Unpacking Carbon in Compute Systems

John Miranda, Intel

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Intel technologies may require enabled hardware, software or service activation.

No product or component can be absolutely secure.

Your costs and results may vary.

Backyard View, Tucson Arizona, June 2020

Operational Carbon

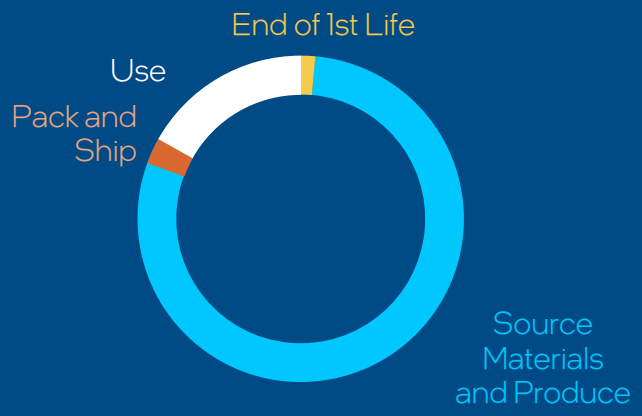
Embedded Carbon

Measurement

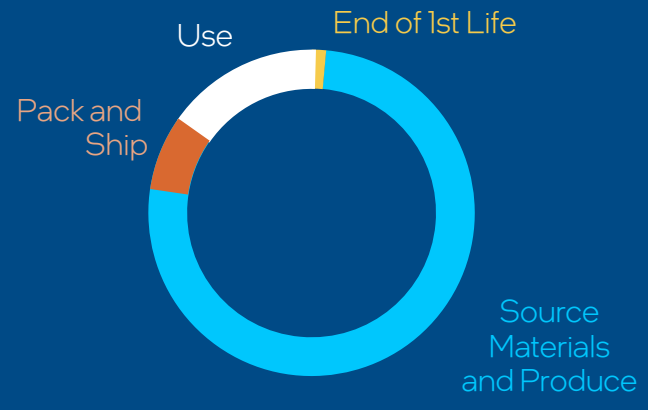
A Rough Intuition on Carbon Equivalent Footprints

Assumes 3-4 Year Initial Life, Excludes Networking

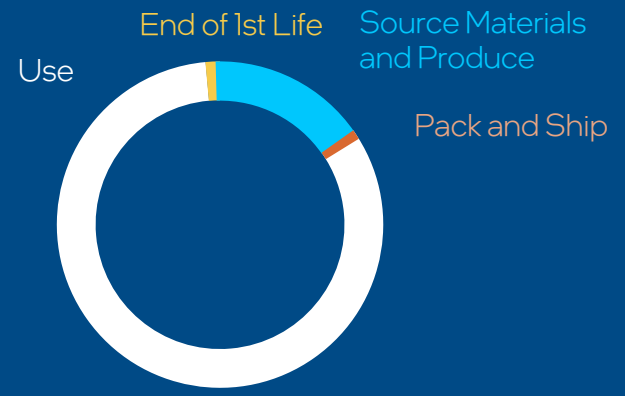
~50 – 80 $KgCO_2e$
(~160 driven miles)



~180 – 500 $KgCO_2e$
(~800 driven miles)



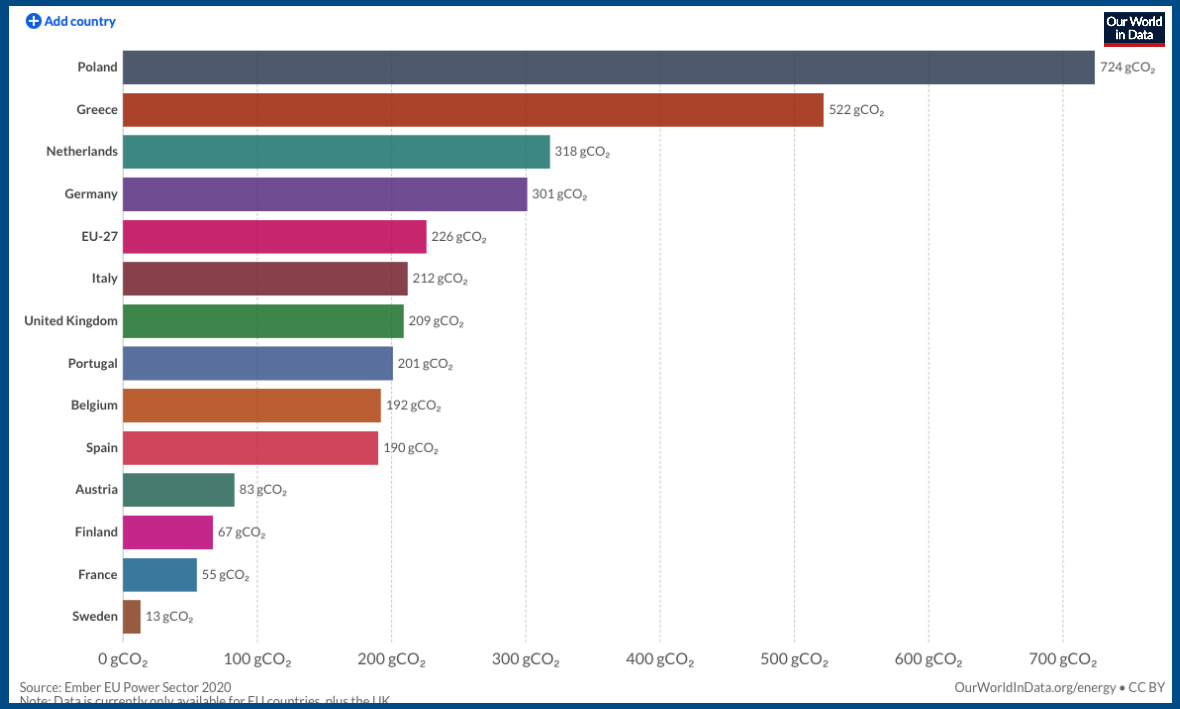
~1700 - 7700 $KgCO_2e$
(~12,000 driven miles)



Source: Various OEMs. Conversion to Miles: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Compute Location Matters: Up to an 80x Carbon Intensity Difference

