



A NEW DAY, A NEW WAY

A Linear Approach to an Exponential Curve *is an Accident Waiting to Happen*

Michael Knight | SVP TTI Inc and President Exponential Technology Group





THE "SHIFT" HAS HIT
THE SUPPLY CHAIN!



Electronic Supply Chain Companies Are Thriving

The market cap for the publicly traded electronic component supply chain companies grew **\$891 billion** to **\$2.8 trillion** in 2020, a **+48%** increase in value during the first year of a global pandemic; combined market cap increased another **\$213 billion** in 2021



	2019	2020	2021
SALES	\$438B	\$478B	\$558B
		+9.2%	+16.7%



Semiconductors Are World's Fourth Most Traded Product

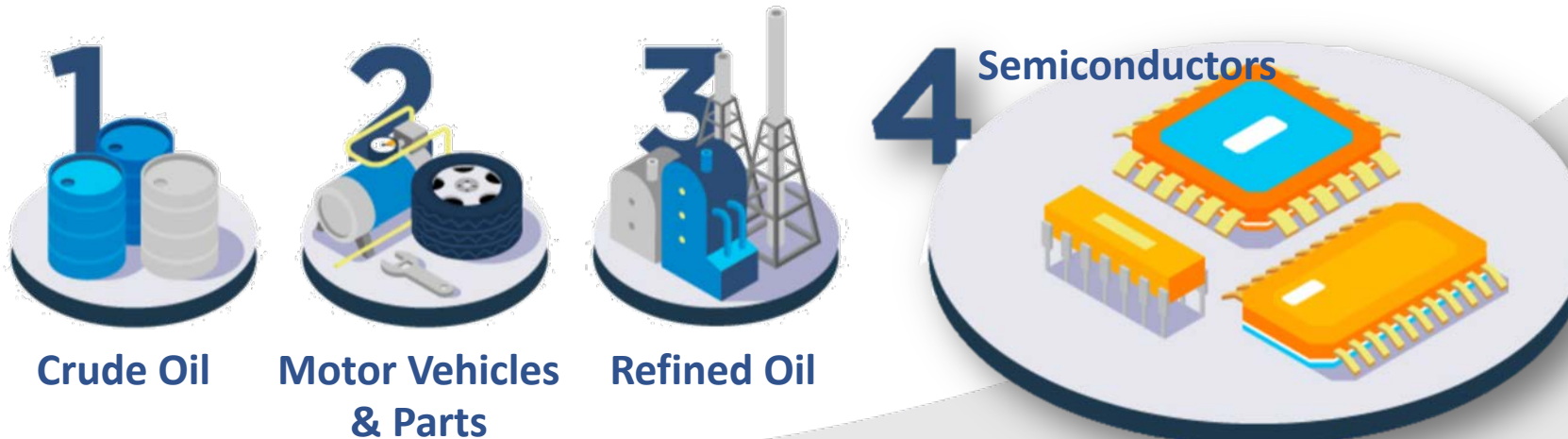
22.5 % of the global gdp is made up by the digital economy

Source: Accenture Research & Oxford Economics

2022 Global Semiconductor Market Forecasts



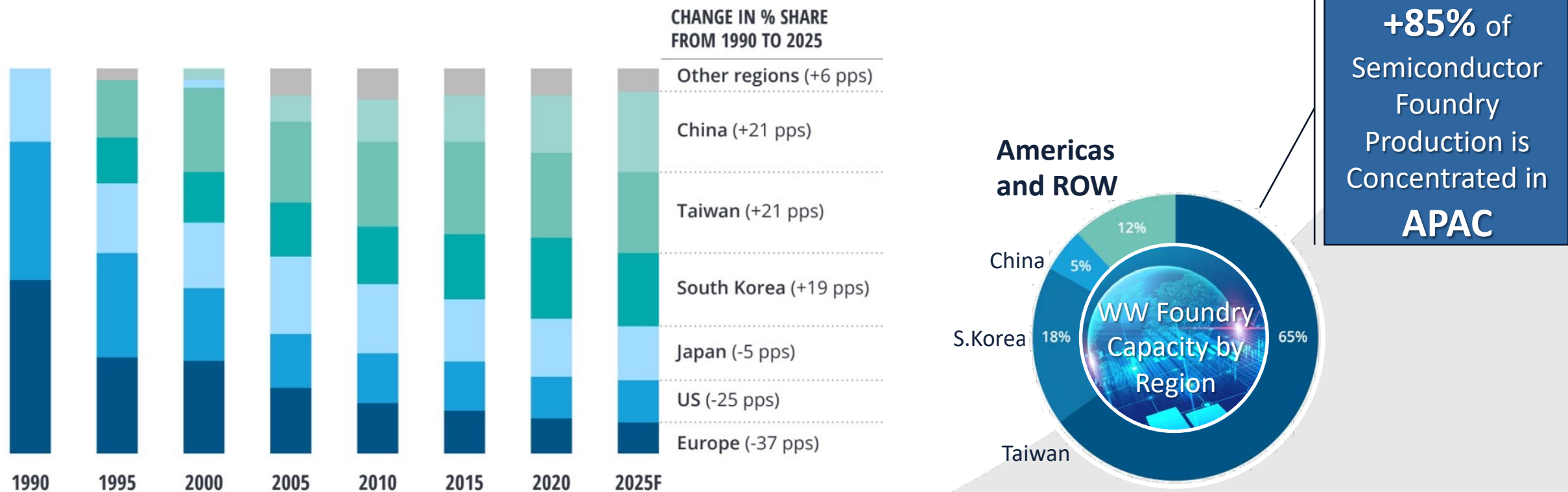
Per SIA, 2021 sales grew 26%.... \$440B to \$556B



PREDICTION: By the end of this decade, semiconductors will be the world's **first** most traded product



Global Semi Capacity by Region | 1990 - 2025



In ten years, Asia went from a third of global capacity to a half, and by 2025 it will be two thirds



What's Driving the Semiconductor Industry?

101010101 **digitization & data generation** 10101010



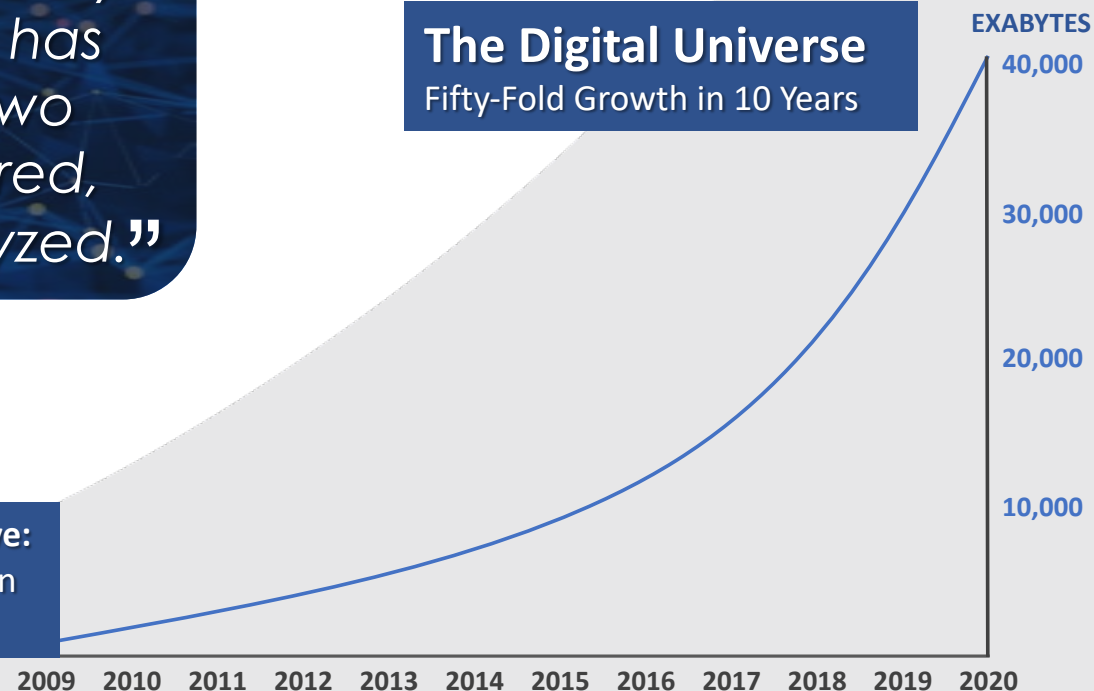
Lip-Bu Tan | CEO Cadence

“ More than 25 million terabytes of data are being created every day and 90% of all data in history has been generated in the last two years; 80% of that is unstructured, and less than 2% is being analyzed.”

The Digital Universe

Fifty-Fold Growth in 10 Years

an exponential growth curve:
initially feels linear but then
shoots upward (i.e. 2017)

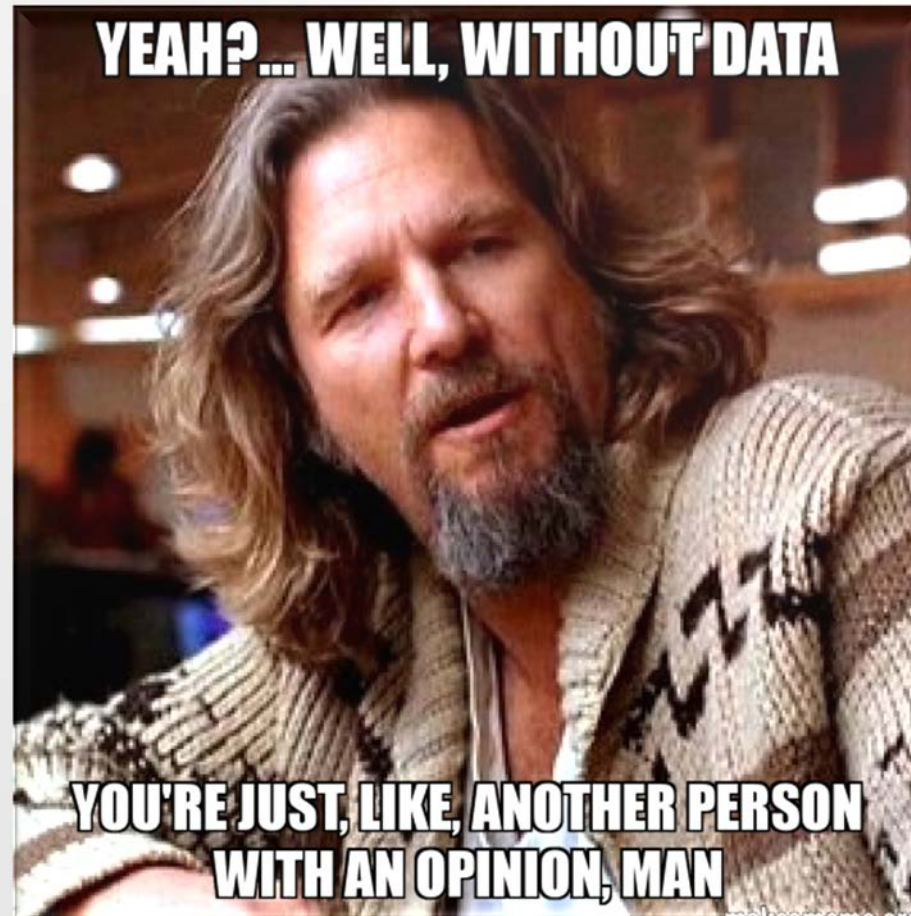


Source: IDC's Digital Universe Study



What's Driving the Semiconductor Industry?

101010101 **digitization & data generation** 10101010





Semiconductor Supply Chain Outlook

ASML, the only producer of the industry's most advanced lithography equipment, is **fully booked** through the start of 2023



"I would not think of this as a peak," said ASML Chief Executive Peter Wennink on a recent earnings call. *"Sales could climb through 2025,"* he said.

