

ACT: Architectural Carbon Modeling Tools

@ MICRO 2024
Tutorial



**CORNELL
TECH**

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Udit Gupta





Climate change is an existential threat to our society that requires immediate, collective actions across all communities and industries.

Computing incurs a growing environmental footprint

1.2-2.2 Billion tons of CO₂

- **On par with** the aviation industry's footprint
- **2.1 - 3.9%** of worldwide emissions (Freitag'21)



Mobile



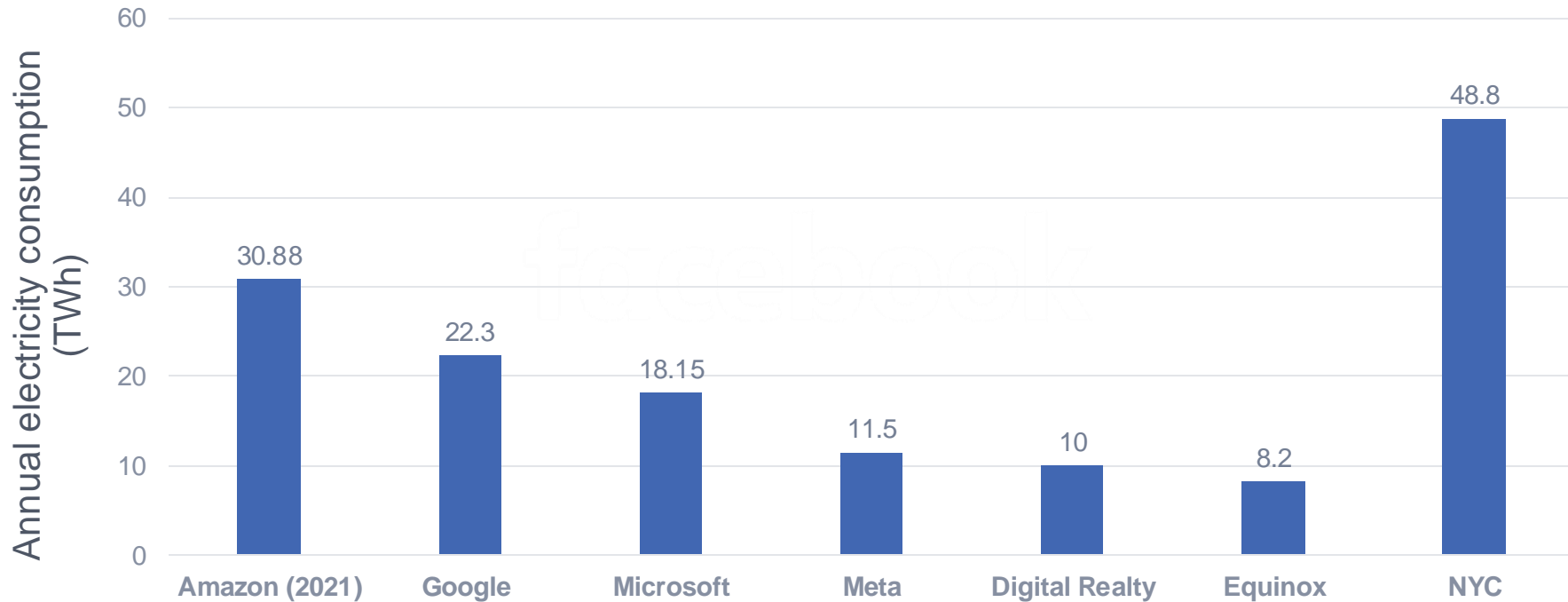
Communication



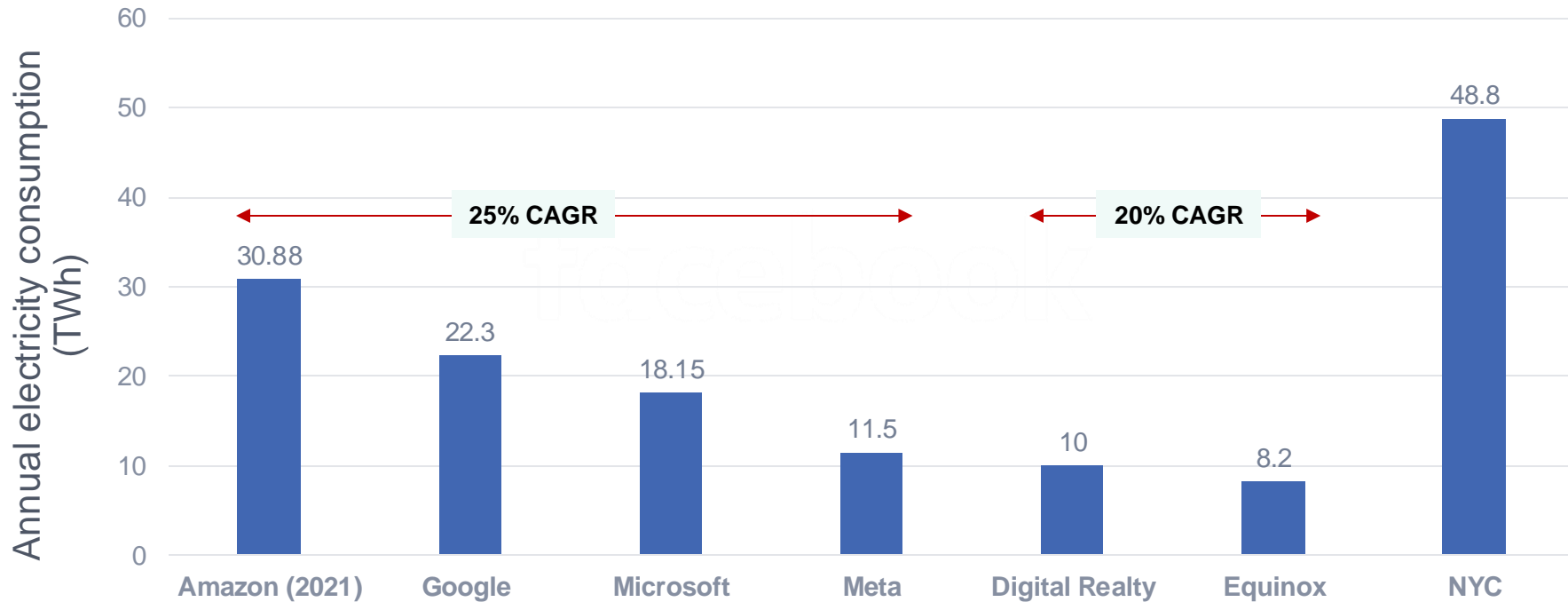
Data center

Computing's emissions are rising given its growing demand!