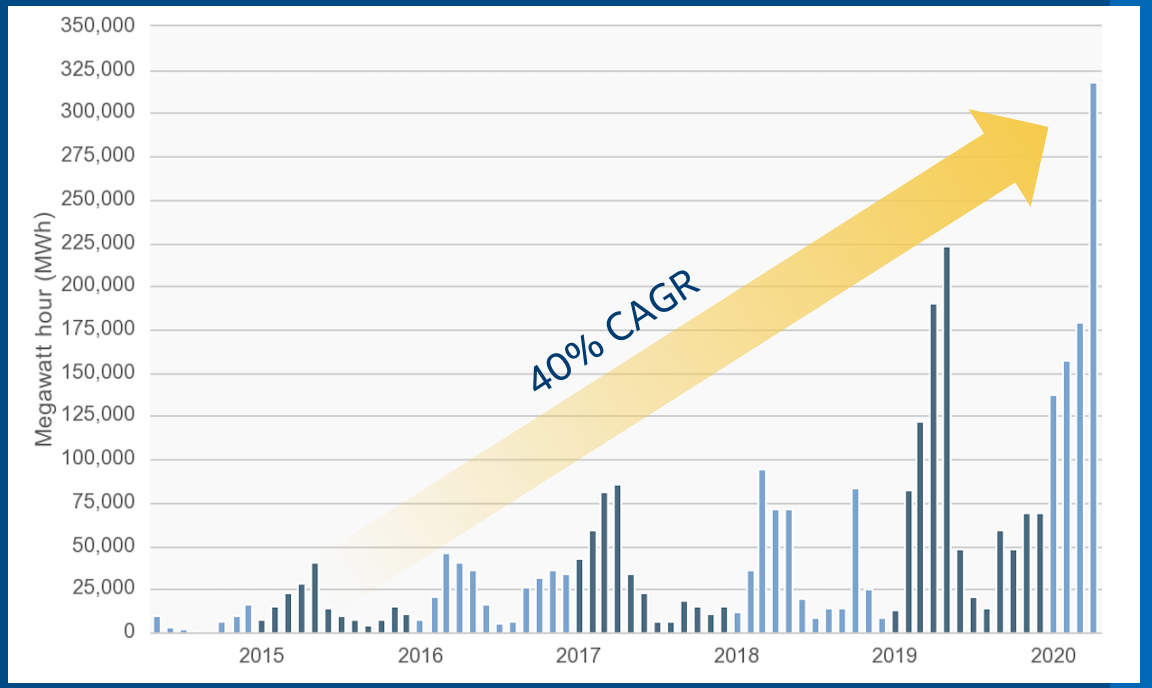
Carbon intensity of electricity per kWh, 2020



Source: https://ourworldindata.org/grapher/carbon-intensity-electricity?tab=chart&region=World

Yet the More Renewable Energy We Have, the More We Waste

Wind and solar curtailment totals by month

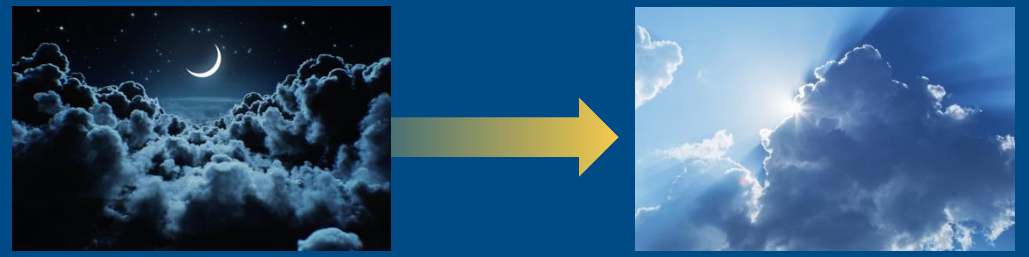


Source: California Independent System Operator

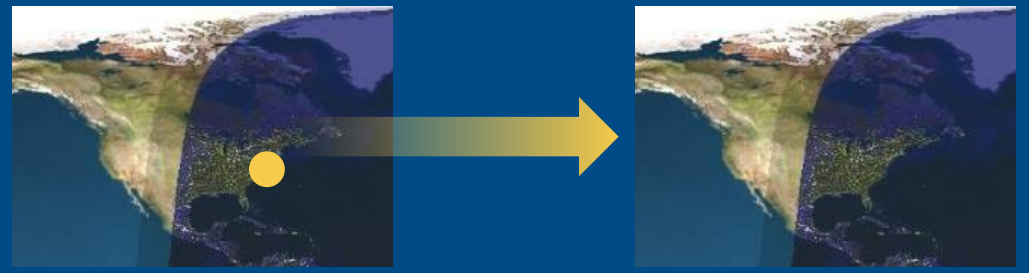
Solving Two Problems:

Compute Carbon Footprint and Energy Challenge

1 **Time Shift** (Run Later)