\$146B | Global chip maker cap ex spending in 2021 was 1/3rd higher than 2020, 50% higher than 2019, and more than double the industry average five years ago. Source: Gartner

-6.7% | Global smartphone production decline as a result of chip shortages. Source: IDC

+\$15B | Construction costs of semiconductor fabs have increased about 13% a year. Source: Azeem Azhar

\$100B | TSMC has an ambitious capacity expansion plan for the next three years, but the chairman of the world's top pure-play foundry says the investments are planned in line with customers' demand.

+11.6%/year | Total foundry sales will break \$100B this year and grow to \$151B by 2025. Source: Longbow Research

<1\$ of every \$6 | in cap-ex spending is earmarked for "legacy" chips where greatest backlogs are. TSMC, Samsung and Intel account for 3/5ths of all 2021 investment and almost all of it is going into leading edge process technology. Source: Gartner

Key Supplier of Wafers for Chips Has Sold Out Through 2026: Sumco expects supply-demand imbalance to last five years and sees little room for factory expansion. Source: Bloomberg 2/22



Semiconductor Supply Chain Outlook

The imbalance between semiconductor supply and demand will be an electronics supply chain gating item well into 2023



*“Right now, **every single end market for semiconductors is up simultaneously;***

I’ve been in this industry 27 years, I’ve never

seen that happen,” Marvell Technology’s CEO Matt Murphy said at a recent CNBC event. *“If it stays business as usual, and*

*everything’s up and to the right, **this is going to be a very***

painful period, including in 2022 for the duration of the year.”

Crisis Mode

The auto industry may lose \$61 billion of 2021 sales from chip shortages



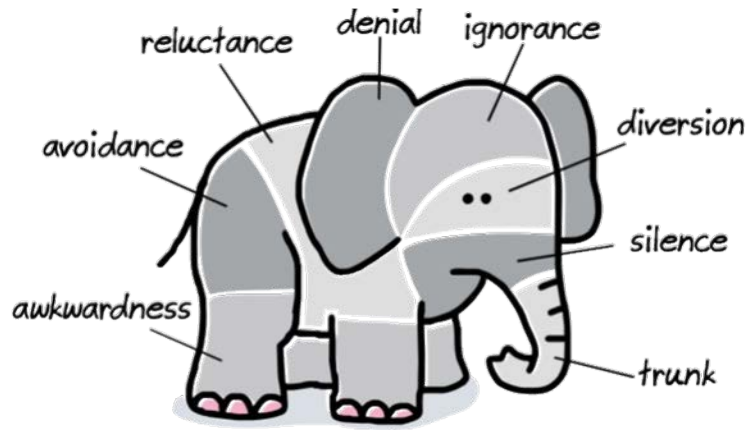
Source: AlixPartners. Estimates based on current rate of volume losses.

Bloomberg



Semiconductor Supply Chain Outlook

The Elephant in the Room



“Despite the change in administrations, Trump-era tariffs remain in place. American importers have paid more than \$106B to cover the cost of those levies to date, and they are now facing skyrocketing shipping costs,” CNN reports.



“It’s going to get worse before it gets better,” SEKO Logistics’ Chief Growth Officer Brian Bourke told The Washington Post. “Global supply chains are not built for this. Everything is breaking down.”

SUPPLY CHAIN
DISRUPTORS

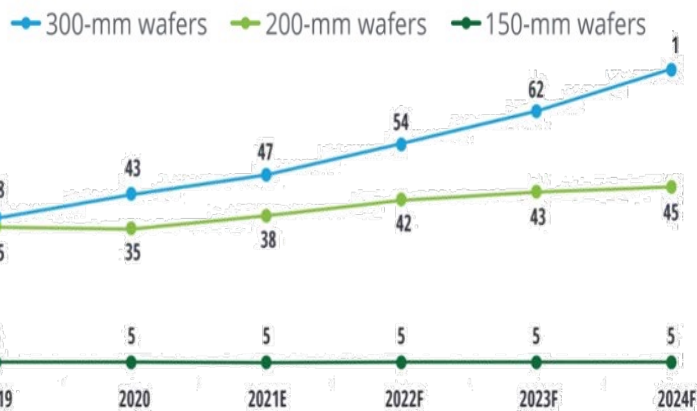
CLIMATE
POLITICS
SHIPPING
PANDEMIC
TRADE WARS
RAW MATERIALS
LABOR SCARCITY
GROWING DEMAND



Semiconductor Supply Chain Outlook

The gap in financial rewards between the two worlds of chip production, newer and older, is stark. A **5-nanometer wafer for advanced chips sells for about \$17,000** as of this year, according to Bain & Co. That price compares with roughly **\$3,000 for a 28-nanometer wafer** for “legacy” semis that perform simpler functions such as connecting devices to Wi-Fi networks. Source: Wall Street Journal

WW Wafer Capacity by Size



Based on millions of 8" equivalent wafers

“Going forward, the restrained bets on the hardest-hit types of semiconductors mean that the world’s legacy chip supply won’t catch up with projected demand through 2024,” Counterpoint Research estimates.

In June, the U.S. Senate approved **\$52B** in funding to support chip research and production, but just **\$2B** was earmarked for legacy chips.

Source: Deloitte analysis of public companies



Semiconductor Manufacturing Incentives by Country

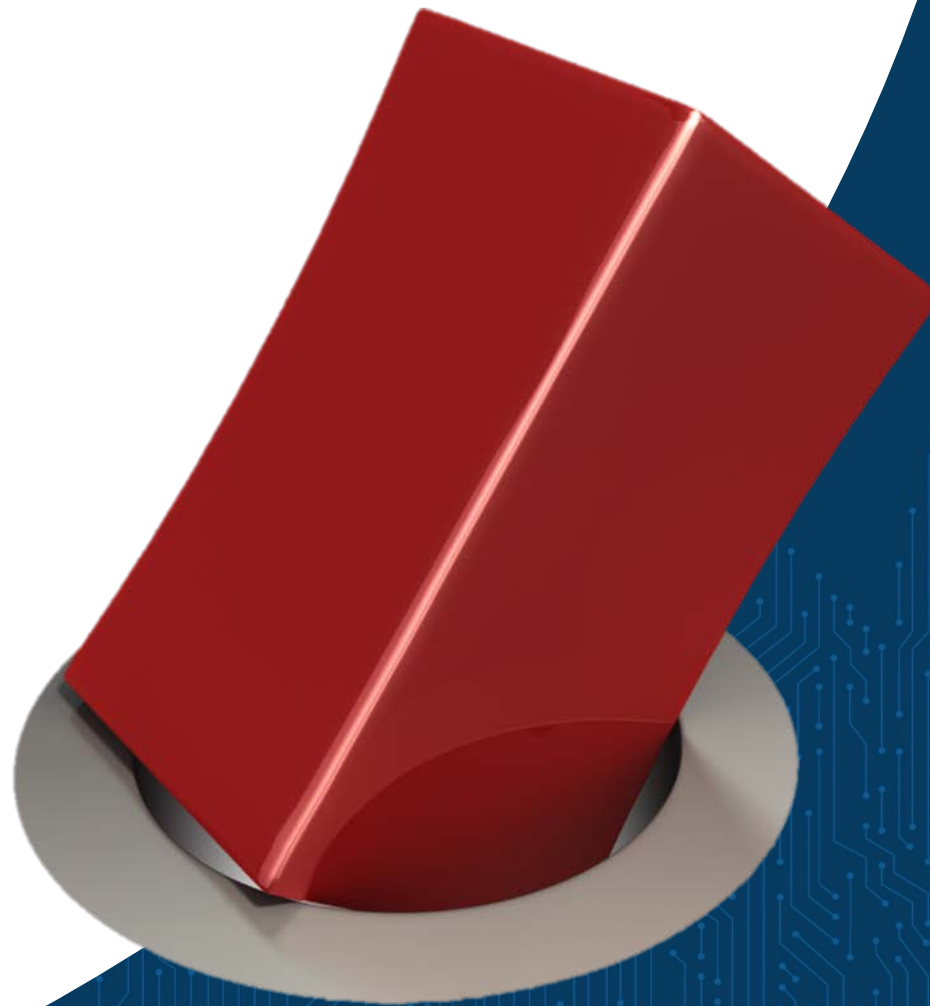
	CHINA	S.KOREA	SINGAPORE	JAPAN	TAIWAN	EUROPE	ISRAEL	U.S.
Share of 300mm manufacturing capacity (2019)	12%	26.7%	6.5%	16.3%	22.9%	2.8%	0.8%	12%
Manufacturing Grants & Subsidies (**2000-2020)	~\$50B	\$7-10B+	\$5B+	\$5-7B+	\$0.5B+	\$2.5B+	\$2.5B+	\$0
Federal Tax Incentives (***2000-2020)	5-yr tax holiday Reduced tax rate Tax credits VAT refunds	5-yr tax holiday Reduced tax rate Tax credits	Reduced tax rate (0-13%)	Tax credits	5-yr tax holiday Tax credits	Tax credits	Reduced tax rate (6-12%) Tax credits	None
Other Federal Manufacturing Incentives	Free/discounted land Infrastructure support Equipment leasing Preferential loans Localization policies	Infrastructure support Equipment incentives Workforce training	Equipment Incentives Hiring Credits	Preferential loans	Free/discounted land Infrastructure support Preferential loans Workforce training Hiring credits	Preferential loans	Free or discounted land	None
CAGR of 300mm Capacity (2013-2020)	15.7%	11.3%	10%	7.4%	6.5%	*	*	2.2%

* Incentives have been focused on maintaining capacity | ** Estimates based on SIA analysis | *** Industry specific tax increases | Sources: IC Insights, SIA, OECD (2019)



**TRADITIONAL SOLUTIONS TO
SUPPLY CHAIN DISRUPTION
ARE NOT AS EFFECTIVE AS
THEY ONCE WERE...**

THERE IS A REASON FOR THAT





Today's Supply Chains Aren't Built for Speed and Resiliency

Aesop the Operations Guy Missed the Point

EFFICIENT
POINT-TO-POINT
SLOW TO CHANGE



ITERATIVE
TURN ON A DIME
FAST TO REACT



Going forward, "**slow and steady**" not only doesn't win the race, it gets **disqualified** at the starting line.



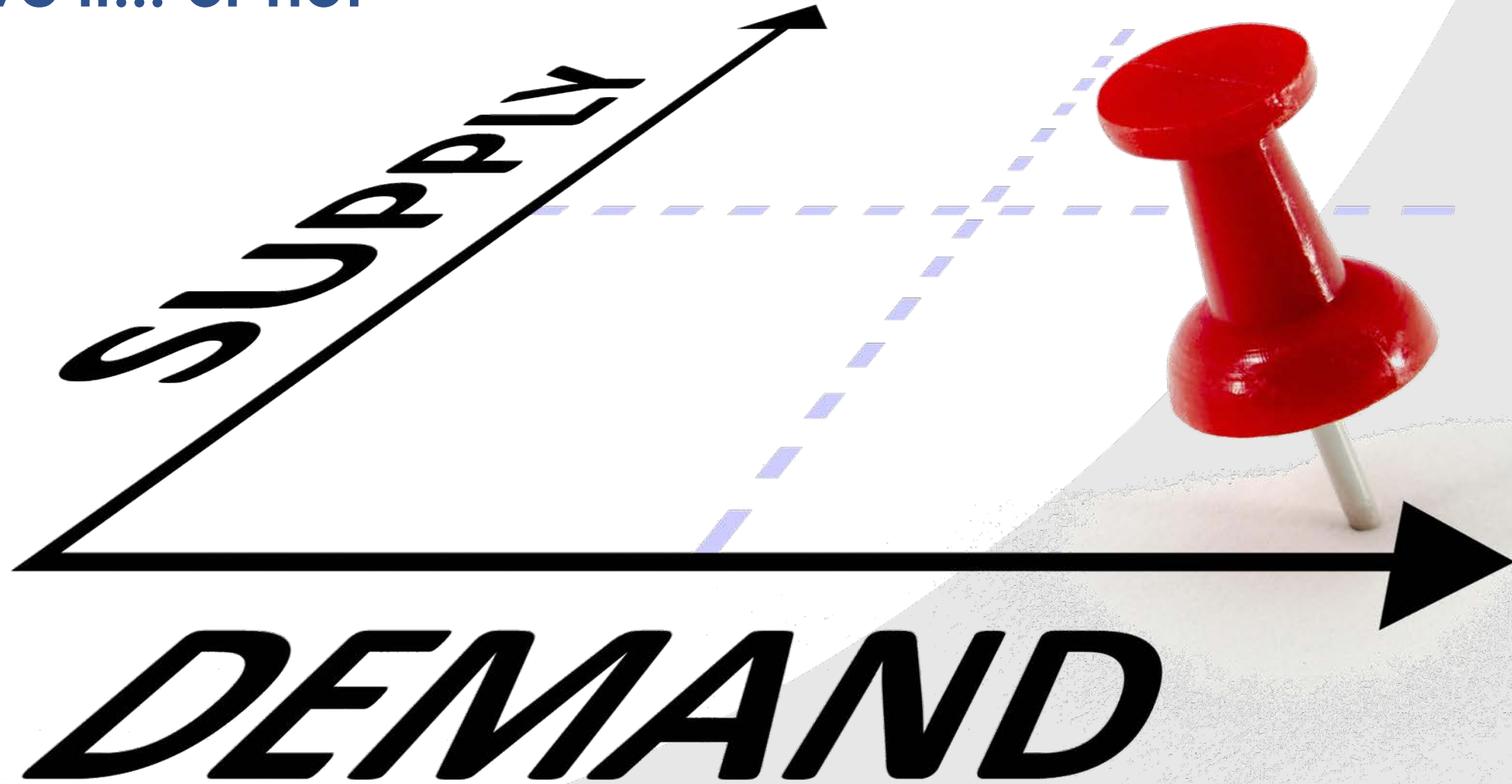
A hybrid approach is often attempted before committing to complete transformation...



