Tech Trends Report

2026

Context

Contrary is a talent and research-driven investment firm. We believe that at the root of every iconic company is one thing: extraordinary people. As extraordinary people build companies, they build on top of foundational trends that are shaping the world around us. But just as important as the fundamental forces driving technology are the second-order effects of those trends.

Each year, our Tech Trends Report isolates the most important currents within technology and the way social behavior forms around them. This report is meant to both isolate the foundational concepts and hint at the progressing second order effects they could cause. Because that's where opportunity lies.

COMPUTATIONAL INTELLIGENCE

- **Foundation Models**
  - SOTA Models
  - Open Source
  - World Models
- **AI Adoption**
  - Enterprise
  - Consumer
  - Vertical Applications
- **Compute Supply & Demand**
  - AI Infrastructure

INDUSTRIALIZATION

- **Transportation**
  - Autonomous Vehicles
  - Logistics
  - Aviation
- **Manufacturing**
  - Production Capacity
  - Robotics
  - Onshoring
- **Defense**
  - Global Conflict
  - Munitions
  - Shipbuilding

DIGITAL INTERFACES & EXPERIENCE

- **Screen Time**
  - Advertising
  - Subscriptions
  - Mental Health
- **Alternative Consumer Hardware**
  - Virtual Reality
  - Augmented Reality
  - AI Hardware
- **Digital Trust**
  - Media
  - Deepfakes
- **The Loneliness Epidemic**
  - Isolation
  - Family Formation
  - AI Companions

RESOURCES

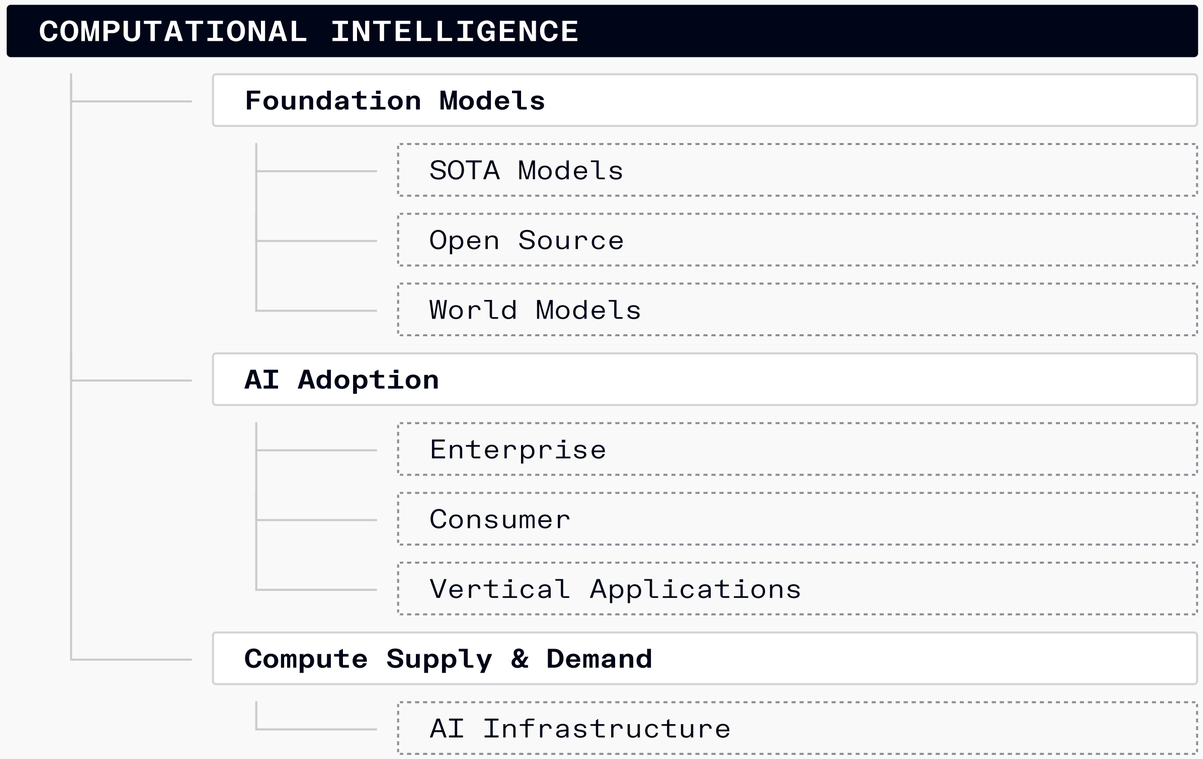
- **Land Use**
  - Data Centers
  - Lunar Bases
- **Energy**
  - Existing Grid
  - Fossil Fuels
  - Renewables
  - Nuclear
  - Batteries

MEDICINE & HEALTHCARE

- **Biotech Manufacturing**
  - Current Capacity
  - Alternative Approaches
- **Shift from Pharma to Biologics**
  - GLP-1s
  - Breakthrough Biologics
- **Human Augmentation**
  - Gene Therapies
  - Longevity
  - Brain-Computer Interfaces
- **Healthcare**
  - State of Healthcare
  - Chronic & Communicable Diseases
  - AI For Medicine

Computational Intelligence

Foundational Models
AI Adoption
Compute Supply & Demand


COMPUTATIONAL INTELLIGENCE
Foundation Models
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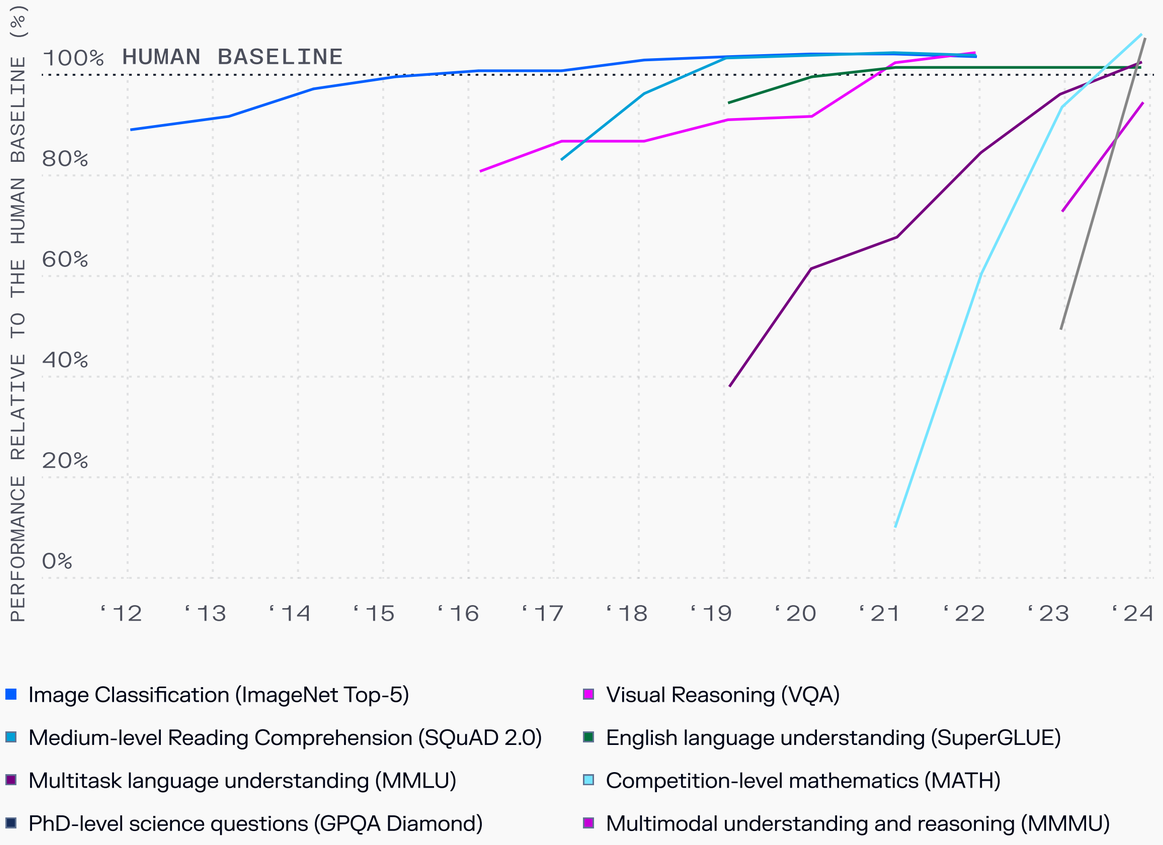
AI Infrastructure

Foundation Models

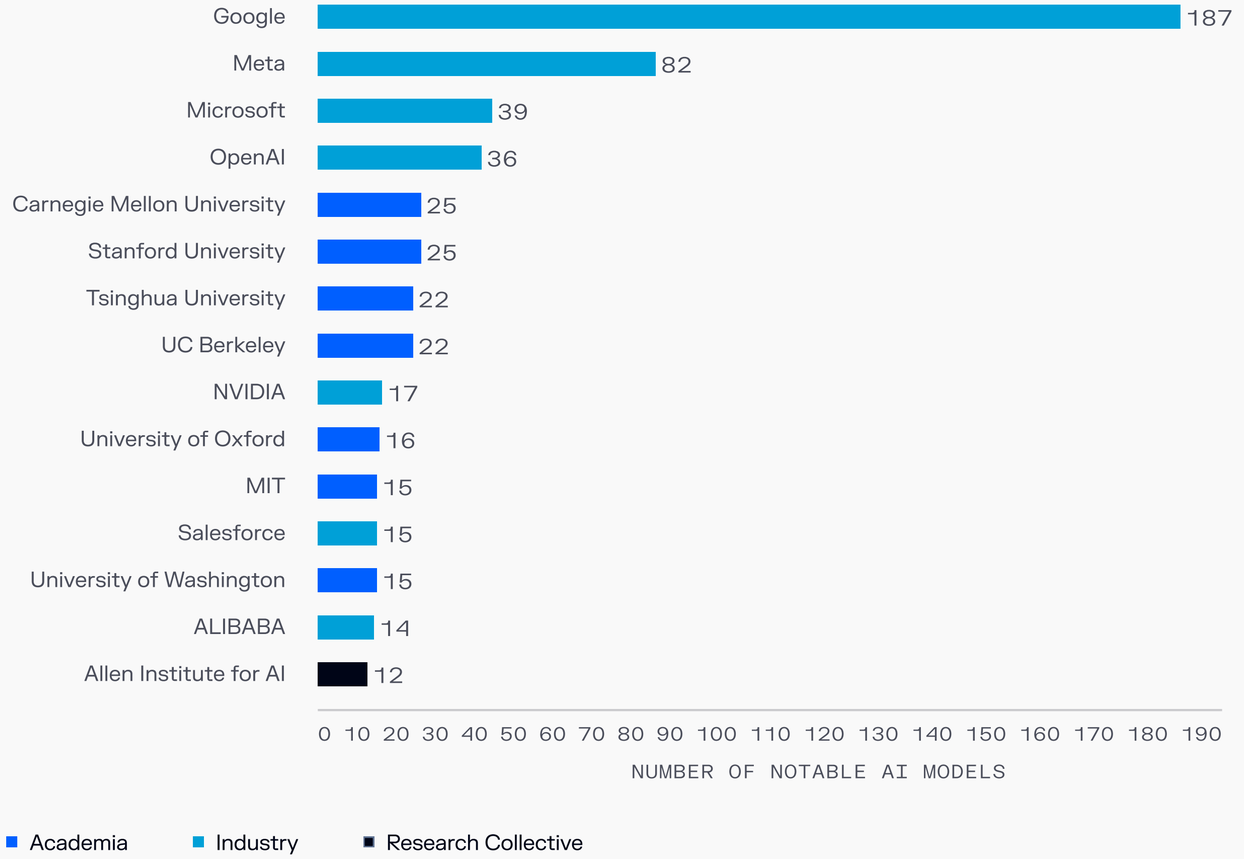
Over the last decade, AI models have rapidly reached a human baseline of performance across a variety of tasks.



Source: Stanford AI Index 2025; The values are scaled to establish a standard metric for comparing different benchmarks. The scaling function is calibrated such that the performance of the best model for each year is measured as a percentage of the human baseline for a given task.

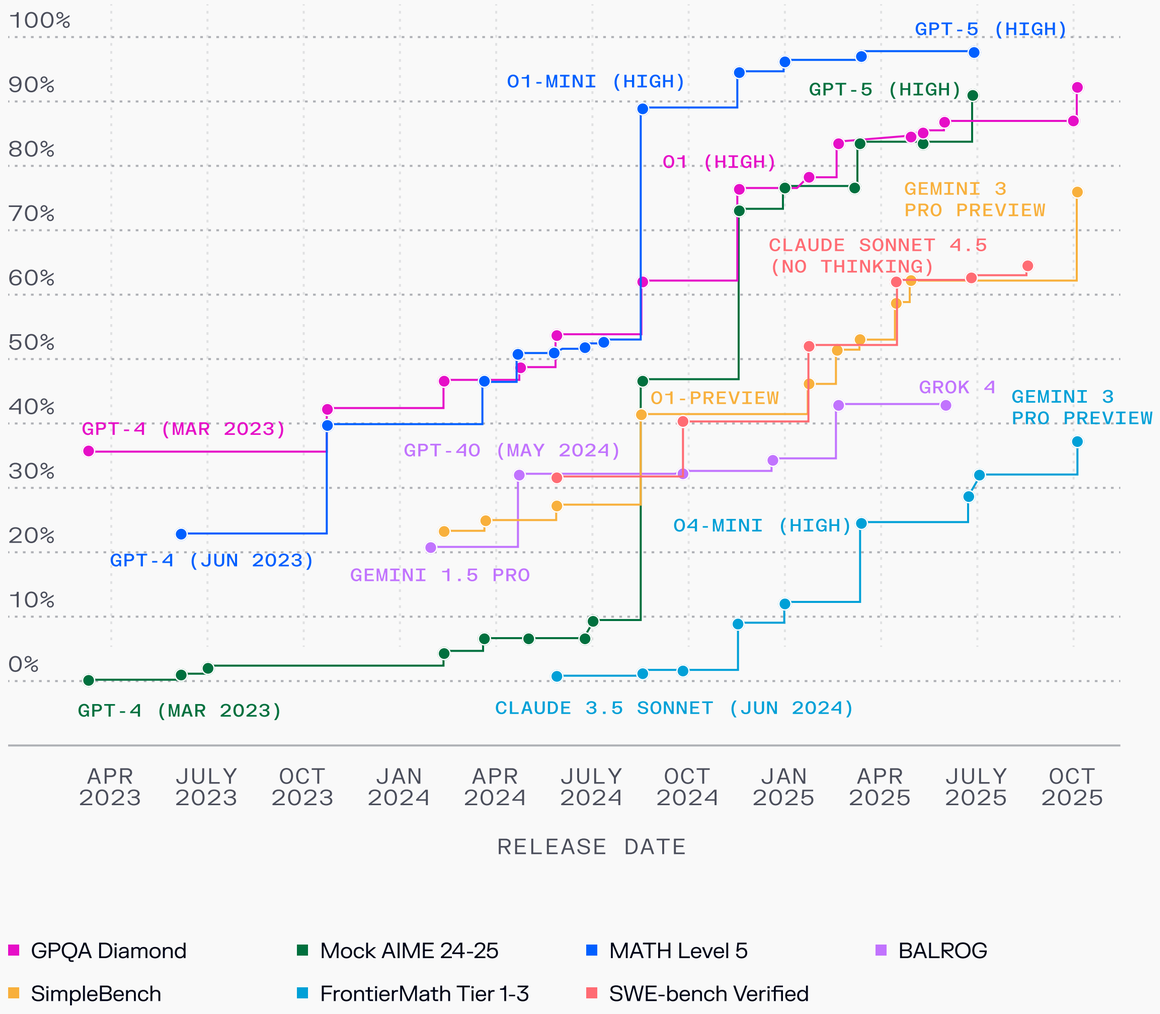
Google, Meta, Microsoft, and OpenAI have led the charge in building notable AI models, followed primarily by academic organizations.

Number of notable AI models by organization, 2014-24 (sum)



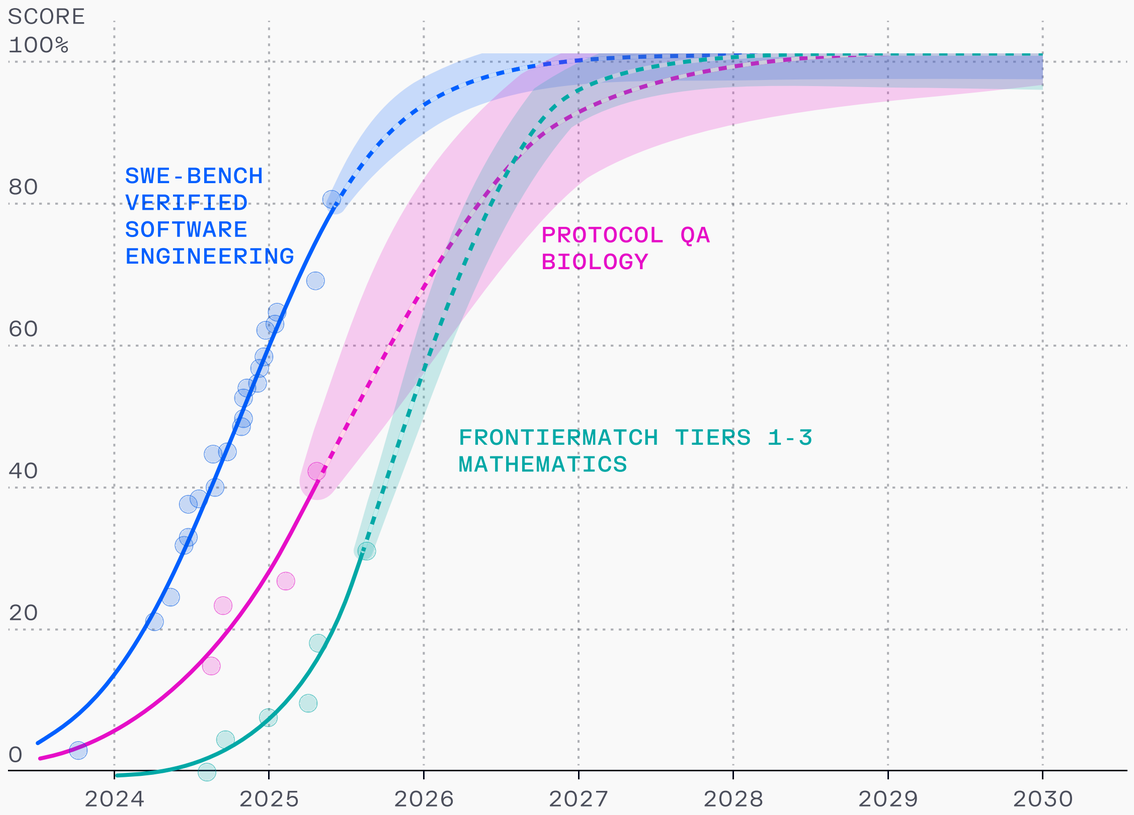
Source: Stanford AI Index 2025; research published by DeepMind is classified under Google

Across companies, models have continued to reach higher benchmarks of accuracy across skills like physics, math, and software engineering.



Source: Epoch AI; November 2025

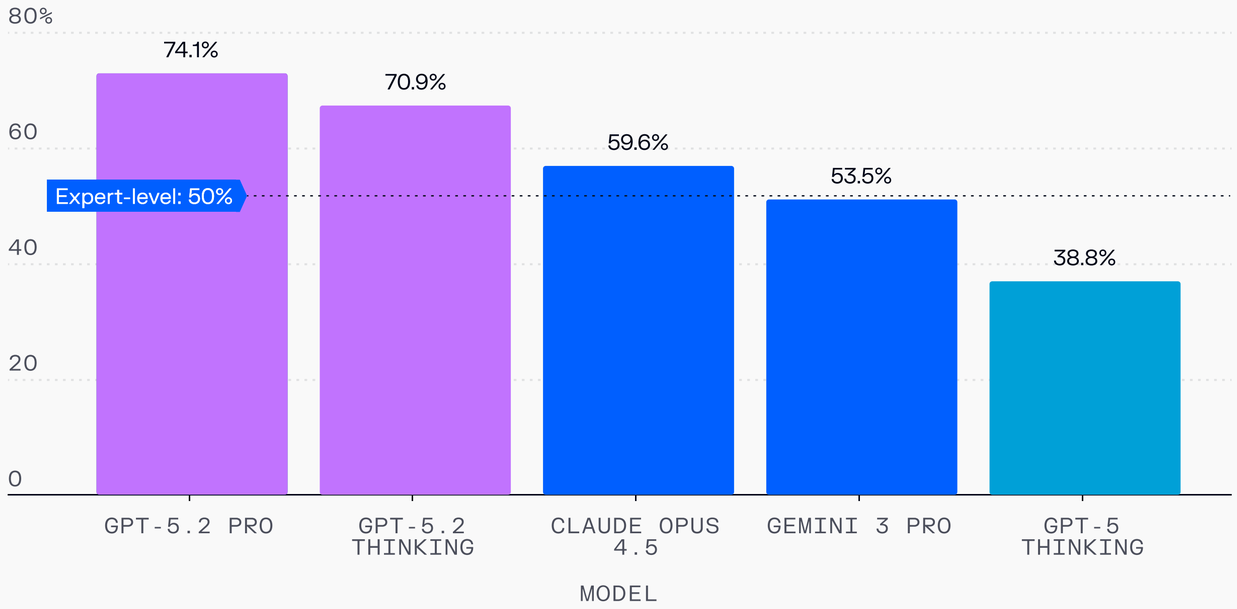
By 2030, AI models across domains like software engineering, biology, and mathematics are expected to be capable of near-perfect accuracy.



Source: Epoch AI

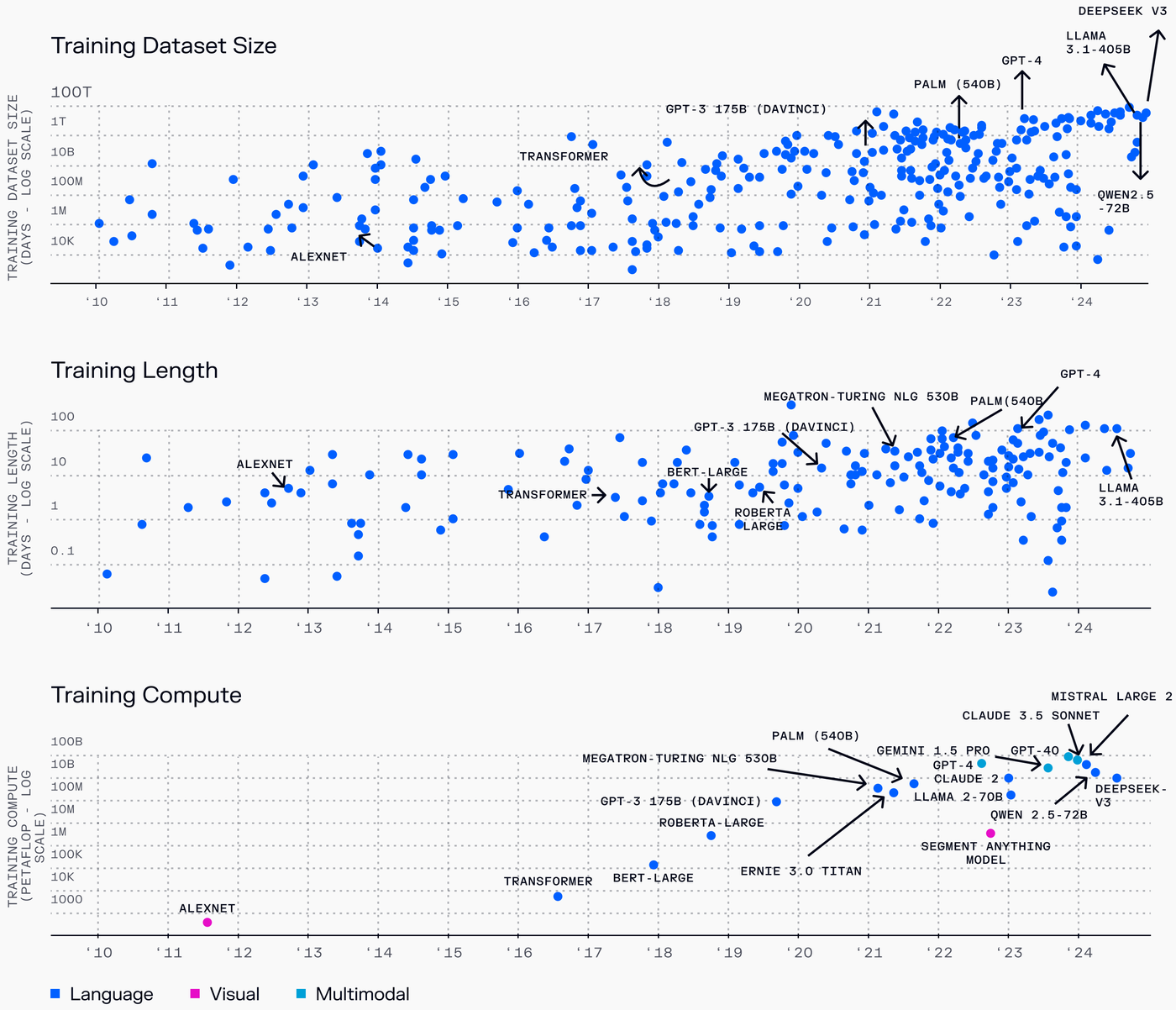
Each subsequent model, from Gemini 3 to GPT-5.2, continues to perform better and better in conducting knowledge work tasks.

Win rate vs industry professional on GDPval



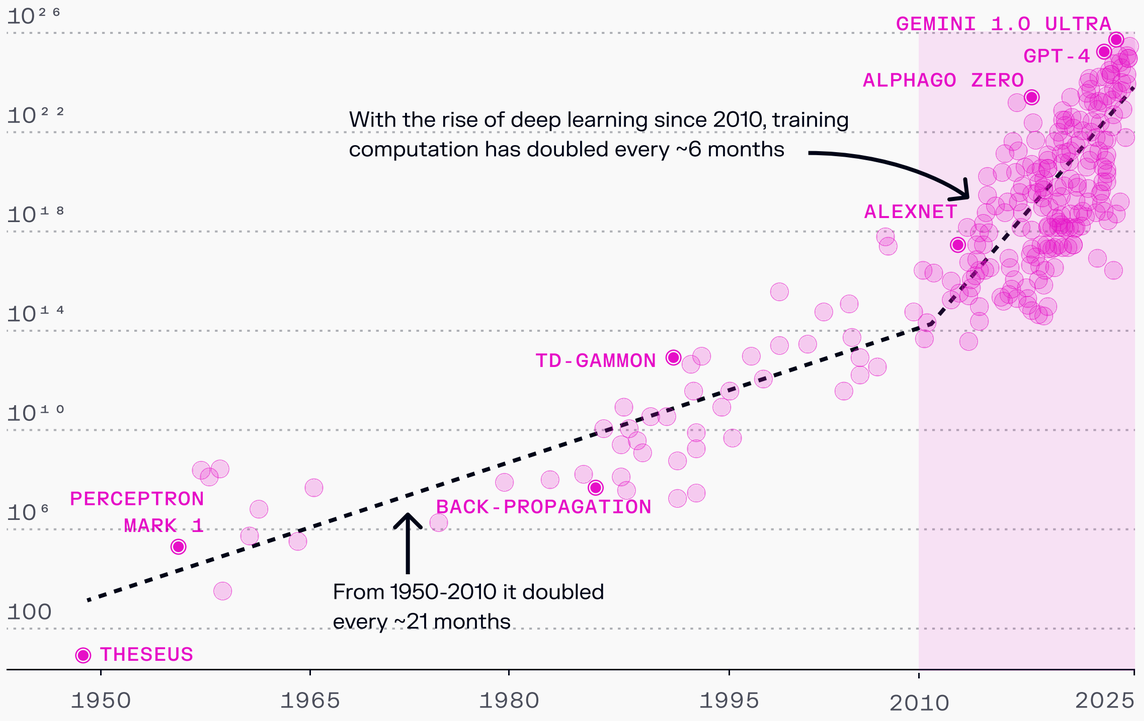
Source: OpenAI

Across the board, state-of-the-art models are adhering to scaling laws: using larger sets of data and more time and compute for training.



Source: Stanford AI Index 2025

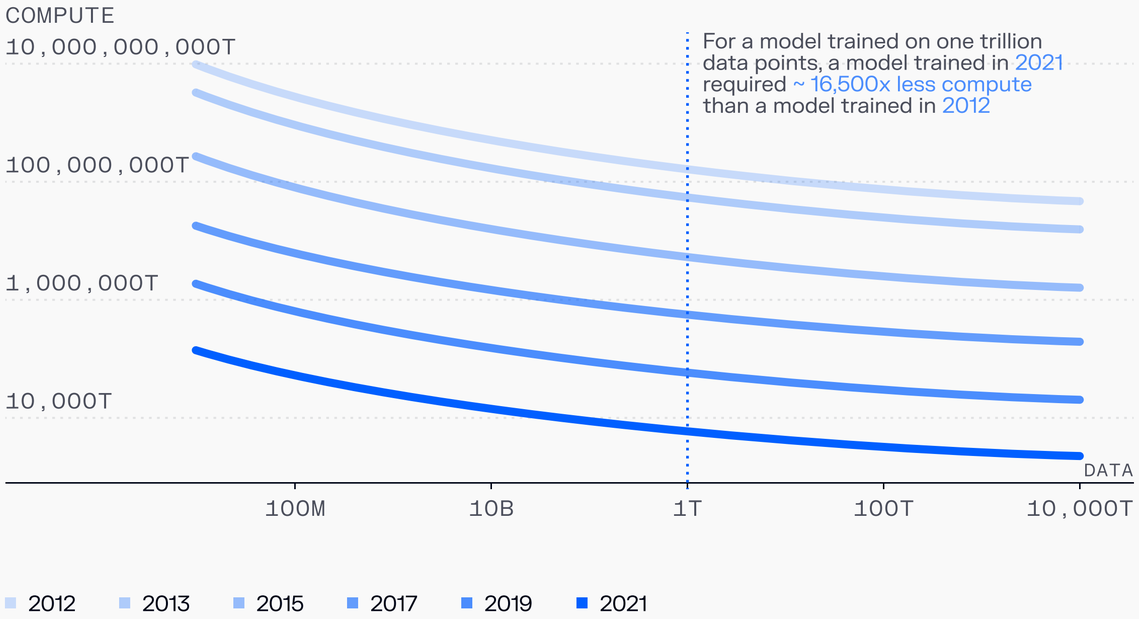
Compute, in particular, had been rising since 1950, but dramatically accelerated starting in 2010.



Source: Epoch AI; FLOP (floating-point operations) refers to the total number of computer operations used to train an AI system. Computation is estimated based on published results in the AI literature and comes with some uncertainty. Epoch expect most of these estimates to be correct within a factor of 2, and a factor of 5 for recent models for which relevant numbers were not disclosed, such as GPT-4.

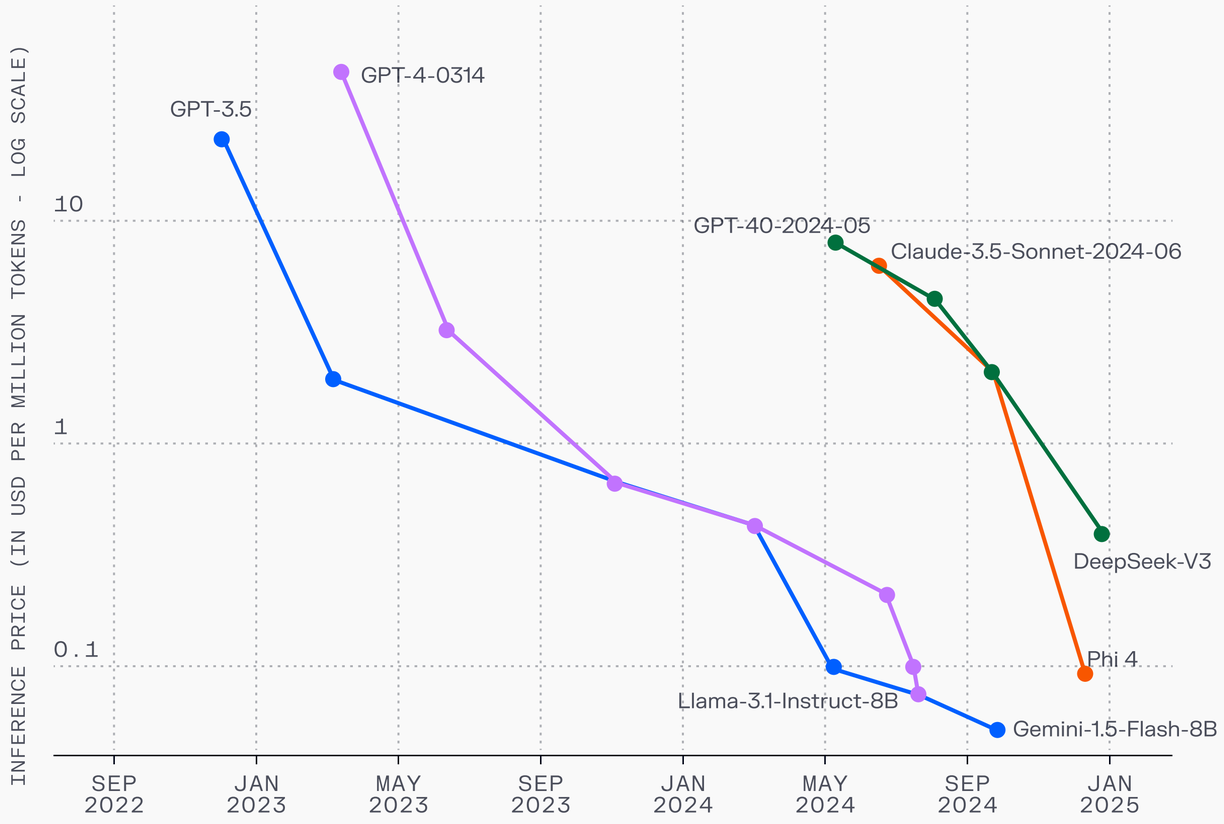
Despite higher volumes of compute being used, comparable performance has been reached with less compute each year.

