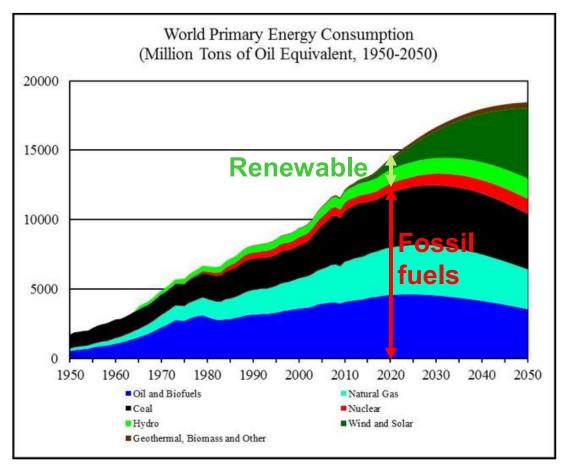


Energy Efficiency Across Electronics Platform

Godwin Maben, Synopsys Fellow

September 14^{th, 2022}

Global Energy Consumption Continues to Rise



https://seekingalpha.com/article/4083393-world-energy-2017minus-2050-annual-report

7X increase in energy consumption since 1950 (70 yrs.)

80% energy from fossil fuels in 2020



Electronics Plays a Big Part in Energy Consumption

ENERGY FORECAST 20.9% of projected electricity demand Widely cited forecasts suggest that the total electricity demand of information and communications technology (ICT) will accelerate in the 2020s, and that data centres will take a larger slice. Networks (wireless and wired) Production of ICT Consumer devices (televisions, computers, mobile phones) Data centres 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030

9,000 8,000 7,933 7,000 6,000 5,000 Data Centers Best 4,000 Data Centers Expected ---- Data Centers Worst 3,000 2,000 1,000 2010 2014 2024 2026 2028 Yea TWh = Trillion Watts 1 TWh \rightarrow 200K homes continuously powered

Electricity usage (TWh) of Data Centers 2010-2030

Source: How to stop data centres from gobbling up the world's electricity (nature.com)

9,000 terawatt hours (TWh)

AI Chips vs. Human Brain – Much Scope for Power Reduction



Hardware	Year	Total Power
IBM Deep Blue	1997	15 KW
IBM Watson	2011	200 KW
Google AlphaGo	2016	300 KW
IBM Summit Super Computer	2018	13 MW