Incremental change
will not future-proof
the supply chain



Believe it... or not





The Laws That Define Drive the Electronics Industry



MOORE'S LAW

In 1965, Gordon Moore, the co-founder of Intel, observed that the number of transistors on a microchip doubles about every two years. For example, in 1993, the Intel Pentium processor had 3.1M transistors. Two years later, the new version of the same processor had 5.5M transistors. By 2003, the number of transistors had jumped to 55M. Another tenet of Moore's Law says that the growth of demand for processing power is exponential.



WRIGHT'S LAW

Pioneered by Theodore Wright in 1936, Wright's Law predicts cost declines as a function of cumulative production. Specifically, it states that for every cumulative doubling of units produced, costs will fall by a constant percentage. This is a corollary to Moore's Law which focuses on cost as a function of time.



GILDER'S LAW

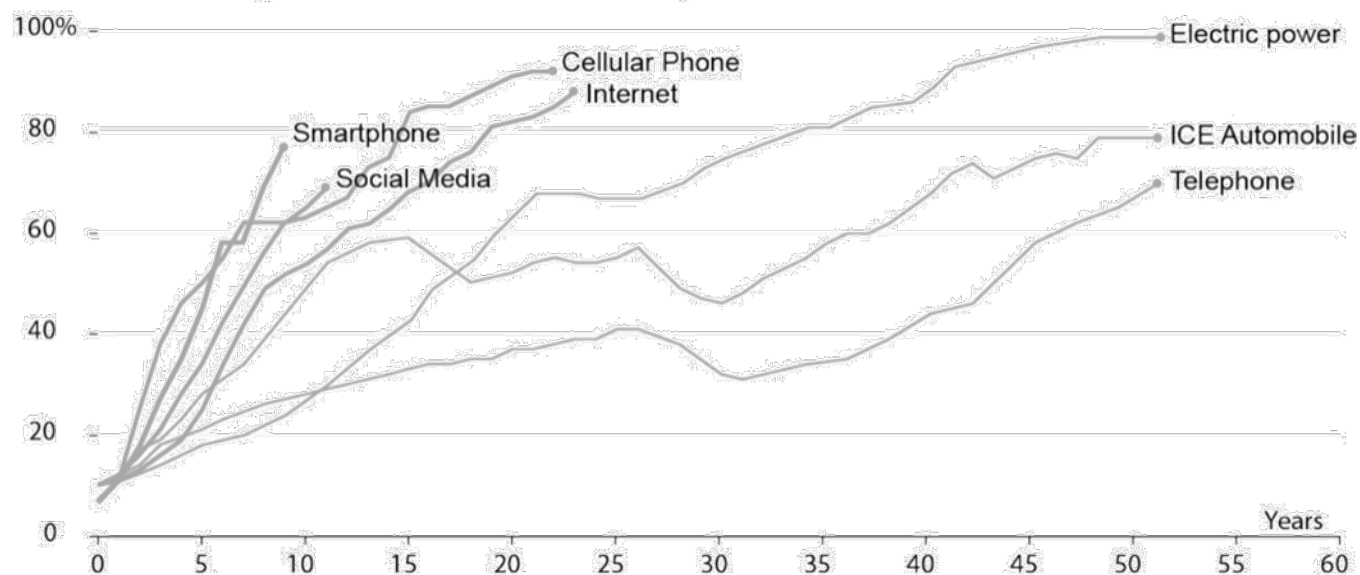
George Gilder observed that bandwidth grows at least 3X faster than computer power which translates into total bandwidth of communication systems tripling every eighteen months. For example, backbone bandwidth on a single cable is now a 1,000x greater than the average monthly traffic exchanged across the entire global communications infrastructure five years ago. Today, more information can be sent over a single cable in one second than a month's worth of information sent over the entire Internet in 1997.



METCALFE'S LAW

Robert Metcalfe, one of the inventors of the ethernet and the founder of 3Com, postulated that a network's value is proportional to the square of the number of nodes in the network. The end nodes can be computers, servers or simply users. For example, if a network has 10 nodes, its inherent value is 100 ($10 \times 10 = 100$). Add one more node, and the value is 121. Add another and the value jumps to 144. Non-linear, exponential growth.

New technologies and applications are arising, combining, and mainstreaming at faster and faster rates driving **exponential growth** in demand and value



Penetration of Major Technologies in the U.S.
Number of years taken to grow from 10% to 75%





The Future of Moore's Law



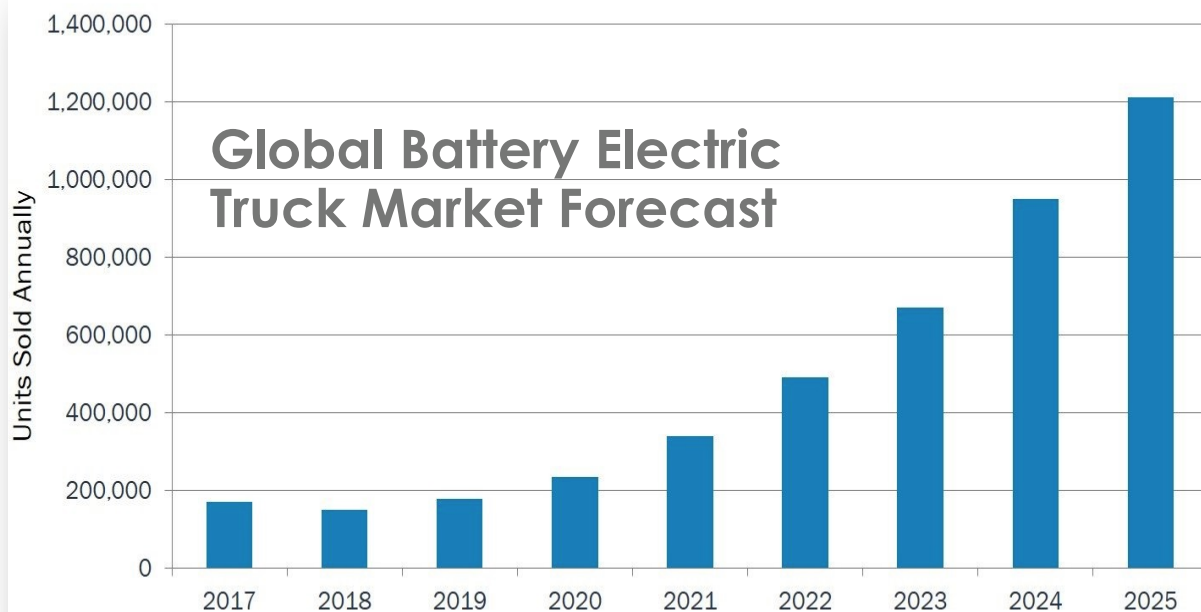
ASML is introducing
new equipment that will
extend Moore's Law and
create processors with
+300B transistors
by 2030



This Is What Exponential Growth Looks Like | Electric Vehicles

*“According to Markets and Markets, the global electric vehicle charging station market size is projected to grow from **2,115** thousand units in 2020 to **30,758** thousand units by 2027. Developing adequate EV Charging infrastructure to cater to the rising demand for EVs on the road is the need of the hour.”*

Tesla share price, past decade



Production ramping exponentially through the 2020's

Source: Interact Analysis



This Is What Exponential Growth Looks Like | Electric Vehicles

Global EV market
21.1% CAGR through 2030

50,000 EV's sold in 2011
3,100,000 sold in 2020

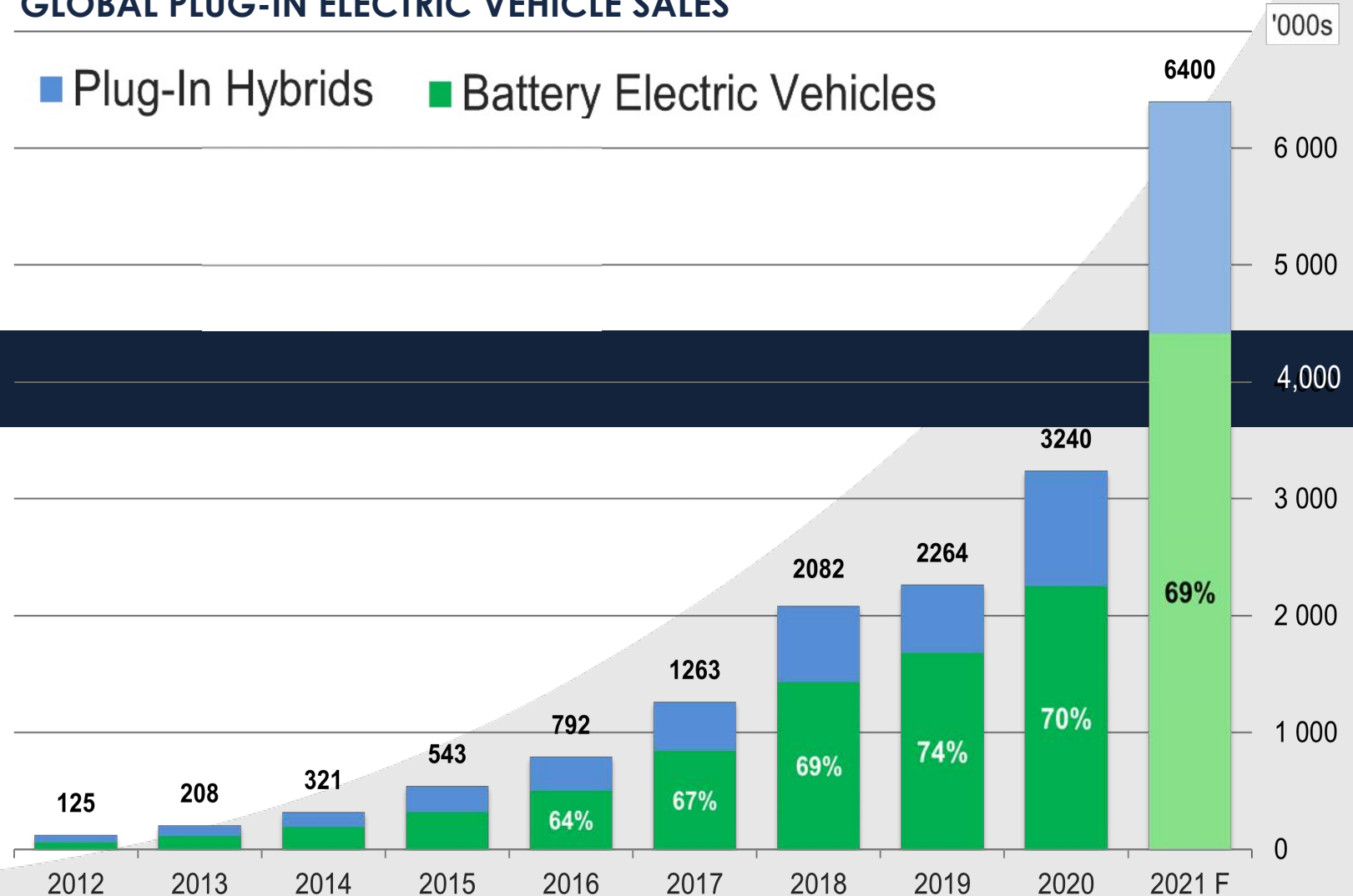
+50x

6% share in China
3% share in Europe
2% share in U.S.