Amount of compute and number of data points required to achieve 80.9% accuracy on an image recognition test



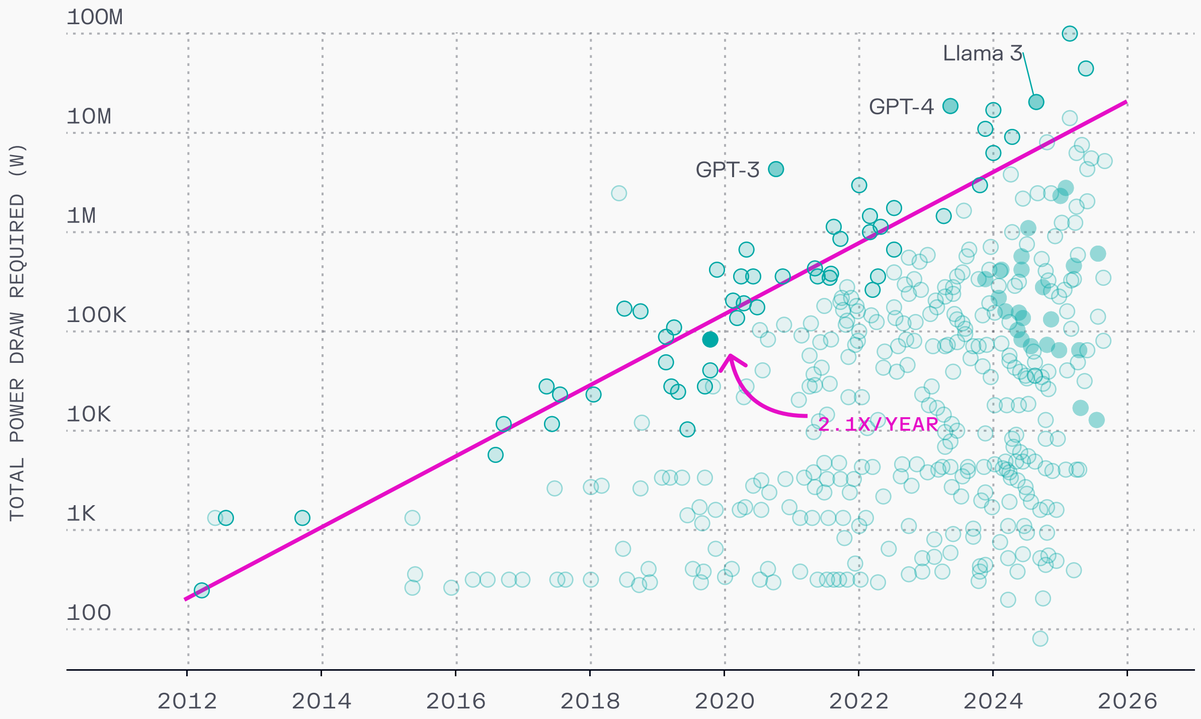
Source: Epoch AI; ResNeXt-101 computer vision system on the ImageNet benchmark. Compute is measured in FLOPs (floating-point operations). Data is measured in the number of images in the training set.

As AI adoption has occurred, inference costs have started to decline across models, both proprietary and open source.



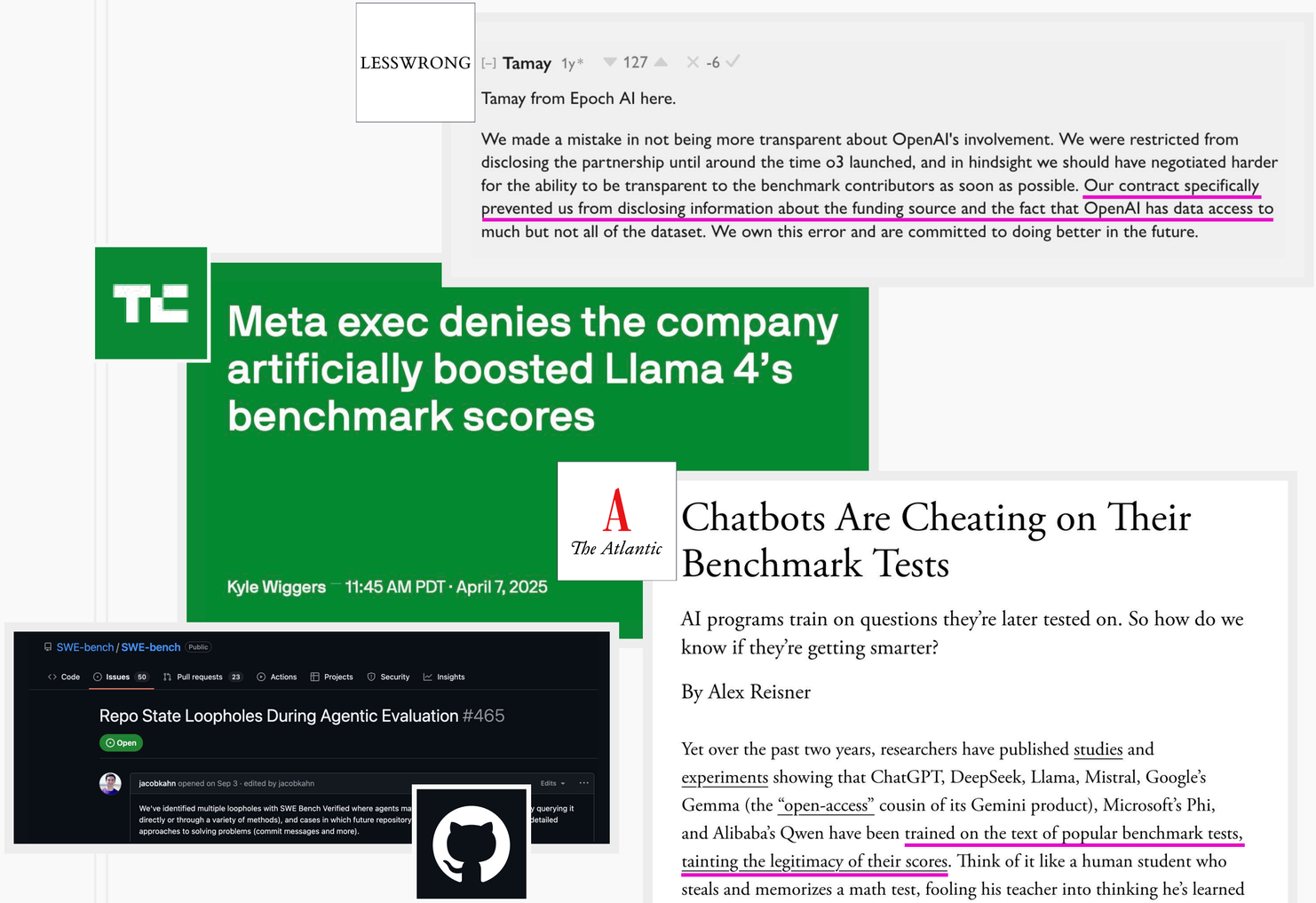
Source: Stanford AI Index 2025

However, power consumption across models has continued to rise significantly as usage increases.



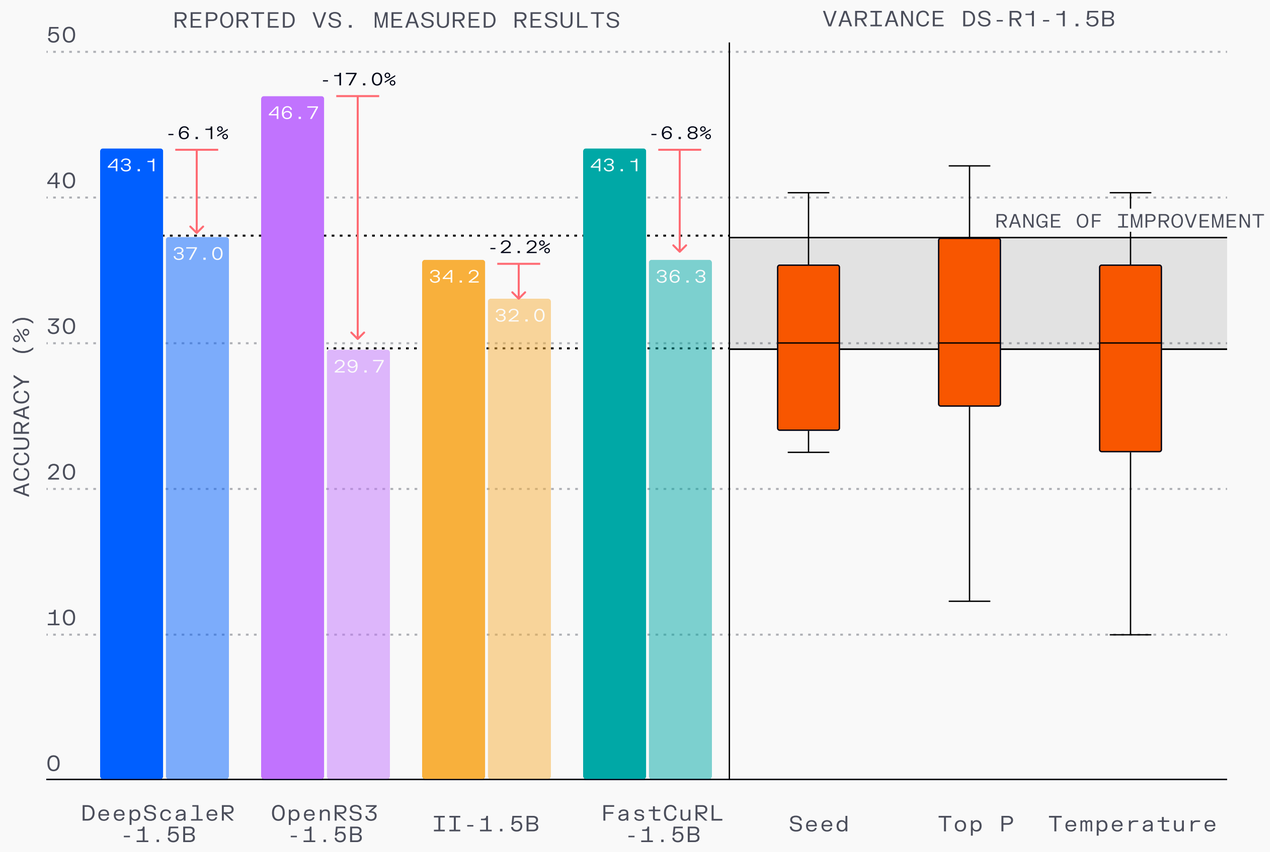
Source: Epoch AI

Despite model improvements, skeptics of model performance cite models accessing benchmark data in training, and issues with benchmark test configurations.



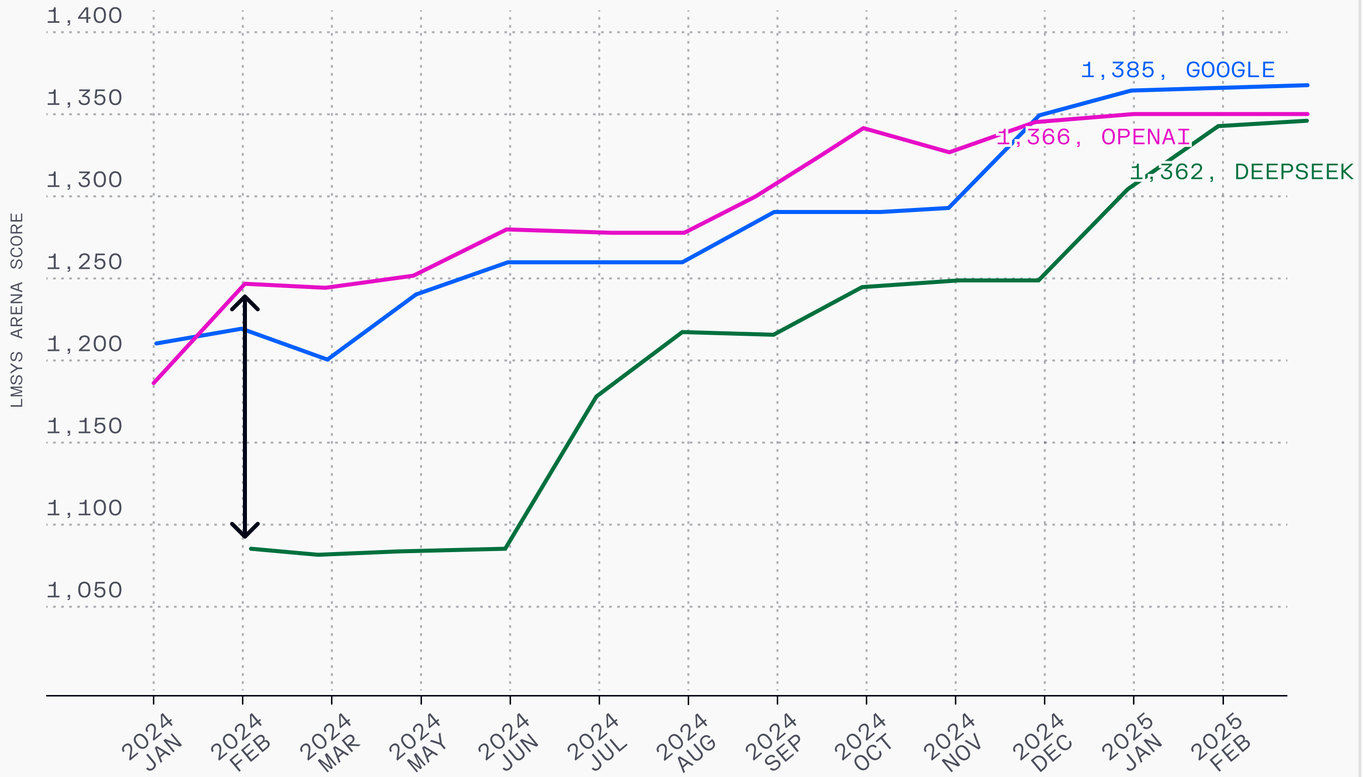
Source: TechCrunch, The Atlantic, LessWrong

Some improvements are described as “meaningful” but don’t account for variation between model runs, which often indicate improvements are not statistically significant.



Source: “A Sober Look at Progress in Language Model Reasoning: Pitfalls and Paths to Reproducibility”, Hochlehnert et al

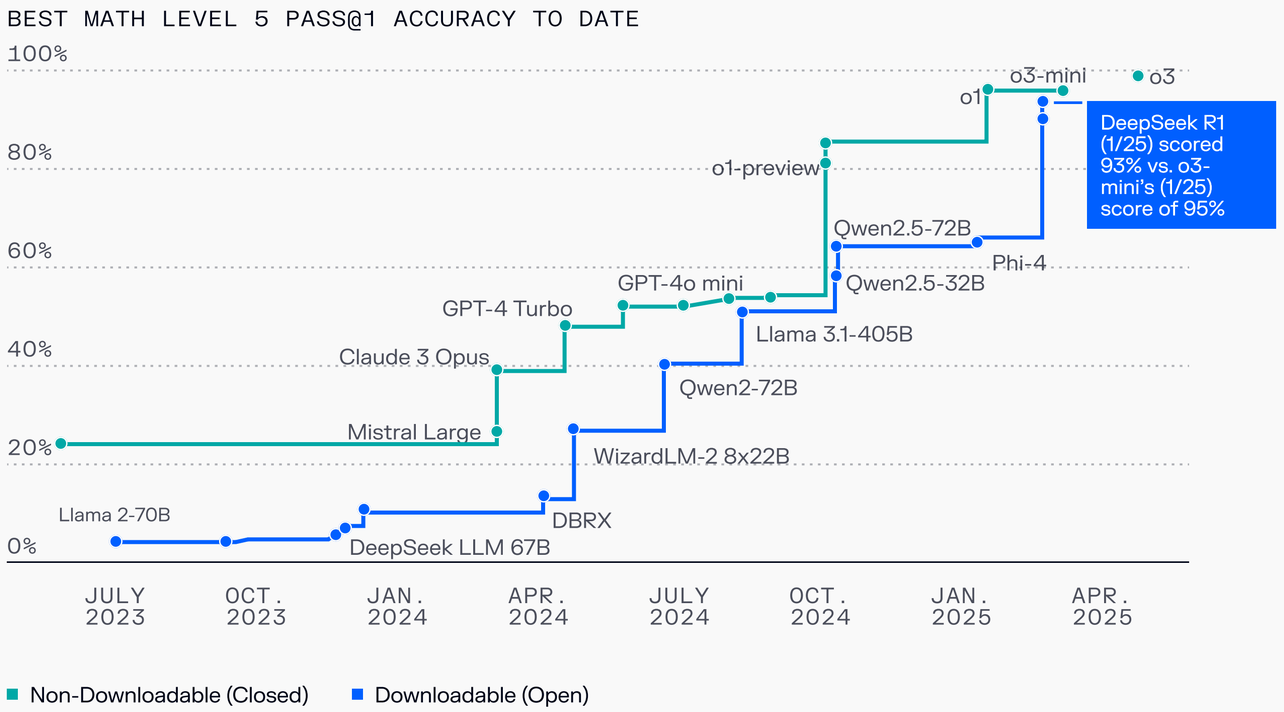
DeepSeek's rapid progress in early 2025 sparked a renewed interest in open source models.



Source: Stanford AI Index 2025; Nestor Maslej et al.

In particular, DeepSeek's ability to achieve comparable scores on complex benchmarks was an important milestone for open source.

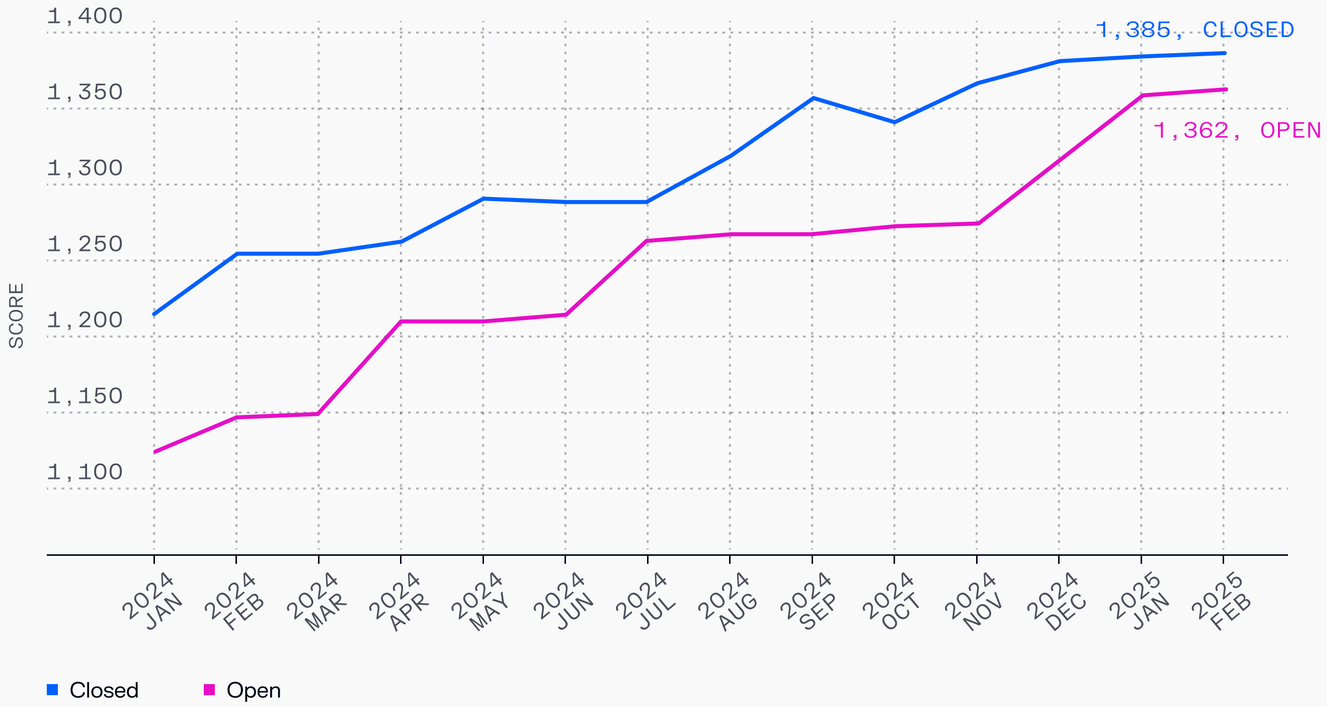
Performance on MATH Level 5 Test, Open vs. Closed LLMs by Year Released



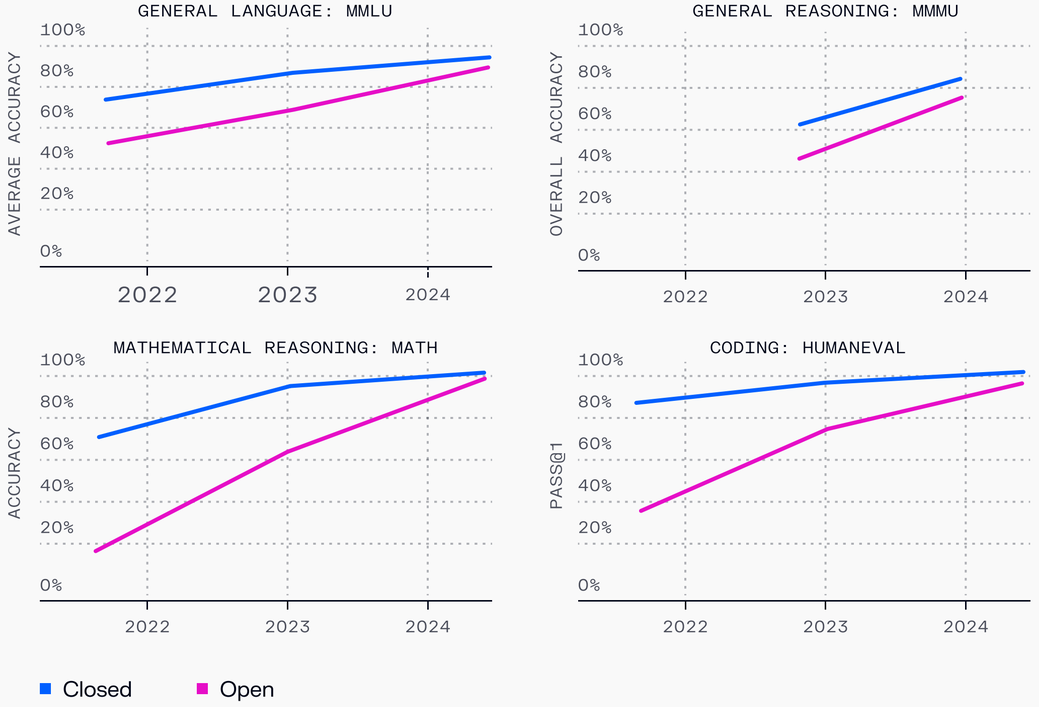
Source: Epoch AI; MATH Level 5 pass@1 refers to the accuracy of an AI model on the MATH benchmark, a dataset of high school competition-level mathematics problems. Level 5 indicates the most challenging problems in the benchmark. 'pass@1' measures whether the model correctly solves the problem on its first attempt.

Open source, in general, has continued to close the gap in terms of both popularity and performance on specific benchmarks.

Performance of top closed vs. open models on LMSYS Chatbot Arena



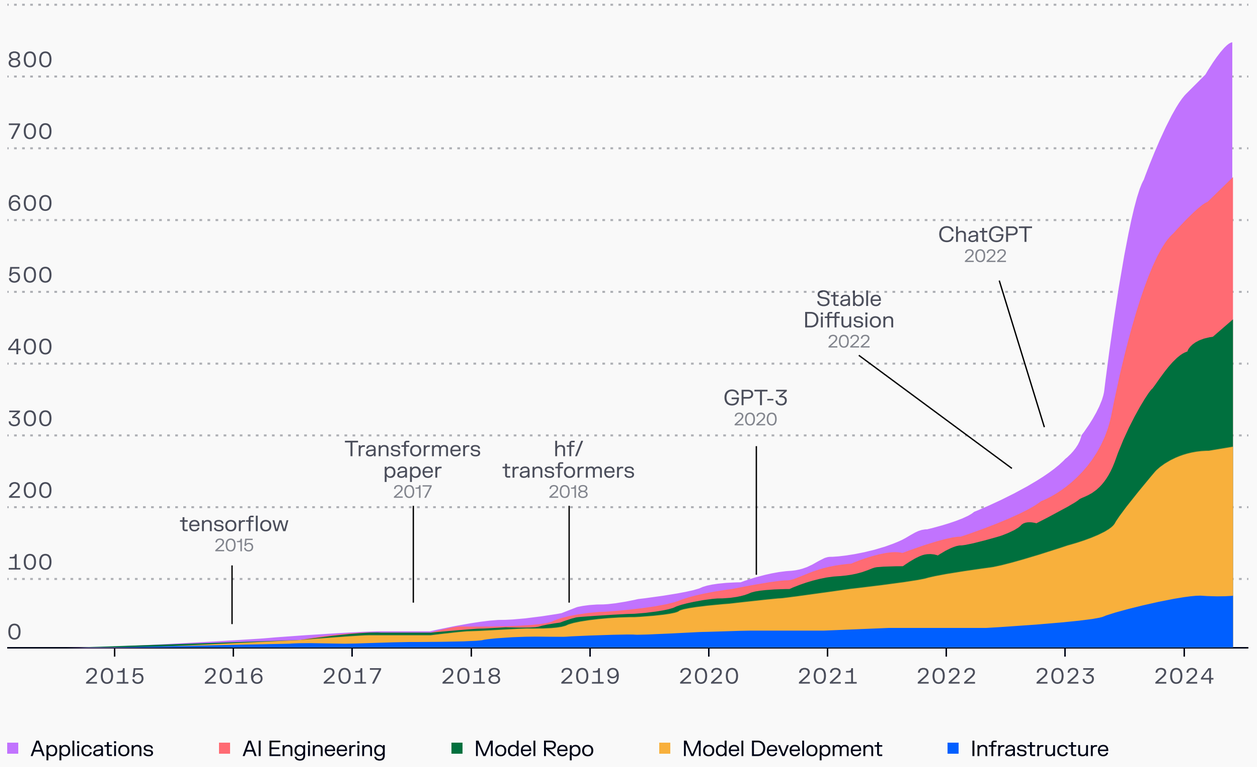
Performance of top closed vs. open models on select benchmarks



Source: Stanford AI Index 2025

Across AI repos on GitHub; Chinese open source stands out, with 6 out of 20 of the most popular AI accounts originating in China.

Number of AI Developer Repositories on Github

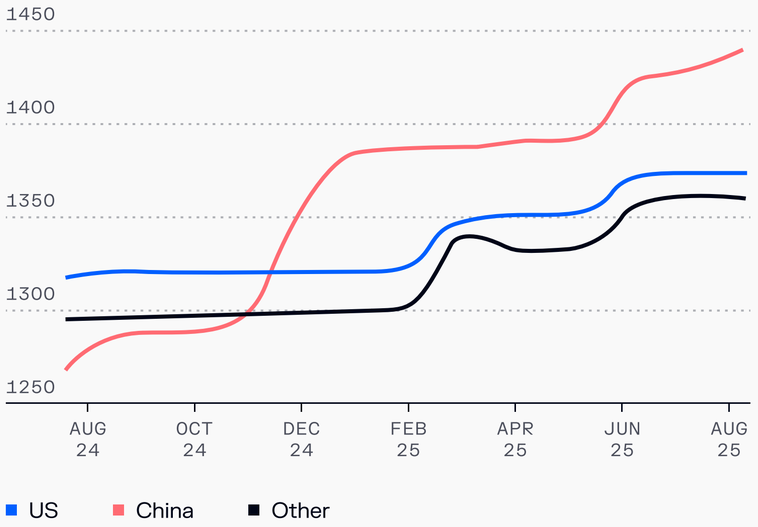


Source: Chip Huyen via GitHub

Over the course of 2025, China's open models have begun to overtake the open ecosystem in the West.

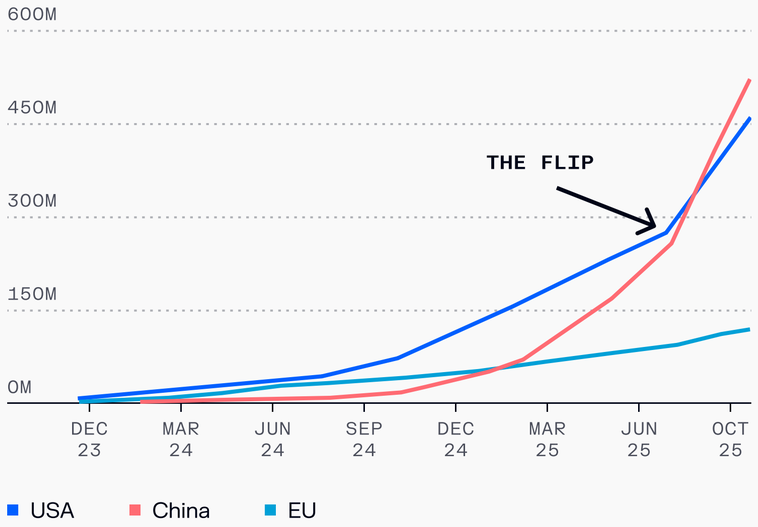
Community Elo Rankings

MONTHLY PERFORMANCE RANKINGS

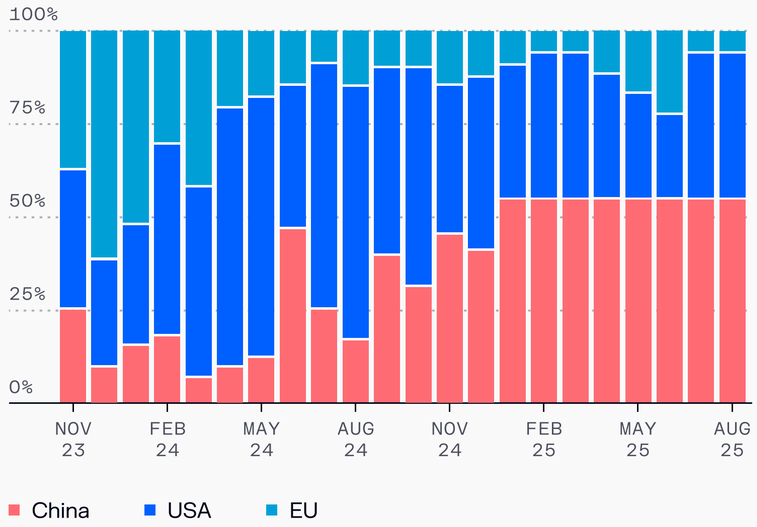


Models Worldwide

CUMULATIVE DOWNLOADS

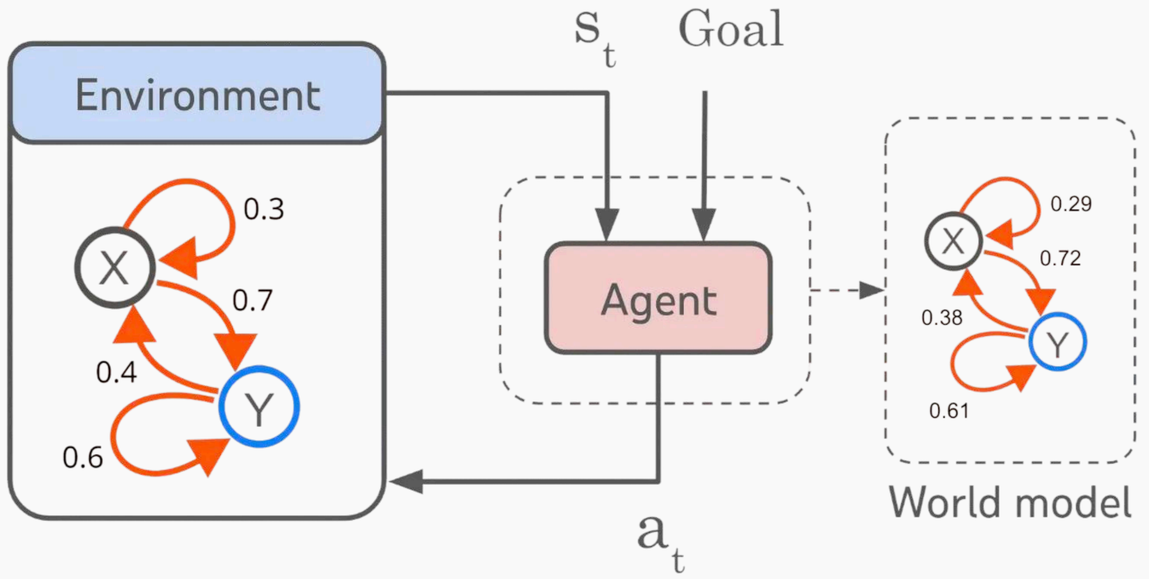


Global Regional Model Adoption by Month



Source: ATOM Project via The State of AI Report 2025

Despite the initial success of LLMs, many AI researchers are focused on World Models as an alternative to transformer architecture. World Models build 3D environments with internally consistent physics and persistent memories.



