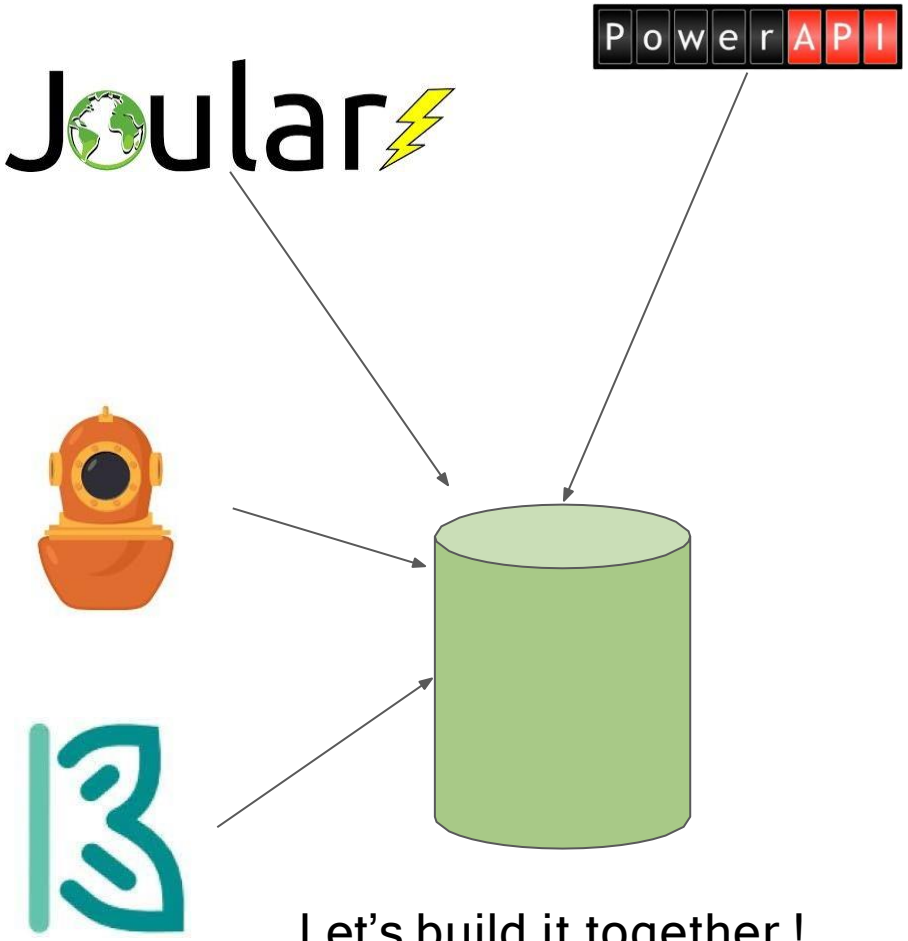
Where to connect my power meter?



Modeling electrical consumption

Open Science





BoaviztAPI
Boagent

Let’s build it together !

Measuring the impacts of manufacturing

Perimeter

End-user equipments

Network

On-prem infra

Cloud (As a service)