*EV semi content value is
2x to 3x higher than ICE*

GLOBAL PLUG-IN ELECTRIC VEHICLE SALES

■ Plug-In Hybrids ■ Battery Electric Vehicles





This Is What Exponential Growth Looks Like | Electric Vehicles

With government support, the auto industry is planning for 50% of all car sales in the U.S. to be electric by 2030

 Audi is committed to 35% of its car sales to be electric by 2025

 VW expects 70% of European sales and 50% of U.S. to be EV by 2030 and will invest \$40B through 2025

 GM says 40% of models will be EV by 2025 and zero ICE by 2035

 Ford investing \$22B in EV tech; 40% of global sales will be EV by 2030

Source: Bloomberg Intelligence, BloombergNEF, Rystad Energy

The **EV Charging Station** market growing at a CAGR of 40% and will reach **\$30 billion** by 2027

Home EV charging spend to exceed **\$16 billion** by 2026

Source: Juniper Research | 2022





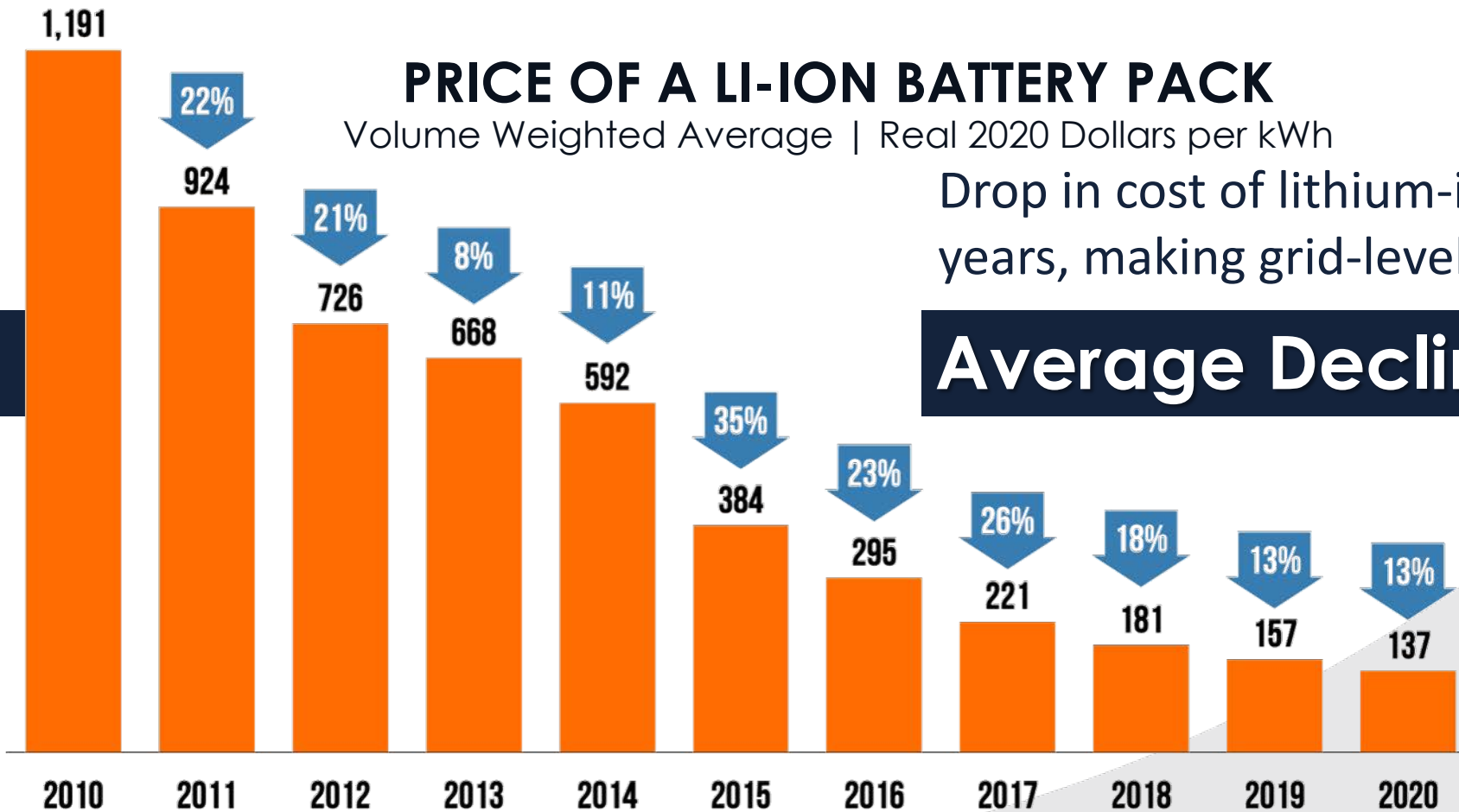
Evidence of the Four Laws at Work | Battery Pricing

PRICE OF A LI-ION BATTERY PACK

Volume Weighted Average | Real 2020 Dollars per kWh

Drop in cost of lithium-ion storage over the last ten years, making grid-level energy storage feasible

Average Decline of 19%/Year



Source: BloombergNEF



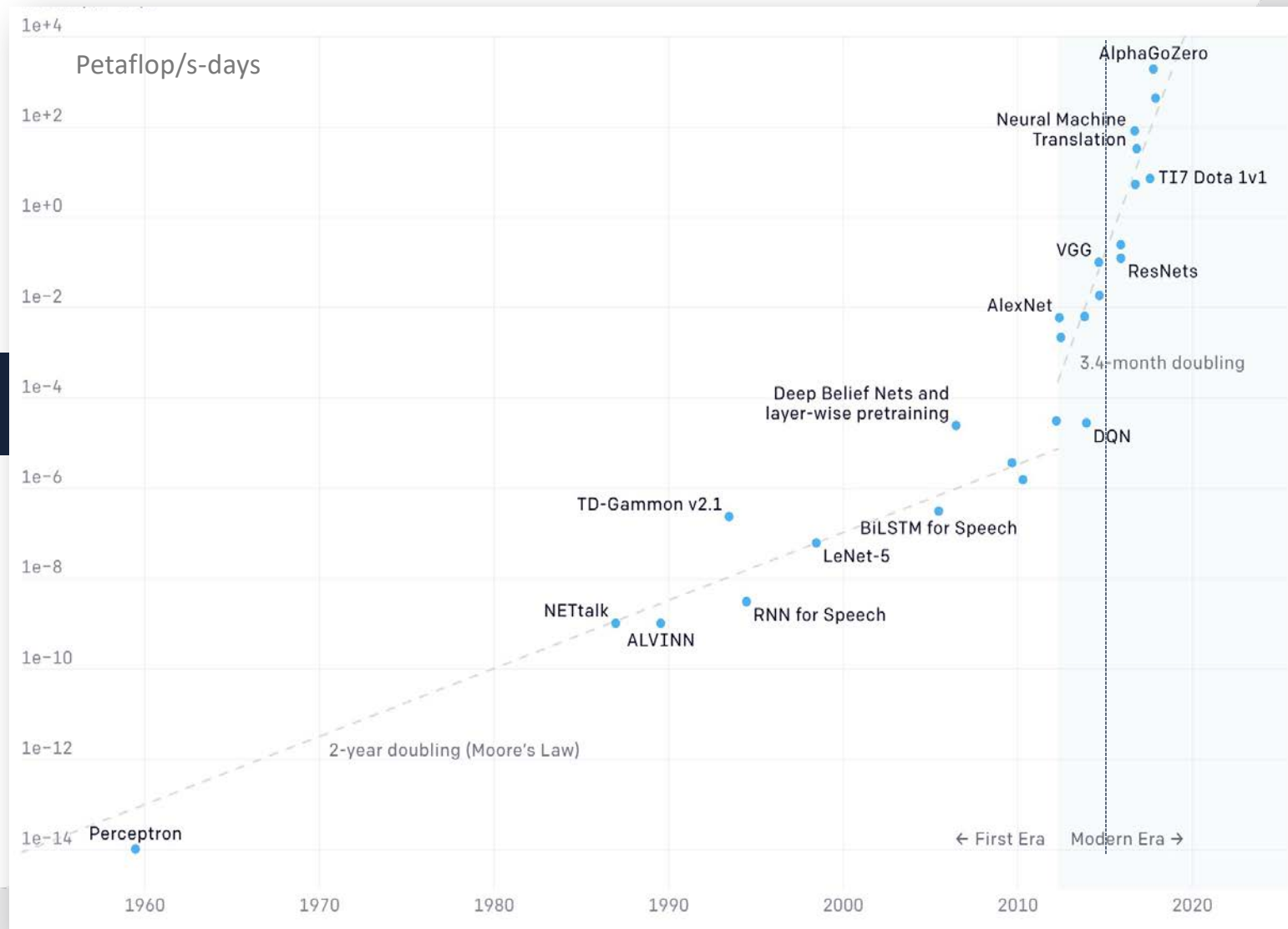
This Is What Exponential Growth Looks Like | Computing Power