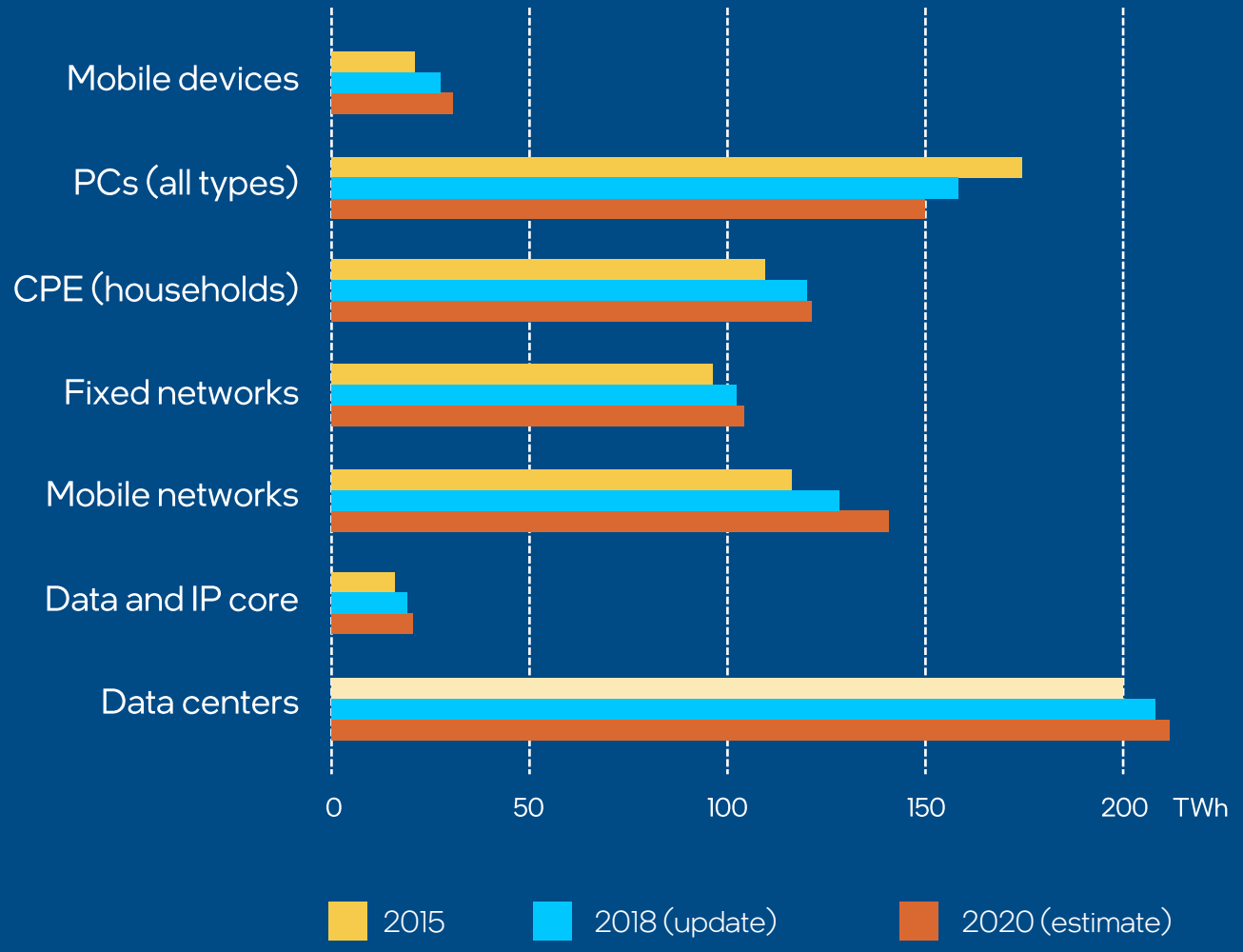


2 **Space Shift** (Run Elsewhere)



- Will devices become “Carbon Aware”?
- Can compute adapt work intensity based on energy profile?

Global Energy for Networks on par with Overall Data Centers needs



Global ICT sector electricity consumption and data traffic 2015-2020, based on [8] Fixed networks include PSTNs, LANs, and fixed broadband (BB) networks (WLAN/WiFi components included as fixed). Mobile networks include all standards, 2G/3G/4G/(5G).

Source: Jens Malmodin. https://online.electronicsgoesgreen.org/wp-content/uploads/2020/10/Proceedings_EGG2020_v2.pdf

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Rising Focus on Embedded Carbon Footprint

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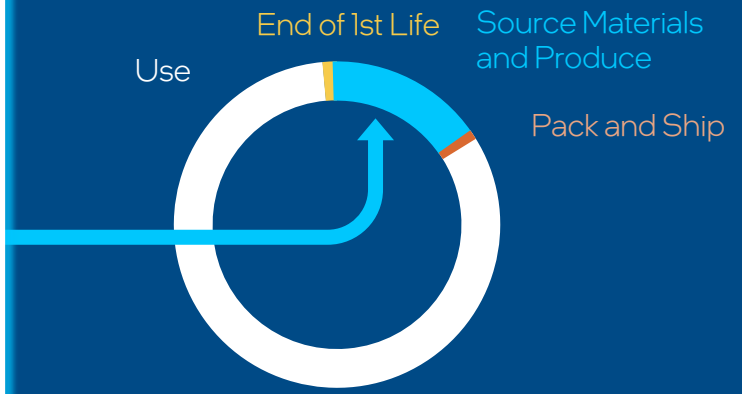
As DC operators offset impact of "use," focus will shift to their supply chain.

...And this will accelerate adoption of Circular Economy Principles.