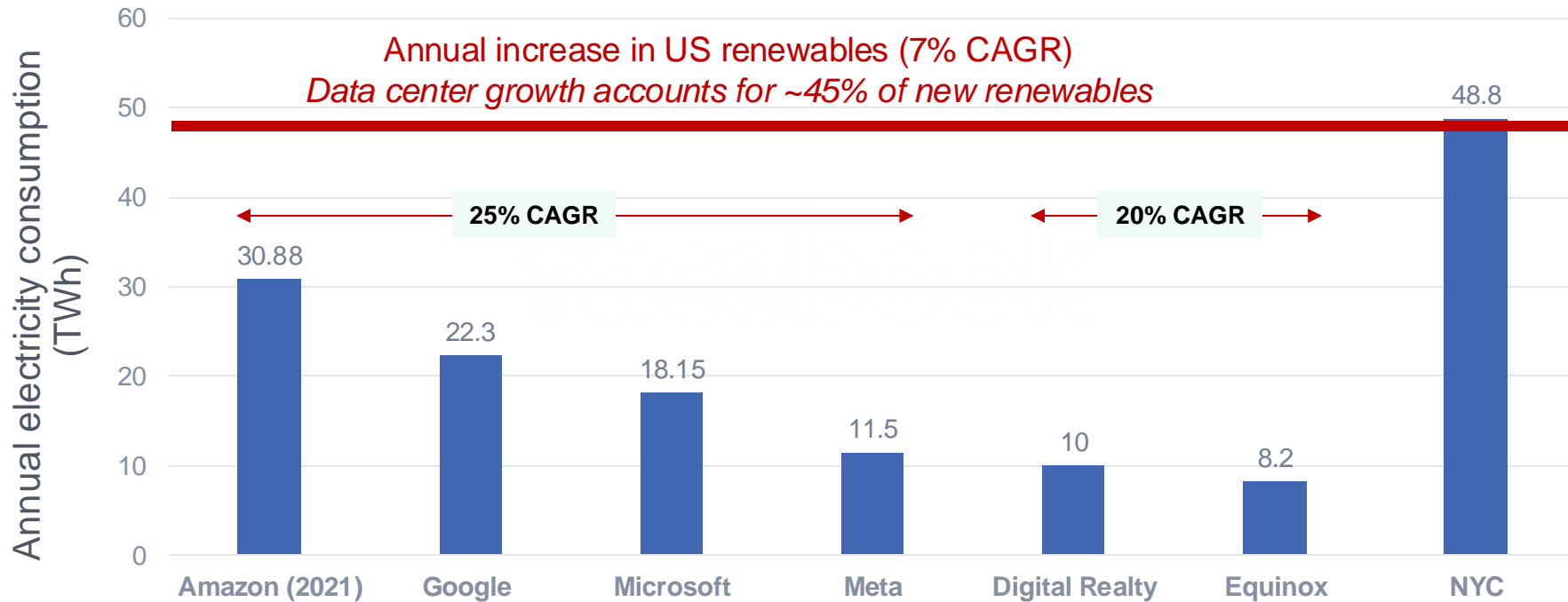
Growing rate of data center energy consumption



Growing rate of data center energy consumption



Growing rate of data center energy consumption



Tech. companies are pledging carbon neutrality



The Keyword

Latest stories

Product updates

Company news

A MESSAGE FROM OUR CEO

Our third decade of climate action: Realizing a carbon-free future



Microsoft | Official Microsoft Blog

Microsoft On the Issues

The AI Blog

Transform

Microsoft will be carbon negative by 2030

Jan 16, 2020 | [Brad Smith - President](#)

Sustainability in the Cloud

Amazon Web Services (AWS) is committed to running our business in the most environmentally friendly way possible and achieving 100% renewable energy usage for our global infrastructure.



FACEBOOK Sustainability

Innovation for our world

Collaboration for good

We are committed to reaching net zero emissions across our value chain in 2030.

In 2020 and beyond, Facebook's global operations will achieve net zero greenhouse gas emissions and be 100 percent supported by renewable energy.

PRESS RELEASE

July 21, 2020

Apple commits to be 100 percent carbon neutral for its supply chain and products by 2030

Green
ESG & Investing

Google Is No Longer Claiming to Be Carbon Neutral

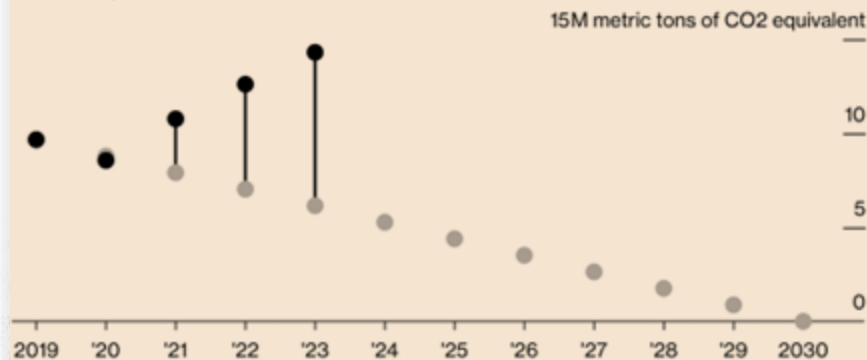
The tech giant, which has seen its planet-warming emissions rise because of artificial intelligence, has stopped buying cheap offsets behind the neutrality claim. The company now aims to reach net-zero carbon by 2030.