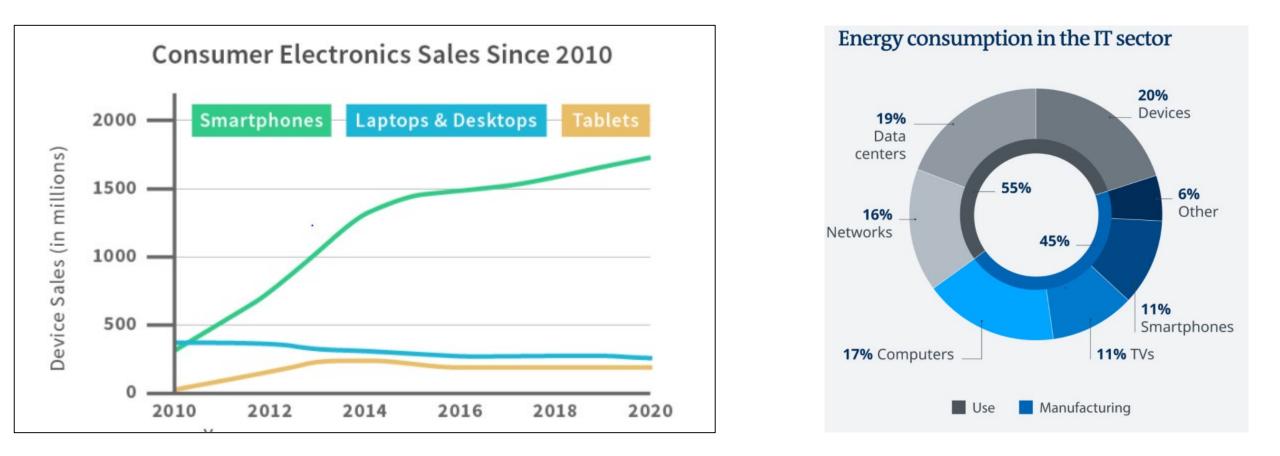
Human Brain



Average Power : 20W

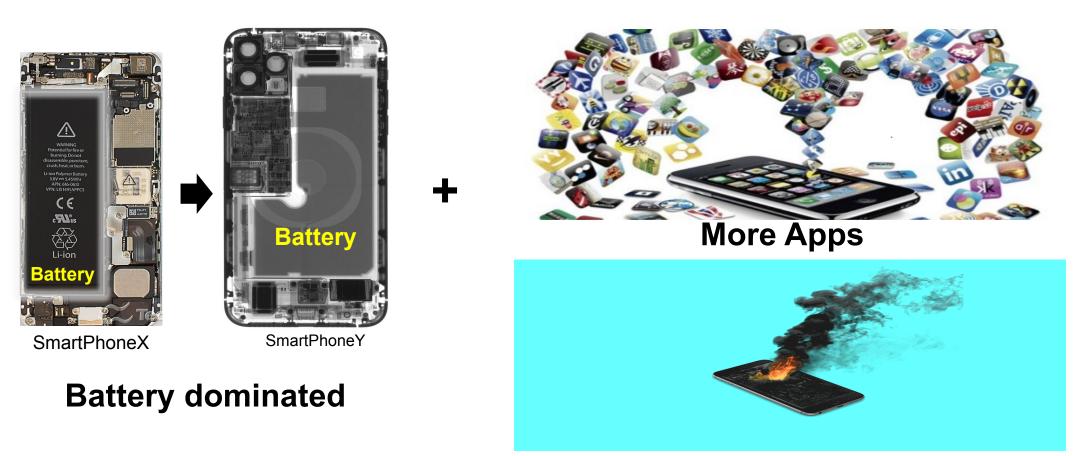
Average Memory: 1.25 TB Average Processing Power: 100 Teraflops Average Frequency: 250-2,000 Hz **10K-100K** times more power efficient!

Mobile Devices are Pervasive



More than 1.5 Billion Smartphones sold annually

Energy Efficiency Key in Mobile Electronics and Mobile Computing



It is all about maximizing battery life – every nanowatt counts!!!

Global Impact on Energy Consumption from Mobile Devices

Power Efficiency Benchmark					
×	Mfc. Process	FPS	Avg. Power (W)	Perf/W Efficiency	
Phone1	7FFP	26.14	3.83	6.82 fps/W	
Phone2	7FFP	34.00	6.21	5.47 fps/W	
Phone3	7FF .	19.32	3.81	5.07 fps/W	
Phone4	7FF	26.59	5.56	4.78 fps/W	
Phone5	7FF	16.17	4.69	3.44 fps/W	
Phone6	8LPP	15.59	4.80	3.24 fps/W	



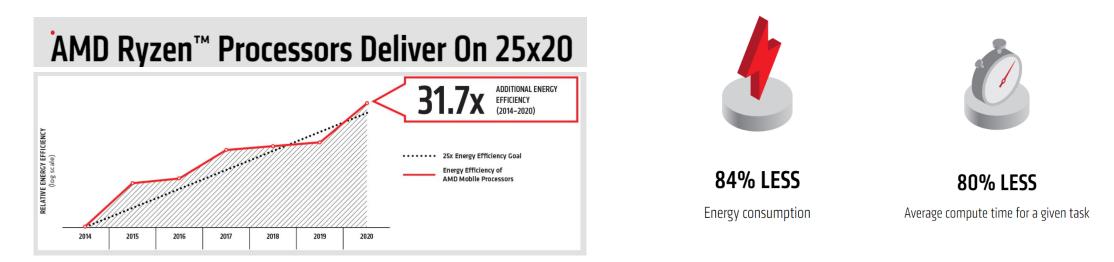
The Impact of Energy Efficiency 4.5% reduction **Power Efficiency Benchmark** Power Efficiency Benchmark Perf/W Avg. Power Mfc. Process Avg. Power Perf/W Efficiency Mfc. Process Efficiency Energy Efficient Phone1 7FFP 289.03 4.78 60.46 fps/W Phone1 7FFP 26.14 3.83 6.82 fps/W 7FFP 328.90 5.93 55.46 fps/W Phone2 6.21 Measures Phone2 7FFP 5.47 fps/W 34.00 7FF 197.80 50.07 fps/W 3.95 Phone3 Phone3 7FF 3.81 5.07 fps/W 19.32 7FF 271.86 6.10 44.56 fps/W Phone4 Phone4 7FF 5.56 26.59 4.78 fps/W 7FF 167.16 4.10 40.70 fps/W Phone5 Phone5 7FF 4.69 3.44 fps/W 16.17 10LPP 150.40 4.42 34.00 fps/W Phone6 Phone6 8LPP 15.59 4.80 3.24 fps/W 8LPP 166.00 4.96 33.40fps/W 5.93W 93W 93W 8895MW **18 Power Plants**