Source: Richard Suwandi

Yann LeCun, former Chief Scientist at Meta AI, has described World Models as capable of answering the question

"If I take action X, what will be the state of the world?"

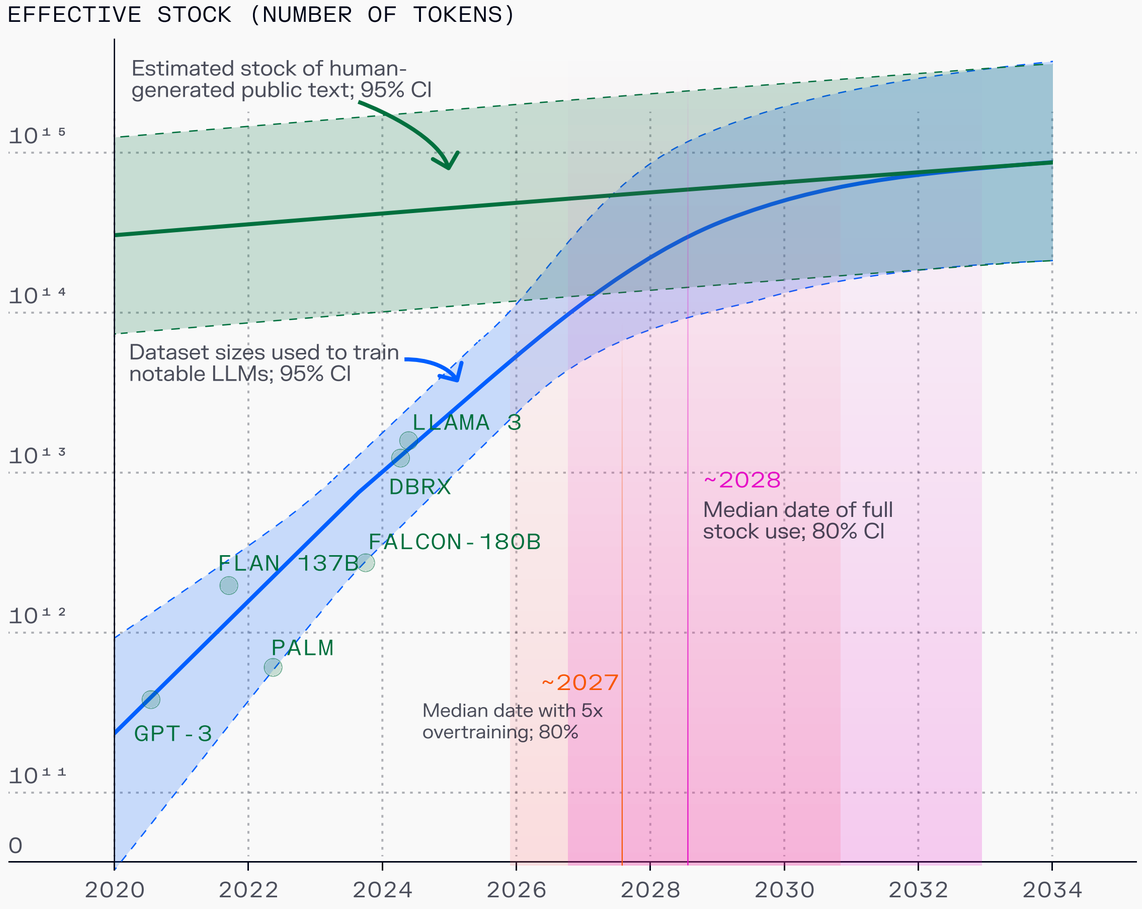
World Models are particularly suited to research that requires simulating complex physical environments with lower volumes of existing data. Such applications range from protein folding and particle physics simulations to testing space or underwater operations.

Yann LeCun speaking at VivaTech Paris in June 2025

Source: Sky News

World Models may also become relevant for creating sets of simulated data used to further train existing AI models as the corpus of existing human-generated data is exhausted.

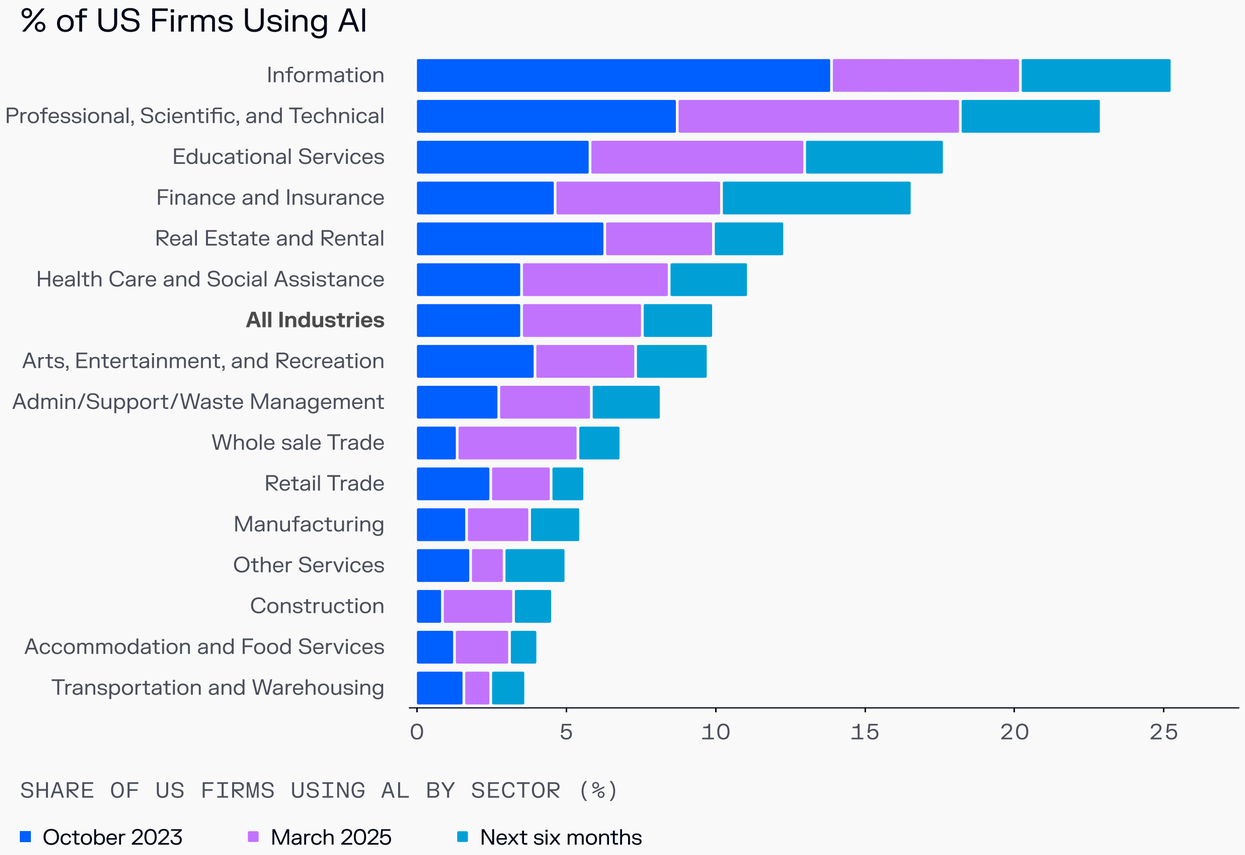
Projections of the stock of public text and data usage



Source: Epoch AI

AI Adoption: Is AI Eating The World?

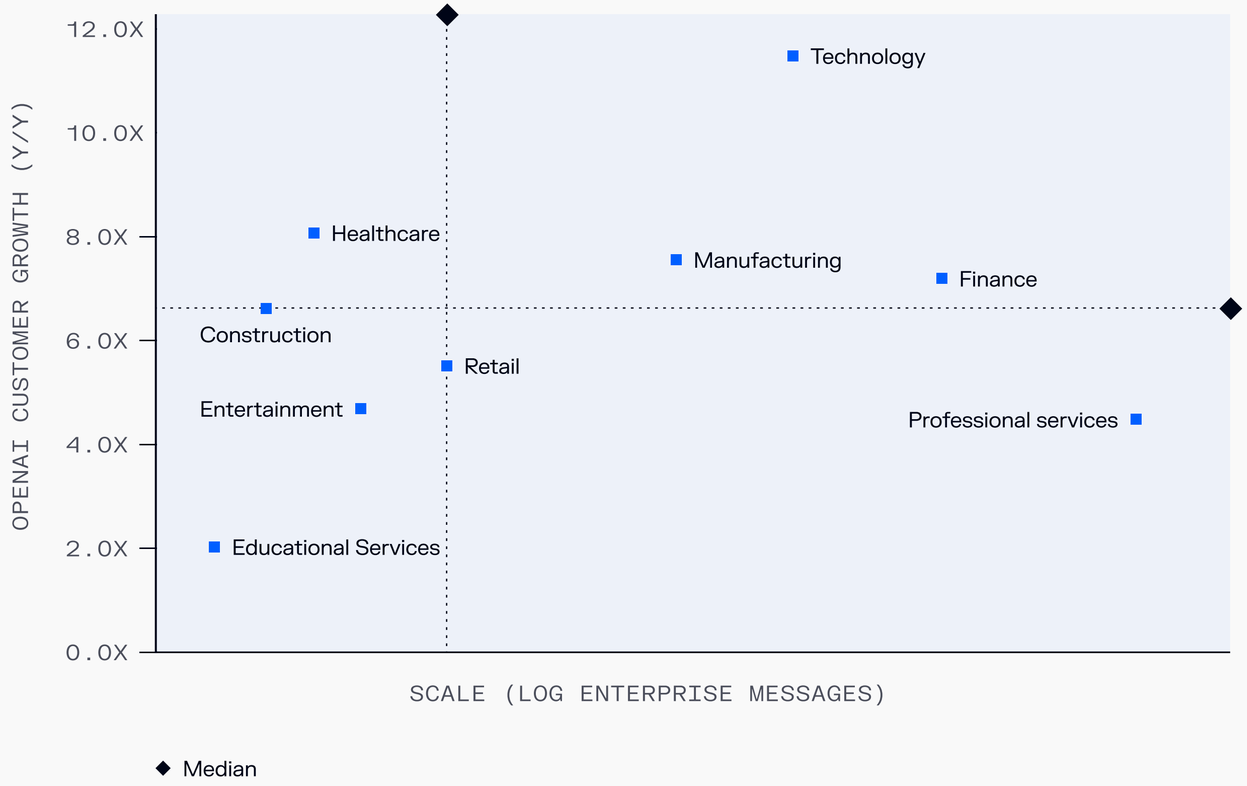
~10% of companies had adopted AI as some part of their products or services as of May 2025.



Source: Census Bureau's BTOS (Business Trends & Outlook Survey) via Goldman Sachs Global Investment Research, '2025 Q1: Adoption Makes Modest Progress, Labor Impacts Still Negligible'; Question asked was 'In the last six months, did this business use Artificial Intelligence (AI) in producing goods or services?' BTOS data are representative of all employer businesses in the USA economy, excluding farms. The BTOS sample consists of approximately 1.2MM businesses with biweekly data collection.

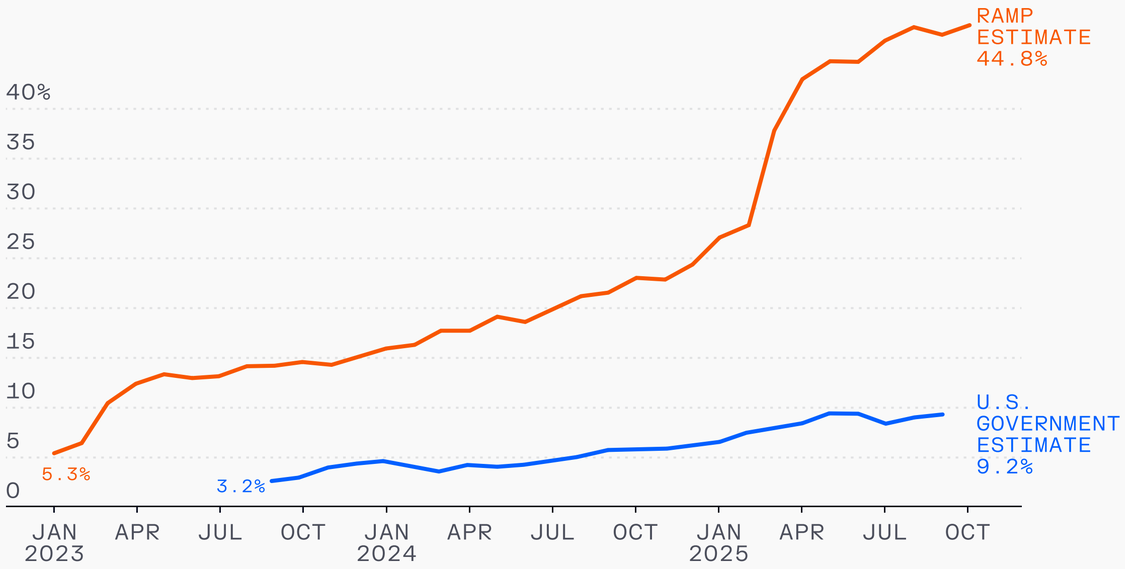
Technology, manufacturing, and finance have been quickest to adopt AI while education and entertainment have been the slowest.

AI adoption by industry: enterprise scale vs. year-over-year growth



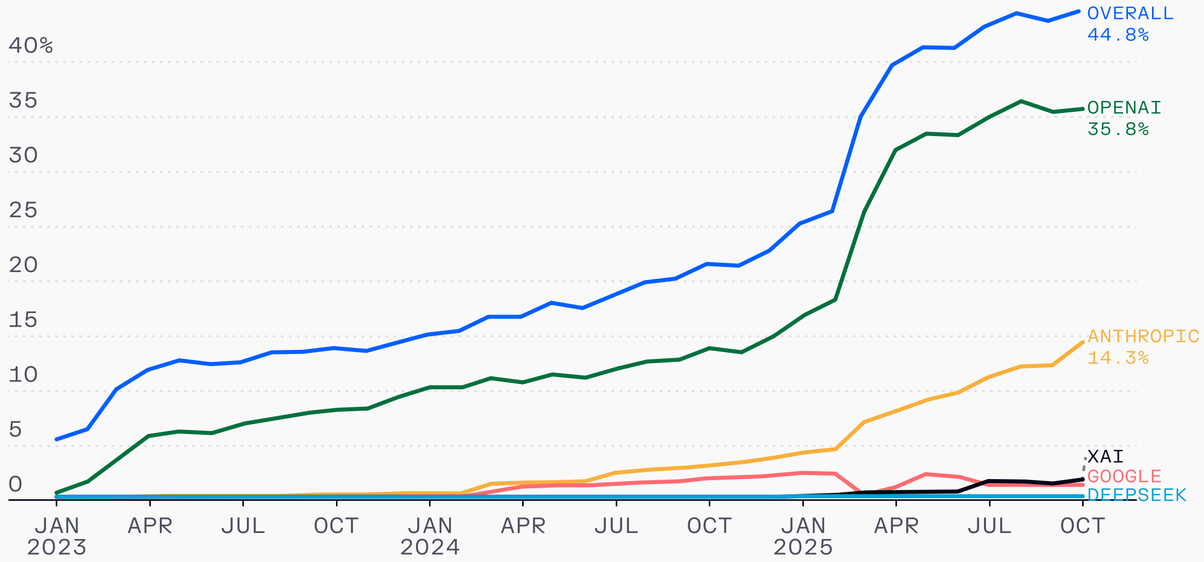
Source: OpenAI's State of Enterprise AI 2025 Report

In terms of general usage, some estimates indicate ~44.8% of US businesses have a paid subscription to some kind of AI model, platform, or tool.



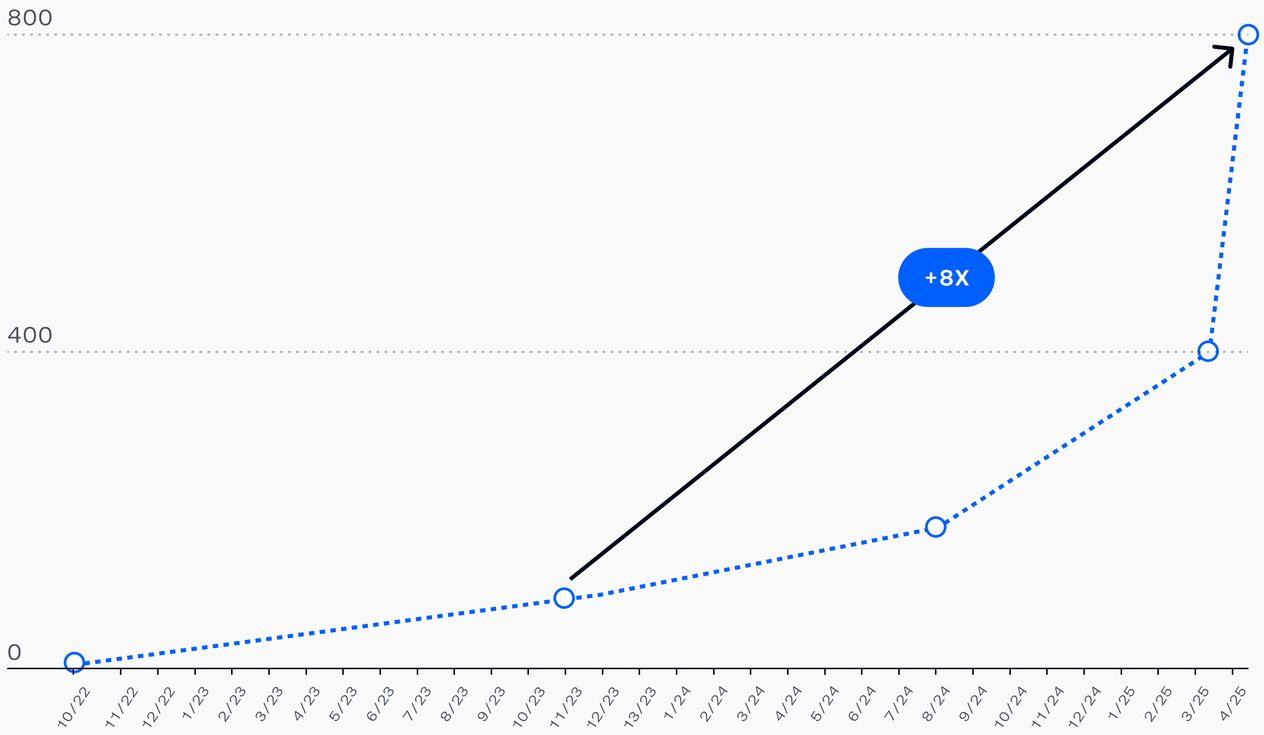
Source: Ramp AI Index; US Census Bureau

OpenAI's products, including ChatGPT in particular, represents a meaningful portion of that adoption across companies.

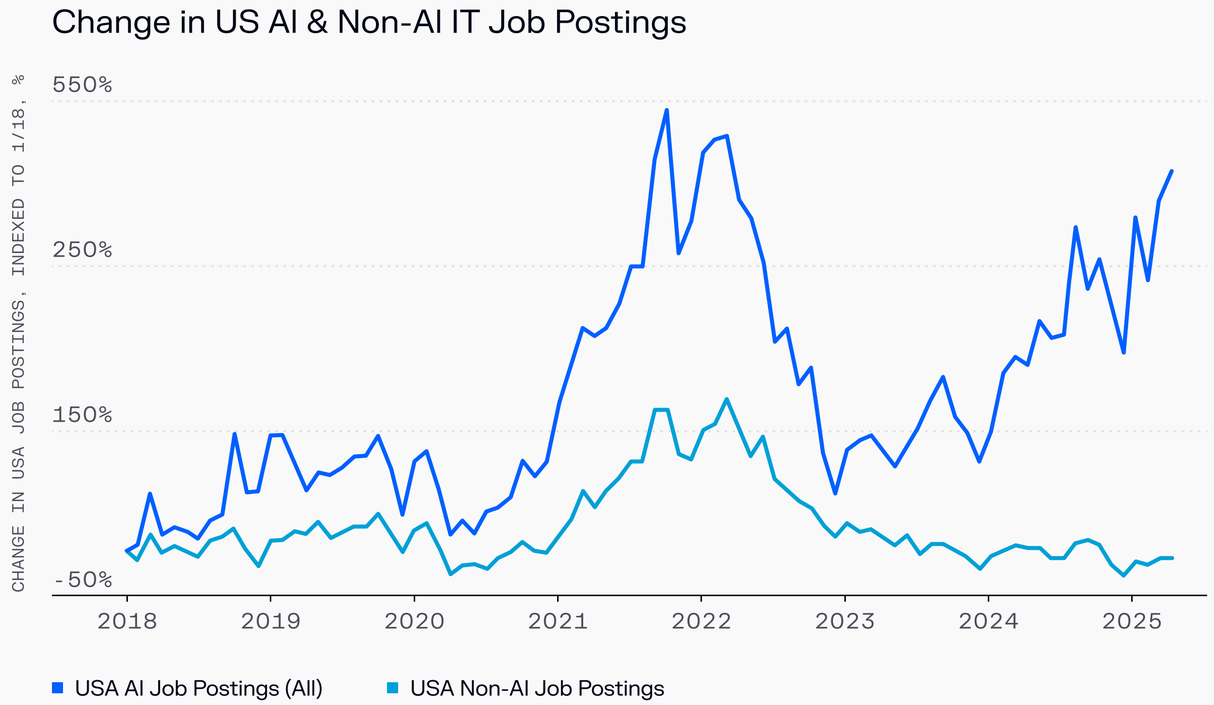


Source: Ramp AI Index; US Census Bureau

From the end of 2023 to April 2025, ChatGPT grew 8x to reach 800 million weekly active users.



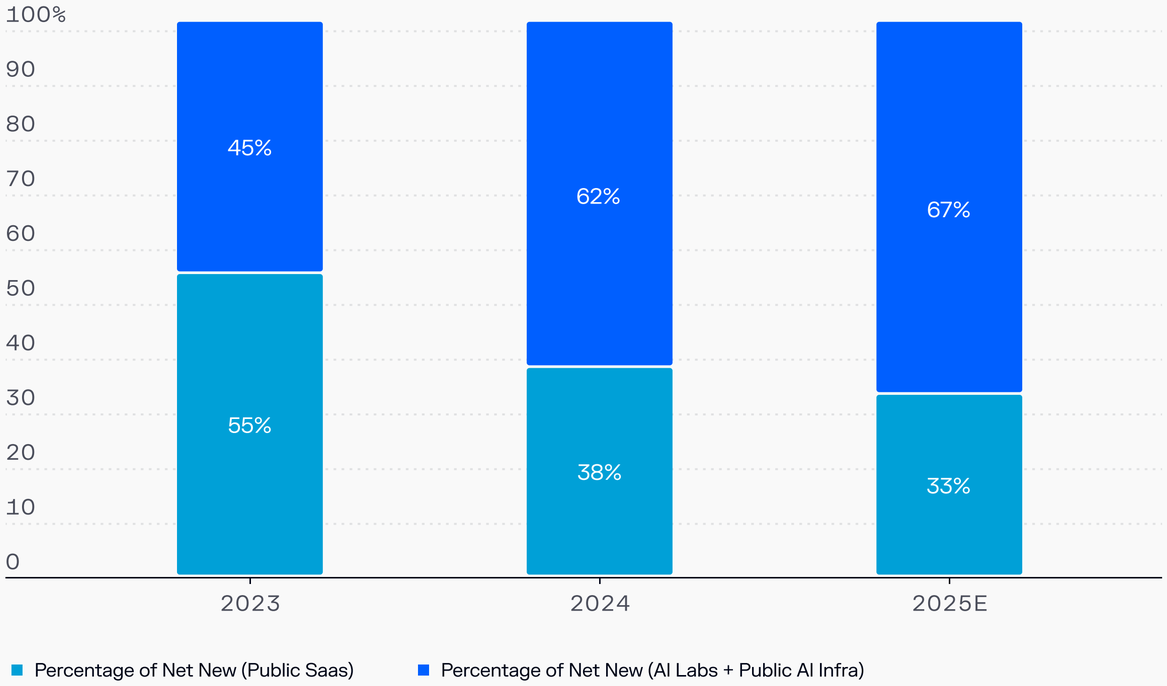
In addition, job postings requiring AI skills have seen a notable rise.



Source: University of Maryland's UMD-LinkUp AIMaps (in collaboration with Outrigger Group); 'AI Job' refers to a job posting that requires AI skills. AI skills requirement in job postings determined using University of Maryland's language processing model. USA-based jobs only. Figures are rounded.

Over the last three years, AI labs and public AI infrastructure companies have drawn an increasingly large percentage of net new ARR relative to traditional public SaaS.

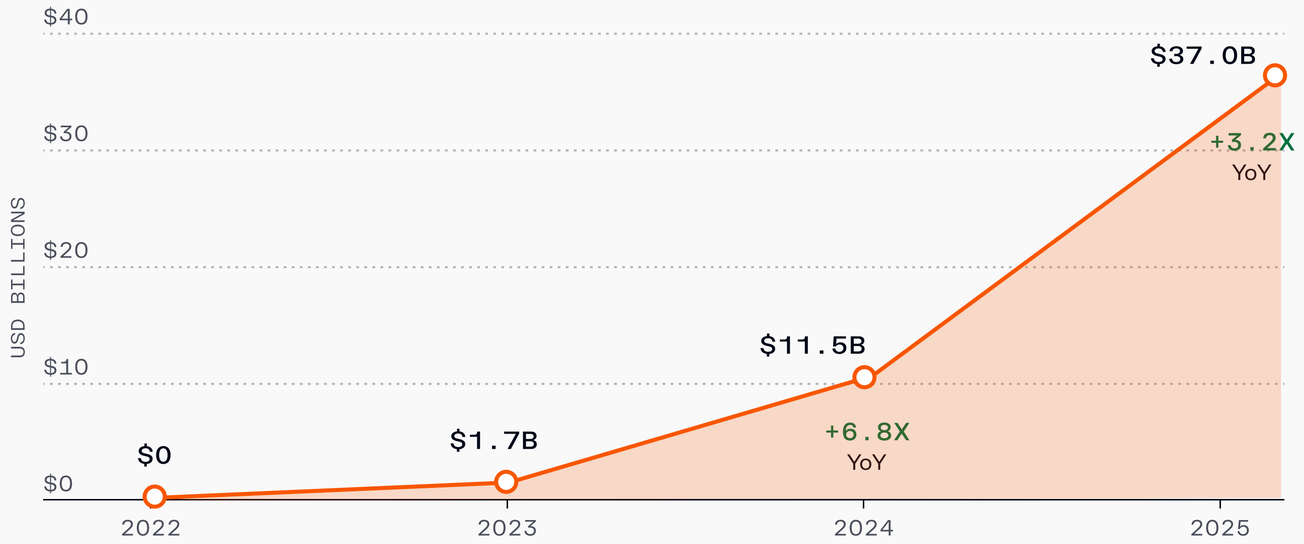
Net New Revenue: Public SaaS vs. AI Labs + Public AI Infra



Source: CapIQ; Meritech; Public AI infra includes Nebius Group, Nvidia Datacenter revenue and CoreWeave. Public Saas includes 100+ pureplay public SaaS companies

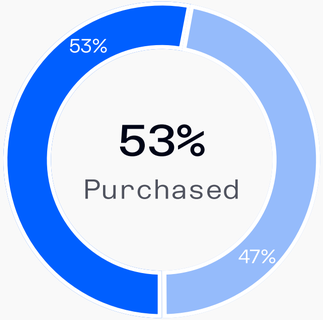
Enterprise AI, overall, is now capturing 6% of the $300 billion global SaaS market as it has scaled incredibly fast since 2022.

Enterprise AI Revenue



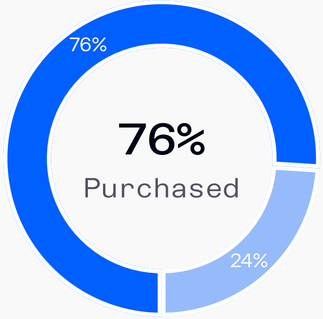
Source: Gartner

Rather than build AI-enabled tools internally, enterprises have increasingly opted to purchase the tools they're using.



AI Adoptions Method: 2024

■ Purchased ■ Built Internally



AI Adoptions Method: 2025

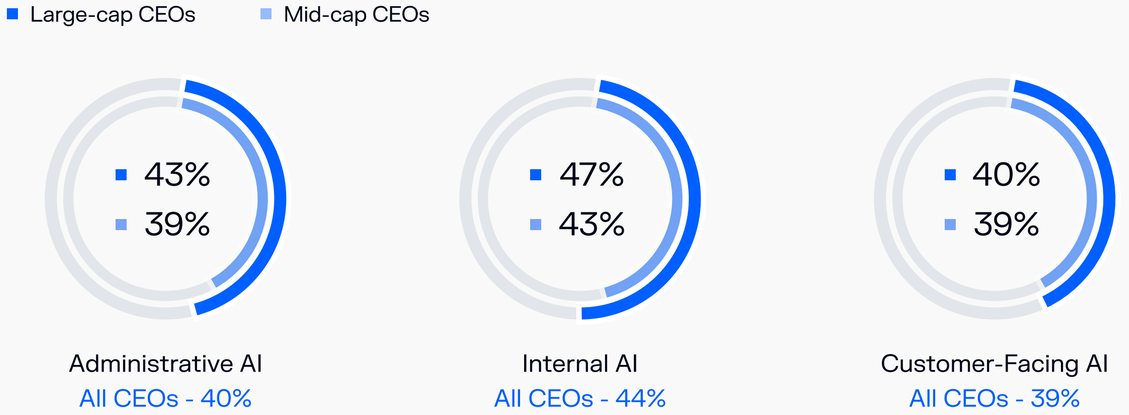
■ Purchased ■ Built Internally

Source: Aaron Chatterji, Tom Cunningham, David J. Deming, Zoë Hitzig, Christopher Ong, Carl Shan & Kevin Wadman, How People Use ChatGPT, NBER Working Paper No. 34255, September 2025

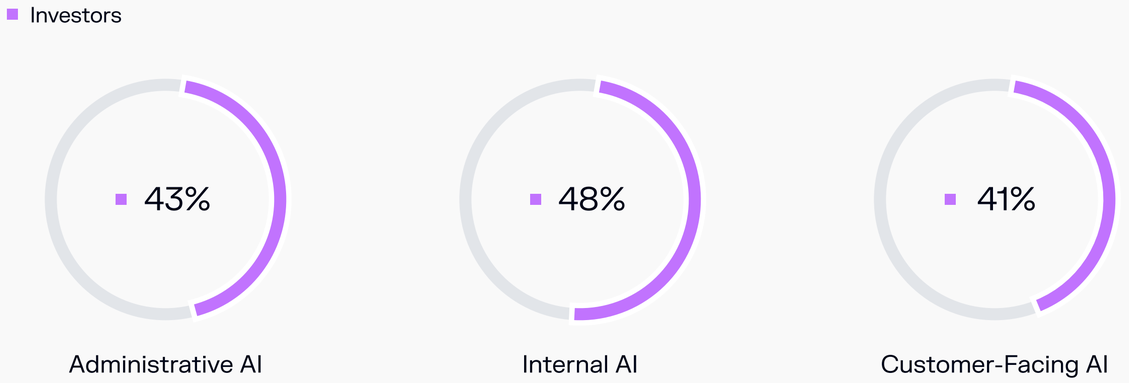
Despite ~60% of public company CEOs saying AI projects have yet to deliver a positive ROI, that isn't stopping 68% of CEOs from saying they plan to increase AI spending in 2026.

Question:
What percentage of AI projects have delivered a tangible ROI?