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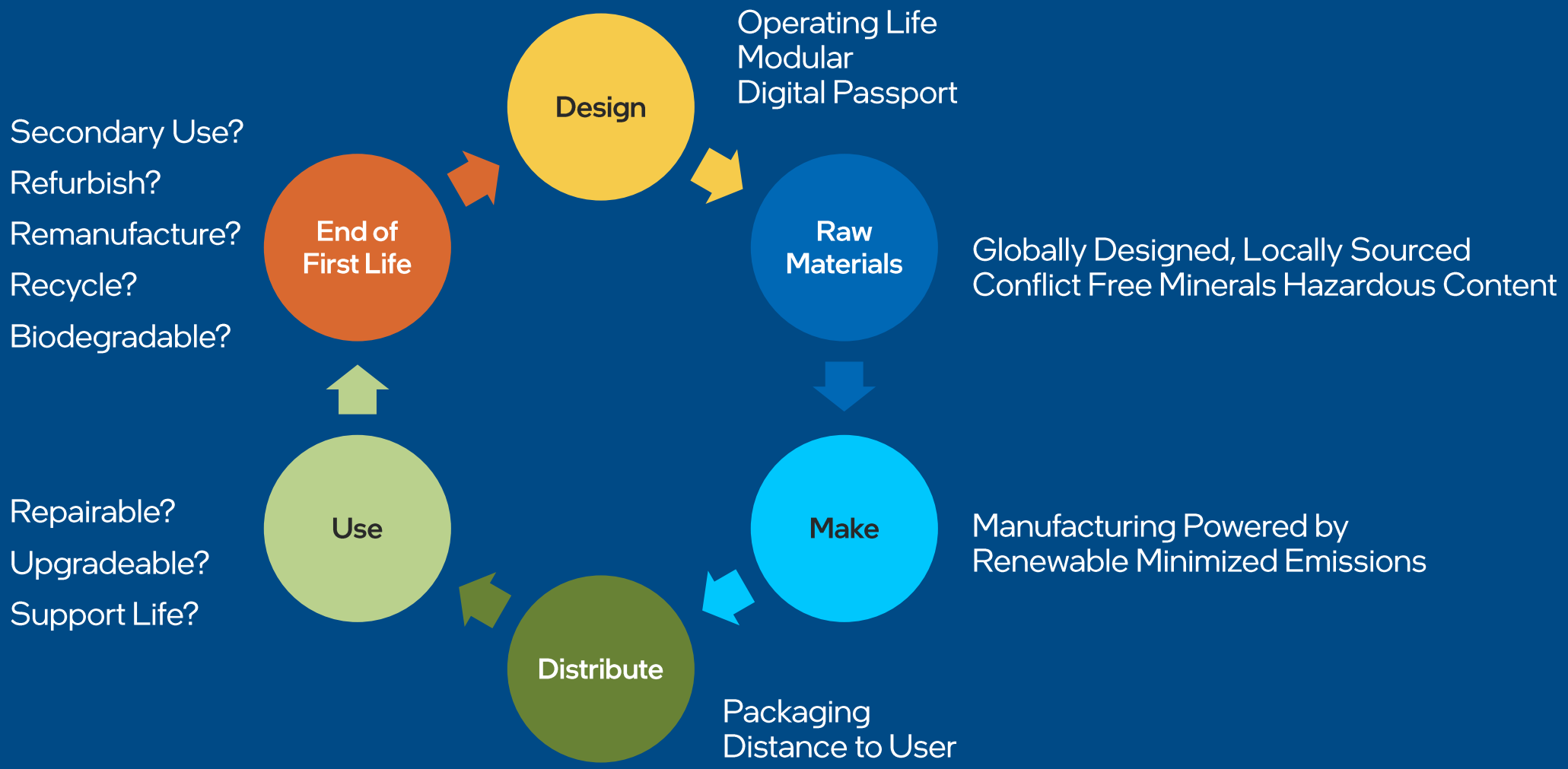
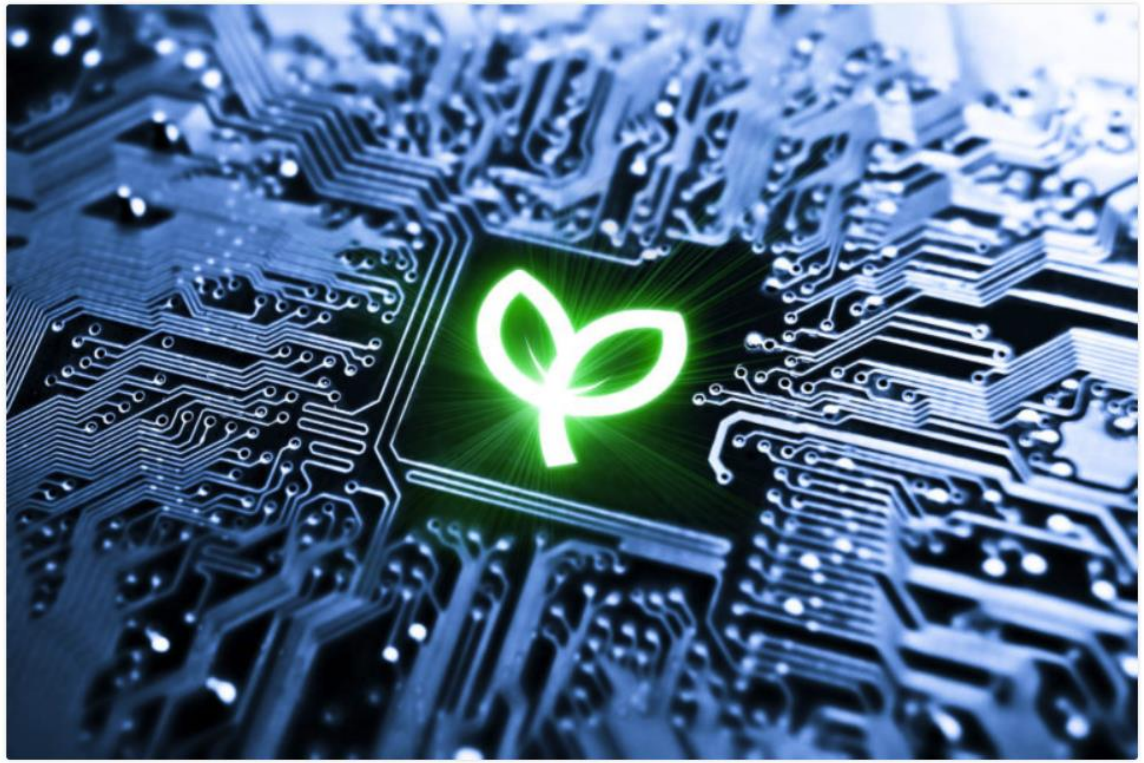
Adopting Circular Economy Principles Begins at Design



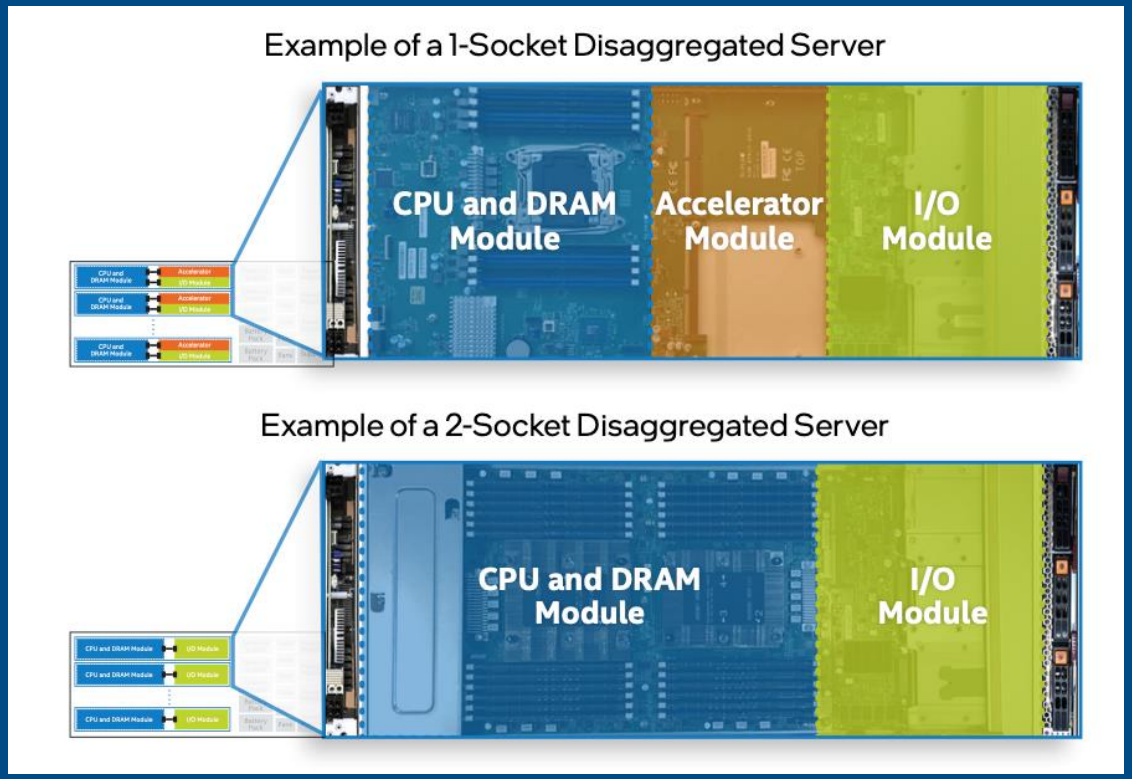
Modularity, Upgradeability, Repairability, Reusability….