Google's Emissions

Artificial intelligence is putting the tech giant's climate goals in peril

● Climate plan (simulated) ● Actual



Source: Google (Scope 1, 2 and 3 data)

Note: Green dots represent linear decline to net-zero emissions goal.

company now aims to reach net-zero carbon emissions by 2030.

The Alphabet Inc. unit has claimed that it's been carbon neutral in its operations since 2007. The status was based on purchasing carbon offsets to match the volume of emissions that were

Interface Inc
14.67 ▲+1.24%

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The AI Race: Why It's So Expensive [Chip Arms Race](#) [Global Energy Strain](#) [DOJ Scrutiny](#) [How Chatbots Work](#)

Green
Cleaner Tech

Microsoft's AI Push Imperils Climate Goal as Carbon Emissions Jump 30%

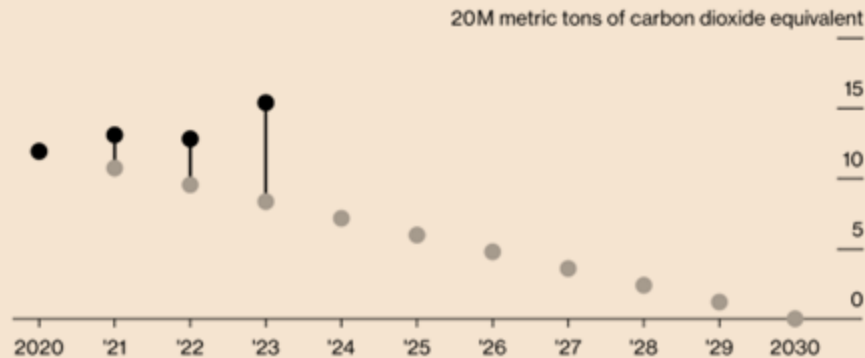
The company's goal to be carbon negative by 2030 is harder to reach, but President Brad Smith says the good AI can do for the world will outweigh its environmental impact.



Microsoft's Emissions

Artificial intelligence is putting the tech giant's climate goals in peril

● Climate plan (simulated) ● Actual



Source: Microsoft (Scope 1, 2 and 3 "management criteria" data)

Note: Green dots represent linear decline to carbon negative goal.

Follow

Amazon.com Inc
199.29 ▼-0.35%

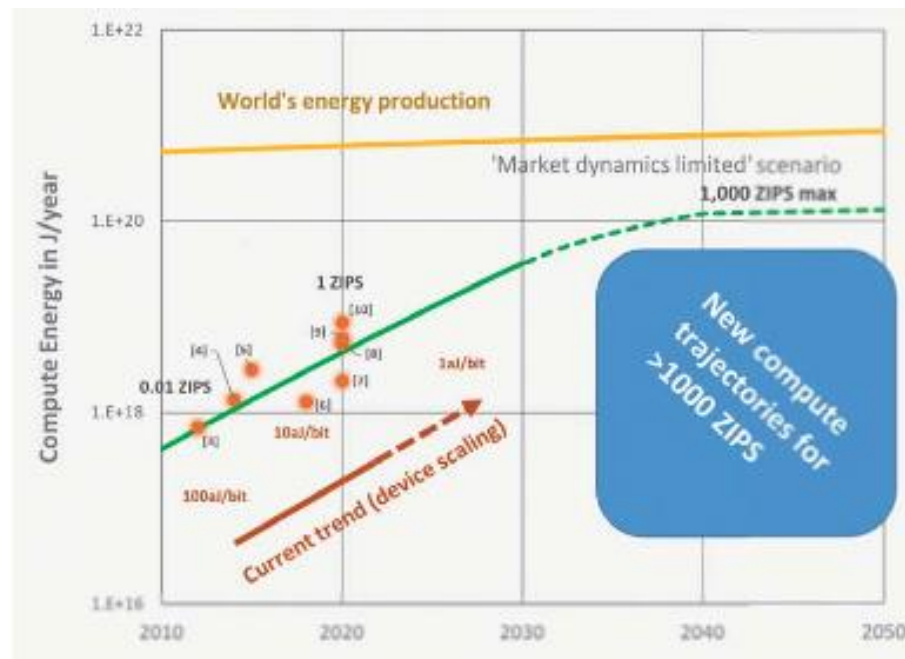
Follow

ambitious and comprehensive plans to tackle climate change. Now the software giant's relentless push to be the global leader in artificial intelligence is putting that goal in peril.