Manufacture

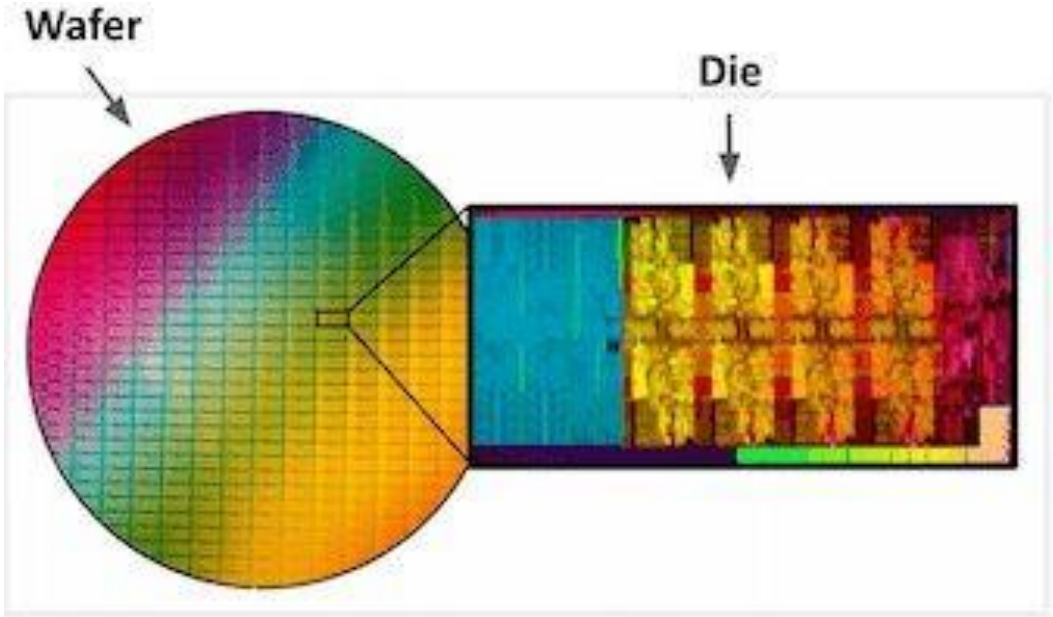
❌

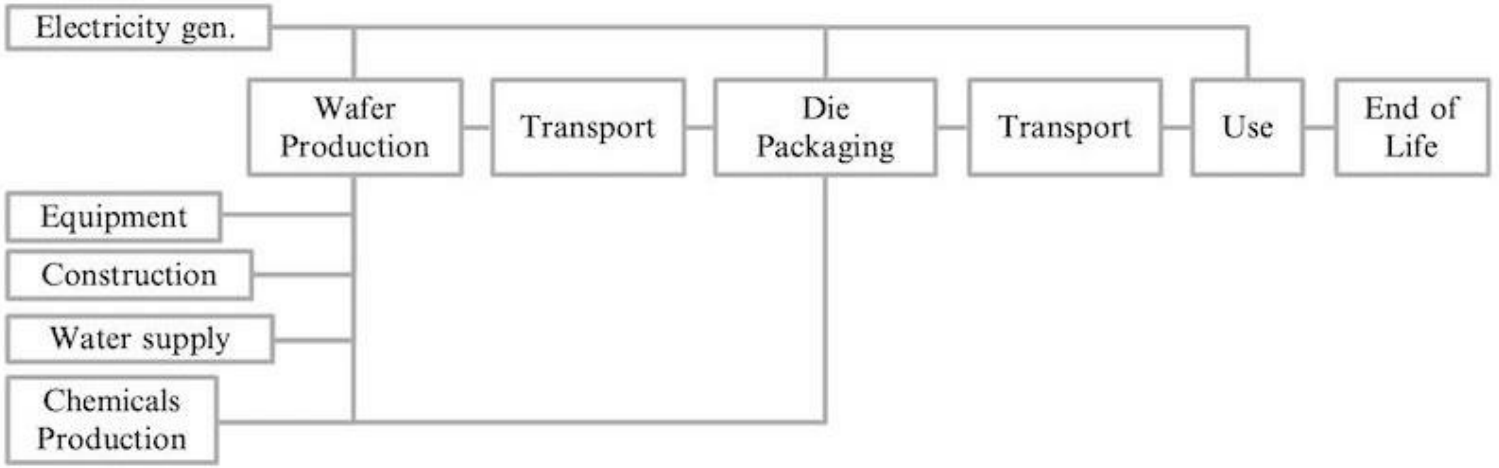
Transport

Use

Waste

Die size


Wafer
Die


Electricity gen.
Wafer Production
Transport
Die Packaging
Transport
Use
End of Life
Equipment
Construction
Water supply
Chemicals Production