i.e. 1 fewer!!!

Example: AMD 25x20 Energy Efficiency Initiative

Goal: 25X reduction in energy efficiency by 2020

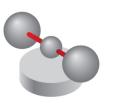


An enterprise that upgrades 50,000 AMD laptops from 2014 models to 2020 models would save



1.4 MILLION

Kilowatt hours



1 MILLION

Kilograms of carbon dioxide equivalent

emissions



EQUAL TO 16,000

Tree seedlings grown for 10 years

Artificial Intelligence/Machine Learning Energy Explosion

7 important benefits of AI for business

- 1. Efficiency and productivity gains
- 2. Improved speed of business
- New capabilities and business model expansion
- 4. Better customer service
- 5. Improved monitoring
- 6. Better quality and reduction of human error
- 7. Better talent management

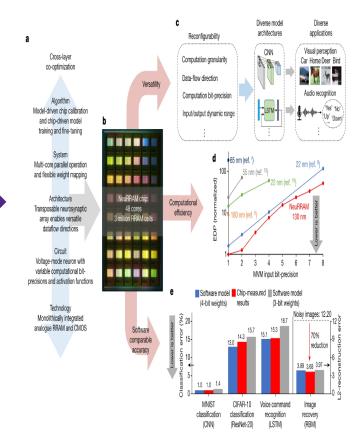


Common carbon footprint benchmarks

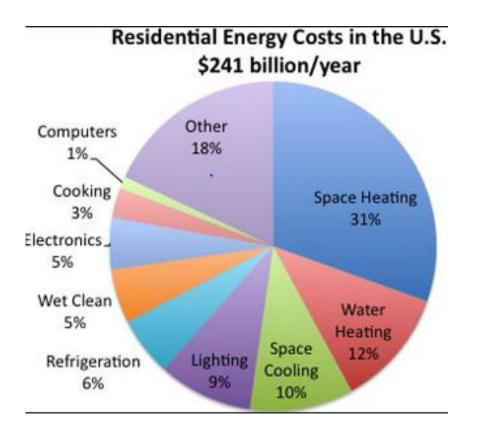
in lbs of CO2 equivalent

Roundtrip flight b/w NY and SF (1 1,984 passenger) 11,023 Human life (avg. 1 year) American life (avg. 1 year) 36,156 US car including fuel (avg. 1 lifetime) 126,000 Transformer (213M parameters) w/ neural 626,155 architecture search Carbon Date of footprint Energy Cloud compute cost original consumption (lbs of (kWh) C02e) (USD) paper Transformer (65M Jun. 2017 27 26 \$41-\$140 parameters) Transformer (213M Jun, 2017 201 192 \$289-\$981 parameters ELMo Feb. 2018 275 262 \$433-\$1,472 BERT (110M Oct. 2018 \$3,751-\$12,571 1.507 1.438 parameters Transformer (213M parameters Jan. 2019 656.347 626.155 \$942,973-\$3,201,722 w/ neural architecture search GPT-2 Feb, 2019 \$12,902-\$43,008

From: A compute-in-memory chip based on resistive random-access memory



Home Electronics Energy Usage Keeps Growing





Energy Efficient Critical Ideas



Design of footwear



SolarGaps – Energy Generating Smart Solar Blinds





Solar Powered Window Socket



PowerShare: Power Transfer Interactions for Mobile Devices



Solar Roadways



Thank You