[redacted]

Written by Shesha Krishnapura | September 1, 2021



https://itpeernetwork.intel.com/ewaste-and-disaggregated-servers/



The disaggregated server architecture is characterized by CPU/DRAM module and a NIC/drives module that can be refreshed independently of each other and the rest of the server components.

Moving From Traditional Linear Economy

7.1B gallons of water saved

We conserved 7.1 billion gallons of water internally and invested in water restoration projects that restored more than 1.3 billion gallons during 2020. These both advanced us toward our goal of net positive water use, resulting in 90% of fresh water usage returned or restored in 2020.

82% green power globally

In 2020, we significantly increased our renewable energy supply and purchases, from 71% to 82% globally, including 100% in the US, Europe, Israel, and Malaysia. Over the last five years, we've purchased more than 26 billion kWh of green power, enough to power more than 2.4 million US households for one year.[1]

5% total waste to landfill

During 2020, we sent approximately 5% of our total waste to landfill and continue to work toward our goal of zero total waste to landfill by 2030. At the end of 2020, circular economy practices were applied to 63% of our manufacturing waste streams via reuse, recovery, or recycling.

Source: https://www.intel.com/content/www/us/en/corporate-responsibility/corporate-responsibility.html

1. Based on average US household energy usage figures published by the US Energy Information Administration.

Operational Carbon

Embedded Carbon

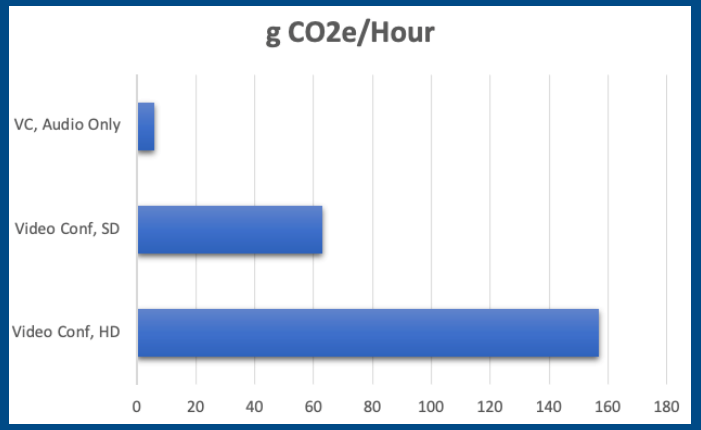
Measurement

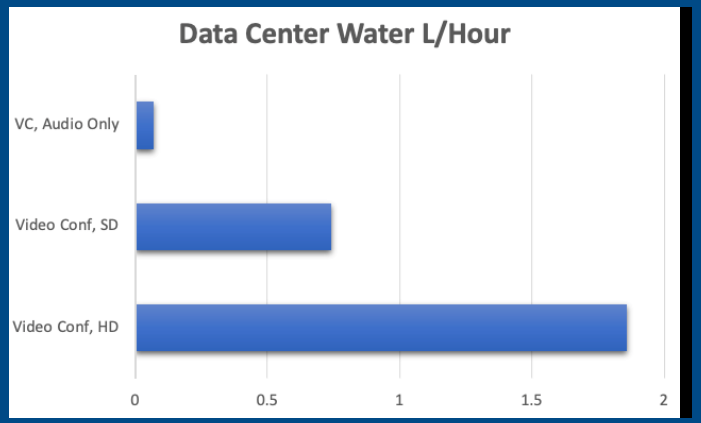
"It is all too easy to ignore the materiality and energy consumption of the Internet, as so much of our time spent using digital devices feels like it takes place in an abstract, incorporeal space." – Grant Faber