7x increase between
2012 and 2018

+300,000X

AI usage of
computational power
vastly outstripped
Moore's law

Source: OpenAI





This Is What Exponential Growth Looks Like | Computing Power

1st iPhone made in 2007

1 billion made by 2012

3.5 billion made by 2020

the iPhone

Today, **100,000x** more processing power than the

Apollo 11 spacecraft,
and **1,000x** faster than
Cray-2 supercomputer





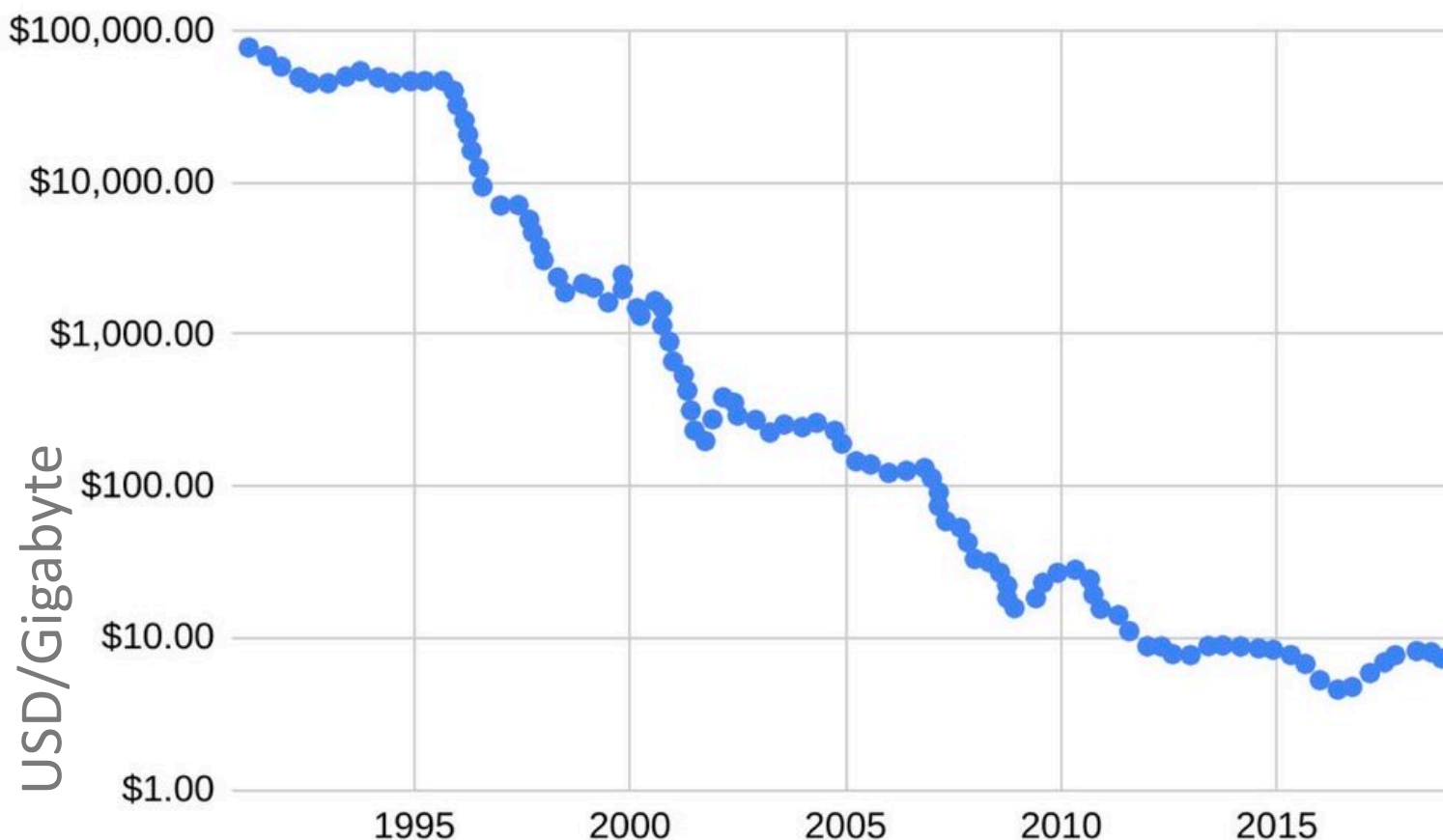
This Is What Exponential Growth Looks Like | Memory Cost

In 2000, \$50 bought an
8-megabyte USB drive

85% CAGR

Today, \$50 buys two
1-terabyte USB drives

Average Real \$ Per Gigabyte of DRAM





This Is What Exponential Growth Looks Like | Connectivity

Increase in computers
connected to the internet...

300X

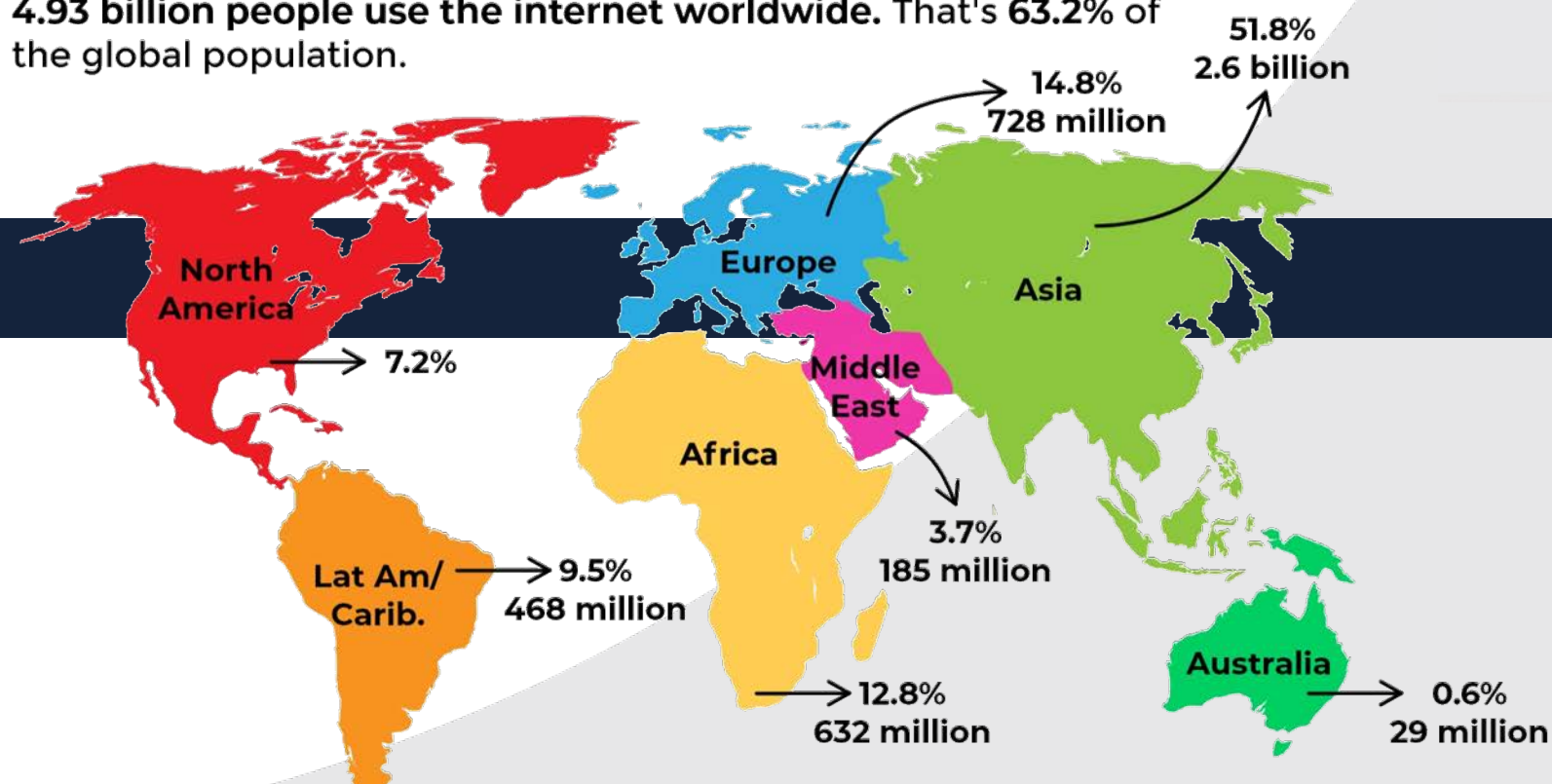
1,024 in 1984

16M in 1995

+5B today

Total Internet Users Worldwide Statistic

4.93 billion people use the internet worldwide. That's 63.2% of the global population.





This Is What Exponential Growth Looks Like | 5G

Cellular IoT market value to exceed \$61 billion globally by 2026

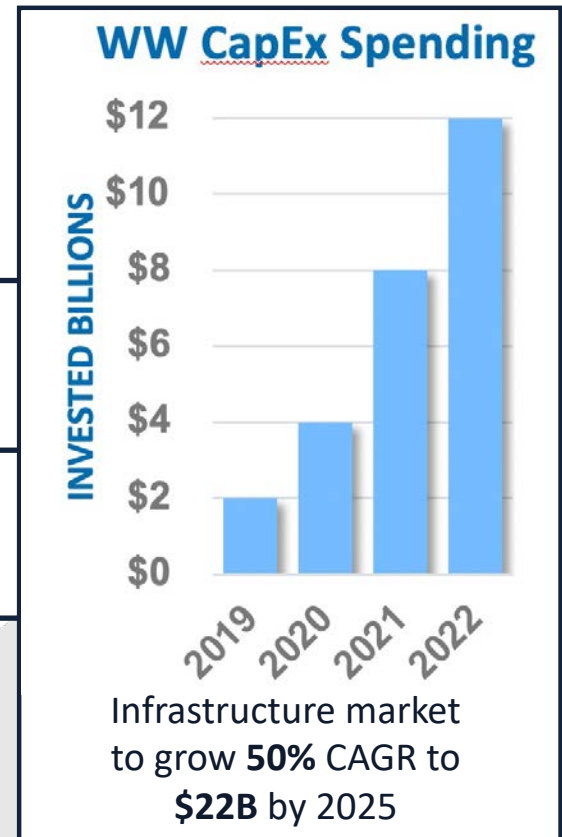
Source: Juniper Research | 2022

Global IP traffic growing **>25%** per year: the amount of IP traffic between 2018 to 2024 will be **4X** greater than all the IP traffic created in the history of the world prior to 2018

Globally, **20 billion** devices connected to mobile networks in 2020, up from 8 billion in 2017

5G is spec'd to deliver **1 million** connections per square kilometer versus **60,680** devices for 4G LPWA

5G devices in 2024... **+23%** global handset connections and **+36%** mobile traffic; each connection will generate **3X** more traffic than the average 4G connection



 **10x**

Connection density

 **10x**

Decrease in latency

 **3x**

Spectrum efficiency

 **100x**

Traffic capacity

 **10x**

Throughput

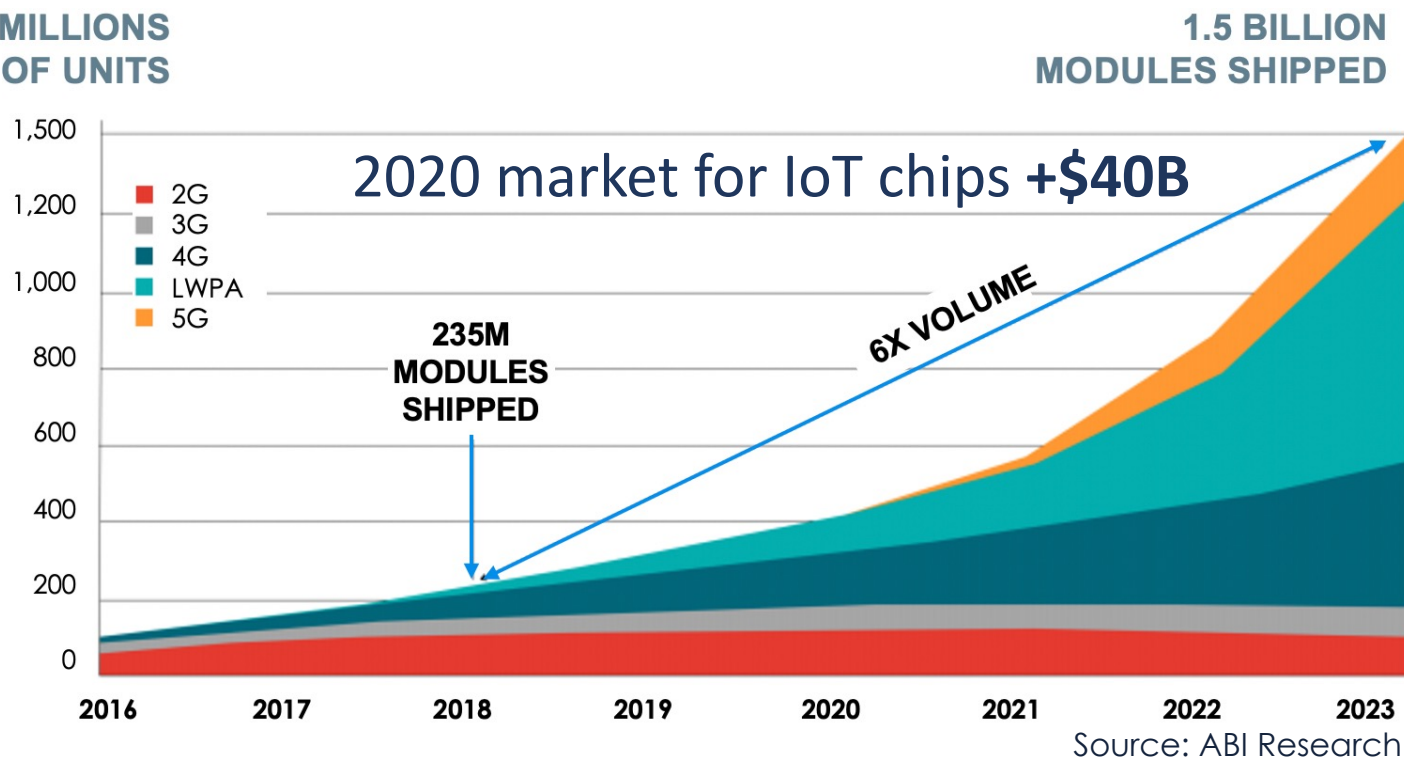
 **100x**

Network efficiency



This Is What Exponential Growth Looks Like | Connected Devices

MILLIONS
OF UNITS



IoT connected devices per human on the planet will increase from **2** per person today to **10** per person by 2025, and the **1 trillion** sensors in the world today will grow to **100 trillion** by the end of this decade