CEOs (Performance)

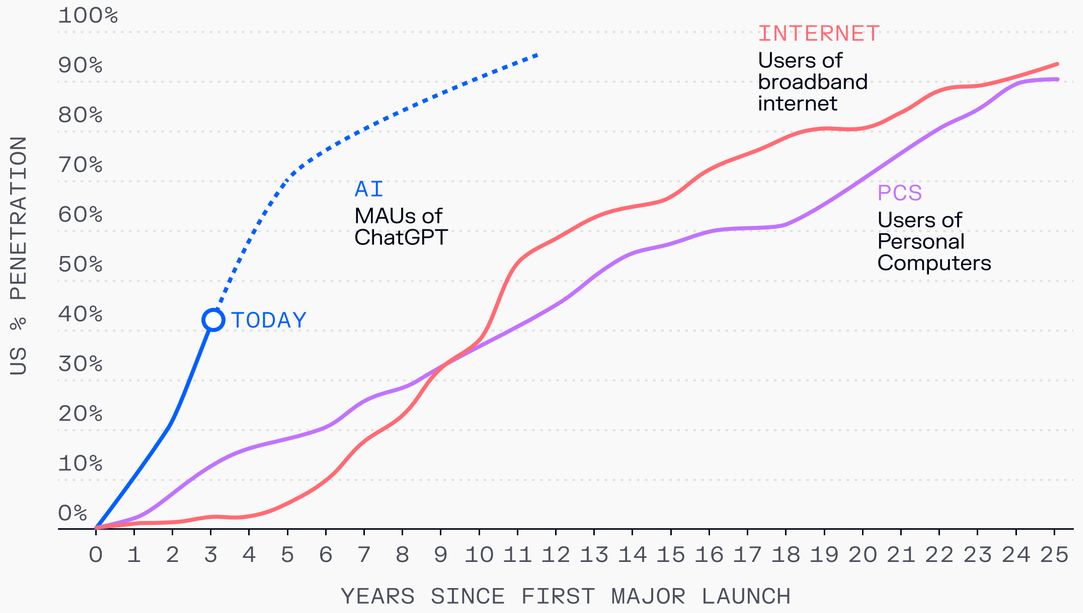


Investors (Expectation)



Source: Teneo

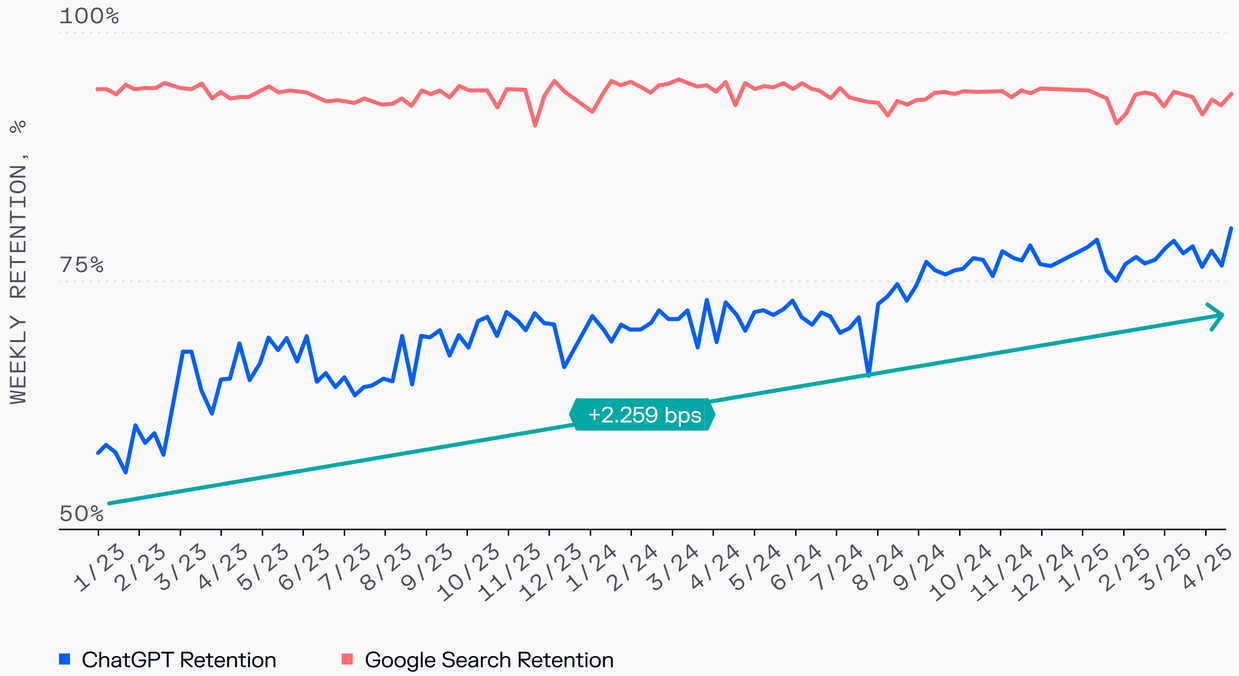
In terms of consumer adoption, ChatGPT has seen a dramatically accelerated adoption curve relative to the internet or personal computers.



Source: Morgan Stanley (PC); World Bank (Internet); Coatue (AI) analysis as of November 2025 (AI = US MAU ChatGPT estimate as determined by Coatue).

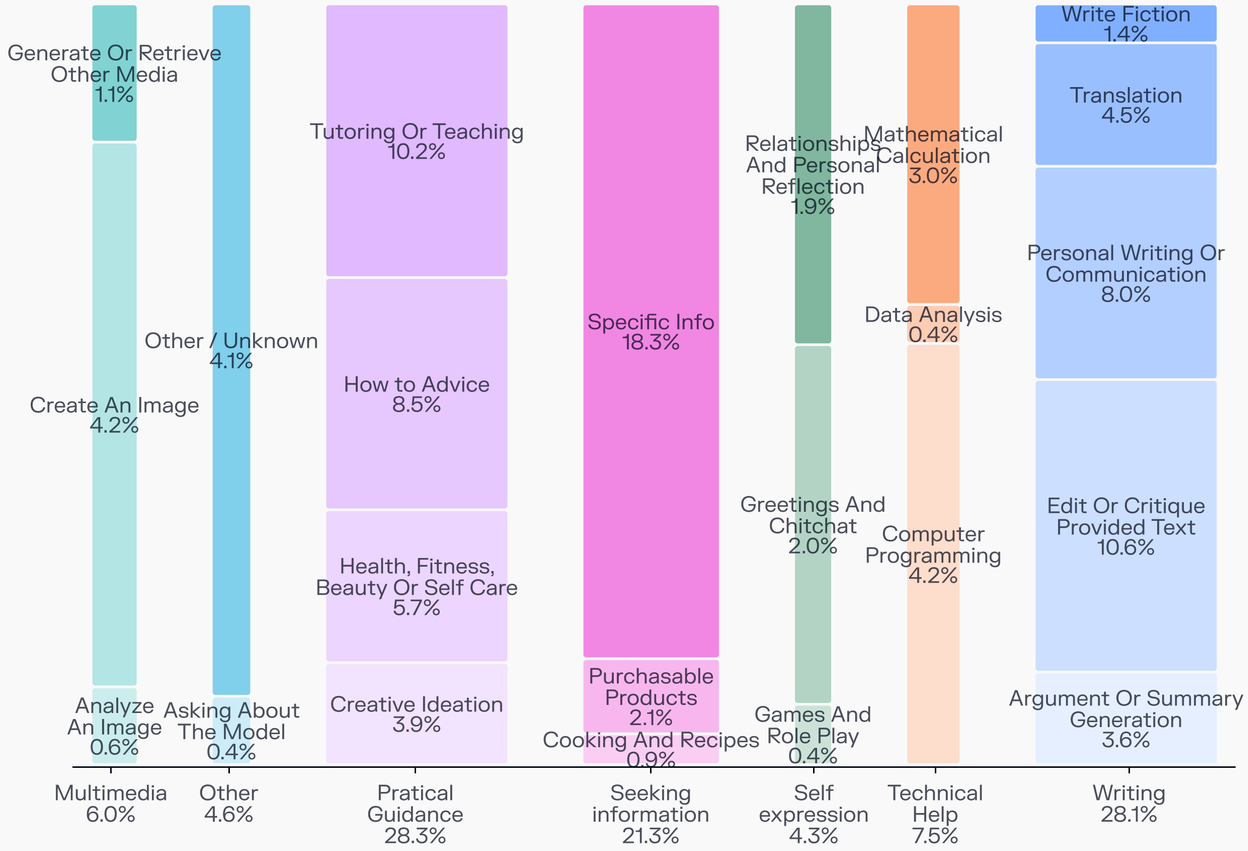
In addition, ChatGPT has seen rising weekly retention rates, approaching that achieved by Google search.

Consumer ChatGPT & Google Search Global Desktop User Retention Rates



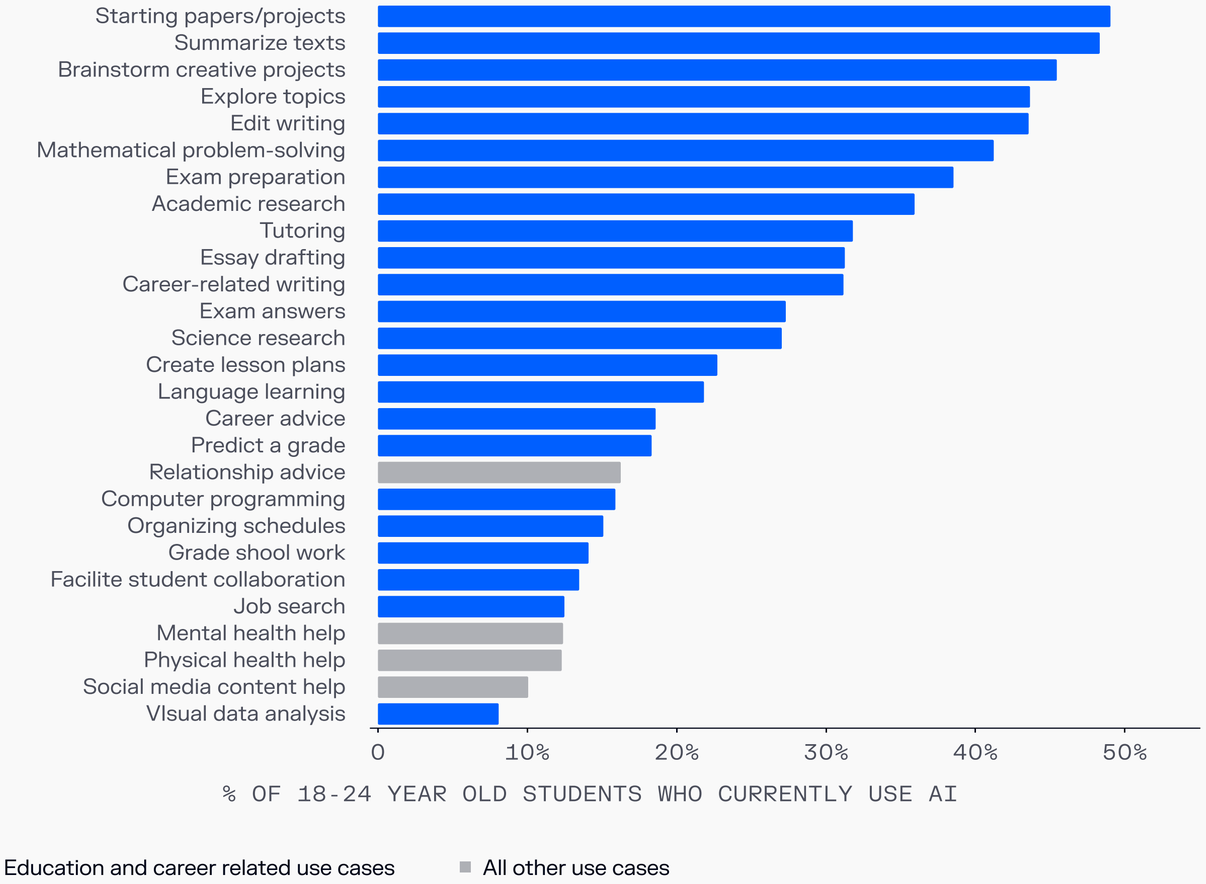
Source: YipitData; Note: Retention Rate = Percentage of users from the immediately preceding week that were users again in the current week. Data measures several million global active desktop users' clickstream data.

ChatGPT use cases primarily include practical guidance, writing, and seeking information.



Source: OpenAI; Each bin reports a percentage of the total population. Shares are calculated from a sample of approximately 1.1 million sampled conversations from May 15, 2024 through June 26, 2025. Observations are reweighted to reflect total message volumes on a given day.

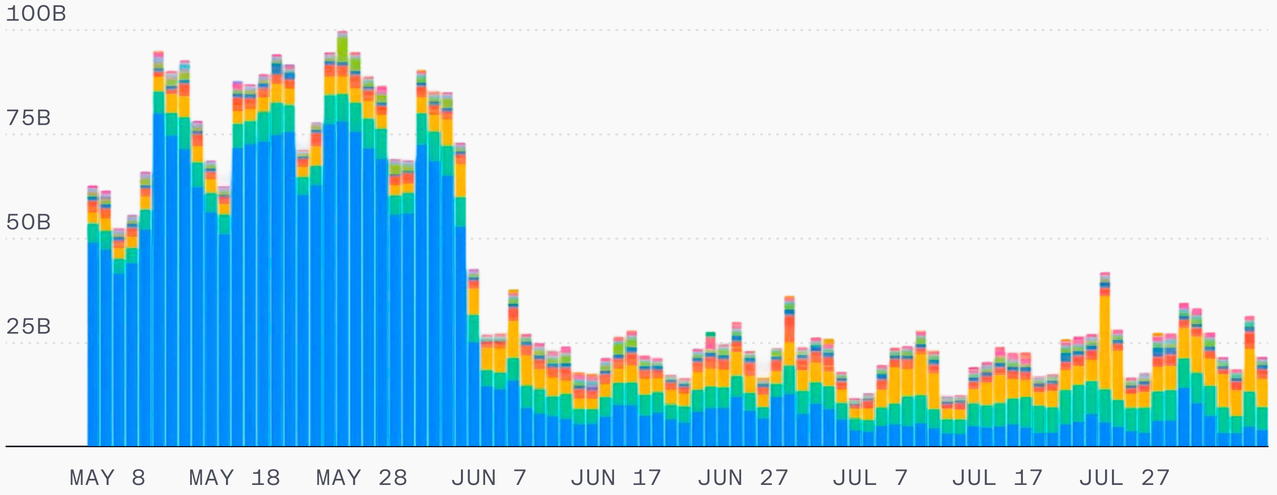
Among users ages 18-24, use cases around starting papers and summarizing texts have reached almost 50% penetration.



Source: OpenAI, 'Building an AI-Ready Workforce: A Look at College Student ChatGPT Adoption in the US'

The fact that younger user groups focus on education use cases of ChatGPT is indicated by the fact that usage sees a notable drop off when school ends.

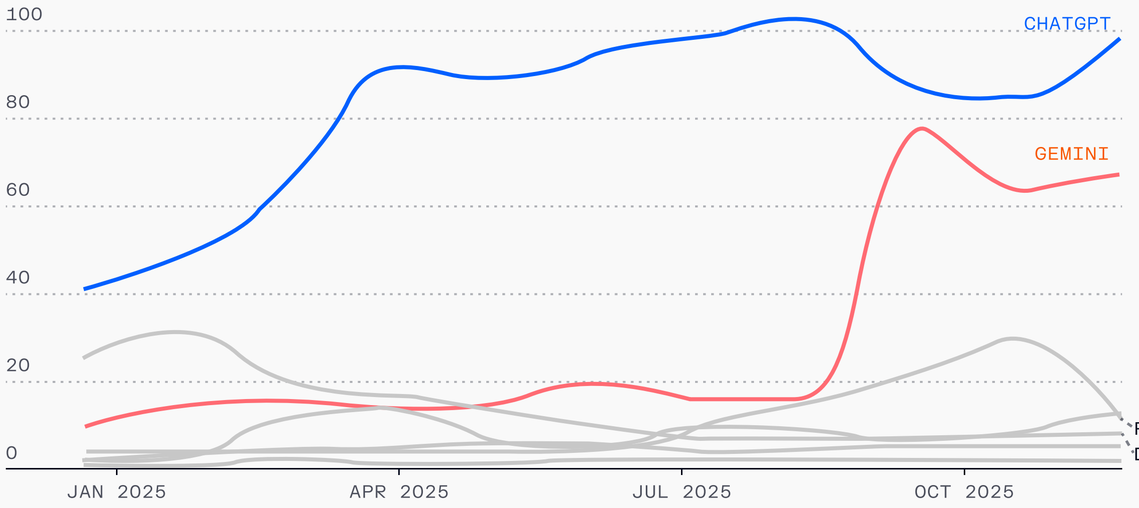
Tokens Processed



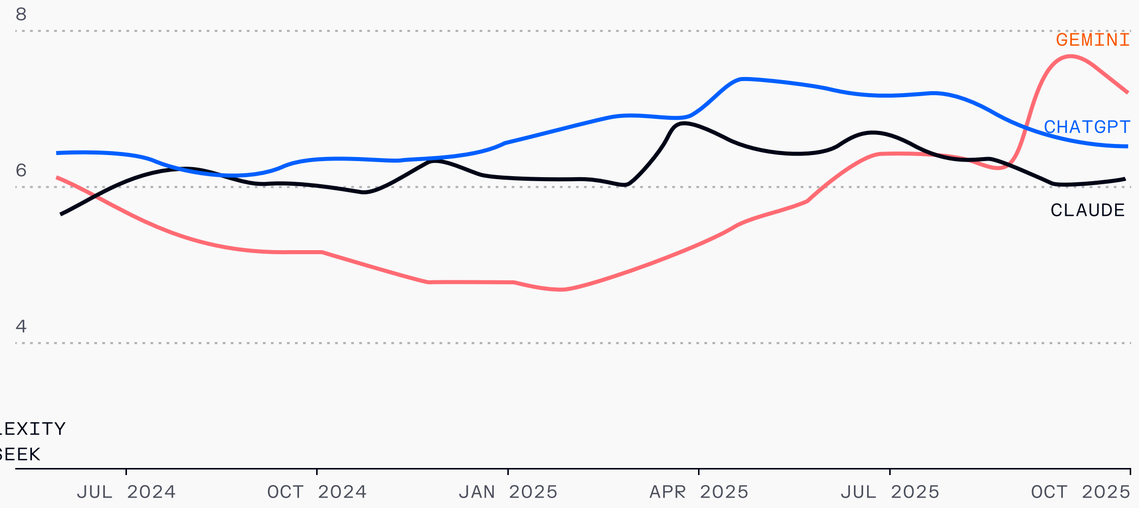
Source: OpenRouter LLM usage from 2.5 million users

However, other AI products, like Google's Gemini, are starting to catch up with ChatGPT in terms of monthly downloads, or even surpass ChatGPT in terms of usage

Monthly Downloads (mn)



Average minutes spent per visit, desktop and mobile web



Source: Sensor Tower and SimilarWeb estimates

AI is poised to impact a number of different verticals meaningfully, across knowledge work, healthcare, legal, software engineering, and more.

U.S. labor spend across key roles

01 Knowledge Work

71m
Knowledge workers

×

$85k
Average salary

=

$6T+

Notion OpenAI

02 Medical

1M
Physicians

×

$400k
Average salary

=

$450B+

ABRIDGE OpenEvidence

03 Legal

1M
Lawyers

×

$150k
Average salrary

=

$200B+

Harvey Norm Ai

04 Software Development

2M
Software developers

×

$130k
Average salary

=

$250B+

CURSOR Windsurf

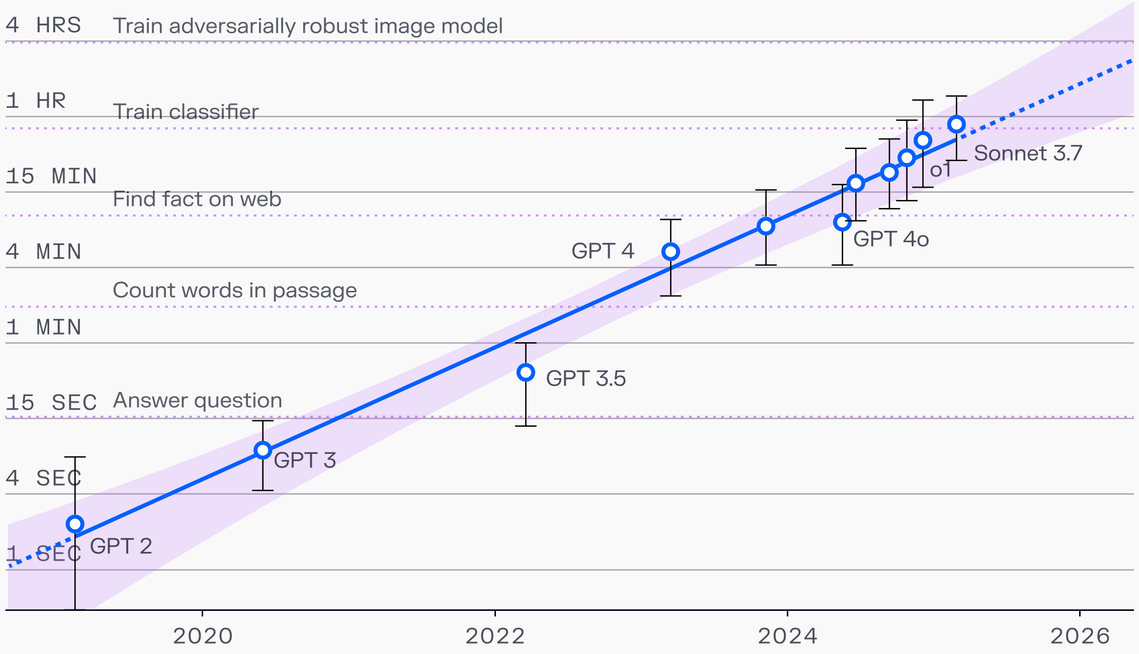
Source: Coatue; US BLS (Knowledge workers), Payscale, ABA (Legal), Doximity Physician Compensation Report (Medical) as of June 2025.

Already, AI companies are seeing a faster ramp to revenue than traditional SaaS.

Median time to annualized revenue milestone

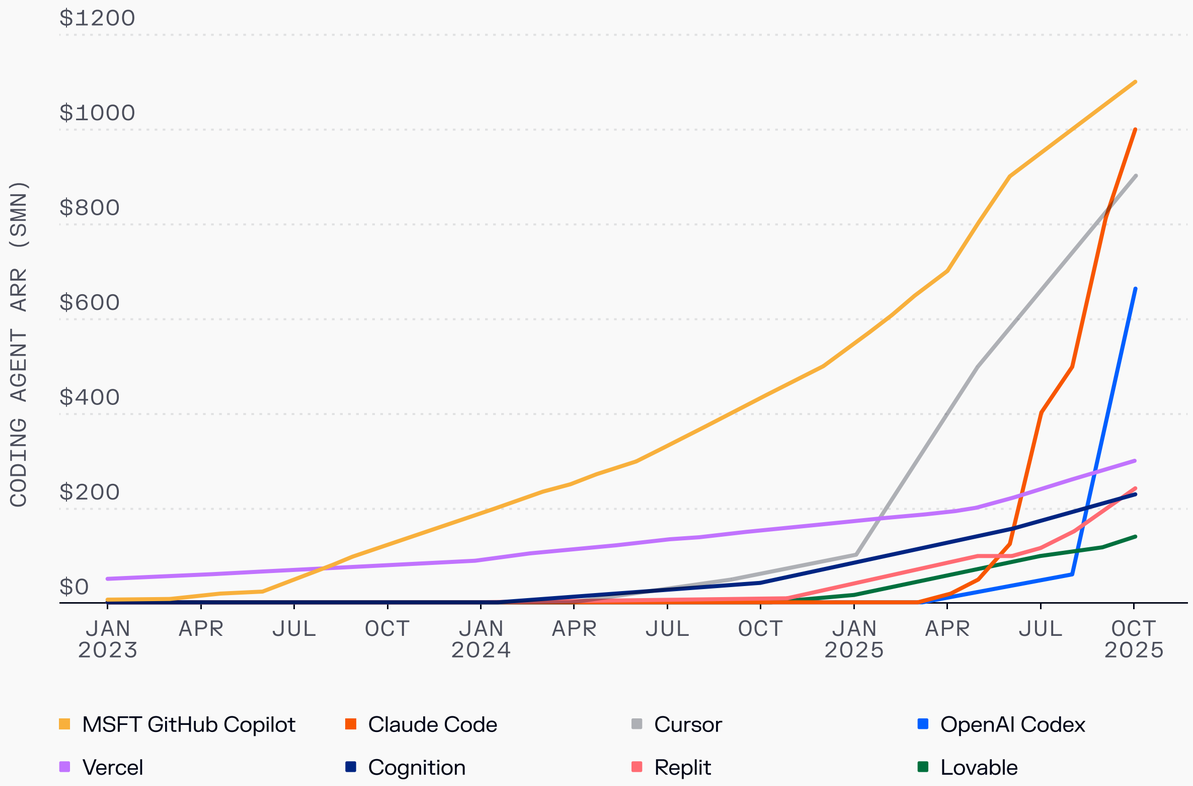
Source: Stripe

In coding, the length of tasks AI can do at a 50% success rate is doubling every seven months.



Source: Metr; The length of tasks (measured by how long they take human professionals) that generalist frontier model agents can complete autonomously with 50% reliability has been doubling approximately every 7 months for the last 6 years. The shaded region represents 95% CI calculated by hierarchical bootstrap over task families, tasks, and task attempts.

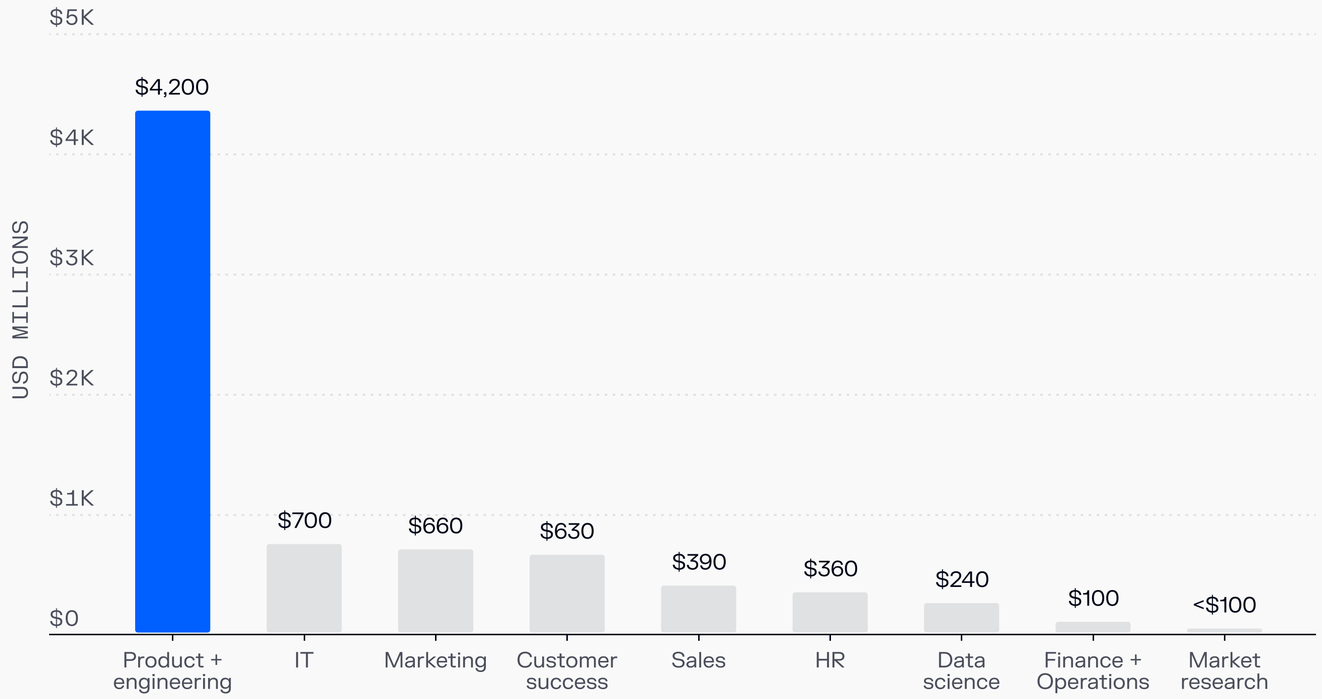
Coding agents like GitHub Copilot, Cursor, and Claude Code are at or approaching $1 billion in ARR.



Source: SemiAnalysis; company disclosures and announcements

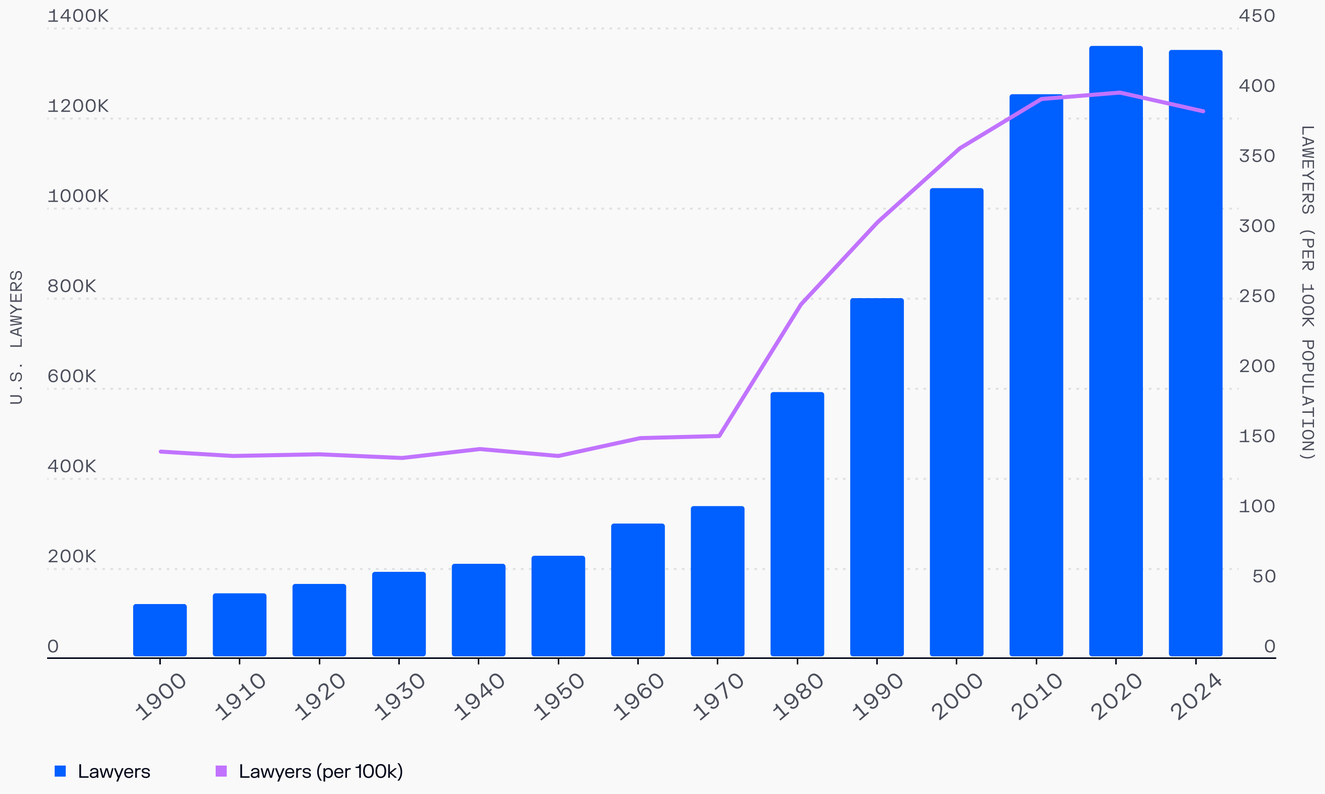
In fact, coding dominates as the category with the most departmental AI spend, far surpassing the likes of IT, marketing, etc.

Departmental AI Spend by Category



Source: Menlo Ventures

In legal work, the US has seen a massive increase in the number of lawyers over the last several decades, a trend that AI is beginning to reverse.