BoaviztAPI : api.boavizta.org/docs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```

```
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  },
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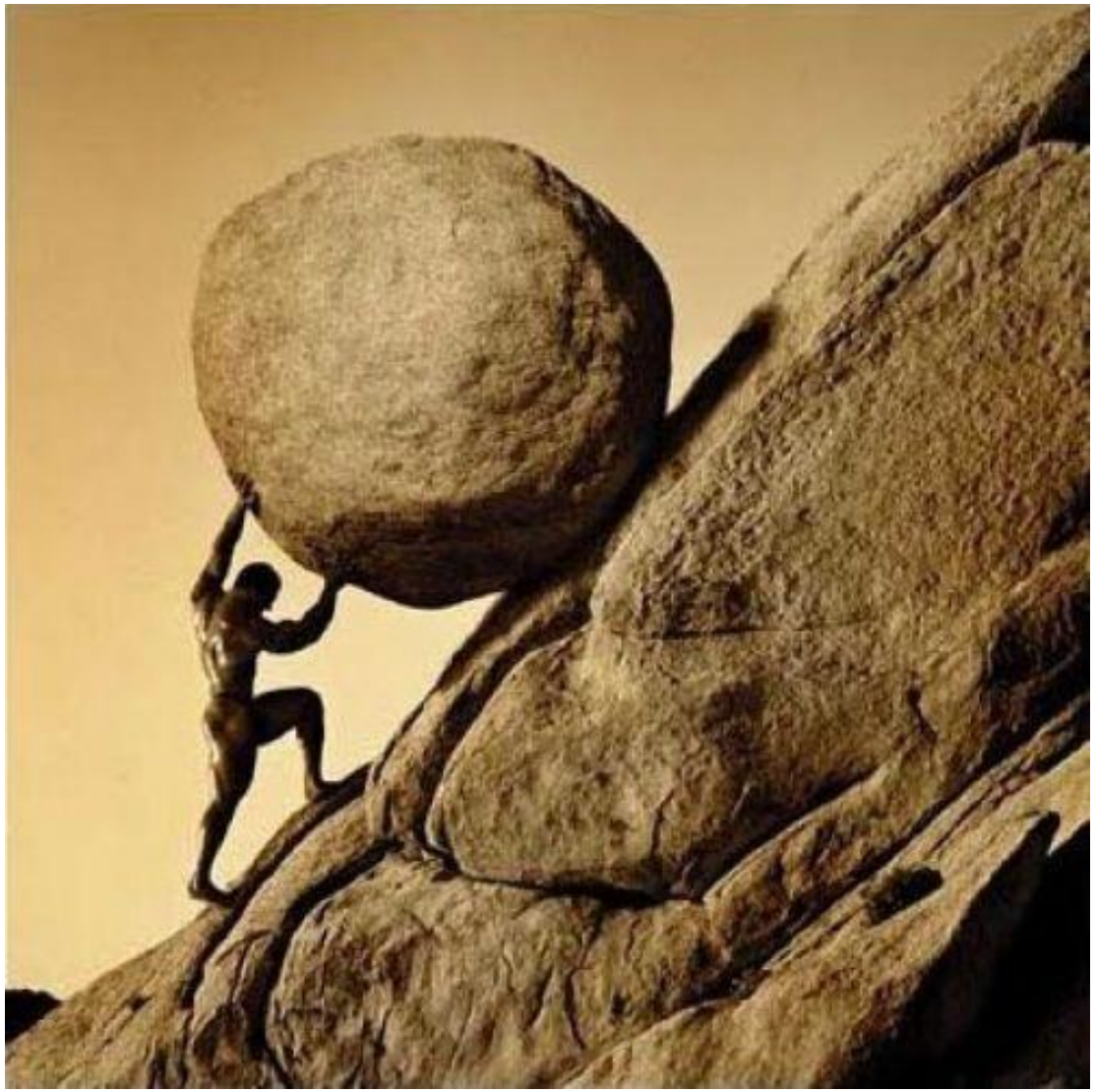
    "unit": "kgSbeq"
  }
}
```

Congratulations! You have the least bad evaluation



In the meantime

1. Refuse
2. Reduce
3. Reuse
4. Recycle
5. Return

The nexus of Green transition & Digital Transformation

Synergies

- Digital transformation for climate neutrality. It can reduce 15-20% of total GHG emissions
- Green transition for sustainable financing and new jobs in green digital transformation

Conflicts

- ICT footprint: >3% of total emissions; electricity consumption increasing (currently ~9%); ewaste growing
- Green transition may block certain digitalisations patterns (built in obsolescence, blockchain mining, single use electronics, etc).

- Today's focus is mostly on the Conflicts because they are measurable.
- What is needed: To realise benefits of Synergies for sustainability and digital sector
- How: Science based methods to measure the contribution of digital to environment

-> leading to sustainable finance for green digital (EU Taxonomy, Green Public Proc.)

Reducing energy consumption of Digital Technologies

Climate Neutral and highly energy efficient datacentres by 2030: review **JRC's CoC,** the Energy Efficiency Directive and the Taxonomy Regulation

Greener electronic communications by 2030:

- Energy efficient telecommunications (5G, 6G)

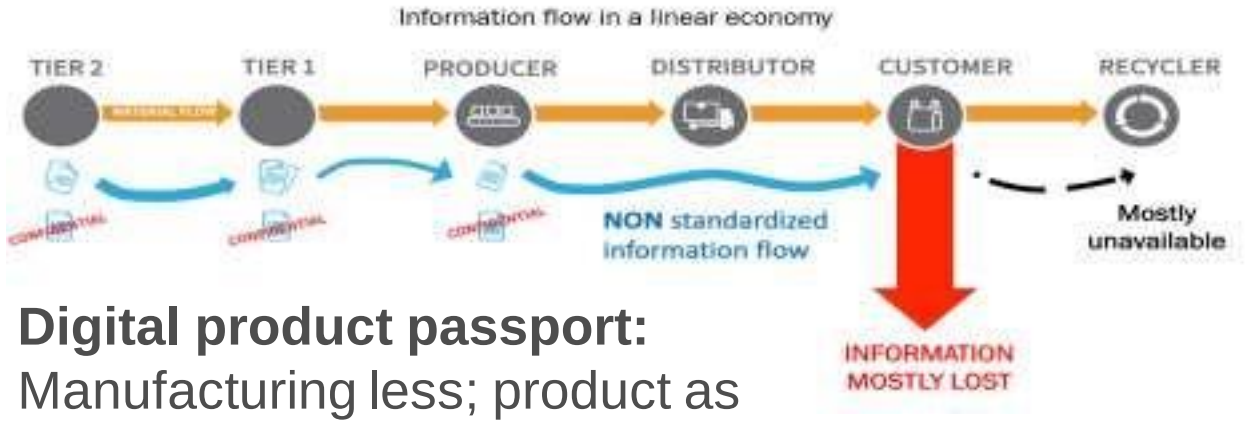
Manufacturing less electronics (Circular Electronics Initiative) Better durability, reparability, refurbishment, recycling for consumer and industrial electronics & IoT

"Right to repair" for consumers.