THE AGE OF SMART... BY 2050



SMART HOMES: \$200B - \$300B



SMART CITIES: \$900B - \$1.7T



SMART OFFICES: \$200B - \$700B



SMART FACTORIES: \$1T - \$3.7T



SMART RETAIL: \$400B - \$1.2T



SMART HEALTHCARE: \$200B - \$1.6T

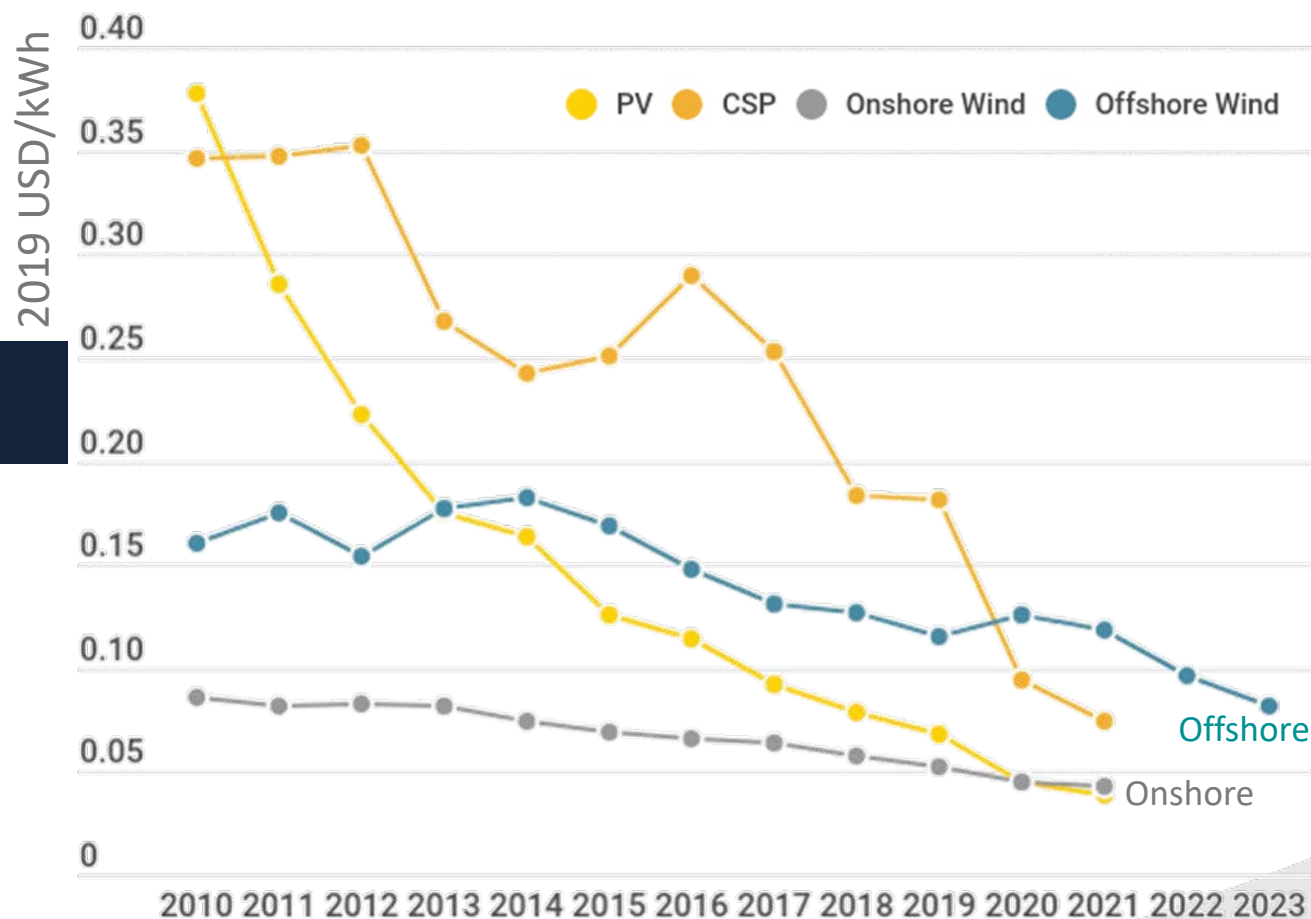


SMART VEHICLES: \$200B - \$700B

Source: PwC



This Is What Exponential Growth Looks Like | Renewable Energy



COSTS FOR SOLAR AND WIND POWER TECHNOLOGIES ARE DECLINING RAPIDLY

Declining cost of generating electricity by wind turbine over the last 10 years

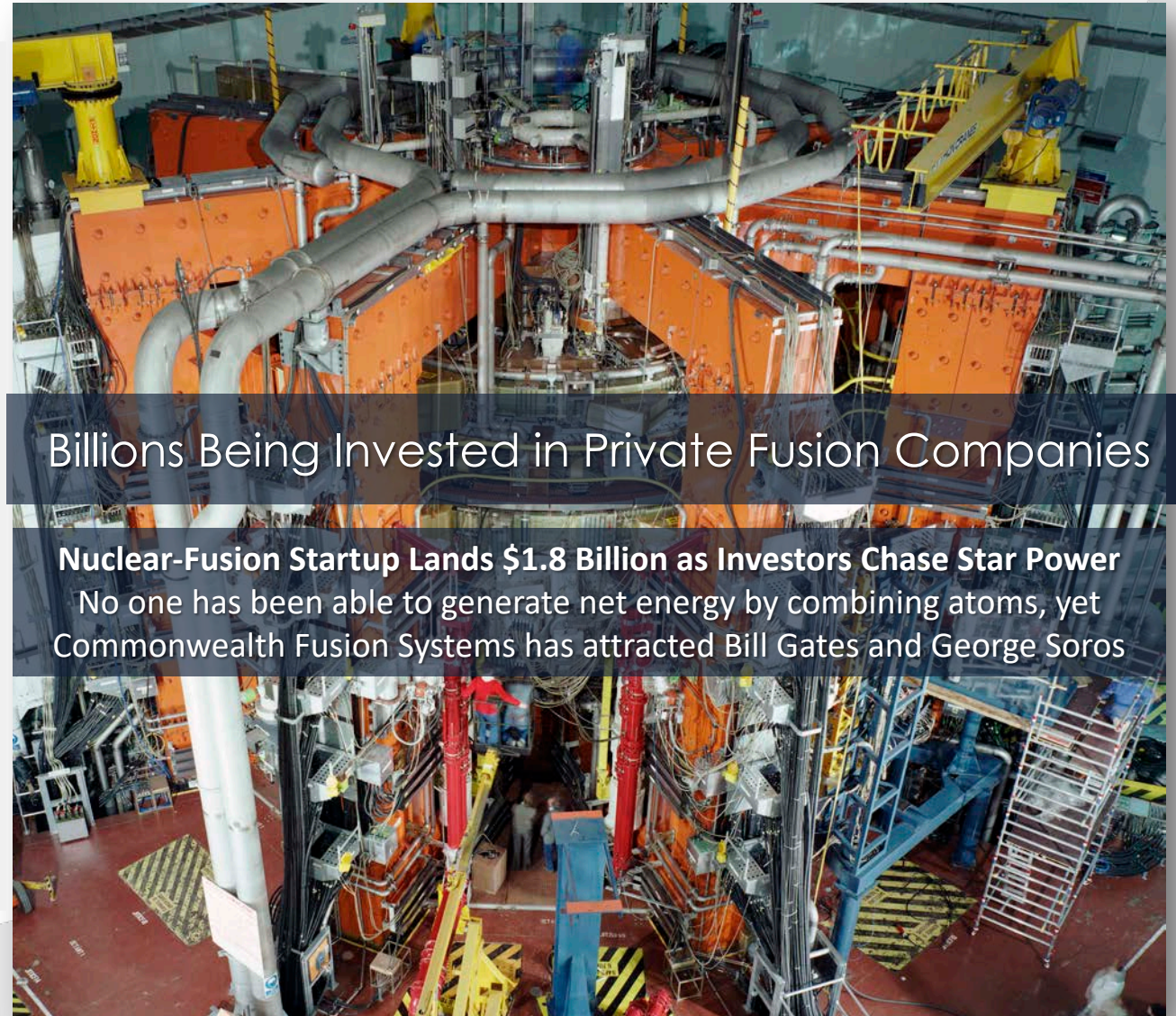
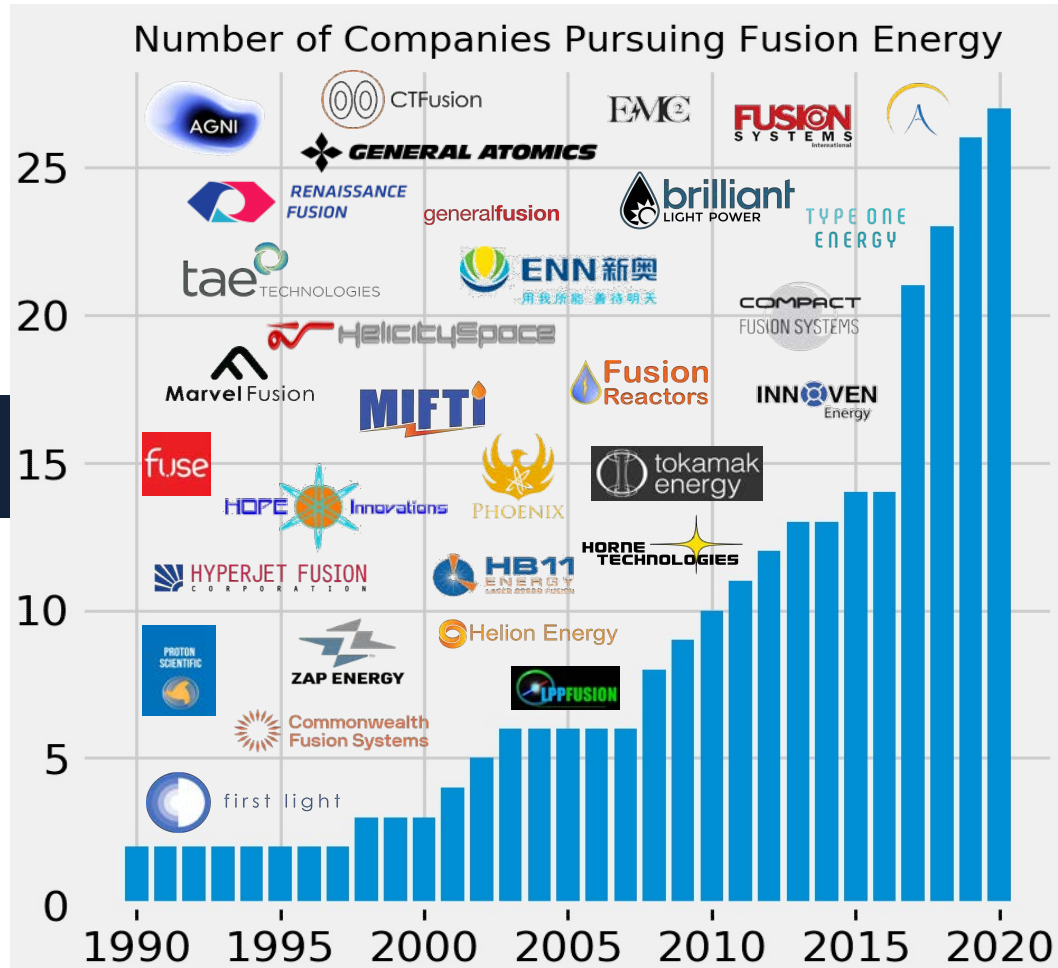
-13%/Year & 500x