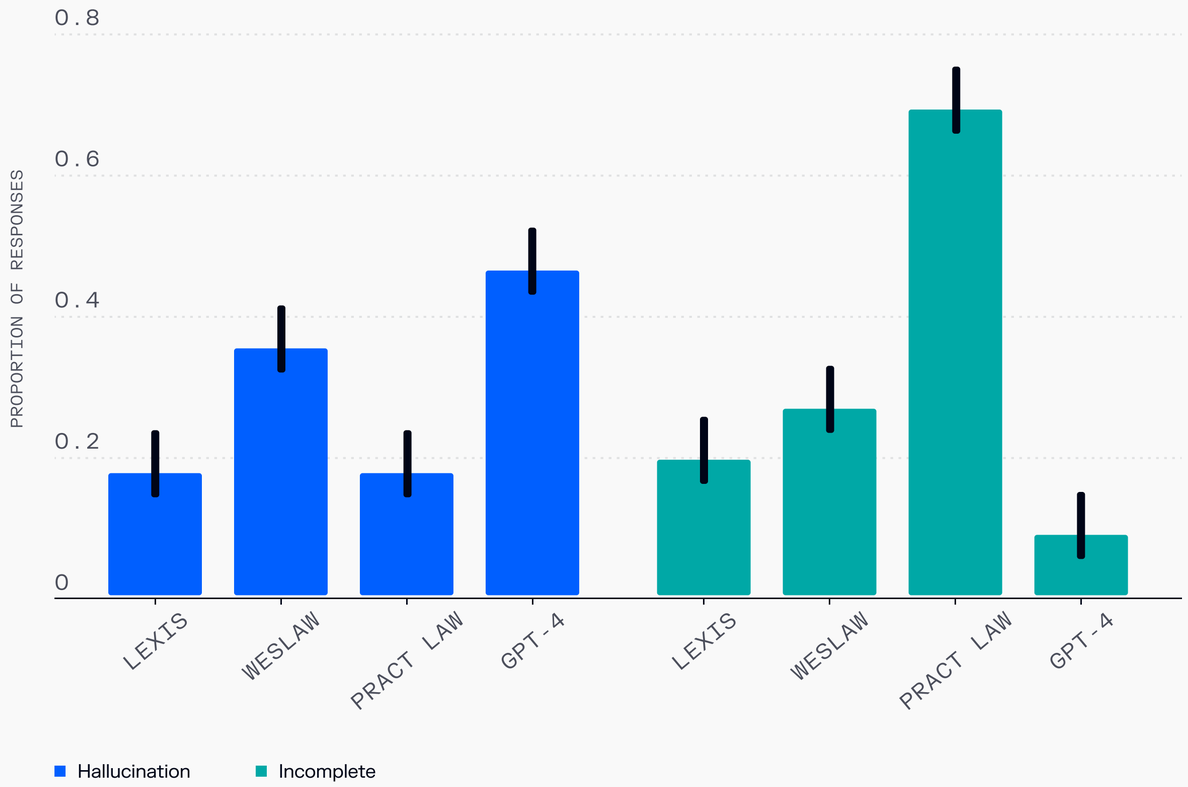


Source: American Bar Association

Already, law firms have seen material impacts from AI. Prominent law firm Clifford Chance, one of the largest international firms, reduced 10% of its London staff by embracing AI.

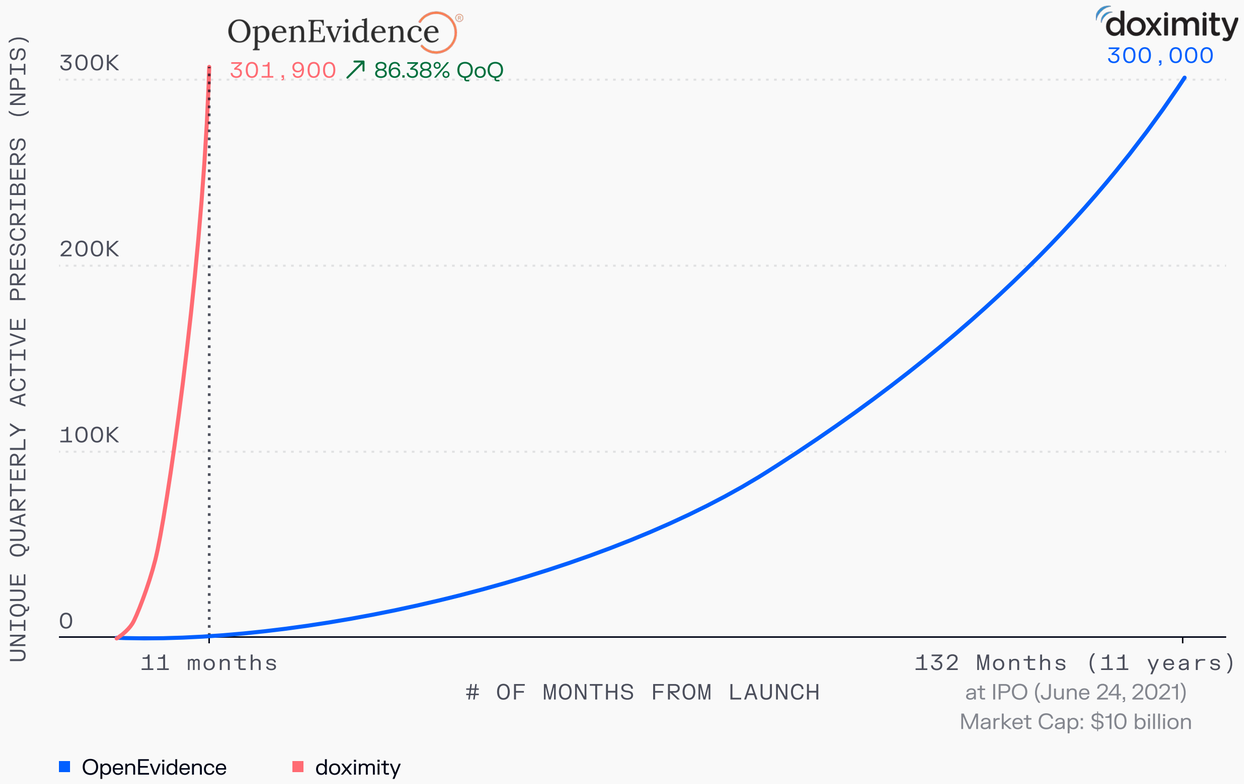
Source: The Guardian

However one analysis of legal-focused AI outputs found legal research tools were still generating hallucinations 17-33% of the time.



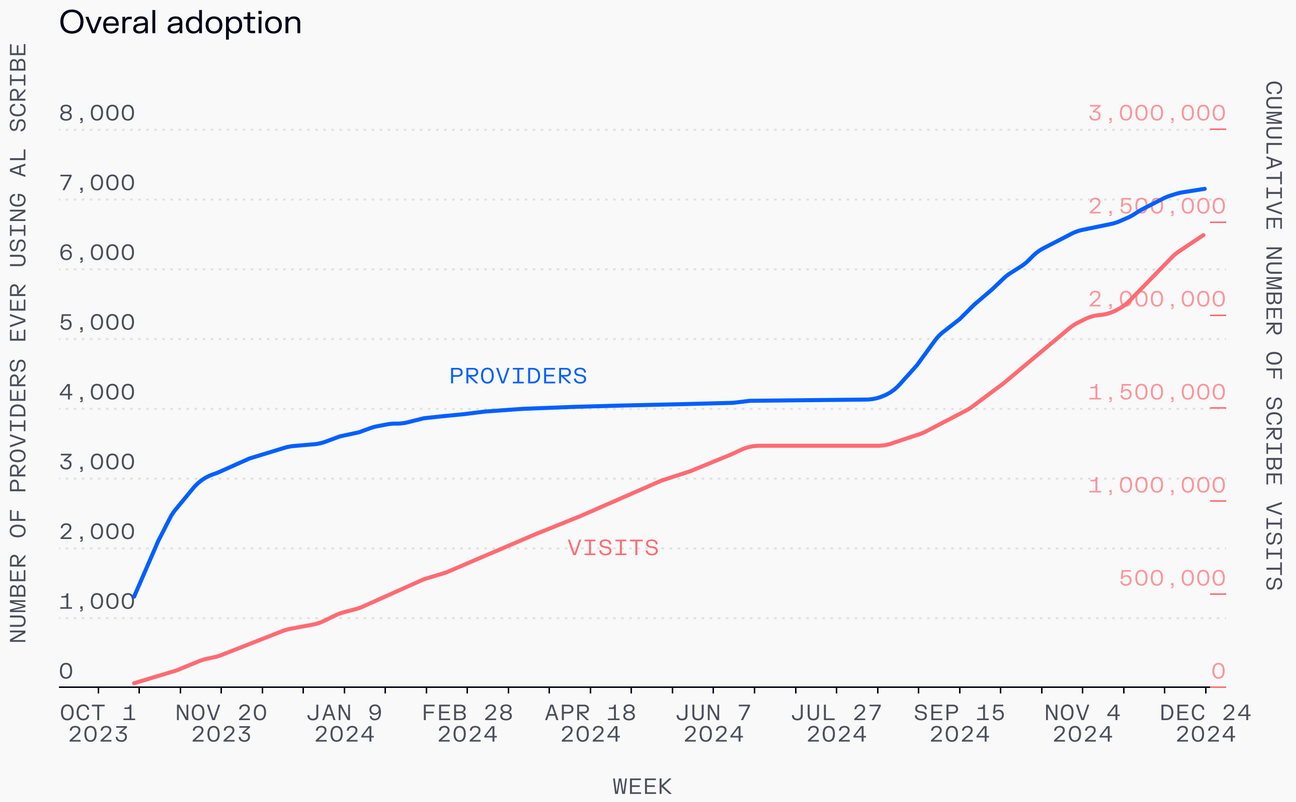
Source: Hallucination-Free? Assessing the Reliability of Leading AI Legal Research Tools; Stanford University

In healthcare, companies like OpenEvidence have reached the same levels of active prescribers in just 11 months that took 11 years for traditional software.



Source: SEC via Tanay Jaipuria

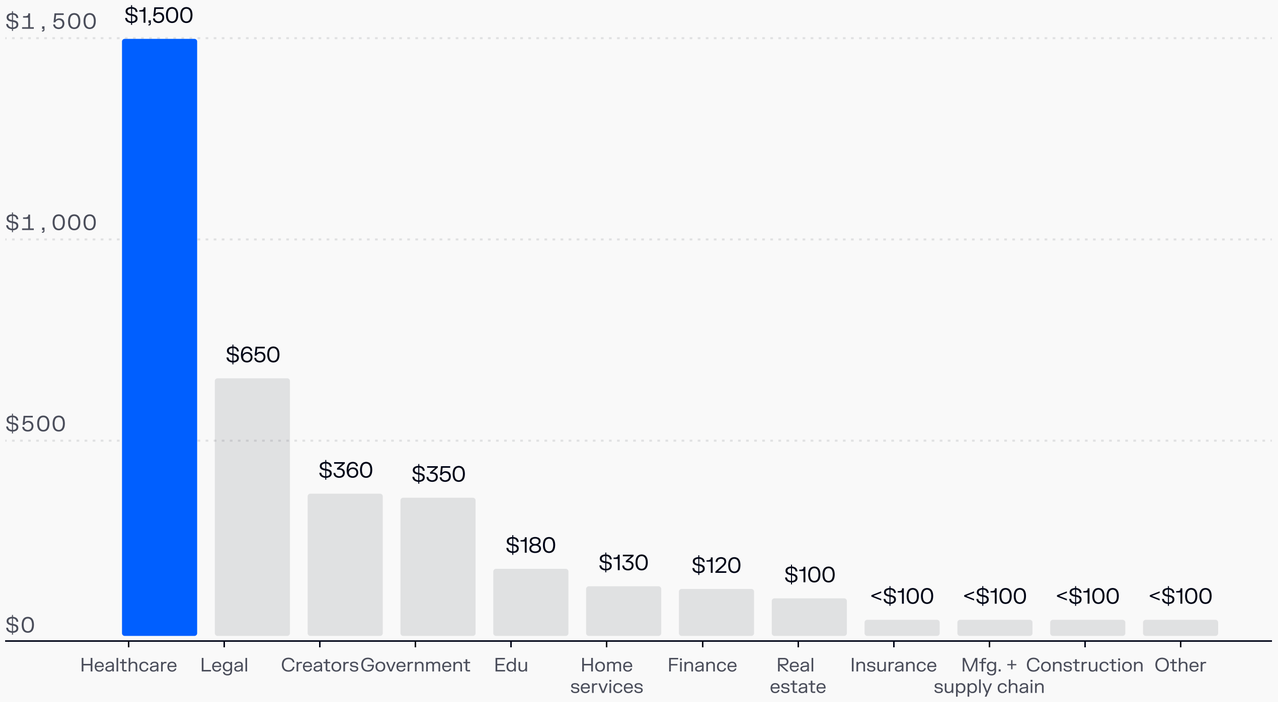
AI used for transcribing medical visit summaries and clinical information has continually increased since its introduction over two years ago.



Source: "Ambient Artificial Intelligence Scribes: Learnings after 1 Year and over 2.5 Million Uses", NEJM Catalyst; Chart shows overall adoption of providers using an AI scribe and the cumulative number of AI scribe visits, from October 2023 through December 2024.

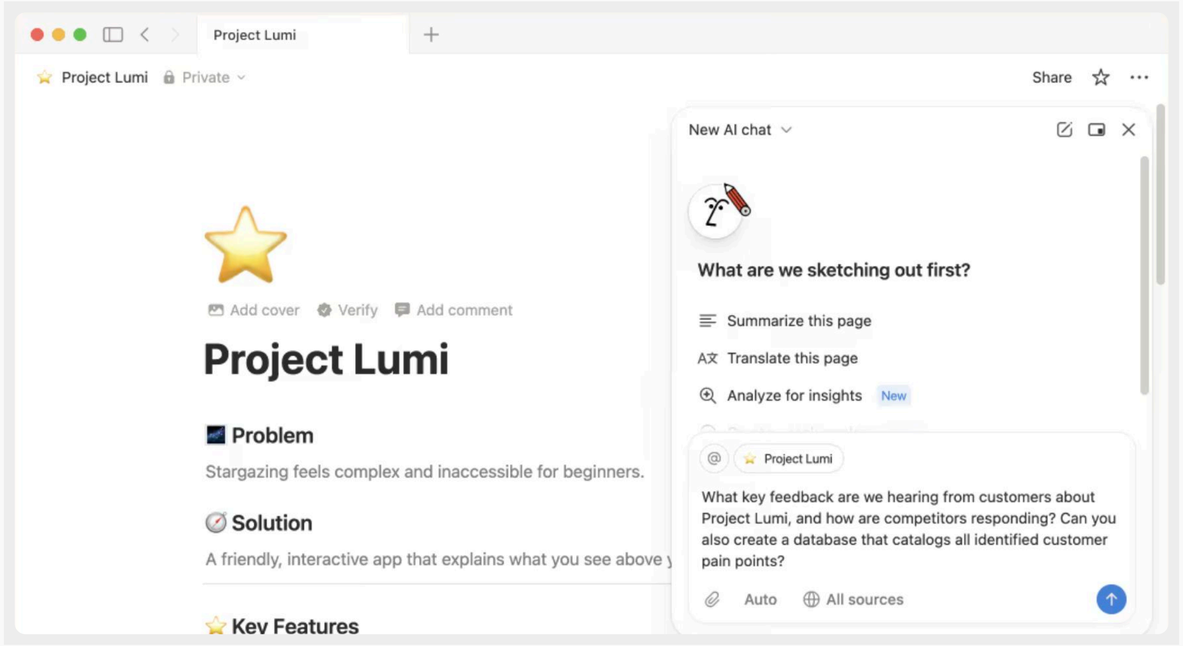
Within vertical adoption of AI, healthcare is by far the highest category in terms of AI spend.

Vertical AI Spend by Category



Source: Menlo Ventures

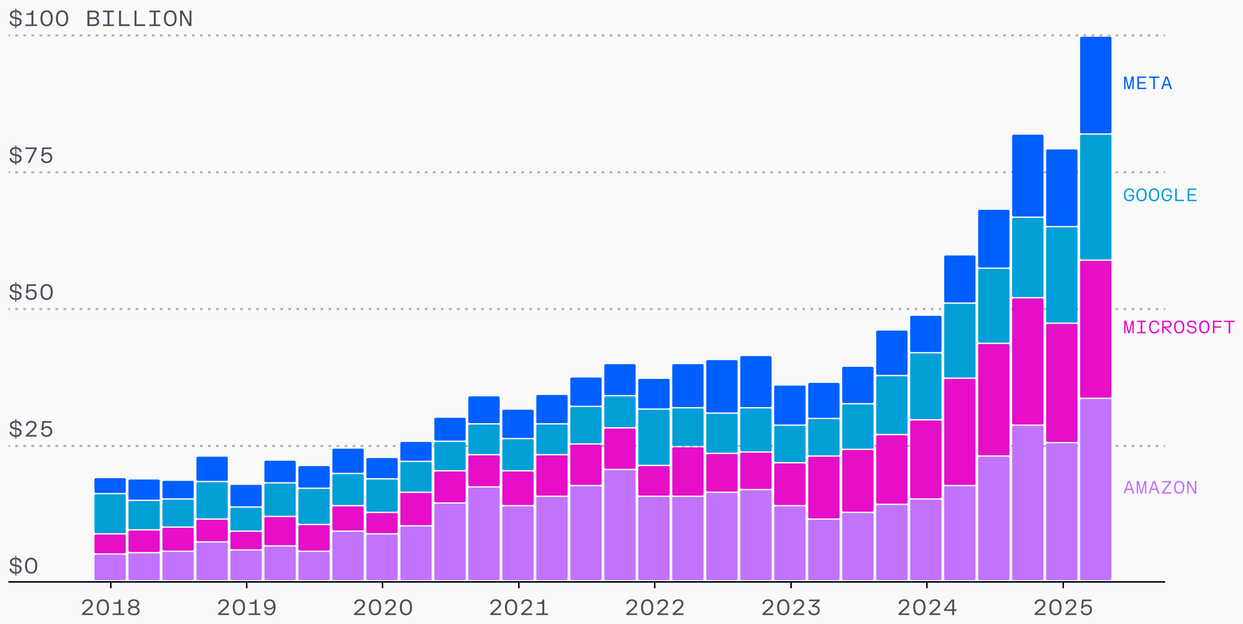
Knowledge work tools, like Notion, have leveraged AI in their existing products. According to the company, 50% of its $600 million ARR is coming from AI products.



Source: Notion

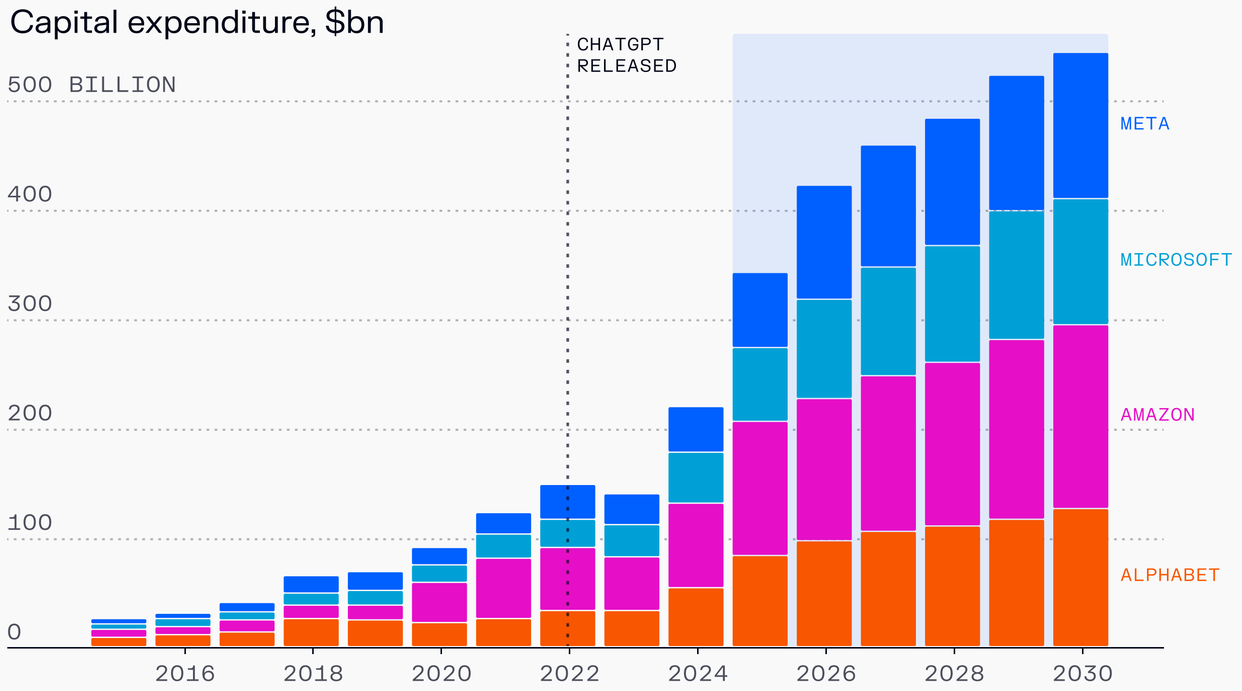
Compute Supply & Demand

By Q2 2025, the hyperscalers were already approaching $100 billion of capital expenditures per quarter on compute.



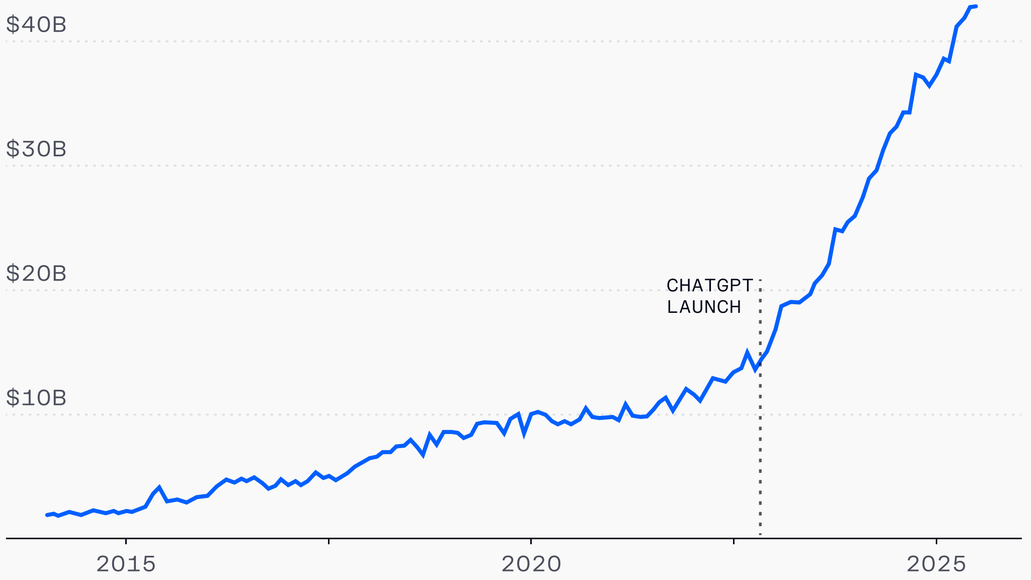
Source: Wall Street Journal; data are for calendar quarters and include finance leases

However, projected AI capital expenditures will push overall CapEx to ~$1.3 trillion by 2027 across traditional data centers, cloud computing, and AI infrastructure.



Source: Financial Times, 30-K findings, S&P Global Market Intelligence

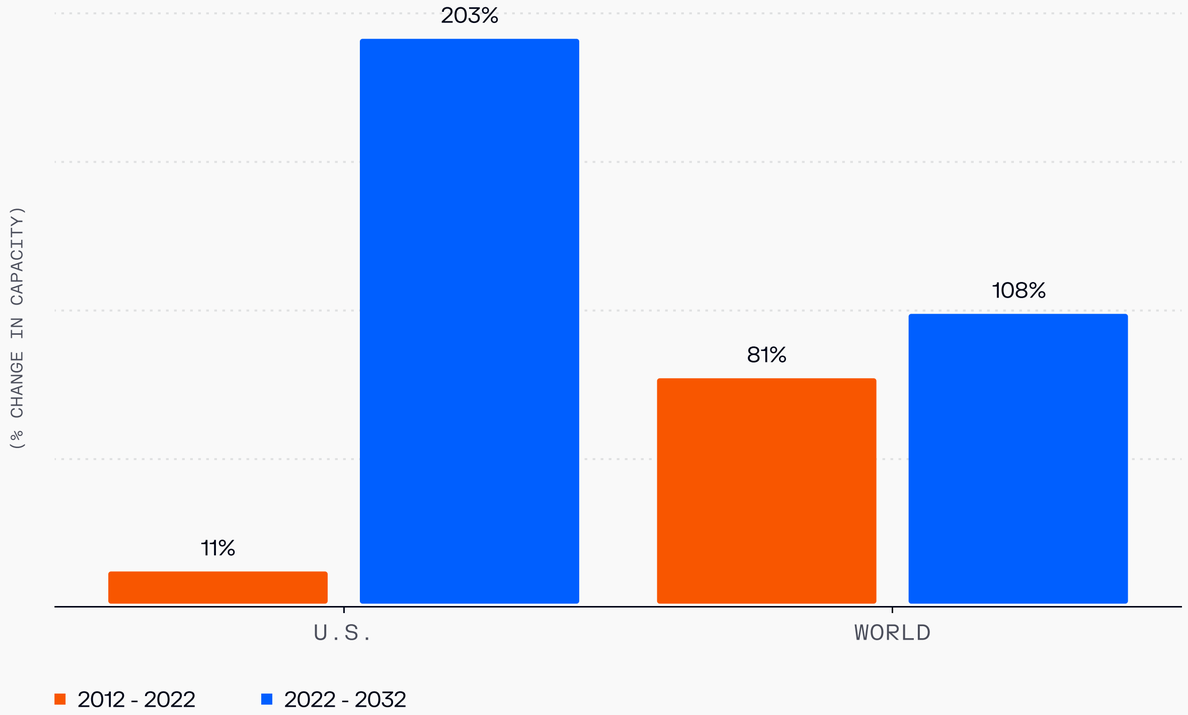
As a result, data center construction has continued to explode since the launch of ChatGPT and the ensuing AI boom.



Source: US Census via Joseph Politano

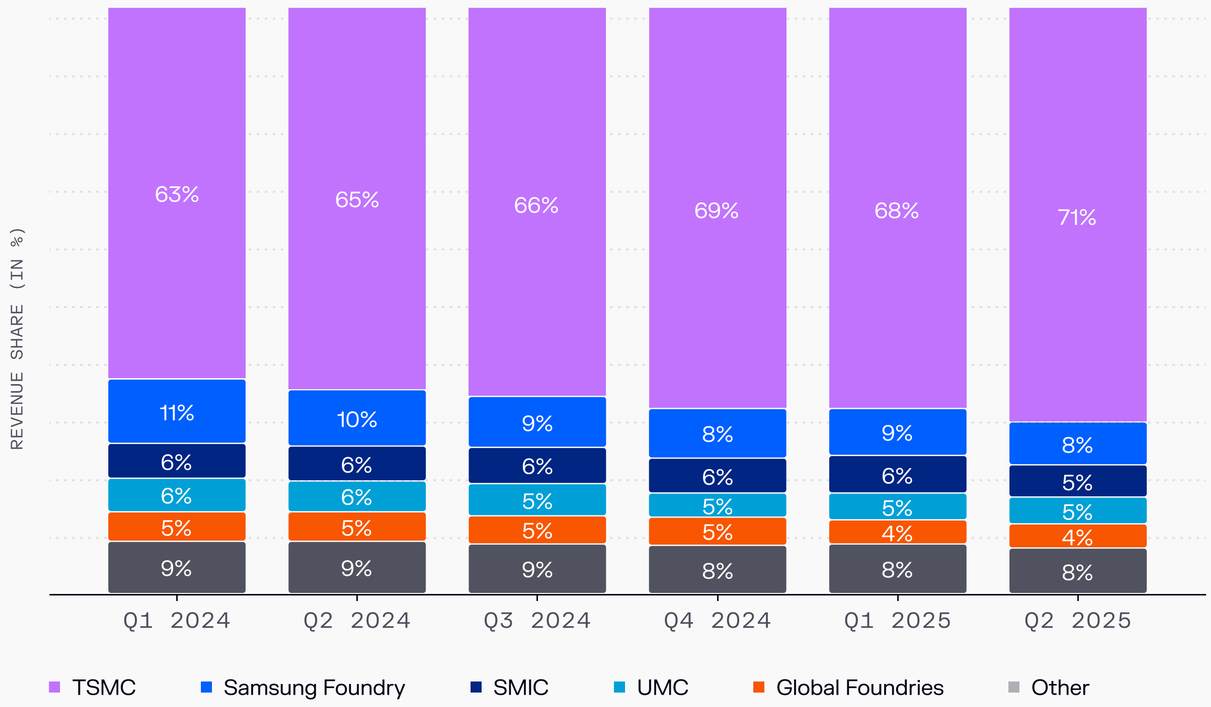
Although global chip fabrication capacity is expected to grow incrementally, the same capacity expansion in the US is expected to explode from 2022 to 2032.

Projected Increase in U.S. Fab Capacity vs. world average



Source: Semiconductor Industry Association

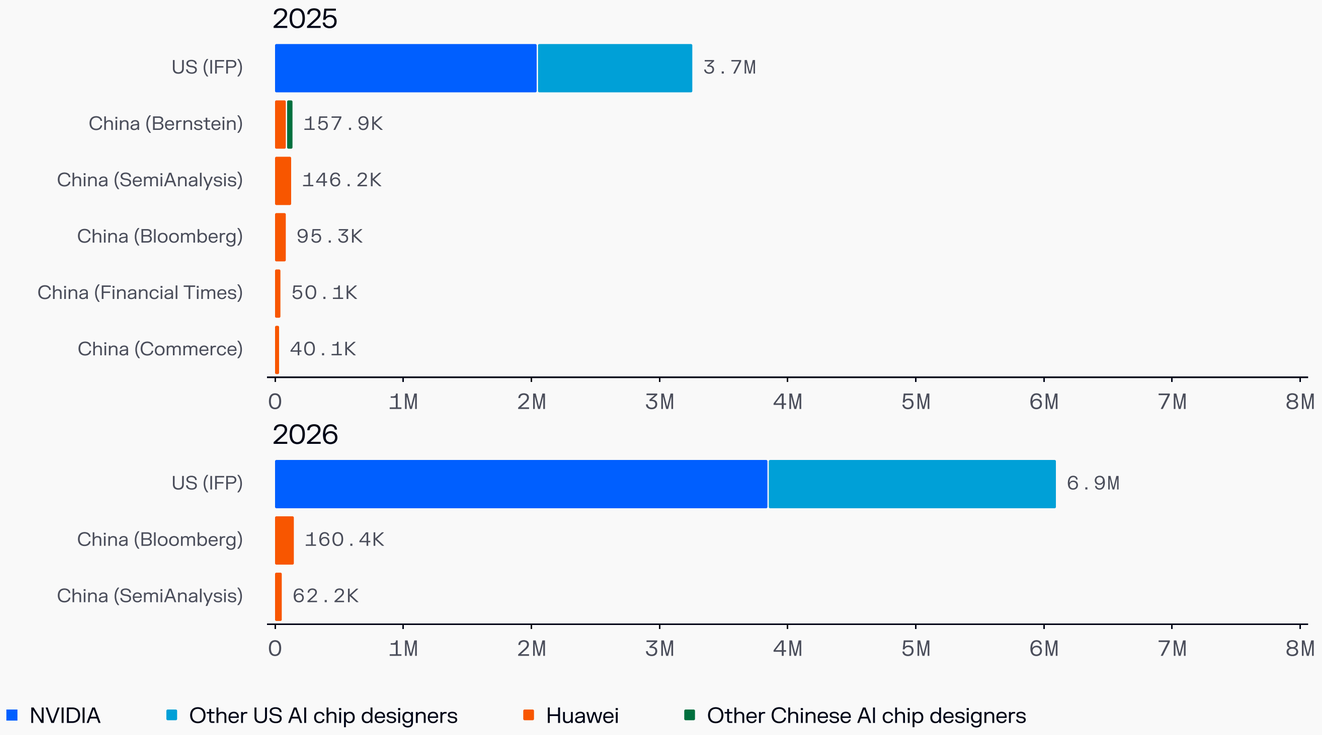
In terms of global chip production market share, TSMC continues to be the dominant foundry player with ~71% as of Q2 2025.



*Source: Counterpoint Research; *Samsung includes foundry services for its internal logic IC business. Totals may not add up due to rounding*

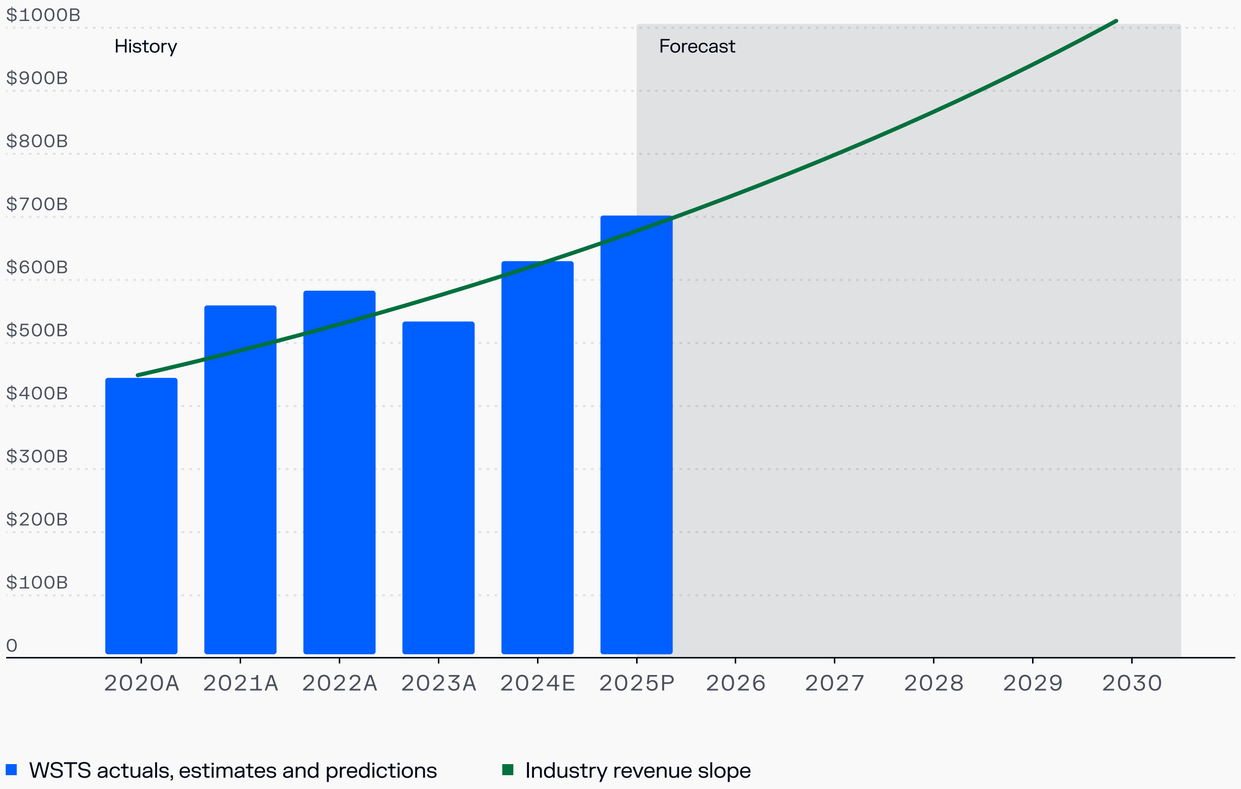
US and Chinese chip production are expected to expand rapidly over the course of 2026.