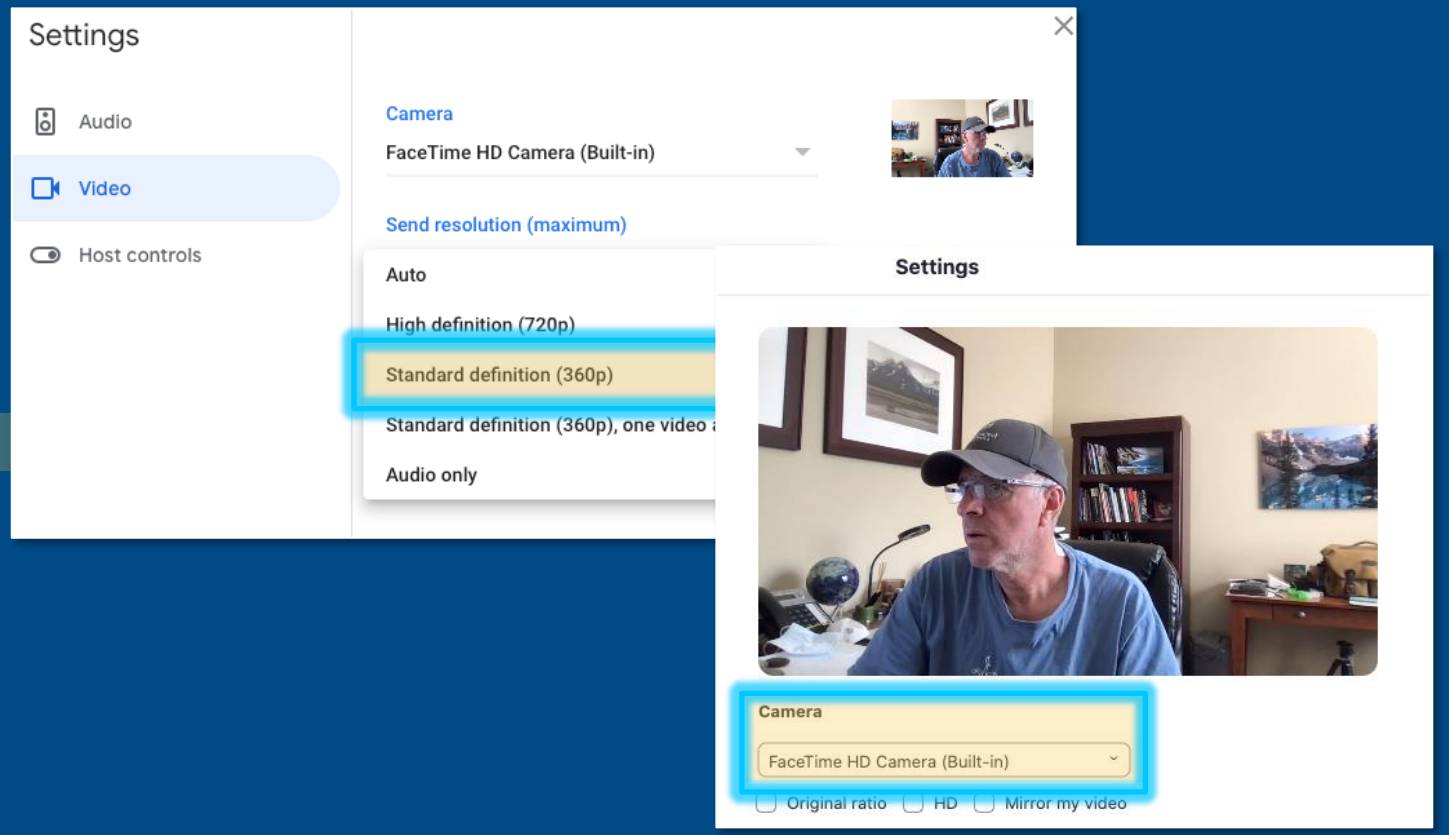
Source: https://www.anthropocenemagazine.org/2021/02/virtual-conferences-have-a-low-climate-impact-but-not-zero/

Videoconference Settings = Large differences in CO_2e

"If 1 million videoconference users were to make this change [turn off video], they would collectively reduce emissions by 9,023 t of CO_2e in one month, the equivalent emissions of powering a town of 36,000 people for one month via coal."







Source Data and Quote: https://www.energylivenews.com/2021/01/18/turn-the-camera-off-during-your-online-chats-to-drastically-cut-emissions/

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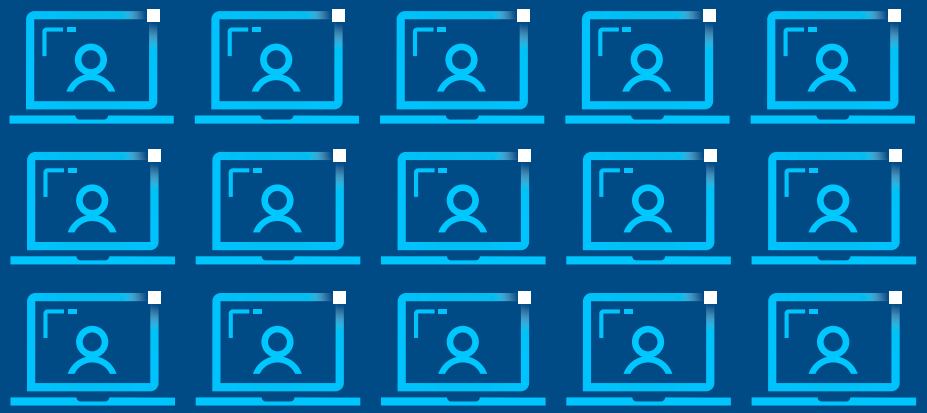


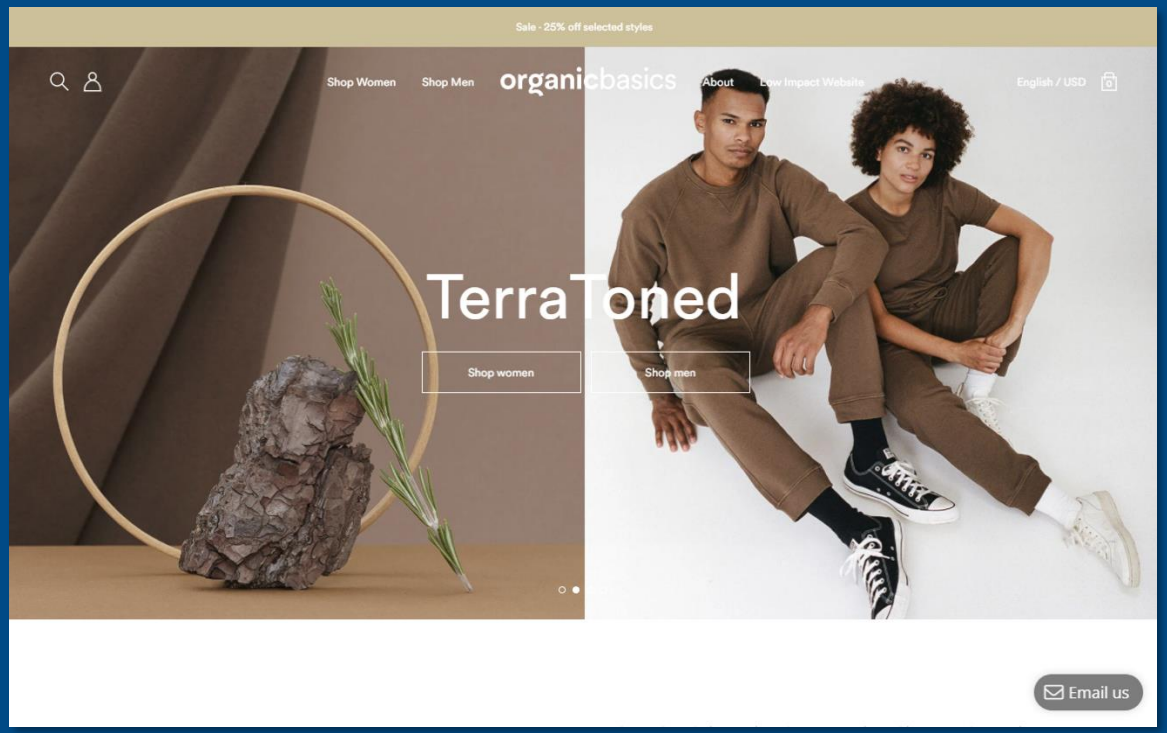
1 Million Videoconference Users With Video On