Between 1975 and 2019, the price per watt of power for a silicon photovoltaic module has dropped from **\$100 to 23 cents**; this is a 500x improvement making solar *less expensive than fossil fuels*





This Is What Exponential Growth Looks Like | Nuclear Fusion



Billions Being Invested in Private Fusion Companies

Nuclear-Fusion Startup Lands \$1.8 Billion as Investors Chase Star Power

No one has been able to generate net energy by combining atoms, yet Commonwealth Fusion Systems has attracted Bill Gates and George Soros

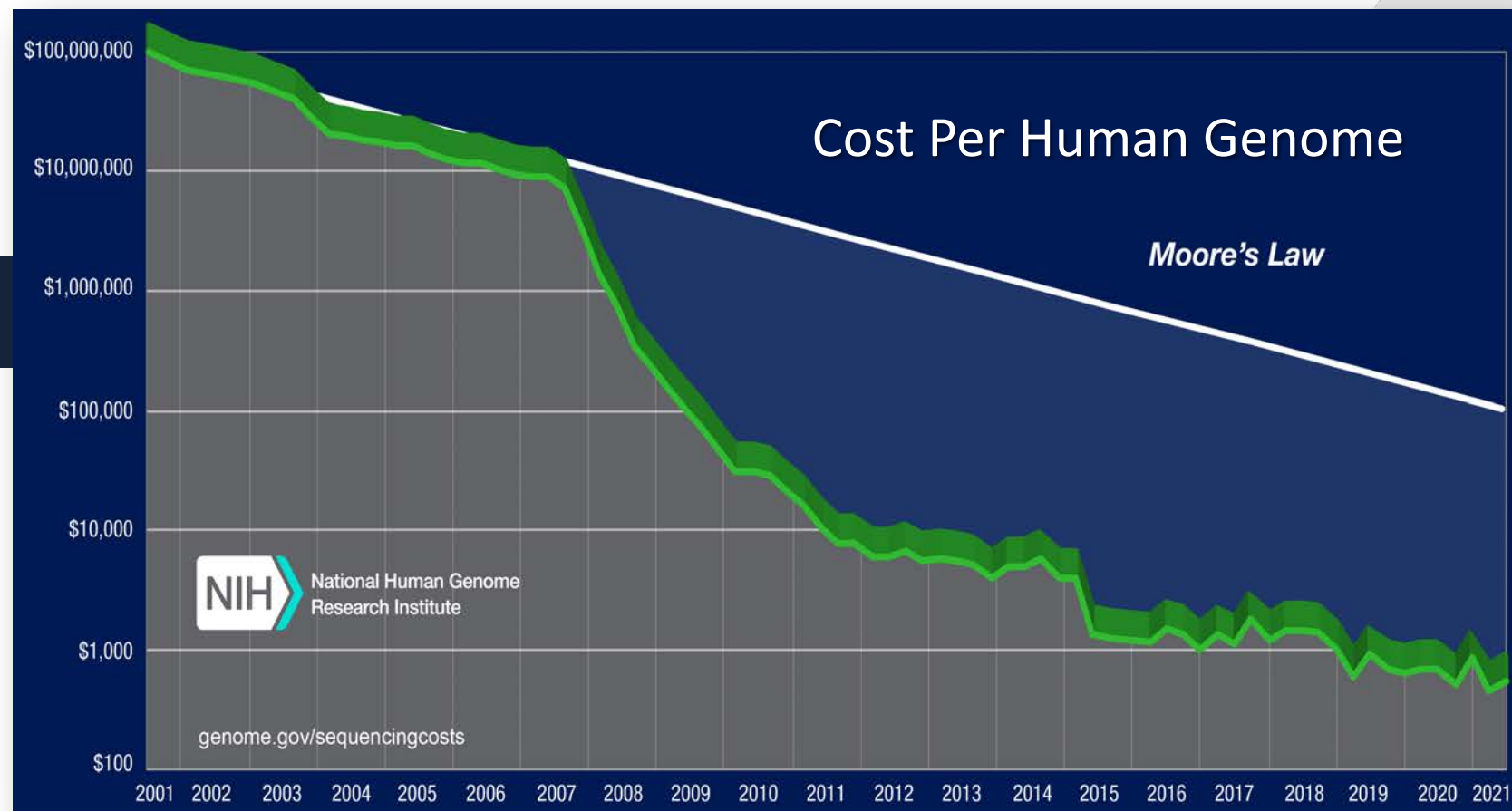


This Is What Exponential Growth Looks Like | Gene Sequencing

Cost of sequencing the human genome has fallen from **\$95M** in 2001 to **\$942**

+1,000,000X

a **million-fold improvement** from the cost of the very first humane genome that was sequenced in 1985





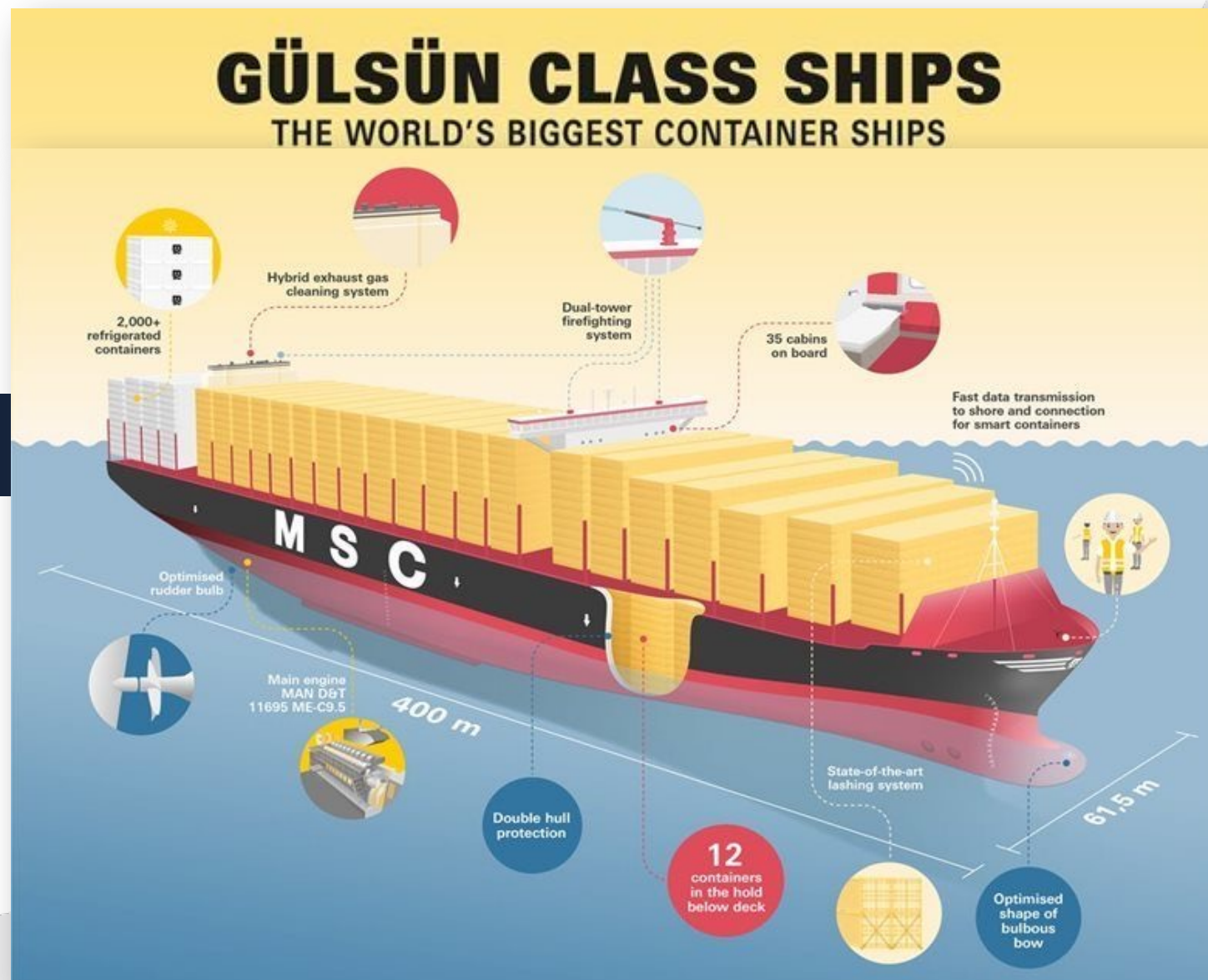
This Is What Exponential Growth Looks Like | Logistics

First ship held **226** containers, one year later **609** containers, today the largest ship holds **23,964** containers

CONTAINER SHIPS

The carrying capacity of 1,358 Boeing 747's or 14,072 heavy duty trucks

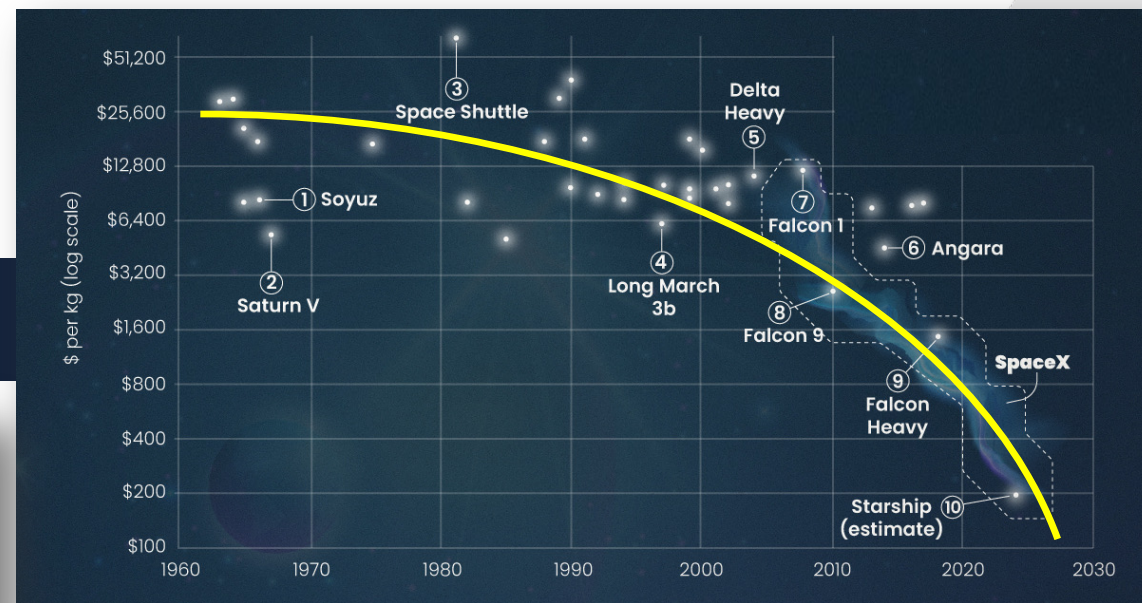
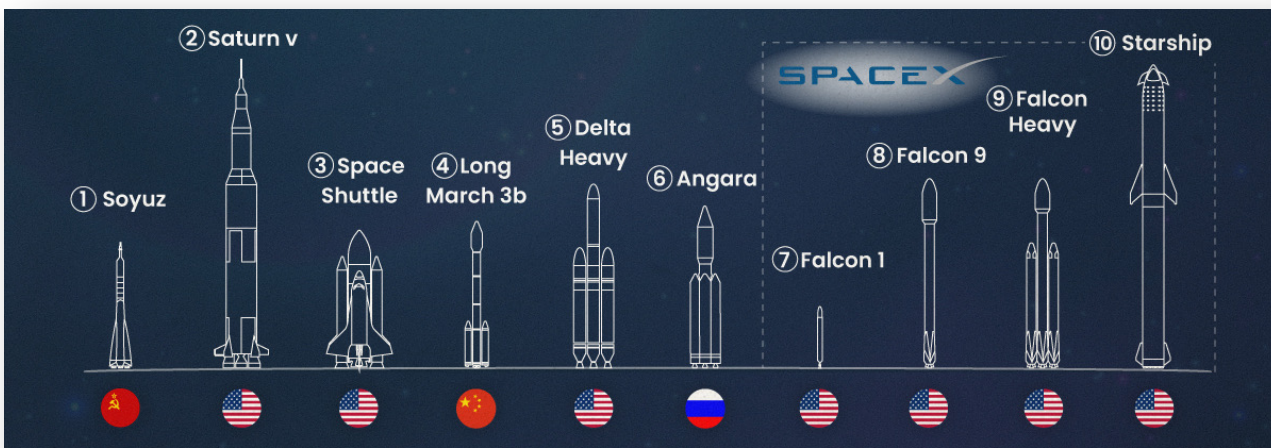
In a single voyage: 223M bananas, 336M pairs of shoes, 47.5K cars, 2.9M washing machines