Quantities are normalized to B300-equivalents. Each row is a separate estimate.



Source: Institute For Progress

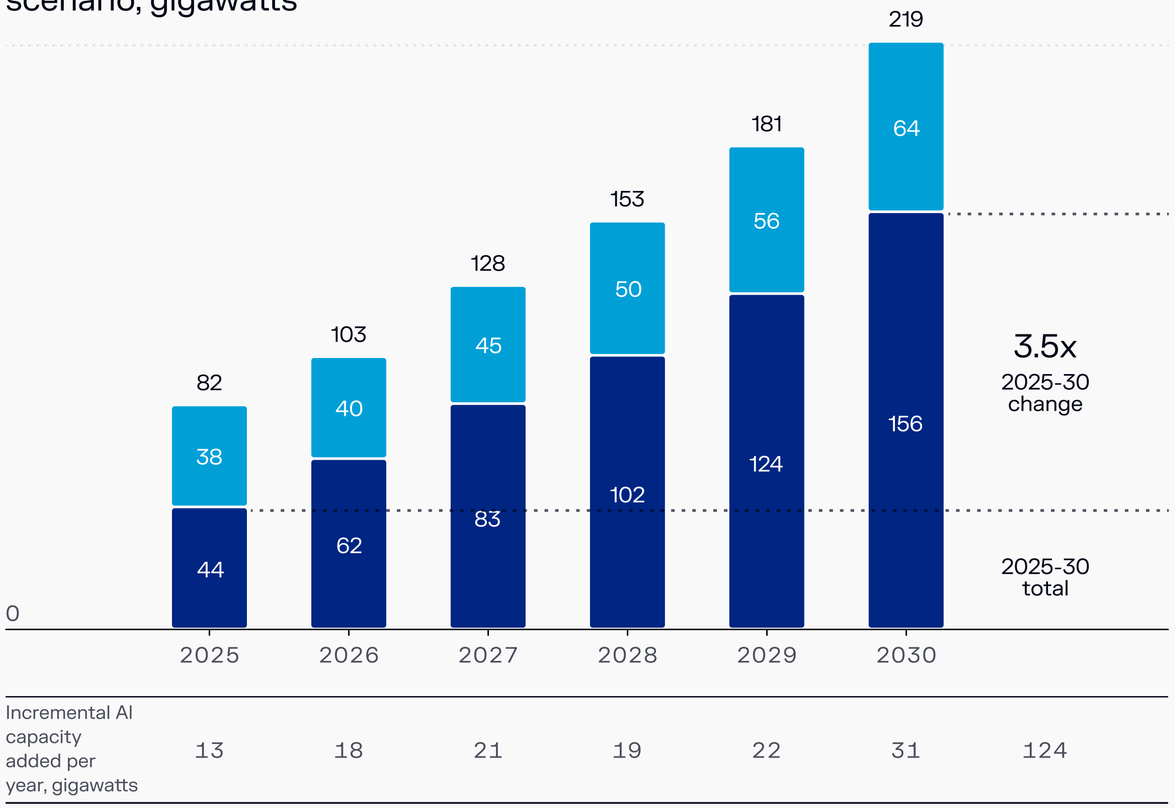
If chip demand continues to grow, some estimates indicate the chip industry could hit $1 trillion of revenue by 2030.



Source: Deloitte; World Semiconductor Trade Statistics

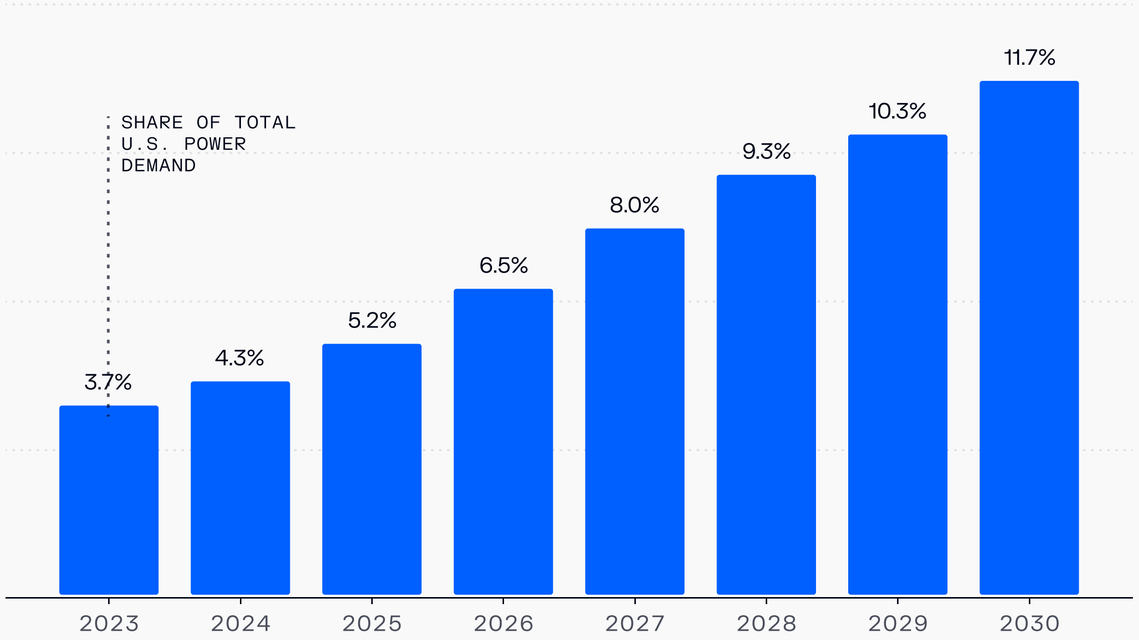
As chip and data center demand skyrocket to keep up with demand for AI, the commensurate energy volumes are poised to expand massively as well.

Estimated global data center capacity demand, 'continued momentum' scenario, gigawatts



Source: McKinsey; Gartner; IDC; Nvidia

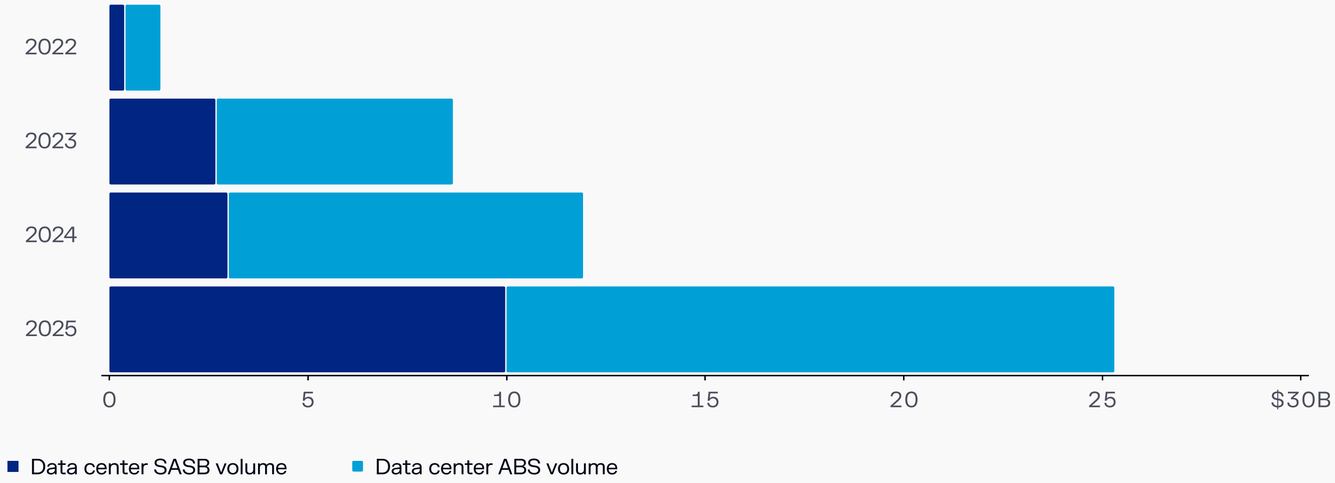
In fact, the percentage of total US electricity used by AI is set to increase from ~5% today to 10%+ by 2030.



Source: McKinsey, IEA

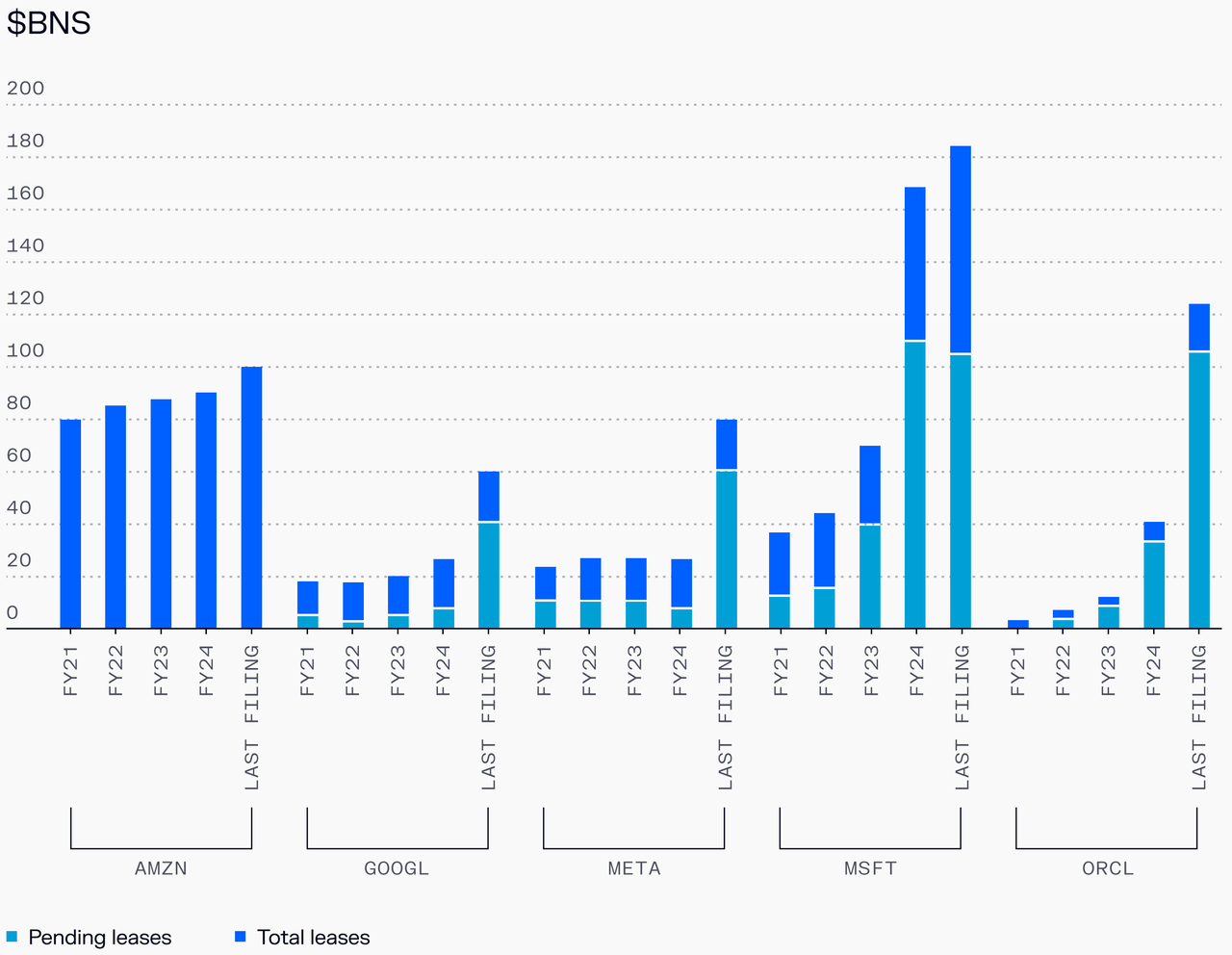
Increasingly, the financing for the data center building is coming from asset-backed lending.

Secured Debt Issuance Linked to Data Centers



*Source: Jones Lang LaSalle; *2025 is a FY forecast*

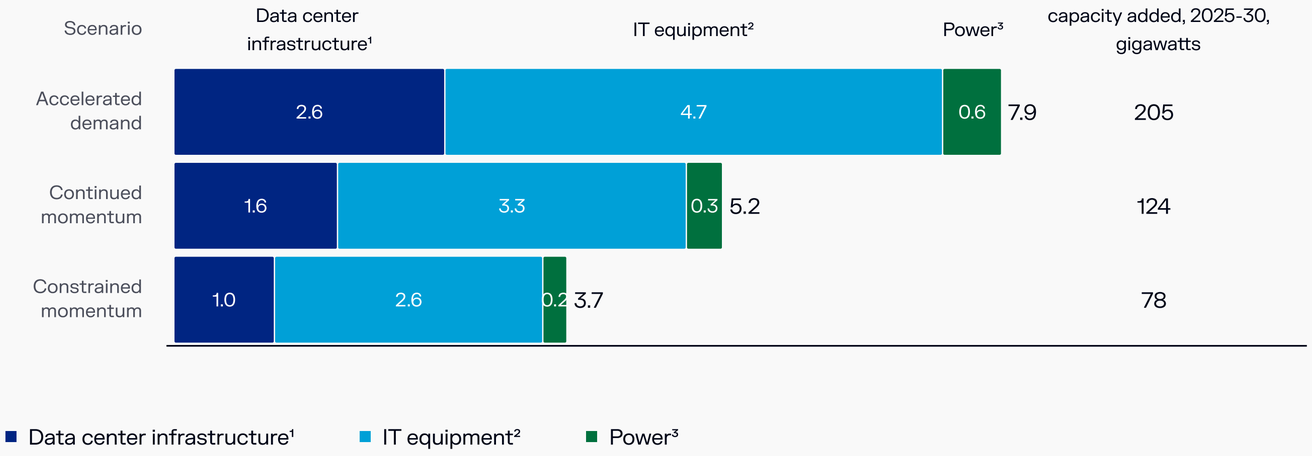
In addition, hyperscalers are massively expanding the volume of leases they're contracting around data center assets.



Source: Company reports; Barclays research; Note: Amazon does not disclose pending leases

Overall, global data center spending could reach $3-8 trillion by 2030; if demand growth holds steady without further acceleration, it would result in ~$5.2 trillion in capital expenditures over the next five years.

Global data center total capital expenditures driven by AI, by category and scenario, 2025-30 projection, $ trillion



Source: McKinsey; Figures may not sum to totals, because of rounding. ¹Excludes IT services and software (eg, operating system, data center infrastructure management), since they require relatively low capex compared with other components. ²Includes server, storage, and network infrastructure. IT capex also accounts for replacing AI accelerators every 4 years. ³Assumes $2.2 billion-$3.2 billion/gigawatt (including power generation and transmission cost) to account for a range of power generation scenarios (eg, fully powered by gas, a combination of gas power and storage, and solar) and regional cost differences. Distribution cost is neglected, as most AI centers are expected to be >50 megawatt scale and connected to a transmission grid.

To put that $5.2 trillion into context, it would represent 17% of GDP from 2025 to 2030; over 2x the percentage of GDP relative to the dot-com boom or the AI capital invested from 2020 to 2024.

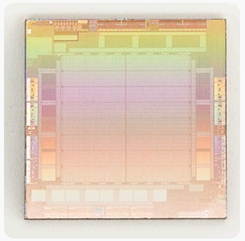
	Dot-com (1996-2000)	AI (2020-2024)	AI (2025-2030)
Beginning GDP ($B)	$8,100	$21,350	$30,500
Investment ($B)	**$500**	**$1,300**	**$5,200**
% GDP	6.2%	6.1%	17.0%
% Economy Impacted*	50%	50%	50%
Required Productivity Growth From Impacted Economy	12%	12%	34%
Required Annual % GDP Growth	**4.4%**	**4.4%**	**5.9%**
Expected GDP Growth**	3.2%	3.2%	3.2%
Required Annual % GDP Growth over Expectations	1.2%	1.2%	2.7%
# of Equivalent Growth Years Since 1960	**16**	**16**	**5**
Actual Average Growth over 5 Years	4.3%	2.4%	-
Actual Average Growth over subsequent 5 years	2.6%	-	-

* Internet penetration grew from 19% to ~50% from 1996 to 2001
** Average GDP growth % since 1960 has historically been 3.2% annually

Source: Contrary analysis; FRED; Company filings

Demand for AI chips has increased with the buildout of data centers, leading hyperscalers to increasingly pursue the development, and eventually sale, of their own chips.

Microsoft's Azure Maia 100 and Cobalt 100 chips are the first two custom semiconductors designed by the company for AI cloud computing.



Meta's custom AI chip is called the Meta Training and Inference Accelerator. Meta claims it outperforms traditional GPUs for low or moderate complexity models.

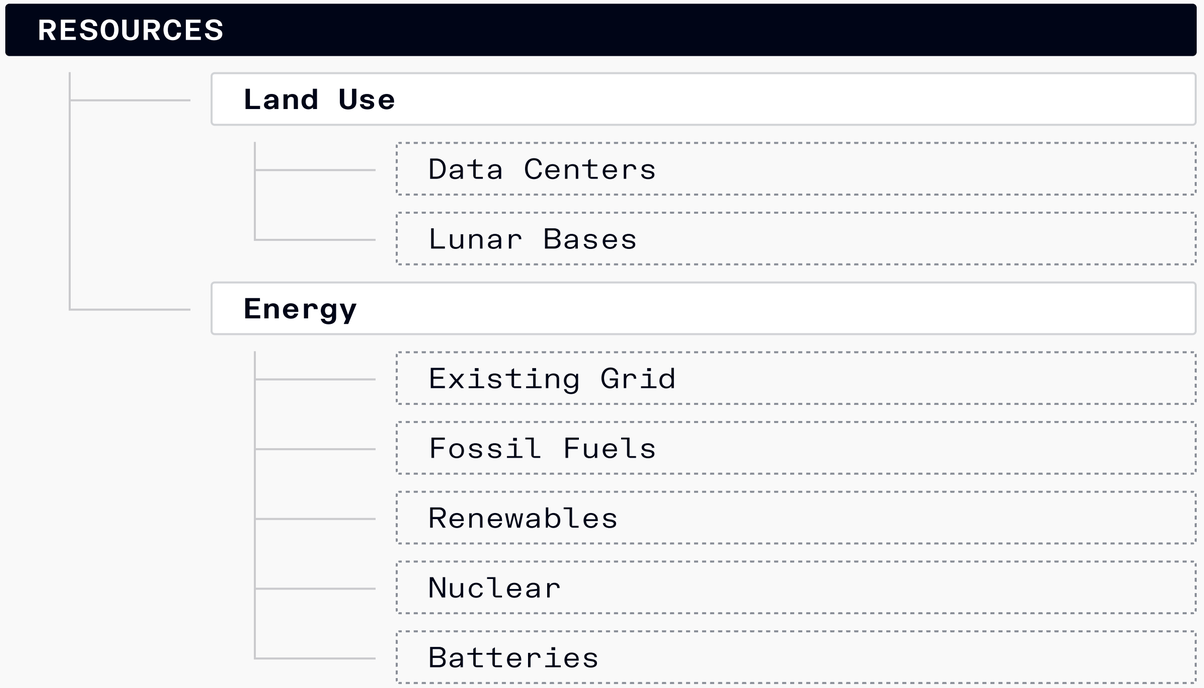
Google's custom chips are called Tensor Processing Units (TPUs), and are designed to accelerate compute for popular AI frameworks like PyTorch, JAX, and TensorFlow.

Apple released its M5 Chip in October, a chip designed to speed up AI workload runtimes for laptops, iPads, and the Apple Vision Pro.

Source: The Verge, TechCrunch, Google Cloud, Apple Newsroom

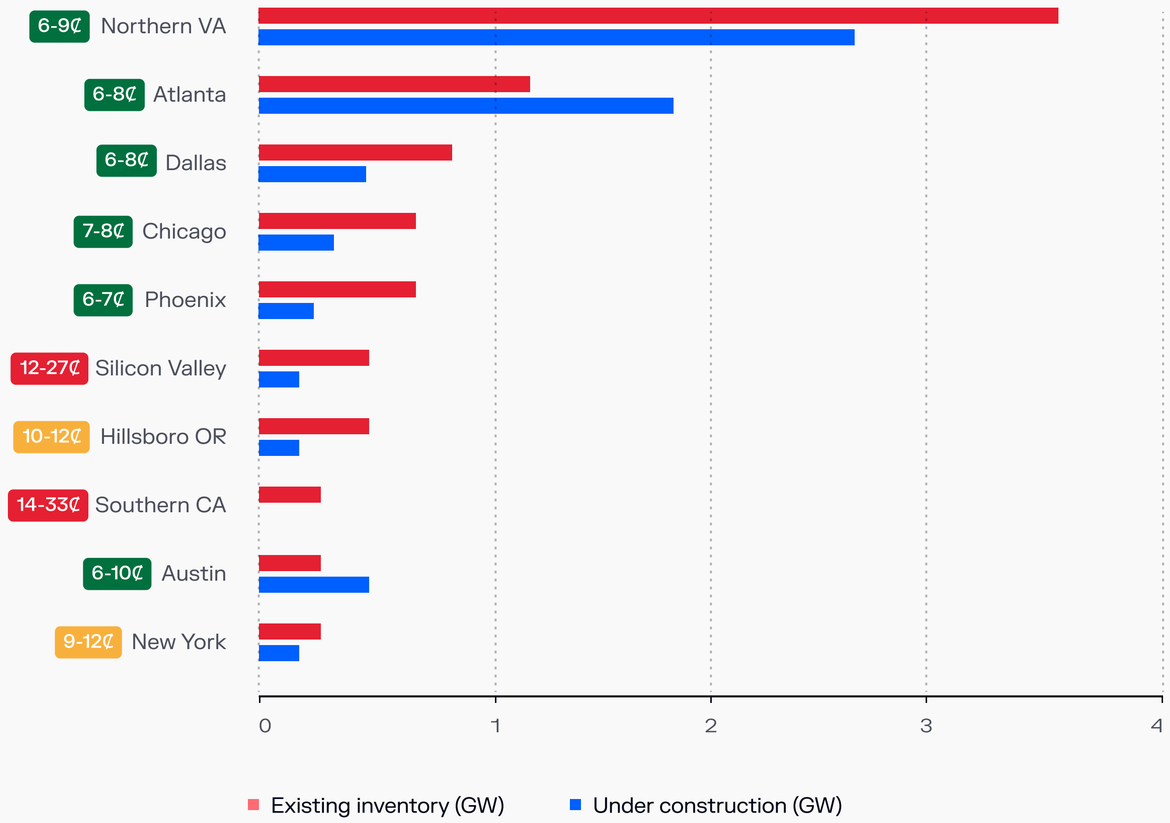
Resources

Land Use
Energy

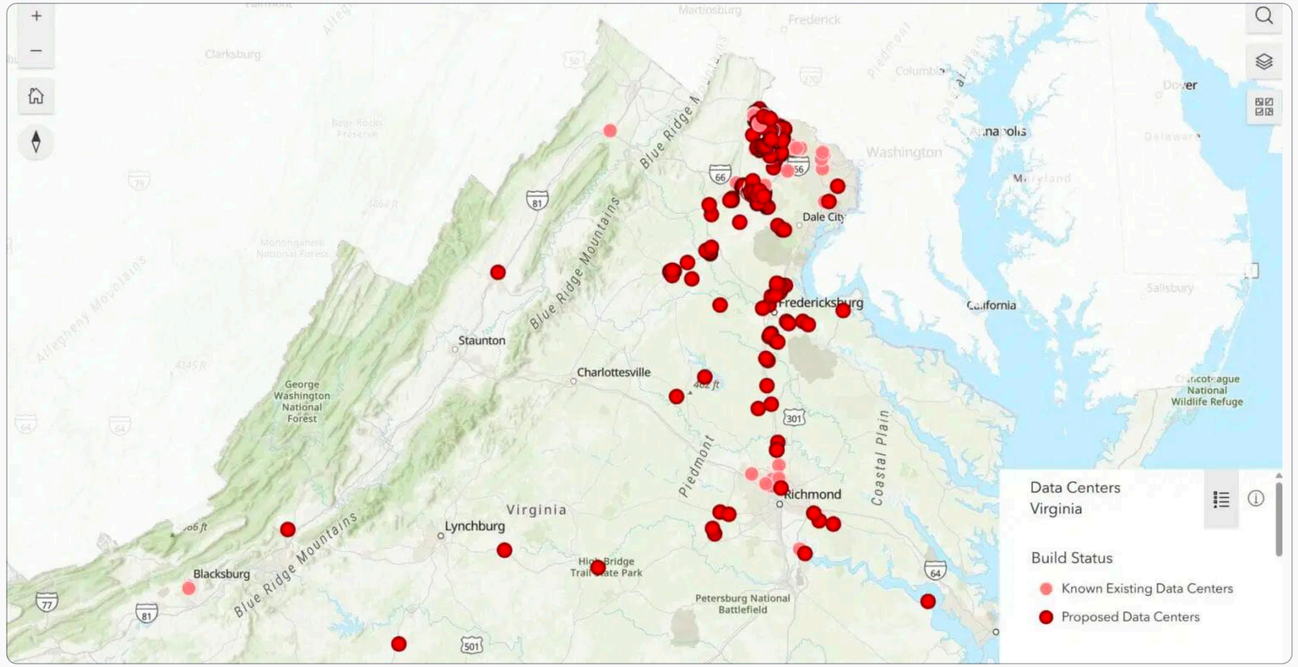

RESOURCES
Land Use
Data Centers
Lunar Bases
Energy
Existing Grid
Fossil Fuels
Renewables
Nuclear
Batteries

Land Use: From Data Centers To Lunar Mining

Data centers tend to aggregate around cheap energy, with 6 of the top 10 markets for data centers offering cheaper energy than the national average of 9.2¢.

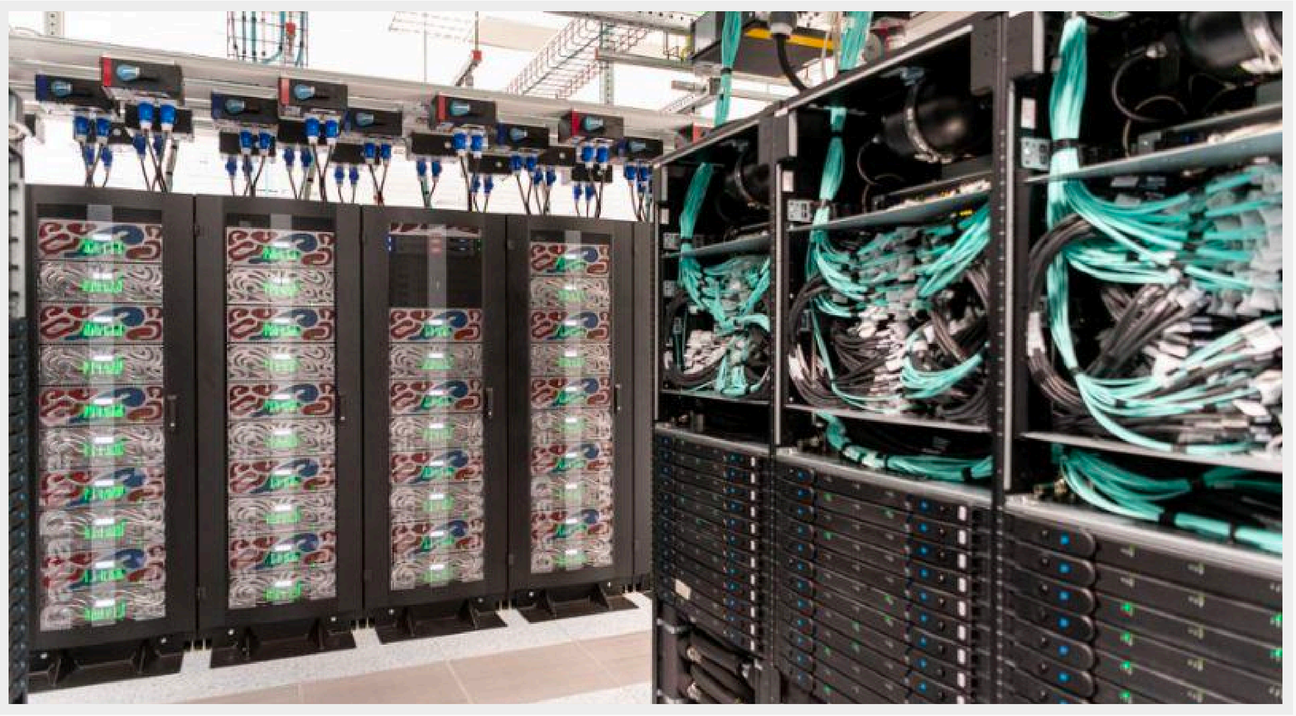


Northern Virginia, dubbed the data center capital of the world, has 27 million square feet of existing data center space in one county alone.



Source: Piedmont Environmental Council

The collective data centers across Northern Virginia used 2 billion gallons of water in 2023, up 63% from 2019.



Data center in Northern Virginia

Source: ECMWF Data Center

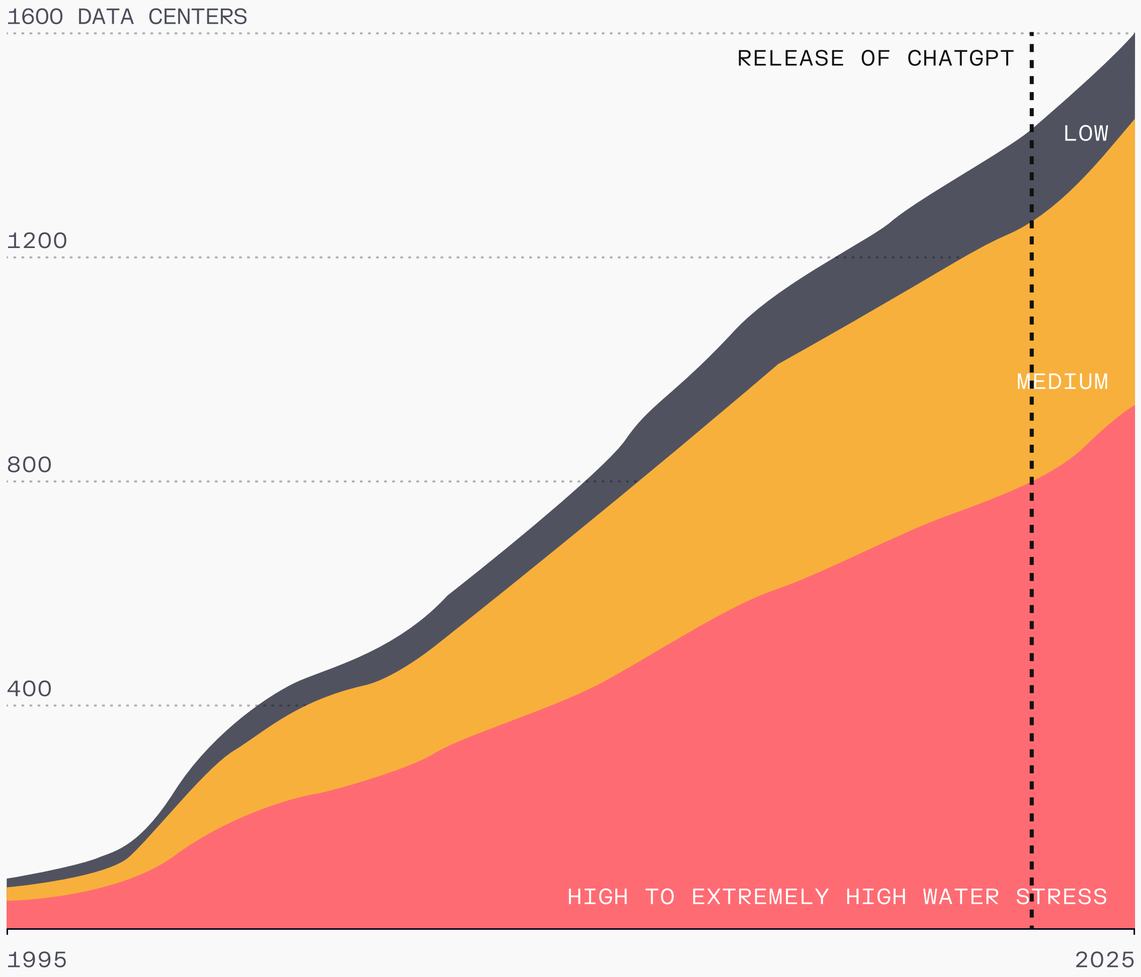
One Meta data center in Georgia used 500K gallons of water per day – 10% of the county's entire water consumption. The county's water rates are expected to increase by 33% over the next two years vs. 2% annual increases historically.