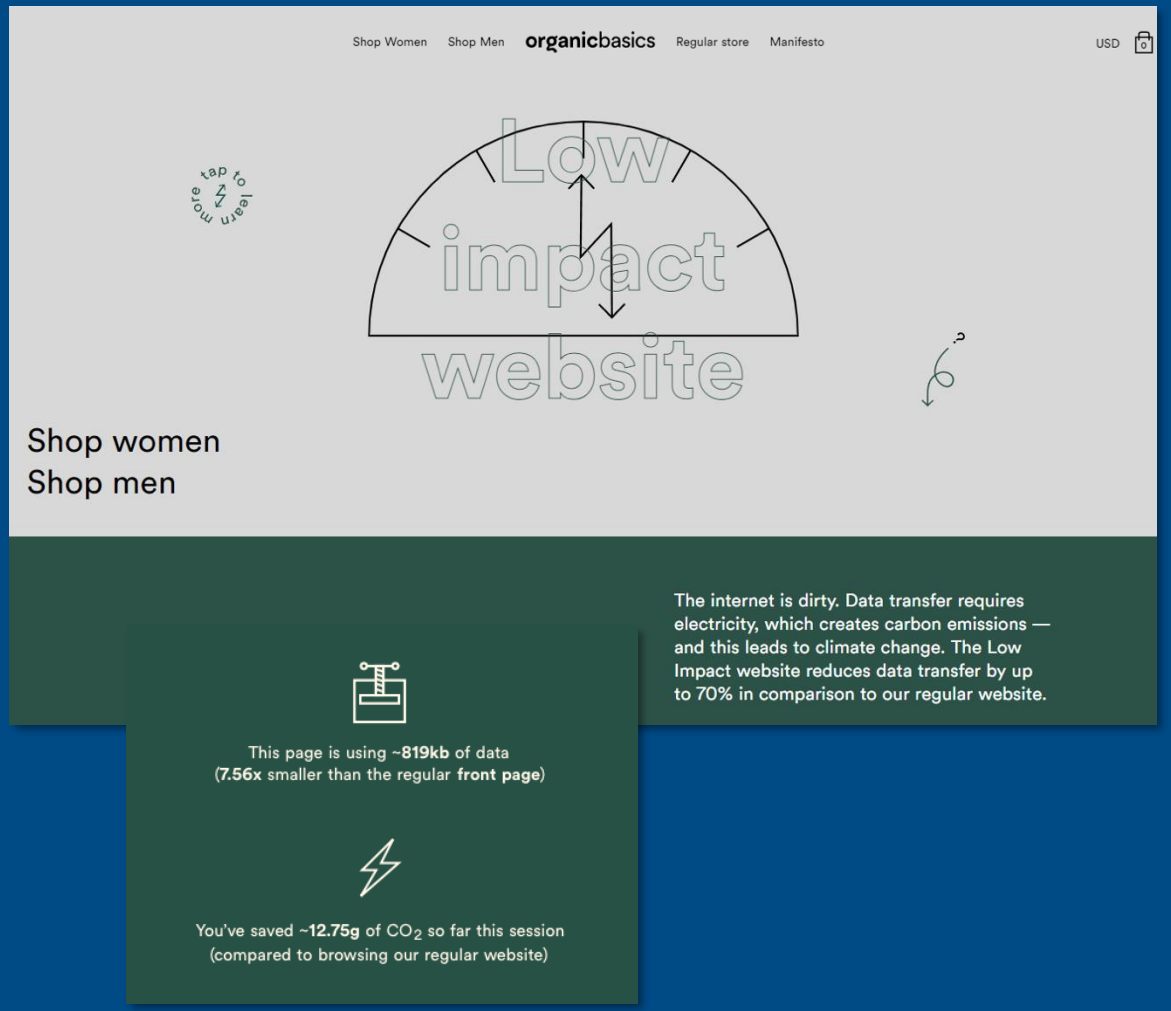
=

A Town of 36,000 People Powered by Coal

Source Data and Quote: https://www.energylivenews.com/2021/01/18/turn-the-camera-off-during-your-online-chats-to-drastically-cut-emissions/

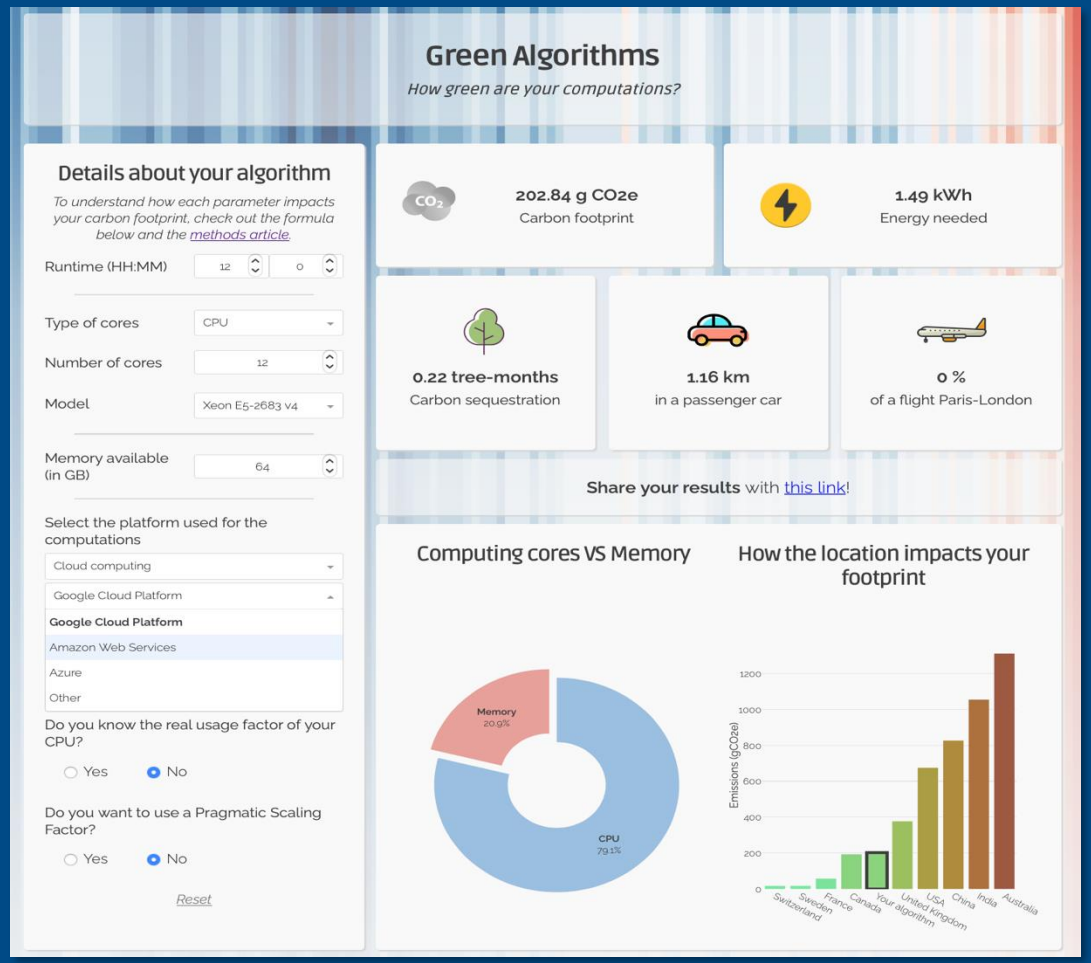
Isolated Signal or Emerging Trend?





