ACT: **A**rchitectural **C**arbon Modeling **T**ools

@ MICRO 2022
Tutorial

Meta

CORNELL TECH

Udit Gupta


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

Over the last 20 years, hardware and software advancements have drastically optimized for performance and energy efficiency

Pre-2000:
"Dennard Scaling"

10x energy efficiency every 5 years

2000-2010:
"Dennard's Hangover"

10x energy efficiency over *decade*

2010-2020:
"Beyond Dennard"

Peak CPU Efficiency: Still 10x over decade

- Specialization: ~10x for key workloads
- Idle power optimization: ~10x for "typical" usage
- PUE optimization: ~1.5x-2x for datacenters

Koomey et. al., 2011
Naffziger and Koomey, 2016

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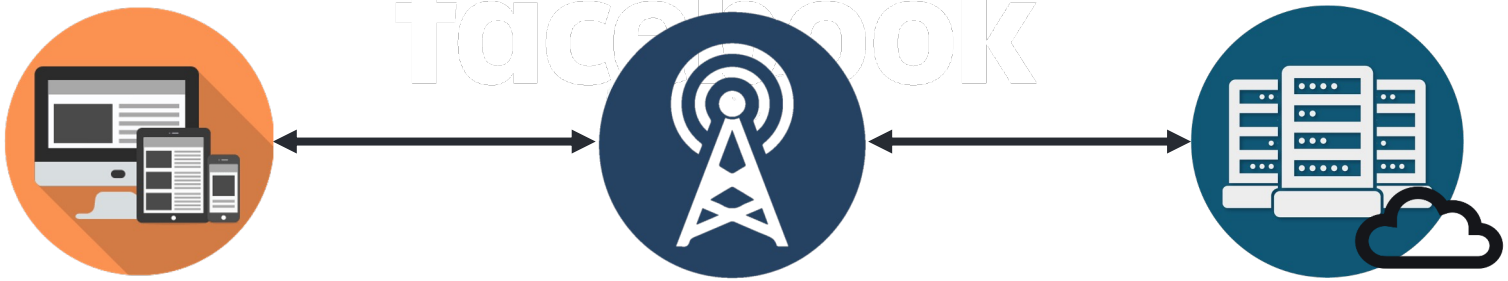
But how have these advances affected computing's environmental sustainability (e.g., carbon footprint)?

Computing incurs a growing environmental footprint

1.2-2.2 Billion tons of CO_2

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



Computing's emissions are rising given its growing demand!

Big Tech. companies are pledging carbon neutrality

Google The Keyword Latest stories Product updates Company news

A MESSAGE FROM OUR CEO

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

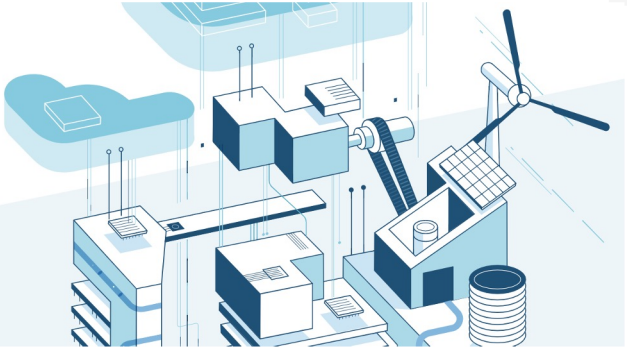
Microsoft | Official Microsoft Blog Microsoft On the Issues The AI Blog Transform

Microsoft will be carbon negative by 2030

Jan 16, 2020 | Brad Smith - President

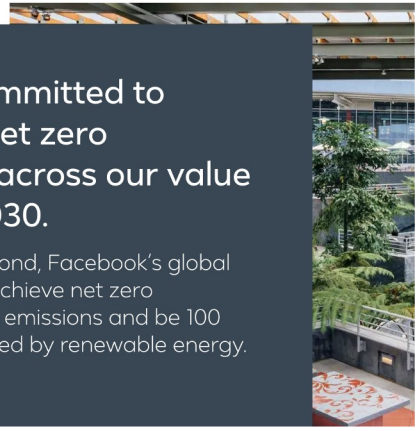
Sustainability in the Cloud

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.

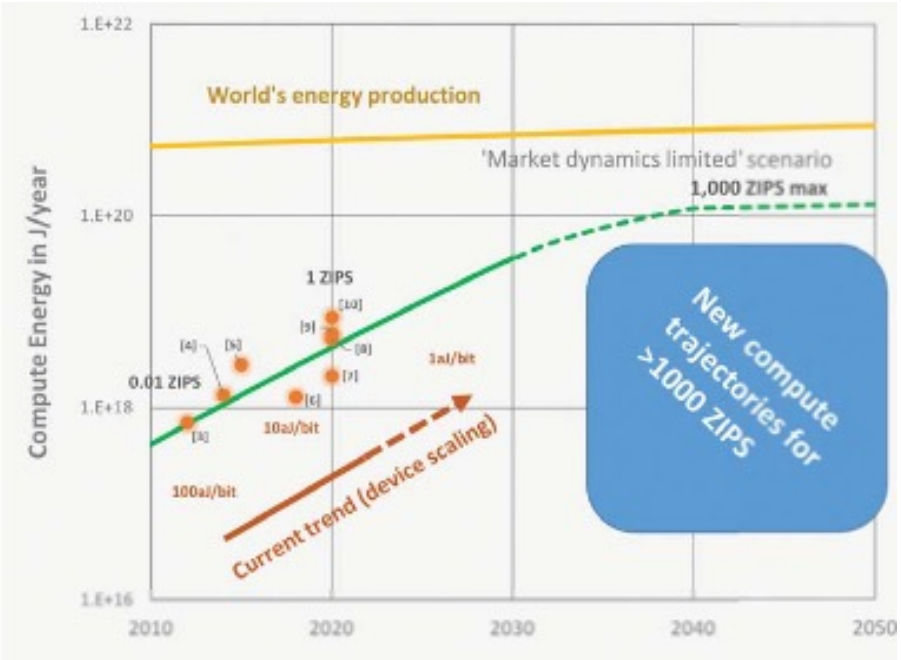
In 2020 and beyond, Facebook's global operations will achieve net zero greenhouse gas emissions and be 100 percent supported by renewable energy.

PRESS RELEASE
July 21, 2020

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

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

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

Sing up on our Google form!

https://forms.gle/hEAju2suaeEnisRQA

ACT MICRO 2022 tutorial registration form

Developing modular, extensible, and commensurate architectural carbon modeling tools will require community-wide efforts. We hope ACT will help jumpstart such efforts.

If you are attending the inaugural ACT tutorial at MICRO 2022 or interested in being part of the community please register below.

ACT Tutorial: Today

Time	Topic
1:00 – 1:15pm	**Introductory remarks**
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 –2:30pm	*Coffee Break*
2:30 – 3:00pm	Hands-on ACT demo's
3:00 – 3:15pm	Extending ACT
3:15 – 3:45pm	*Office Hours*
3:45 – 4:00pm	Closing remarks