Low power processors, software, quantum computing and AI: investing in new ultra-low-power

European Commission

Digital solutions to reduce energy consumption



Digital contribution: reduction by up to 15%-20% of total emissions with deployment of today's technology.

Digital product passport: Manufacturing less; product as a services business models

Smart mobility: reduction of transport emissions up to 37%; **smart buildings** with emissions reduction by 17%;

Destination Earth / digital twins: High Performance Computing, AI for better anticipation of extreme events prediction, energy demand/supply modeling

Also: smart energy networks; Precision farming, Energy-lean Blockchain for emissions accounting, smart cities; AI for climate; smart manufacturing;

RRPs: Missed opportunity to use digital solutions for climate action

European Commission

European Green Digital Coalition

35 CEOs of ICT companies, that lead their own transition to climate neutrality by 2040, have committed on behalf of their companies to take action in the following areas:

- Investing in the **development and deployment** of green digital solutions with significant energy and material efficiency that achieve a net positive impact in a wide range of sectors.

- Developing **methods and tools** to measure the net impact of green digital technologies on the environment and climate by joining forces with NGOs and relevant expert organizations.

- Co-creating, with representatives of others sectors, **recommendations and guidelines** for green digital transformation of these sectors that benefits environment, society and economy.

https://digital-strategy.ec.europa.eu/en/policies/european-green-digital-coalition
https://www.greendigitalcoalition.eu/

Data Centre – Other ongoing activities

- Digitalisation of Energy Action Plan
  - Will address benefits and challenges of digitalisation of the energy system (data exchange in energy to support
    consumer empowerment, cybersecurity)
  - Aims to put forward some further elements on Data Centres.
  - Will look beyond data centers at the ICT value chain
  - Adoption June 2022 (tbc)
- Code of Conduct 2022
  - Adoption in the coming days
- Taxonomy section on Data Centres
  - Up and running
- Recovery & Resilience Facility
  - Green Data Centre requirements mainstreamed accross plans
- Regulation laying down ecodesign requirements for servers and data storage products:
  - Preparatory work for the review is ongoing. Conclusion of the review to be presented at the Consultation Forum by ~Q3/Q4 2023.
- Study
  - Publication in February 2022

university of groningen

VU VRIJE UNIVERSITEIT AMSTERDAM

Sustainability-Aware Software Architecting for the Future Cloud: the SustainableCloud project