Source: https://lowimpact.organicbasics.com/usd

Models Require Manual Input, Can Telemetry Reshape?



Source: http://www.green-algorithms.org

Full End-to-End Accounting: What Role for Telemetry?

Σ =

Cloud

Compute HW
- CPU, xPU
- Memory, Storage

Orchestration SW
- Provisioning
- uServices

Infrastructure
- Cooling (PUE)
- Heat Reuse (ERE)
- Regional Energy Profile

+

Connectivity

Data Volume

Distance

Speed

Regional Energy Profile

+

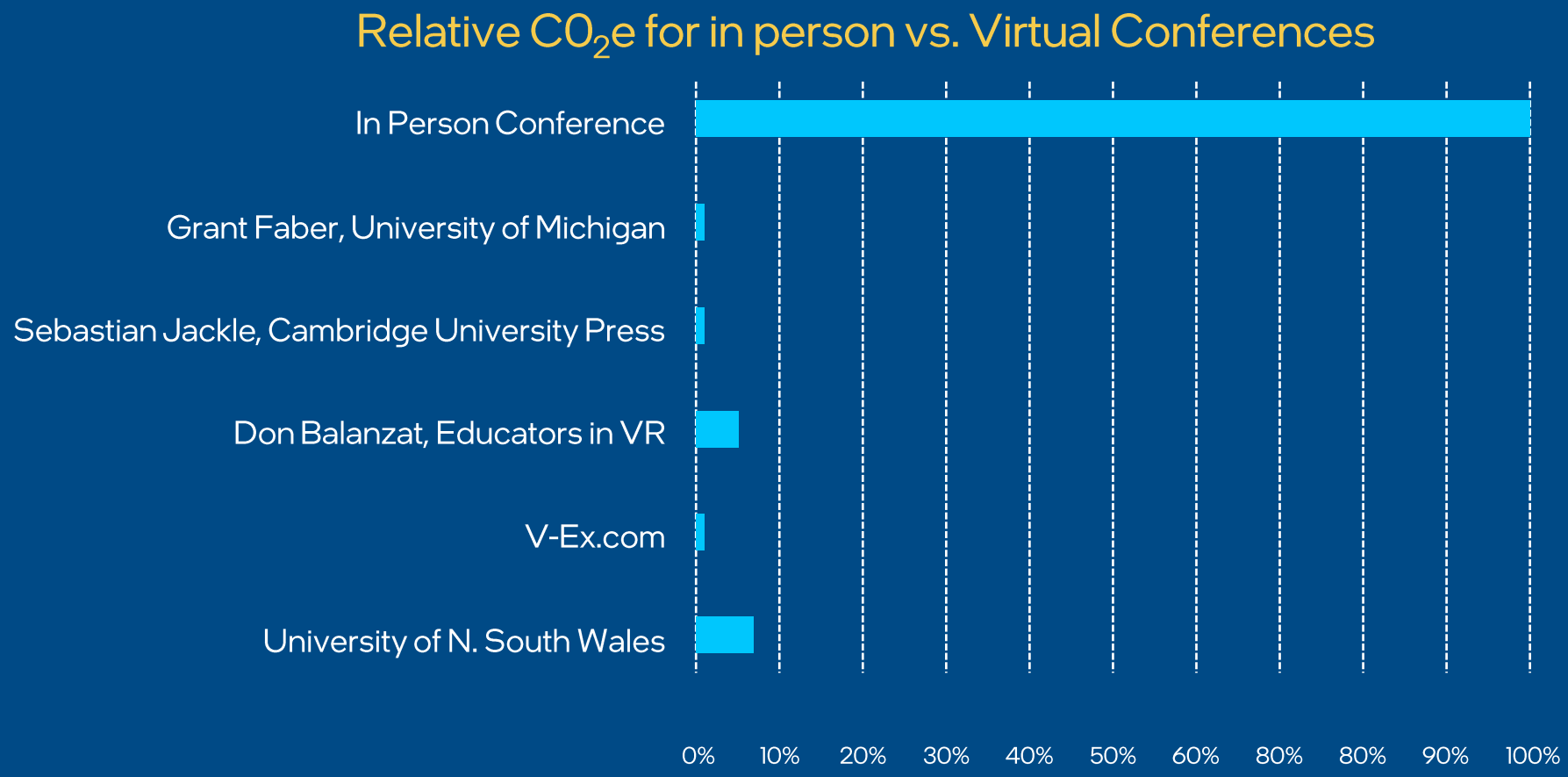
Devices, IoT, Cloud

Device Power Modes

Regional Energy Profile

Awareness, Education, Standards, Reporting

Yet Compute Can Offer a Positive Handprint Effect…



U of North S Wales
v-ex.com
Educators in VR
Cambridge University Press
Framework to estimate emissions from virtual conferences, Grant Faber


Re-connect Software with Efficiency
Implement Design Principles of Circularity
Offer End Users Consumption Visibility & Choices

Thank you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