This Is What Exponential Growth Looks Like | Space Flight Cost

Today, launching a spacecraft is
10X cheaper than 10 years ago

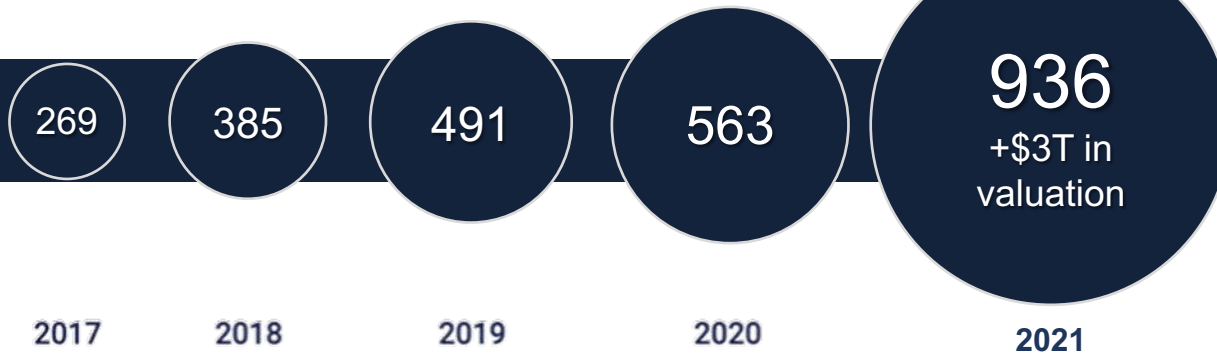


Cost per kilogram (inflation adjusted) for space launches



This Is What Exponential Growth Looks Like | Unicorns

Global Unicorn Count | 2017 – Q3 2021



The screenshot shows a detailed index of unicorn companies categorized by industry. The categories include:

- Artificial intelligence
- Auto & transportation
- Cybersecurity
- Consumer & retail
- Data management & analytics
- E-commerce & direct-to-consumer
- Fintech
- Edtech
- Hardware
- Internet software & security
- Health
- Mobile & telecommunications
- Travel
- Supply chain, logistics, & delivery
- Other

Each category lists numerous company names, often accompanied by their stock exchange tickers.





This Is What Exponential Growth Looks Like | Robots

American factories ordered
29,000 robots valued at **\$1.5B**

Source: Association for Advancing Automation

+37% Growth in 2021



Professional Use Service Robot Sales | Billions USD





Using Technology To Grow Grass

DIY Sprinklers Have Never Been So Easy

TO Team Orbit <offers@orbit.store> Saturday, February 26, 2022 at 5:39 AM
To: mknights63@gmail.com

Orbit®

Lawn. Garden. Life.

B-hyve

Watering

Gardening

Outdoor

Install Your Own Irrigation System



Anyone can DIY an in-ground irrigation system with the Orbit Sprinkler System Designer!

With our design tool, you can easily trace a Google map of your yard, use your own sketch, or just start designing from scratch to get your instant, customized sprinkler plan. We'll automatically add all the parts you'll need to your cart on the Orbit Store for an easy checkout experience.

While installing a sprinkler system can be challenging, we've made the installation process easier than ever before with a comprehensive step-by-step installation guide, push-to-connect pipe and fittings, pre-assembled manifolds, and B-hyve Smart Sprinkler Timers.

- Mass customization
- Appealing to DIY'ers
- Speed and convenience



Exponential Thinking Required



- “Now, we are predicting the fastest, deepest, most consequential technological disruption in history and with it, a moment civilization has never encountered before”
- “In the next 10 years, key technologies will converge to completely disrupt the five foundational sectors - **information, energy, food, transportation, and materials**”
- “These underpin our global economy, and with them every major industry in the world”
- “Costs will fall by **10X** or more, while production processes become an order of magnitude (**10x**) more efficient, using **90% fewer** natural resources and producing **10X to 100X** less waste”

Rethinking Humanity by Tony Seba and James Arbib



eXponential
TECHNOLOGY GROUP

TECHNOLOGY TREND PREDICTIONS



25 Megatrend Predications

Analysis of articles, podcasts, whitepapers and interviews by leading forecasters





25 Megatrend Predications

Analysis of articles, podcasts, whitepapers and interviews by leading forecasters

- (1) The creator economy will flourish (2) Highly unequal global recovery (3) Ransomware ramps up (4) Social commerce picks up steam (5) Inflation slowly eases off (6) Regulation is coming for crypto (7) Bullish on European and Japanese equities (8) Meta's metaverse plans fall flat (9) Climate change is back in the spotlight (10) Growing influence of ESG factors (11) China will have a rocky start to 2022 (12) Interest rates will go up (13) You'll be hearing a lot more about NFTs and Web3 (14) Rich countries will move from pandemic to endemic phase (15) Continued growth of crypto (16) 4 to 5% global GDP growth (17) Industrial real estate remains hot (18) Modest gains for equities (19) Geopolitical tensions will flare up

-
- (20) Increased volatility (21) Big tech gets even bigger (22) Onshoring trends continue (23) Another banner year for electric vehicles (24) Supply chain disruptions ease off, but slowly (25) Shifting labor dynamics... workers are in the driver's seat



10 Mega Tech Trend Predications



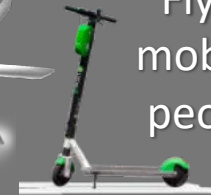
Nuclear fusion will be the ultimate abundant green-energy source



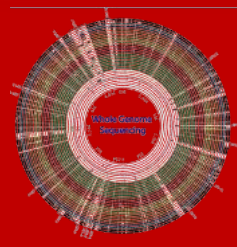
Quantum computing and blockchain will be the death of cybercrime



Supersonic planes will take aviation to new heights



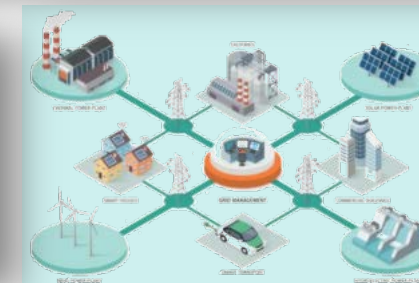
Flying cars and micro mobility will move the people of tomorrow's megacities



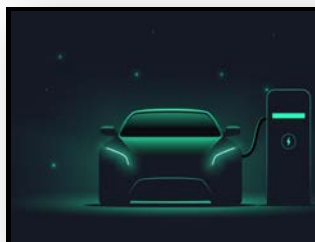
Gene mapping & AI will personalize healthcare driving real progress in quality of life for all



Automation of everything is inevitable due to changing labor dynamics



A new-deal style program will at last modernize the electric grid



Electric Vehicle adoption will hit the "tipping point" sooner than widely believed



Wireless broadband technologies will exponentially drive IoT proliferation



Sensors & AI make healthcare real-time & ubiquitous



A Sign of the Times, and of Things to Come

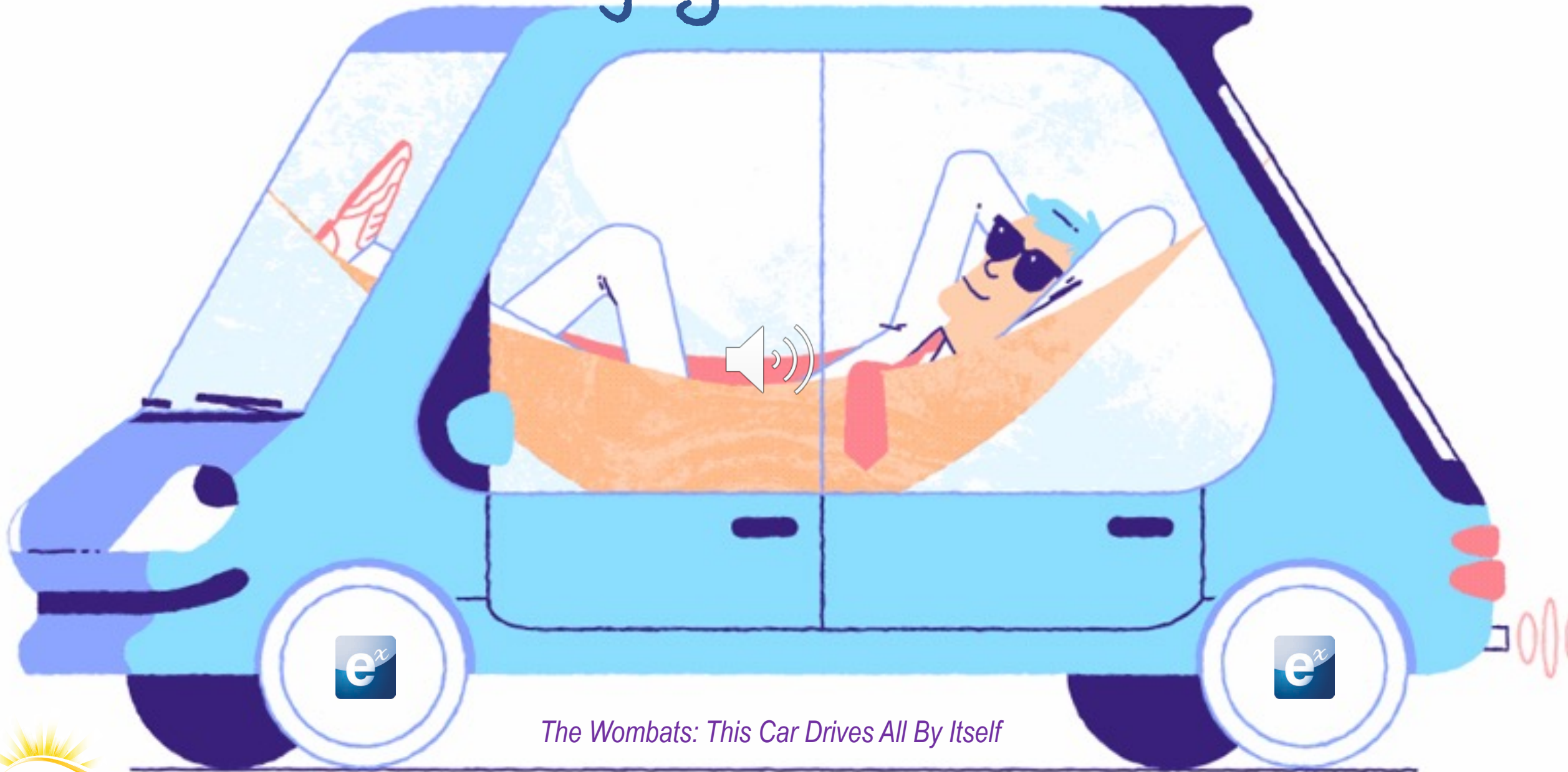


“The persistence of the chip deficit boils down to one overarching factor: a significant surge in demand, driven by digital transformation and accelerated by the pandemic. And consumer devices aren’t the only thing, or even the main thing, driving this demand: every mechanical product in industry is becoming increasingly digital, and every vertical sector is becoming ever more reliant on digitization.”

Wall Street Journal | January 28, 2022



Enjoy the ride!



The Wombats: This Car Drives All By Itself