NWO

Vasilios Andrikopoulos

SEARCH group

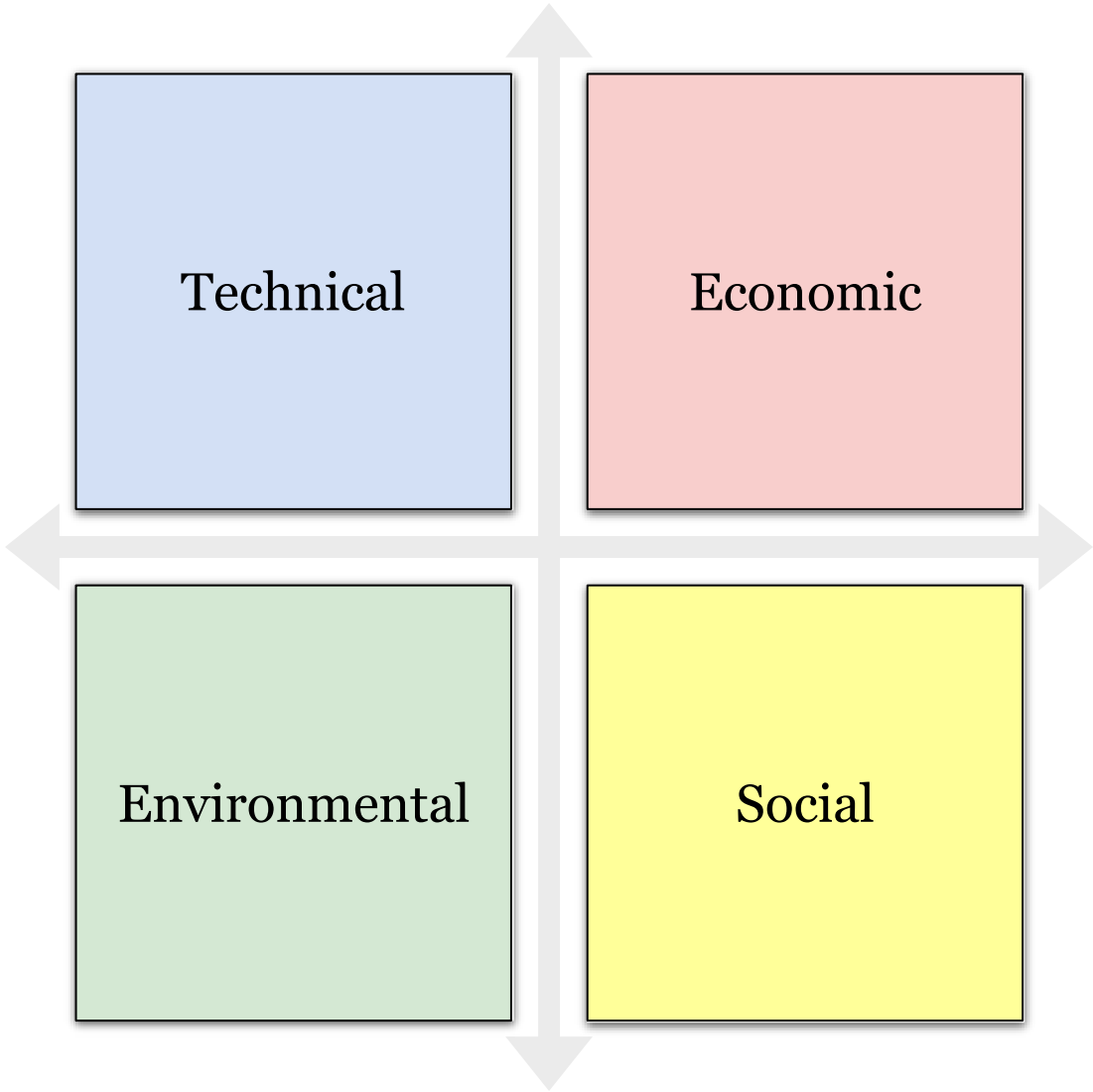
v.andrikopoulos@rug.nl

https://vandriko.github.io/

university of groningen

Background

- Sustainability as a multidimensional concern [Lago et al. 2015]
- Project scope: SaaS providers



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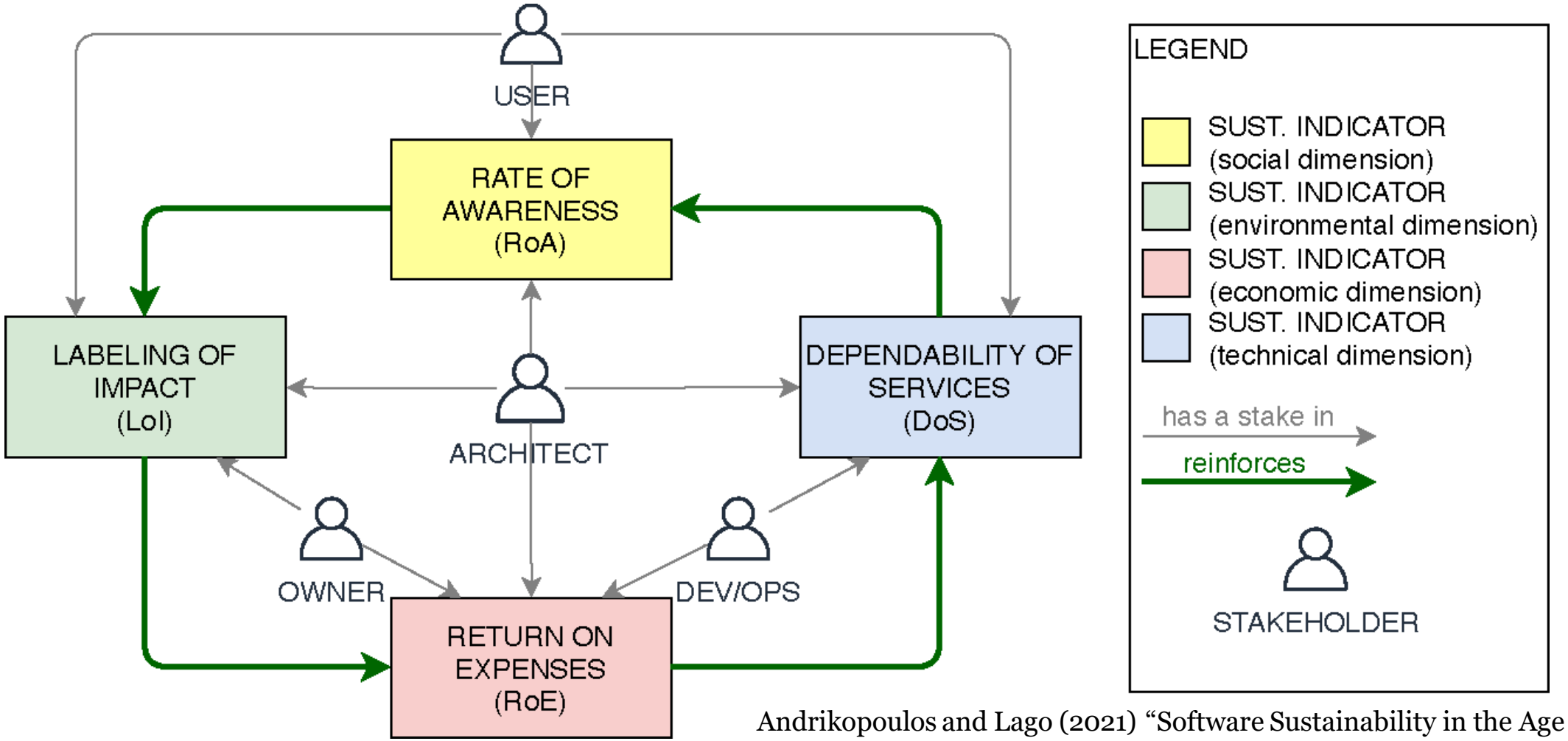
The SAAFramework in a nutshell