The Seattle-based company's total planet-warming impact is about

SRC decadal plan calls attention to ICT rising energy footprint

Ever-rising energy demand for computing vs. global energy production is creating new risk, and new computing paradigms offer opportunities to dramatically improve energy efficiency.



NSF Dear Colleague Letter on Sustainable Computing



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NSF 22-060

Dear Colleague Letter: Design for Sustainability in Computing

March 15, 2022

Dear Colleagues:

Environmental impacts of computing technologies extend well beyond their energy consumption and require a holistic focus on broader sustainability. Negative impacts of greenhouse gas emissions, depletion of rare earth elements, and e-waste are exacerbated by the proliferation of computing throughout society and treatment of computing systems as disposable commodities with planned obsolescence. Furthermore, environmental concerns range from the better-known carbon footprint from energy consumption (e.g., cloud) to equally important concerns of embodied carbon^[1], generation of methane, carcinogens, volatile organic compounds, and eutrophication, among others. Widespread use of compute intensive techniques (e.g., blockchain and artificial intelligence), handling and moving massive amounts of data, the rollout of next generation wireless/edge networks, and growth of smart devices amplifies the environmental concerns of this proliferation of computing. A new sustainable way of thinking about computing, across the full lifecycle -- including manufacturing, operation, and disposal -- is necessary to meet the needs of the present without compromising the wellbeing of future generations.

<https://www.nsf.gov/pubs/2022/nsf22060/nsf22060.jsp>

NSF Expeditions in Computing

Carbon Connect: An Ecosystem for Sustainable Computing

U.S. National Science Foundation Expedition in Computing



Rethinking computing infrastructure,
from semiconductors to datacenters,



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NSF Expeditions in Computing for
Computational Decarbonization
of Societal Infrastructures at
Mesoscales (NSF CoDec)

[Learn More](#)

ACT Tutorial Motivation and Goals

Provide the necessary background and tools to enable researchers to incorporate sustainable as a first order design target

- Provide a brief overview of the sustainability implications of modern systems,
- Detail the ACT methodology,
- Demonstrate how to use ACT,
- Demonstrate how to extend ACT

ACT Tutorial: Today



Time	Topic
1:00 – 1:15pm	Welcome to the ACT tutorial!
1:15 – 1:30pm	Motivation: Understanding the source of computing's emissions
1:30 – 2:15pm	Overview of ACT: An Architectural Carbon Modeling Tool
2:15 – 2:45pm	Hands-on ACT demo's
2:45 – 3:00pm	Extending ACT
3:00 – 3:30pm	Coffee break

ACT Tutorial: Today

Time	Topic	
3:00 – 3:30pm	Coffee break	
3:30 – 4:30pm	Designing Cloud Servers for Lower Carbon	Jaylen Wang (Carnegie Melon University)
	Extending ACT to evaluate HI and FPGA for Sustainable Computing	Chetan Choppal (Arizona State University)
	Carbon-Efficient Optimization for Computing Systems	Mariam Elgamal (Harvard University)
	Silicon-Photonics for Sustainable AI	Farbin Fayza (Boston University)
	Energy-/Carbon- Aware Evaluation of 3D IC Architectures with DCIM	Hyung Joon Byun (Cornell Tech)
Group discussion		

Sign up!



ACT Tutorial Feedback and Updates Signup

Thank you for joining us for the ACT Tutorial! We value your feedback and would love to stay connected. Please share your thoughts, contact details, and let us know which updates on our sustainability efforts you'd like to receive.

alugupta@gmail.com [Switch account](#)



* Indicates required question

Email *

☐ Record alugupta@gmail.com as the email to be included with my response

Name *

Your answer

Affiliation *

Your answer

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