Meta data center in Georgia

Source: New York Times; Plateau Excavation

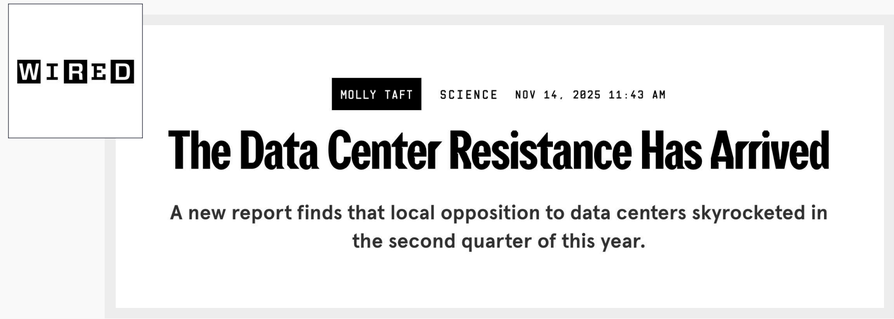
Increasingly, data centers are being built in water-stressed areas.
The number of data centers being built in these areas has increased by 70% over the last three years.

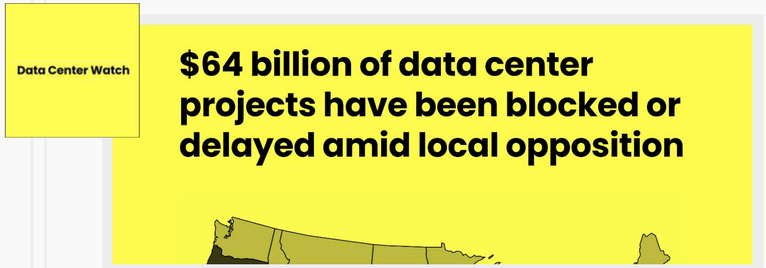
Number of facilities built in the US by year and water stress zone

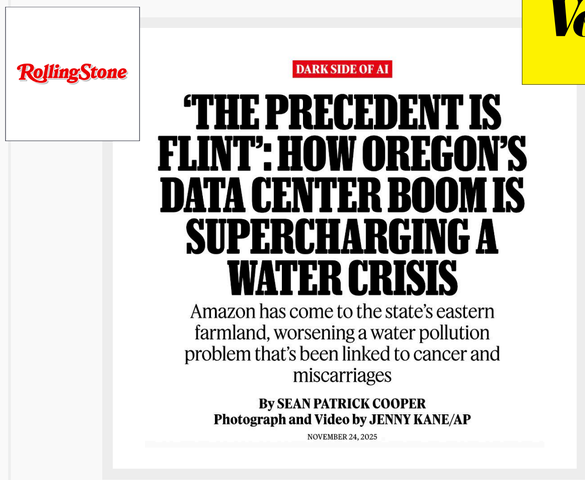


Source: DC Byte; World Resources Institute

Rising electricity prices and concerns surrounding water usage and contamination have led to opposition to data centers in many proposed locations.

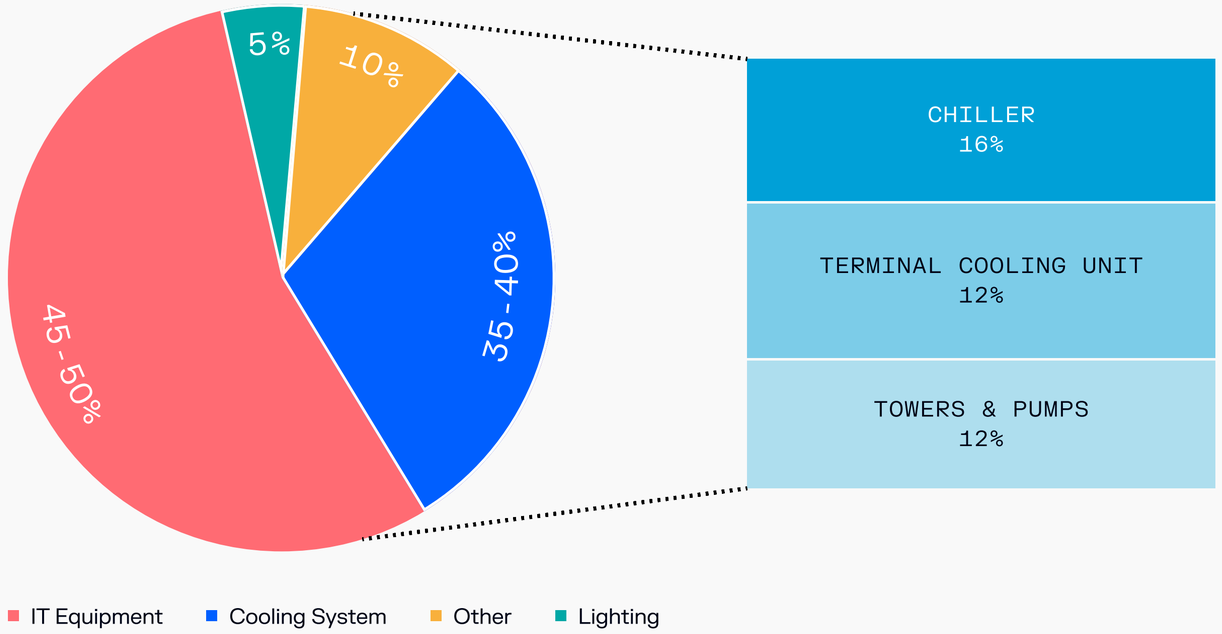






Source: Data Center Watch, Vox, Wired, Rolling Stone, CoStar

Water is such a critical component of data center operations because cooling can represent nearly half of a data center's power consumption.



Source: "Cooling Technologies for Internet Data Center in China: Principle, Energy Efficiency, and Applications", MDPI

Land use limitations and resource shortages have led data center developers to look elsewhere for build locations. One such alternative is building floating or underwater data centers.

Floating or underwater data centers could also reduce cooling costs. While traditional data centers can use more than 50% of total electricity on cooling, underwater data centers (UDCs) expend less than 10% on cooling.

Nautilus Data Technologies launched the first floating data center in 2021

Source: Microsoft

For example, Microsoft's Project Natick submerged a full server rack 117 feet underwater for two years in Scotland's North Sea in 2018. The asset was connected to shore via fiber-optic cable. The experiment found that there were 8x fewer hardware failures in the underwater data center, which housed computers in a steel cylinder filled with dry nitrogen instead of oxygen.

Microsoft's Project Natick vessel removed from the waters off Scotland's Orkney Islands in 2020

Source: BBC, Energy Reporters

Elon Musk has indicated interest in building distributed data centers using assets like Tesla inference. He explained:

"If we've got all these cars... we could actually have a giant distributed inference fleet.... if you've got tens of millions of cars in the fleet, or maybe 100 million cars, and each has, I don't know, a kilowatt of high-performance inference capability, that's 100 gigawatts of inference power distributed with power and cooling included."

Tesla's Robotaxi fleet is not yet near the magnitude Musk referenced, but the concept of a distributed data center has already been tested by startups and Google DeepMind Researchers.

A fleet of Teslas awaiting export

Source: InsideEVs, Torque News

Finally, another alternative for data center builds includes building data centers either in orbit or on the moon. In 2025, Lonestar Data Holdings sent a data storage unit to the moon.

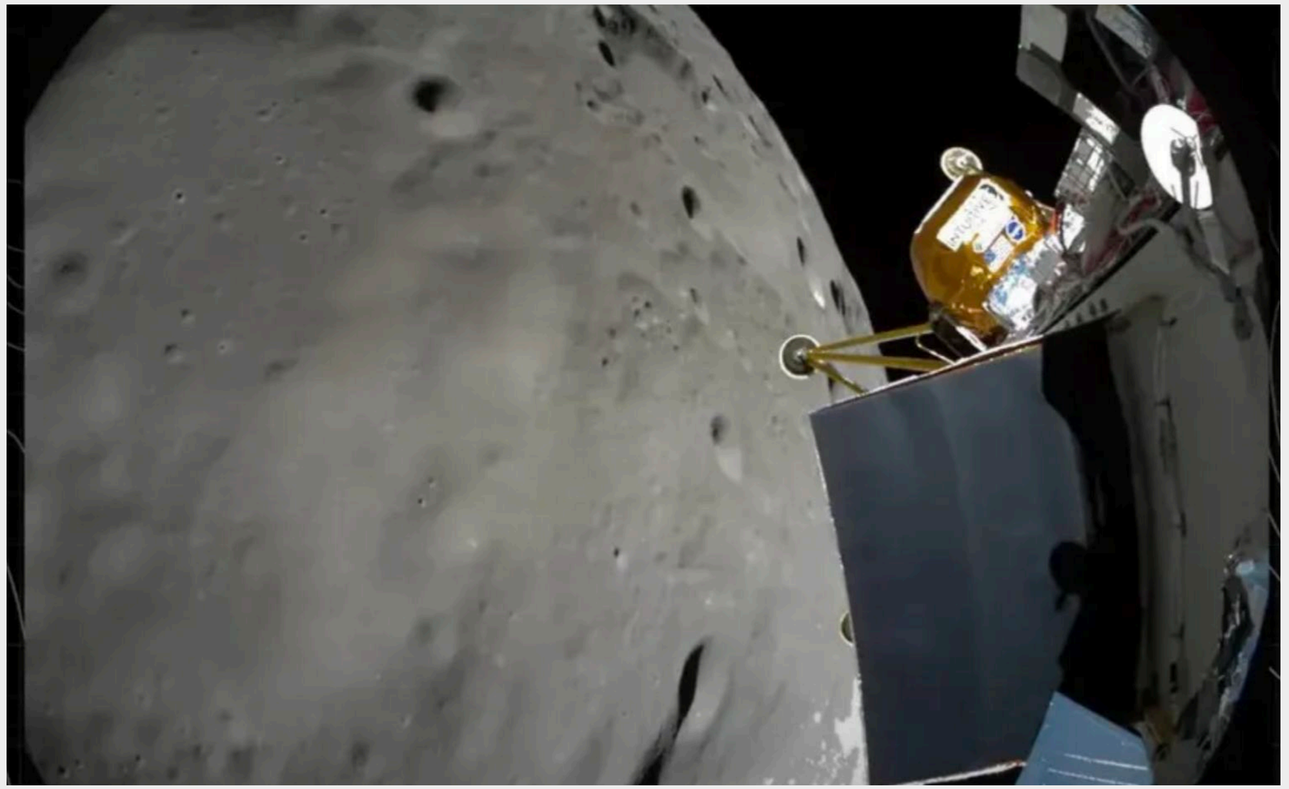


Image from Nova-C Athena lander before touching down with Lonestar Data Holdings data storage unit

Source: Intuitive Machines

Multiple companies have explored the feasibility of placing data centers on the moon, or in orbit around the Earth or the Sun.

Benefits include protection from natural disasters and atmospheric corrosion, and colder ambient temperatures. Primary drawbacks include the immense installation and operational costs inherent in launch costs, and the logistical challenges of managing those assets, as well as the significant latency for data transmission.

Elon Musk has said, “Simply scaling up Starlink V3 satellites, which have high speed laser links would work. SpaceX will be doing this.”

Artistic rendering of potential orbital data center design.

Source: Sify

Beyond lunar data centers, building a lunar base has been compelling for decades for a number of reasons - access to water, Helium-3, and deposits of rare earth metals.

Geological surveys show that the moon contains 3 crucial elements:

Water

Vital for supporting life and agriculture beyond Earth; can be converted into rocket fuel

Helium-3 (^3He)

Rare element sough for future developments in energy sector like nuclear fusion

Rare earth metals (REMs)

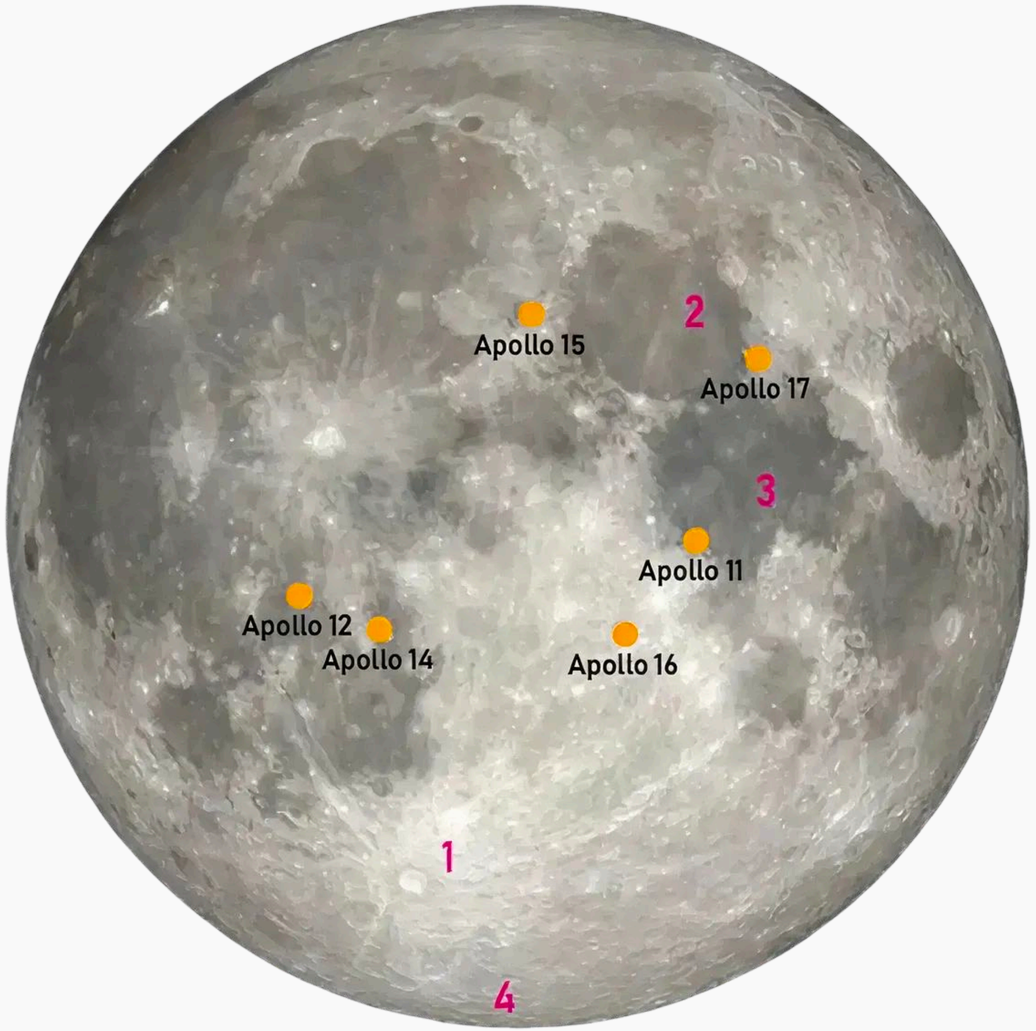
The fifteen lanthanides, as well as scandium and yttrium - used in modern electronics and mostly produced in China

Source: NASA

There are only a few viable locations for a lunar base:

1. South Pole - Aitken Basin
2. Mare Serenitatis / Taurus - Littrow Highlands
3. Mare Tranquillitatis / Mare Fecunditatis Transition
4. Oceanus Procellarum

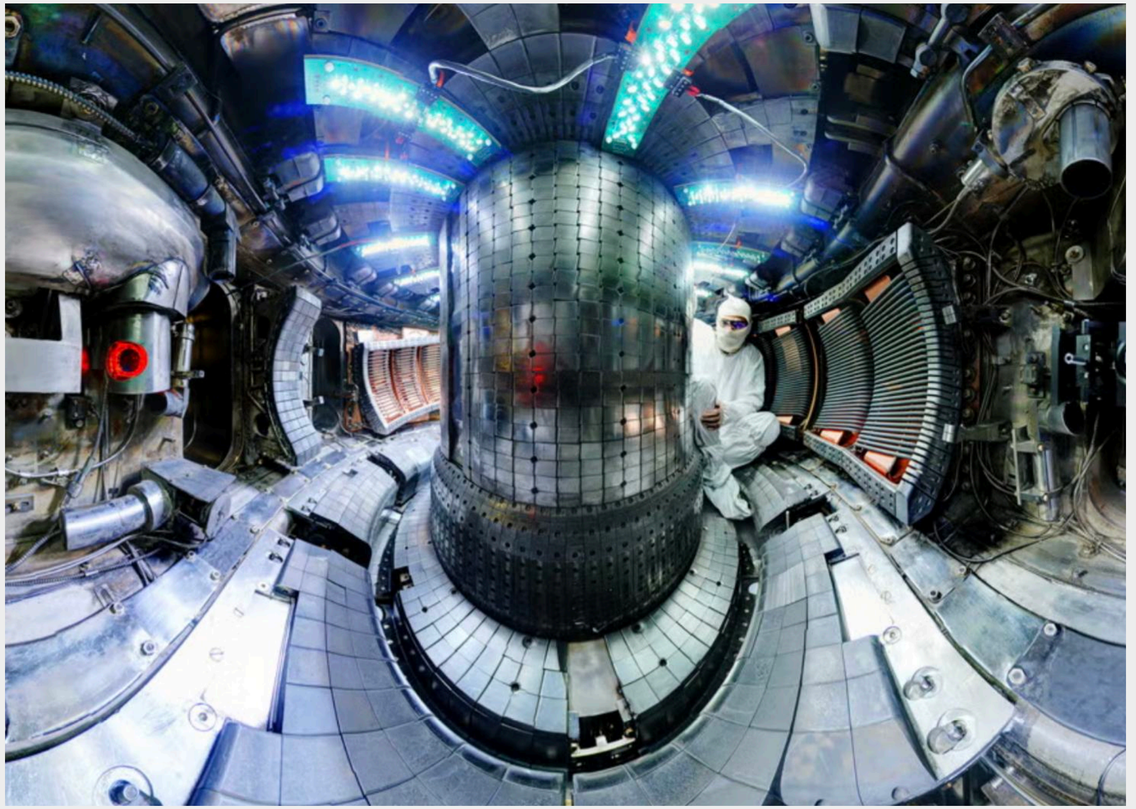
Each include flat and stable locations, proximity to lava tubes, high titanium-content basalts, ilmenite-rich soils, or ice deposits for water.



Source: New Scientist

In particular, the Moon's lack of an atmosphere allows solar winds to bombard the surface with large quantities of Helium-3.

It is believed that this isotope could provider a safer approach to nuclear energy in a fusion reactor as its not radioactive and wouldn't produce dangerous nuclear waste.



Fusion reactor experiments using Helium-3 at MIT

Source: Bob Mumgaard, Plasma Science and Fusion Center

Light rare earth elements (LREEs) are valuable for EVs, wind turbines, oil refining, and battery electrodes.

Platinum group metals (PGMs) could be used on Earth for scrubbing emissions in automotive catalytic converters and facilitating hydrogen fuel cell reactions.

Heavy rare earth elements (HREEs) are valuable for heat-resistant additives that prevent magnets from demagnetizing at high temperatures, phosphors for color-accurate LED displays, and precision components in lasers and defense systems.

Earth Use

Light Rare Earth metals

57	58	59	60	62
La	Ce	Pr	Nd	Sm
Lanthanum	Cerium	Praseodymium	Neodymium	Samarium
138.91	44.956	140.91	144.24	150.36

CURRENT AND POTENTIAL USE

Catalysts, lasers, electrodes, cancer treatment, magnets, nuclear shielding

Platinum Group

44	45	46	76	77	78
Ru	Rh	Pd	Os	Ir	Pt
Ruthenium	Rhodium	Palladium	Osmium	Iridium	Platinum
101.07	102.91	106.42	190.23	192.22	195.08

CURRENT AND POTENTIAL USE

Catalytic converters, catalysts, jewelry, radiation shielding, corrosion-rosistant metals, alloy strengtheners

Heavy Rare Earth Metals

21	39	64	65	66	68
Sc	Y	Gd	Tb	Dy	Er
Scandium	Yttrium	Gadolinium	Terbium	Dysprosium	Erbium
44.956	88.906	157.25	158.93	162.5	167.26

CURRENT AND POTENTIAL USE

Radiation shielding, electronic components, lasers, super conductors, dental applications

PATHWAY

Develop and demonstrate technologies to support efficient prospecting, extracting, and delineation

Source: Reuters, The Lowy Institute

Water is the central resource for survival and transport on the moon, from radiation shielding to fueling rockets and providing breathable air. Oxygen can be extracted from lunar rocks and used for propulsion systems or powering regenerative fuel cells. Synthesized hydrogen peroxide can act as fuel for small "hopper" vehicles or enable sterilization for medical purposes

Regolith (moon dirt) can be sintered into bricks for roads and landing pads or piled over habitats to provide thermal and radiation insulation. Refined from this soil, aluminum can replace copper for electrical wiring and serve as the primary structural metal, while silicon can be processed to manufacture glass and solar panels.

H_2O

Water
Environmental Control Life Support System Necessity

H_2O_2

Hydrogen Peroxide
Monopropellant

2
H
Hydrogen
1.0078

Hydrogen
Propellant production

8
O
Oxygen
15.999

Oxygen
Propellant production

PATHWAY

- Develop and dominate technologies to support efficient prospecting, extracting, processing, and domination
- Support frequent revision of planned architectures to leverage. in resource utilization developments
- Support exploration architectures that rely on tSFU.
- Develop and mature systems and technologies to utilize resources capable of supporting multiple critical aspects of potential architecture

^3He

Helium-3
Fusion fuel

PATHWAY

Develop/support development of power-generating Ho-3 fusion reactor

13
Al
Aluminum
26.982

Aluminum
Electronic components, solid rocket fuel

PATHWAY

Develop and demonstrate extraction technology

26
Fe
Iron
55.845

Iron
Tools/structures, additive manufacturing

PATHWAY

Support development of energy-efficient additive manufacturing

14
Si
Silicon
28.086

Silicon
Components of solar arrays, glass, ceramics

PATHWAY

Develop/support development of systems for in site purification and manufacturing

Lunar Regolith
Construction material

PATHWAY

- Develop/support development of systems for in-site processing and use
- Support use in exploration architectures

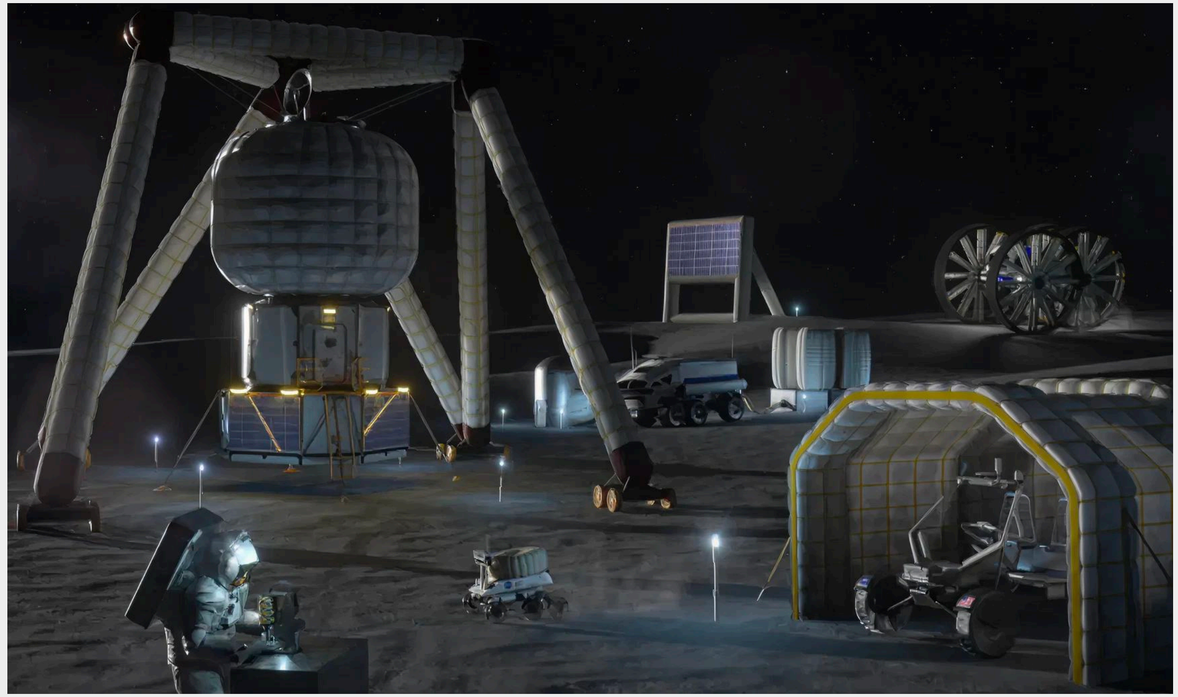
Source: Reuters, The Lowy Institute

Both Chinese and American missions are planned for the next decade to bring autonomous and manned missions to the moon to survey mineral distributions and gather data for future lunar missions, even as the geopolitics of lunar mining are actively debated.

Mission	Type of Mission	Organization	Planned Date
Artemis II	Crewed Lunar Flyby	NASA	April 2026
Intuitive Machines IM-3	Robotic Lander	Intuitive Machines, NASA	Mid 2026
Chang'e 7	Orbiter, Lander, Rover, Drone	China	Mid-Late 2026
Astrobotic Griffin 1	Heavy Robotic Lander	Astrobotic, NASA	July 2026
Firefly Blue Ghost Mission 2	Orbiter and Lander	ESA	Late 2025
Artemis III	Crewed Lunar Lander	NASA	Mid-2027
Luna-26	Orbiter	Russia	2027
Chandrayaan-4	Sample Return	India	2027-2028

Source: Lunar Resources Registry

The cost of lunar mining is steep compared to mining on Earth. The cost of equipment delivery alone is expected to surpass $200 million, and a lunar base set up to perform the processing required to return refined minerals back to Earth would cost an estimated $20 billion.



NASA rendering showing what a future lunar mining operation might look like.

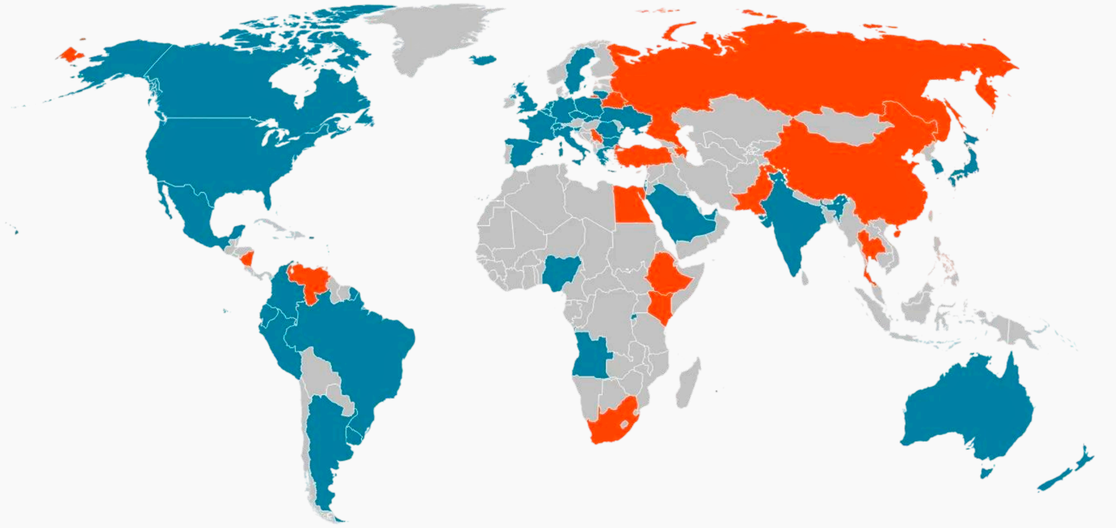
Source: Space.com, Space News

China and Russia have announced the International Lunar Research Station, a joint project aiming to install a human-occupied base and energy source on the moon.

The US, on the other hand, proposes moon development in line with the Artemis Accords; a set of non-binding principles for peaceful, transparent, and sustainable civil space exploration and use.

Artemis Accords vs. International Lunar Research Station (ILRS)

THE COUNTRIES THAT HAVE SIGNED UP TO THE US ARTEMIS ACCORDS, CHINA'S ILRS - OR NEITHER OF THEM, YET

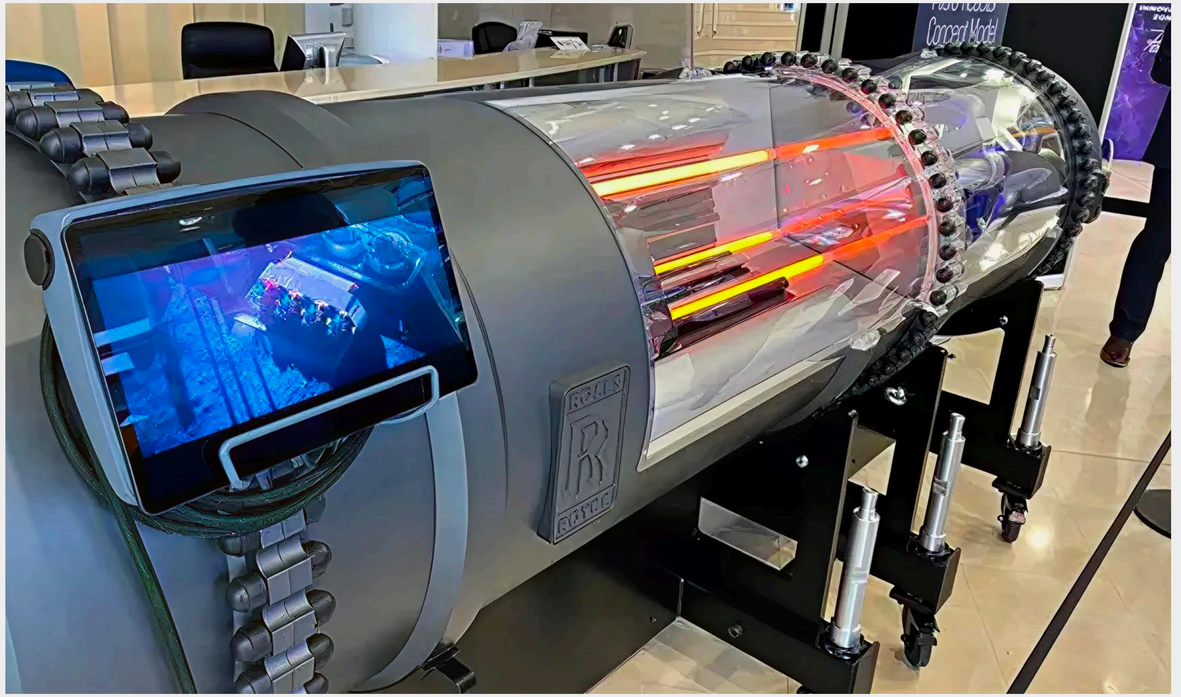


Artemis Accords ILRS Neither

Source: The Atlantic, Reuters, NASA

These global government agencies are considering lunar energy sources to power future bases or mining operations.

In August, the US Space Force announced intentions to install a 100kW nuclear reactor on the moon by the end of the decade.

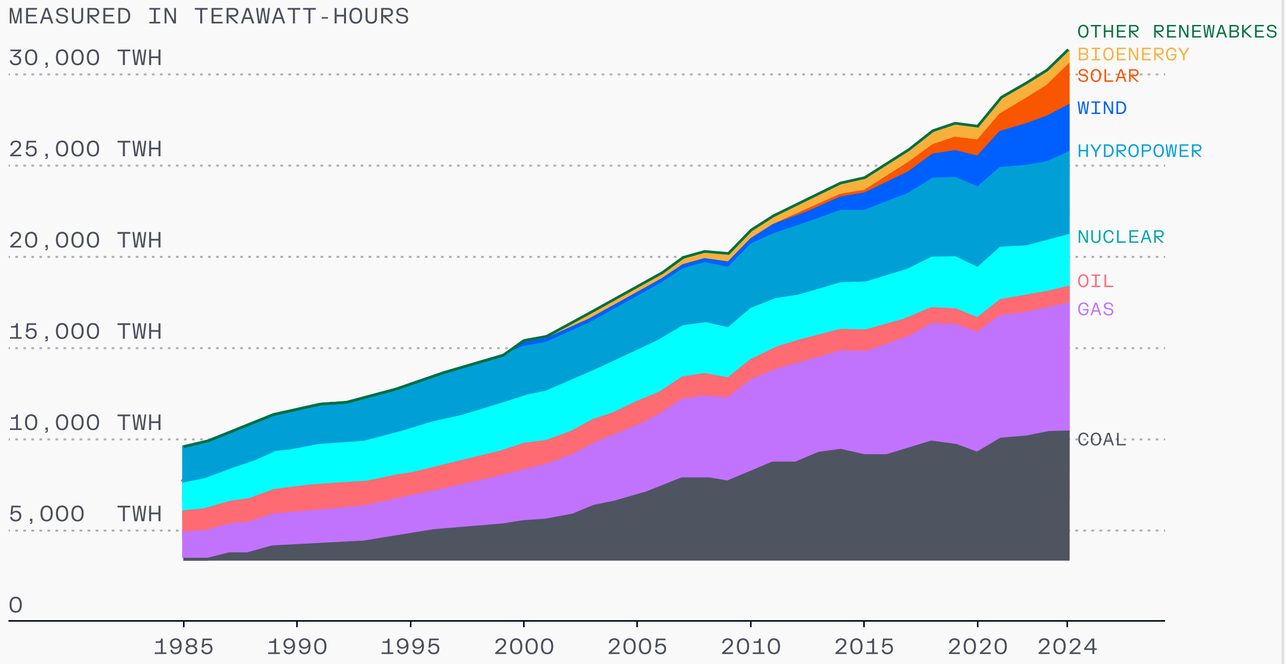


Lunar nuclear reactor mockup, designed and manufactured by Rolls Royce.