Andrikopoulos and Lago (2021) "Software Sustainability in the Age of Everything as a Service" (LNTCS,volume 12521), Springer

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Main propositions

1. To use SAAF to create ***self-sustaining systems*** that deliver sustainability ***across all dimensions***

2. Achieve this by ***indicators*** being a positive feedback loop

3. Adopt different research methods to collect evidence on the above

Sources of data center energy estimates

Mytton & Ashtine, Joule 6, 1–25, 2022

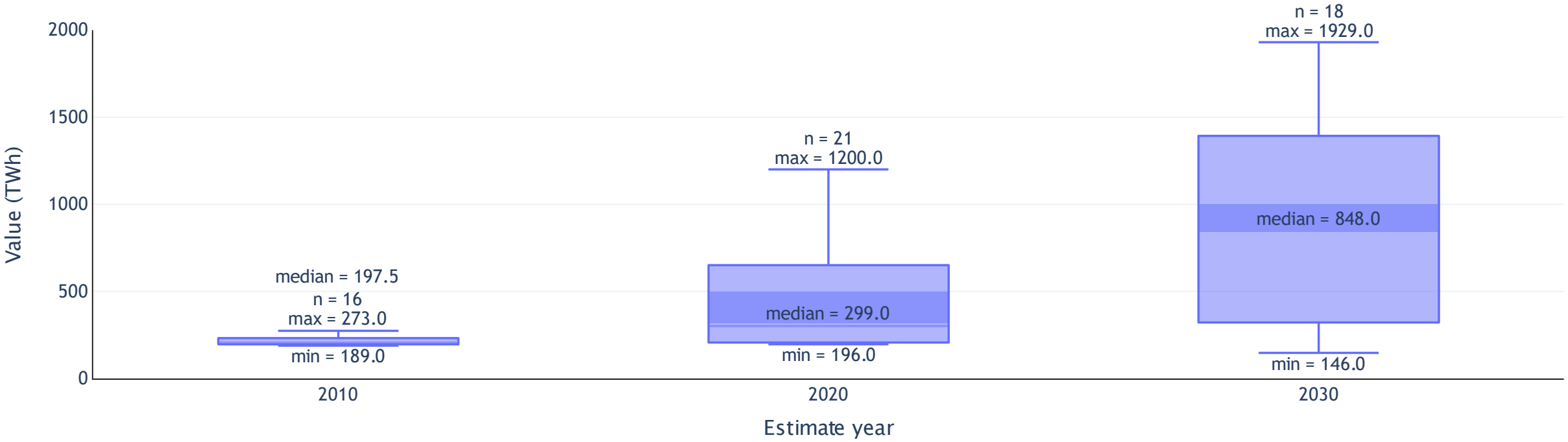
10.1016/j.joule.2022.07.011

Key findings

- 258 data center energy estimates from 46 publications 2007 - 2021.
- 676 sources used.
  - 31% peer-reviewed.
  - 38 non-peer reviewed reports.
  - Reliance on private data from IDC (43%) and Cisco (30%).
  - 11% of sources had broken web links.
  - 10% were cited with insufficient detail to locate.

Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

Global data center energy estimates as ranges in TWh



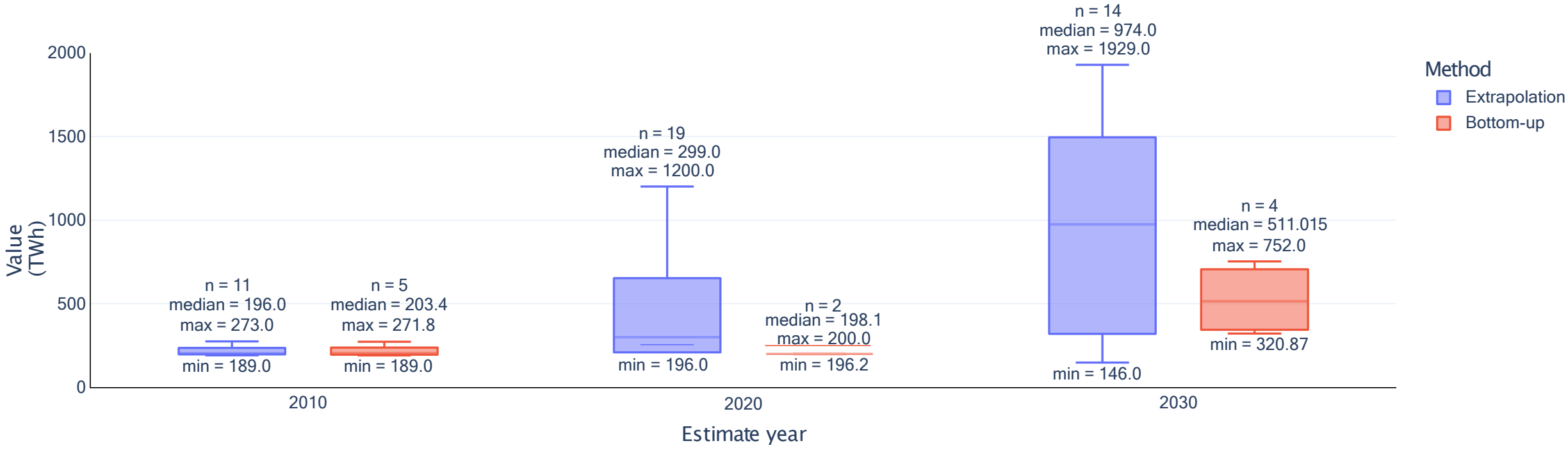
Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

Different methodologies

- Bottom-up
- Top-down
- Extrapolation

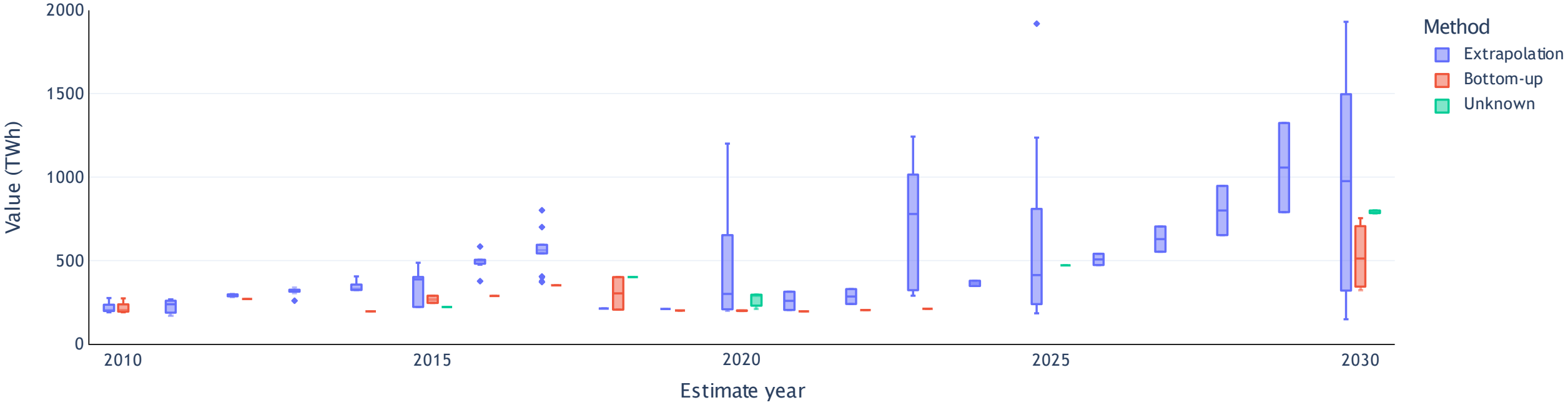
Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

Comparing methodologies

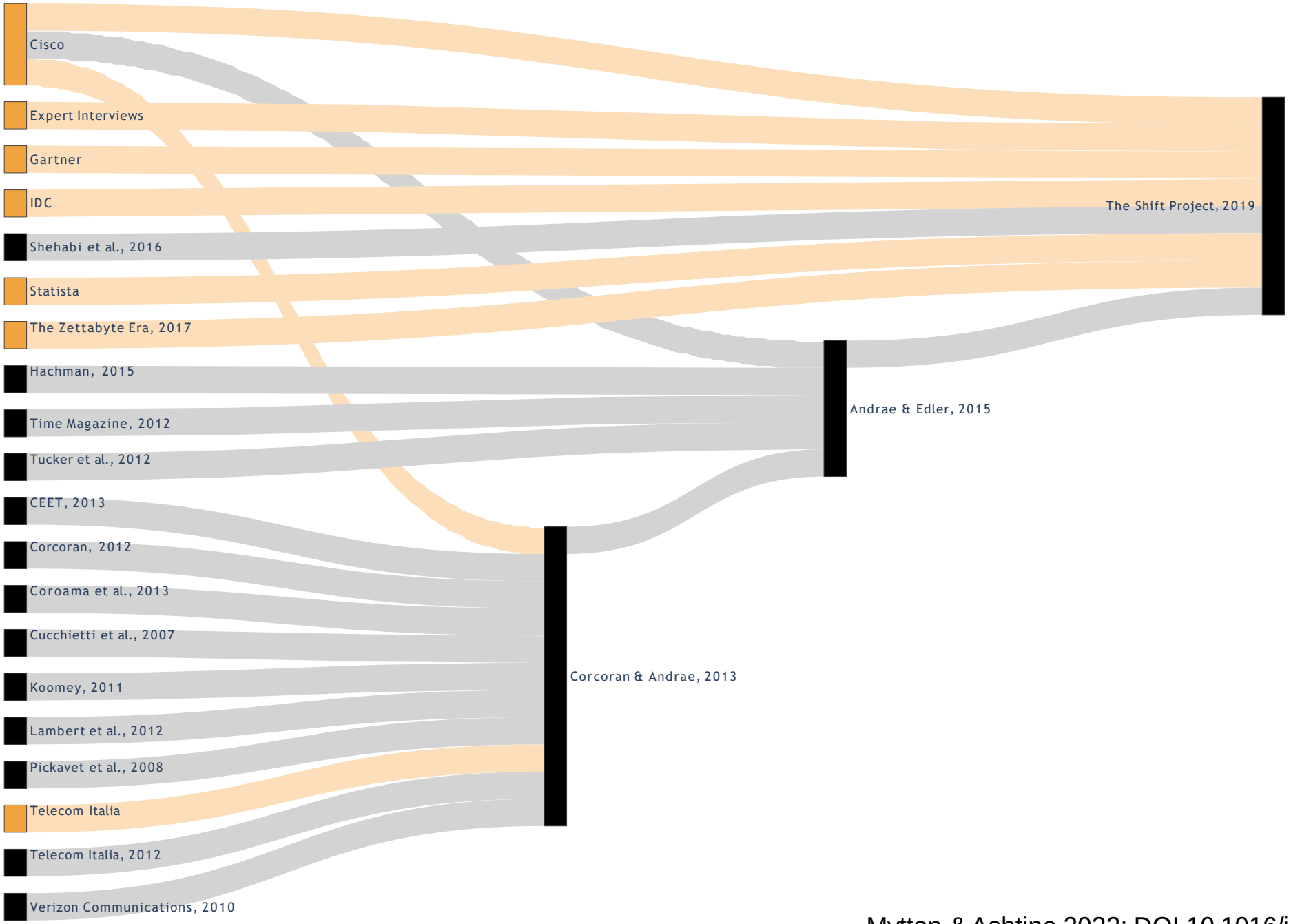


Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

Future predictions



Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011



Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

Britain | Gridlocked

Britain's overstretched electricity grid is delaying housing projects

The grid needs to be expanded to cope with the demands of net zero

Jun 2nd 2022

On May 24th the Greater London Authority, a governance body for the capital, wrote to the person in charge of planning and economic development in the borough of Ealing. The letter, entitled "Electricity Capacity in West London", noted that housing developers were facing delays in connecting new homes to the grid, and that electricity would not be available to them until between 2027 and 2030. New battery-storage systems and data centres had already gobbled up capacity.

1 How old is the publication / data source?

> 3-5 years less reliable

Relevant for today's DC technology?

Over-extended projections reduce confidence

2 What is the basis for estimates?

Historical top-down or bottom-up more accurate

Projections carry higher risk

Demand and energy consumption link?

Justified extrapolation assumptions?

3 Are key sources and calculations available?

Onus should not be on reader to examine sources in detail

Data provenance must be transparent

Lack of discoverable sources should raise immediate caution

Calculations clearly defined?

Mytton & Ashtine 2022: DOI 10.1016/j.joule.2022.07.011

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