Source: The Atlantic, Reuters, NASA, Space.com

The Global Energy Ecosystem

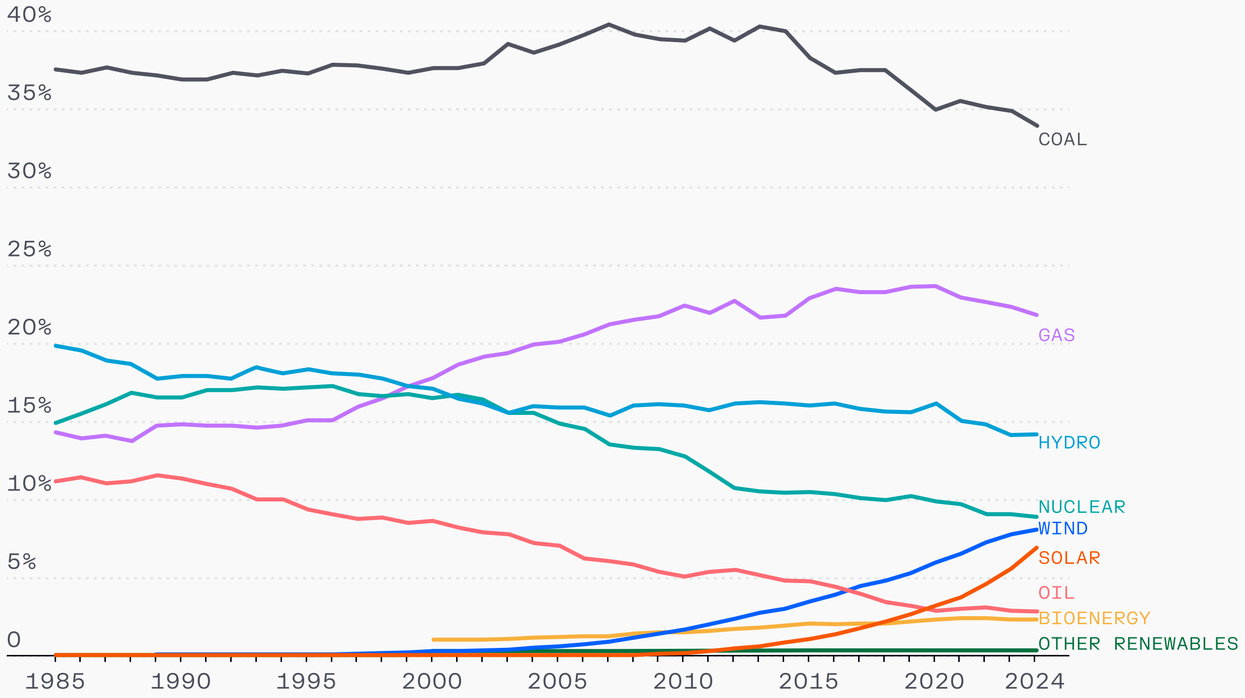
Globally, energy production is growing quickly. In 2024, total energy production was at 30,853 terawatt-hours (TWh), up about 25% from a decade prior.



Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

Fossil fuels including gas, coal, and oil were the largest sources of energy globally, at about 60% of the global energy mix, although their share was declining. Meanwhile, wind (8.1%) and solar (6.9%) are by far the fastest-growing sources of energy.

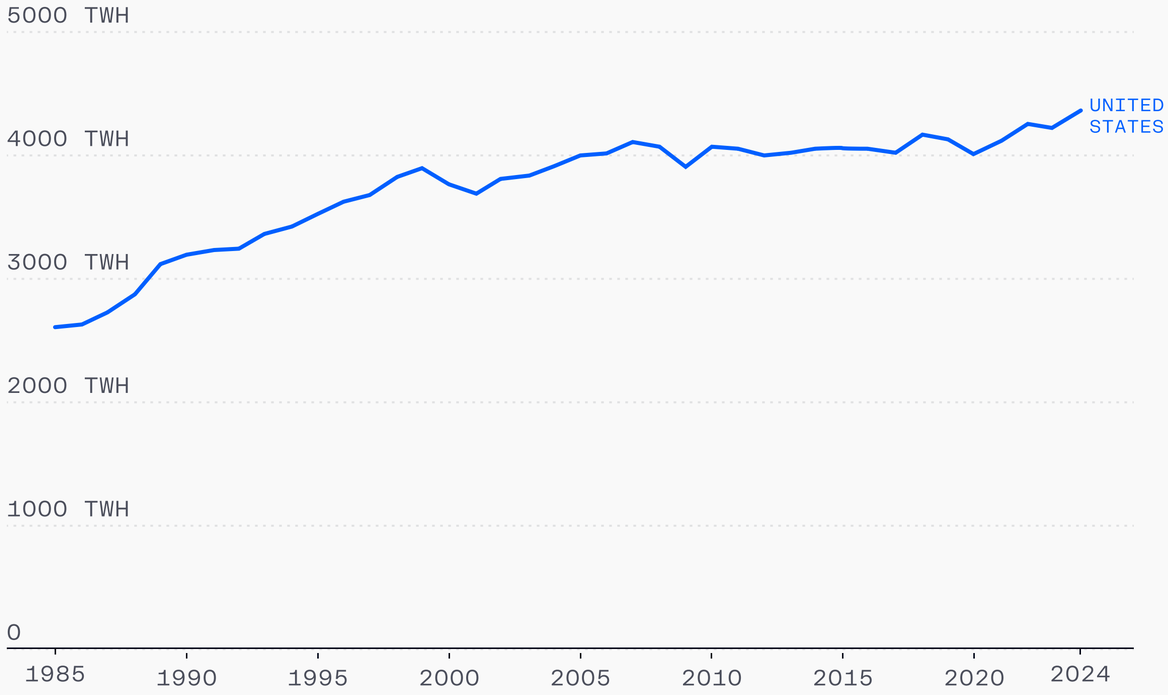
Global share of electricity production by source



Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025); Our World in Data

Total US electricity generation in 2024 was 4,387 TWh, resuming growth after a long period of stagnation. US energy generation grew just 6.3% in the 20 years from 2000 to 2020, but grew 7x faster at 8.5% from 2020 to 2024 alone.

TOTAL ELECTRICITY GENERATED IN EACH COUNTRY OR REGION, MEASURED IN TERAWATT-HOURS[1].



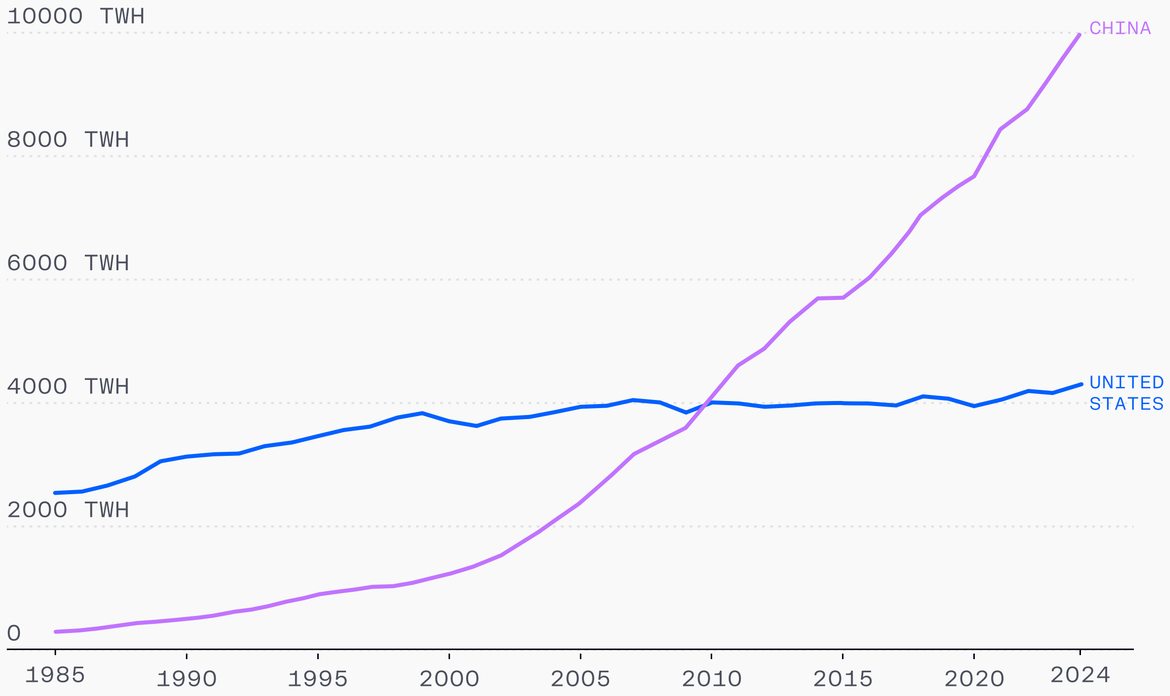
Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

However, this growth pales in comparison to China, which overtook US total energy generation in 2010.

As of 2025, China produced more than twice as much energy as the US annually, at 10,072 TWh in total production.

Electricity generation

TOTAL ELECTRICITY GENERATED IN EACH COUNTRY OR REGION, MEASURED IN TERAWATT-HOURS.

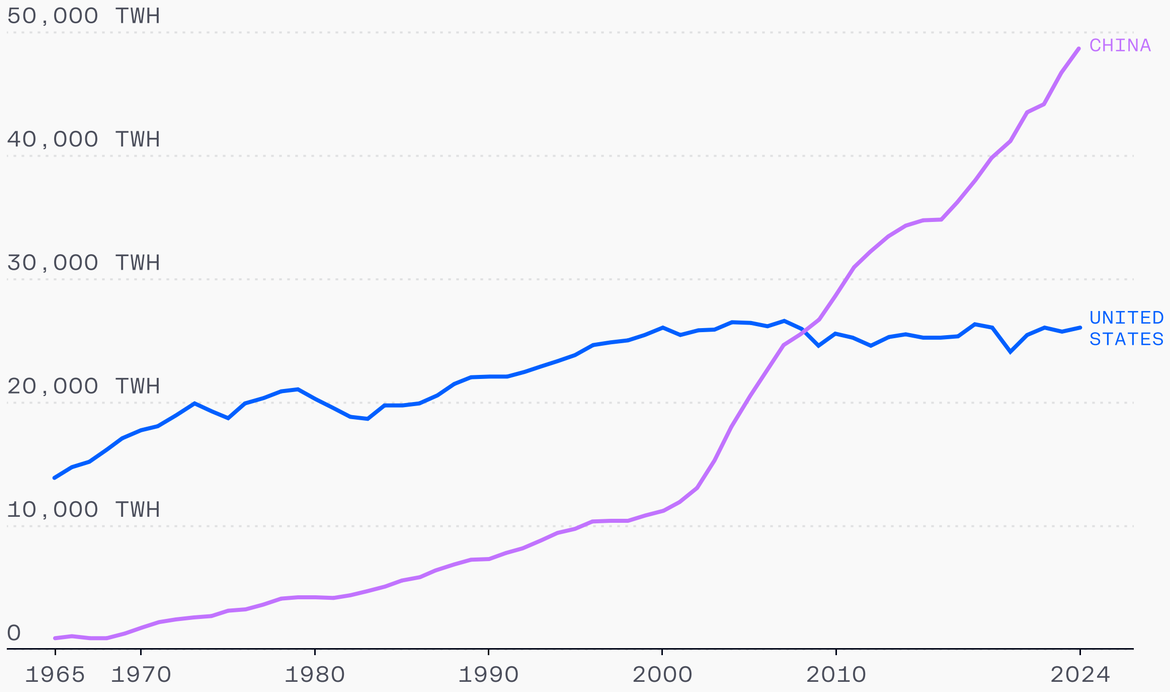


Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

Meanwhile, total US consumption in 2024 was 26,529 TWh, almost half of China's consumption (48,987 TWh).

Primary energy consumption

PRIMARY ENERGY CONSUMPTION IS MEASURED IN TERAWATT-HOURS, USING THE SUBSTITUTION METHOD.

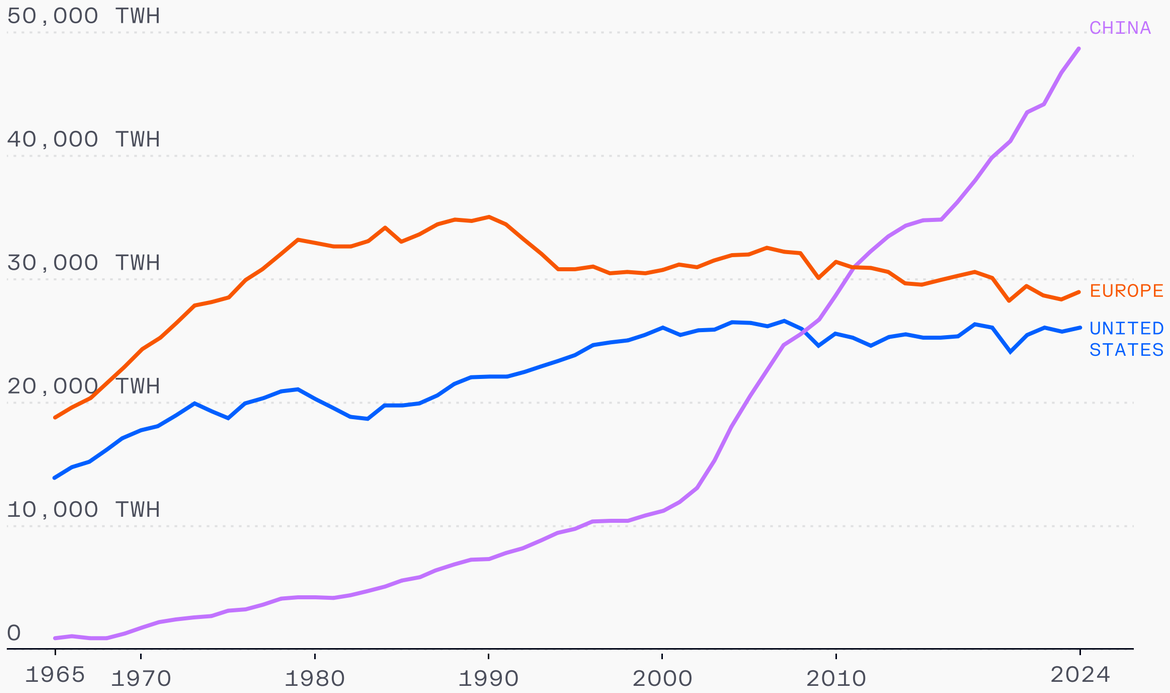


Source: U.S. Energy Information Administration (2025); Energy Institute - Statistical Review of World Energy (2025); Our World in Data

By contrast, European energy consumption has actually declined significantly from its peak, falling 17% from 35,398 TWh in 1990 to 29,280 TWh in 2024.

Primary energy consumption

PRIMARY ENERGY CONSUMPTION IS MEASURED IN TERAWATT-HOURS, USING THE SUBSTITUTION METHOD.

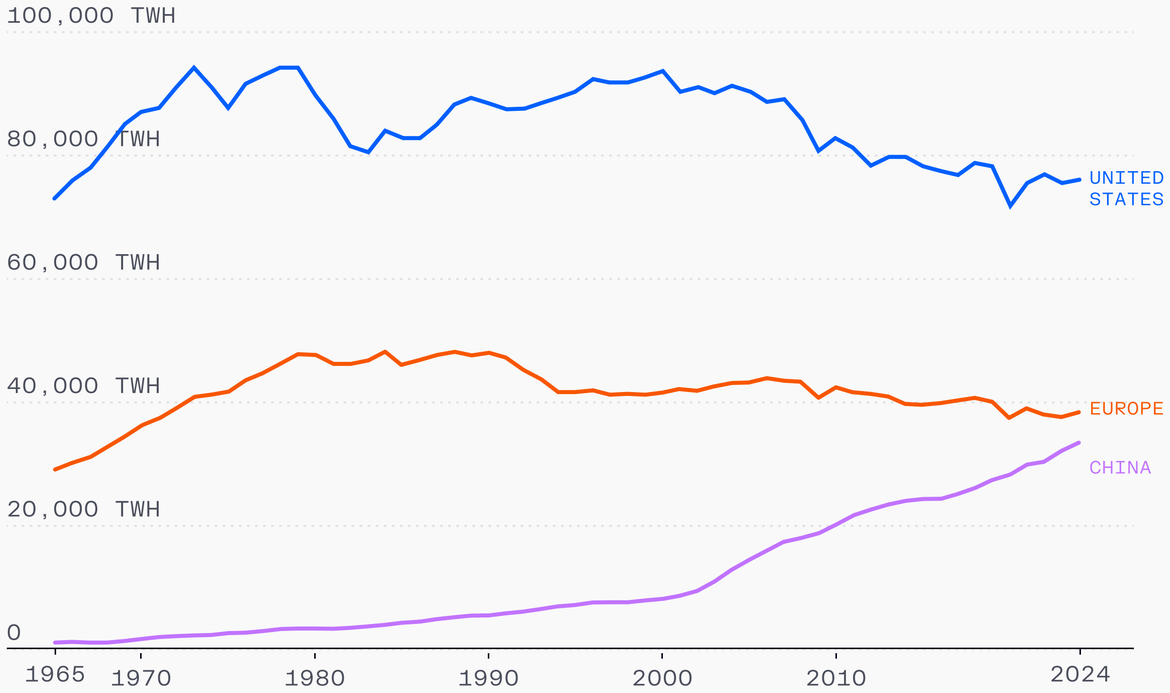


Source: U.S. Energy Information Administration (2025); Energy Institute - Statistical Review of World Energy (2025); Our World in Data

Per capita, US energy consumption has fallen 18% from 2000 to 2024, with China growing 2.7x over the same period. However, the US still exceeds China's energy usage per capita by over 2x.

Primary energy consumption

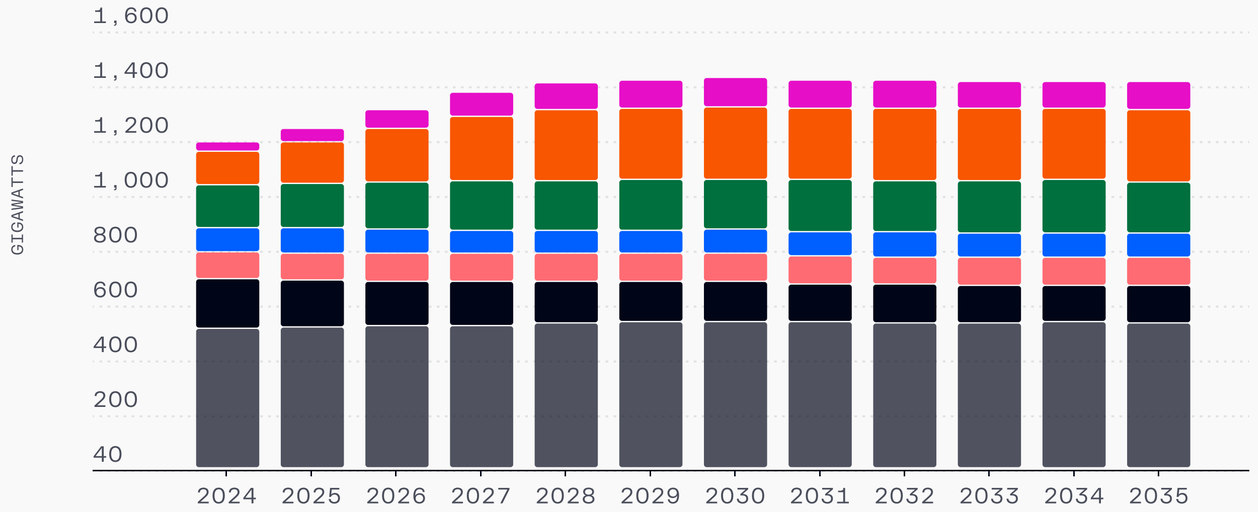
MEASURED IN KILOWATT-HOURS PER PERSON. HERE, ENERGY REFERS TO PRIMARY ENERGY USING THE SUBSTITUTION METHOD.



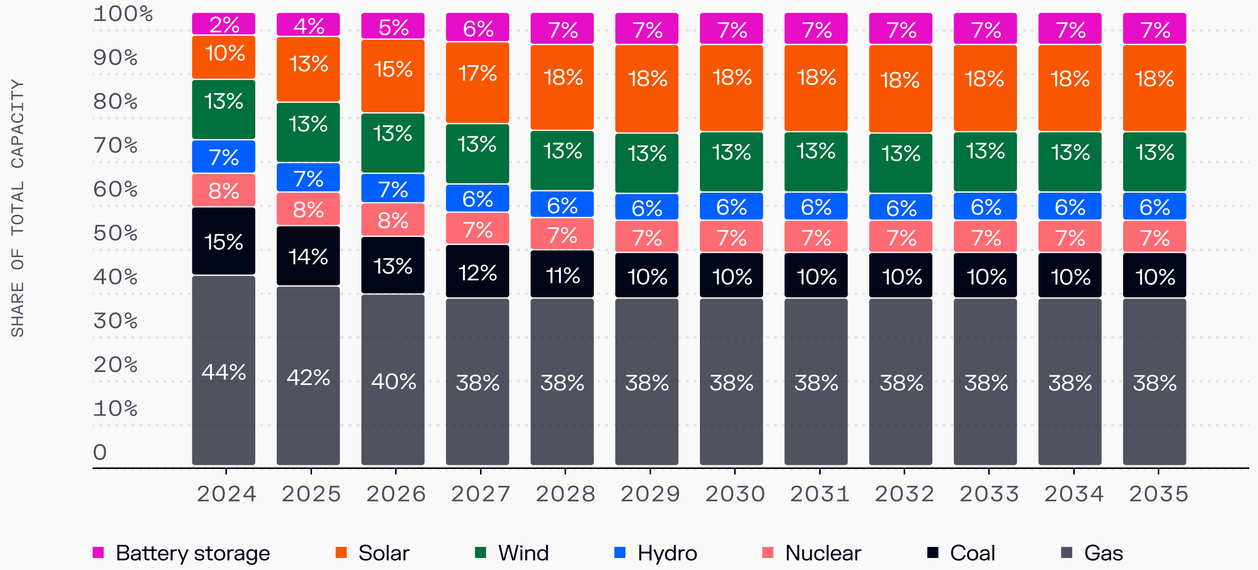
Source: U.S. Energy Information Administration (2025); Our World In Data

In the US, total energy capacity is projected to increase by 13% between 2025 and 2035. The majority of the growth is expected to come from solar and wind.

Projected US power generation capacity by source



Projected US power source capacity by source

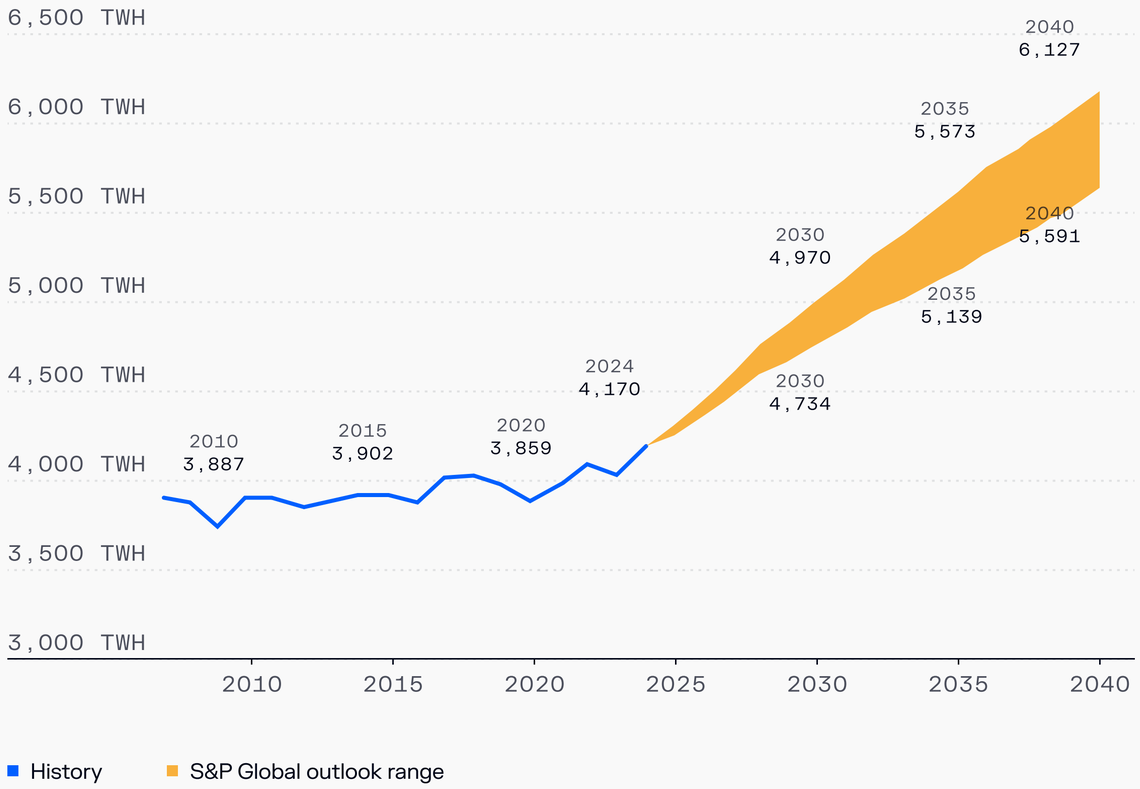


Source: LSEG, US Energy Information Administration; Reuters

However, US energy demand is projected to far outstrip supply in terms of US lower 48 net on-grid electricity demand.

By 2040, electricity demand is expected to grow by 35-50%, driven by manufacturing growth, data center buildout, and the electrification of heating and transportation.

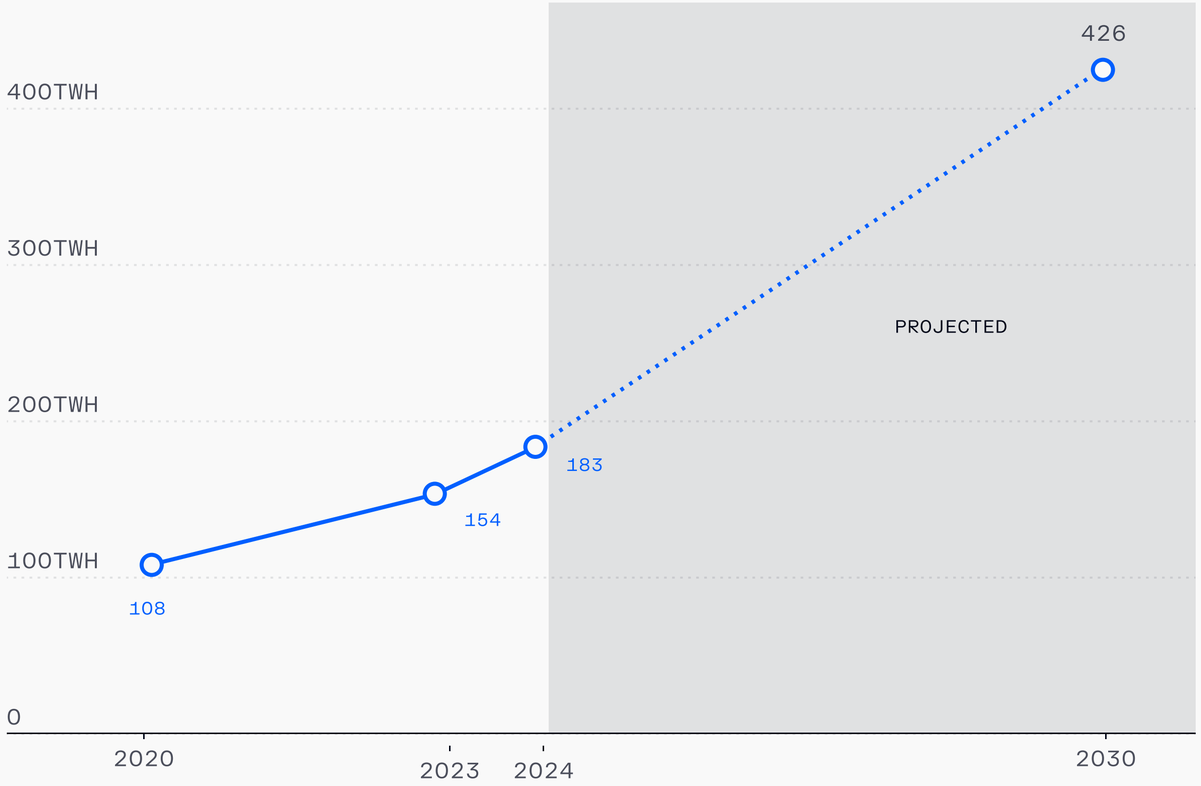
US Electricity Demand Growth: Historical and Projected



Source: S&P Global Commodity Insights

US data centers used 183 TWh in 2024, or about 4% of total consumption. This is expected to grow by at least 133% to 426 TWh by 2030, although far more growth is possible.

Total Electricity Consumption by US Data Centers

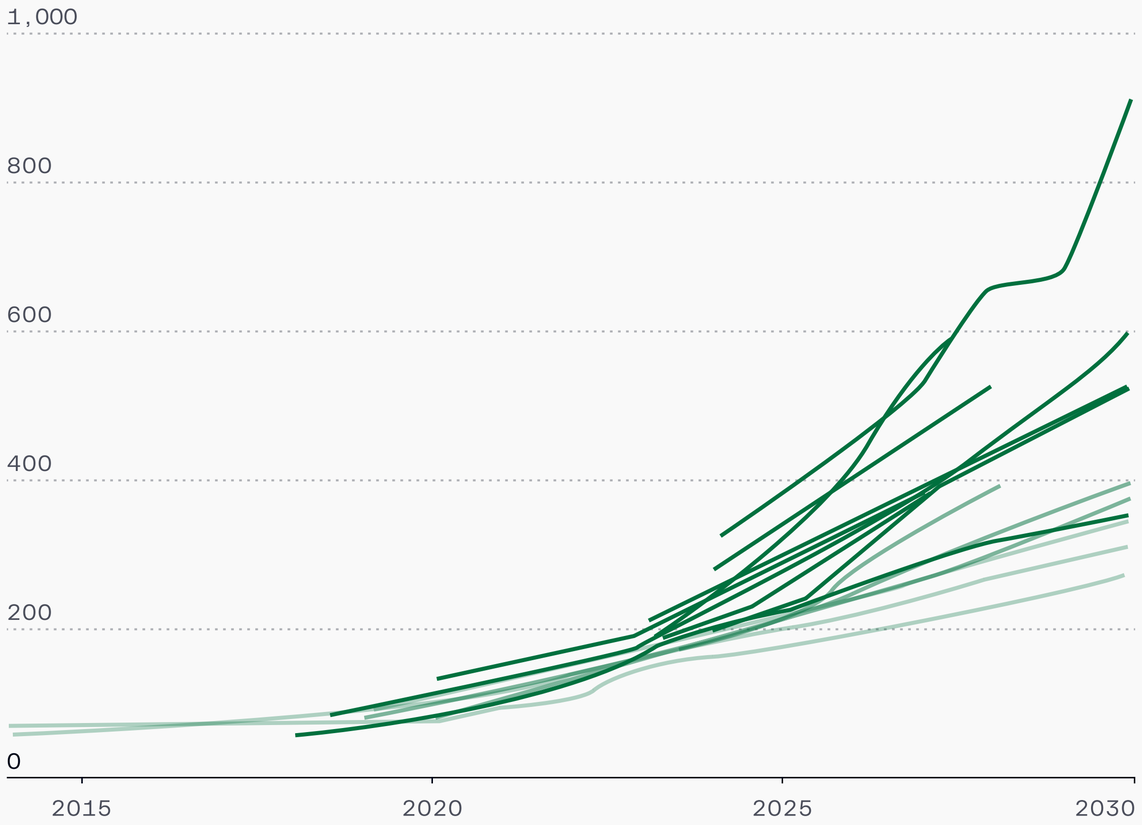


Source: Pew Research

As a result of this rapid growth, there could be a 40% gap between supply and demand for data center energy as soon as 2026.

US data center power use is set to rise, although estimates vary

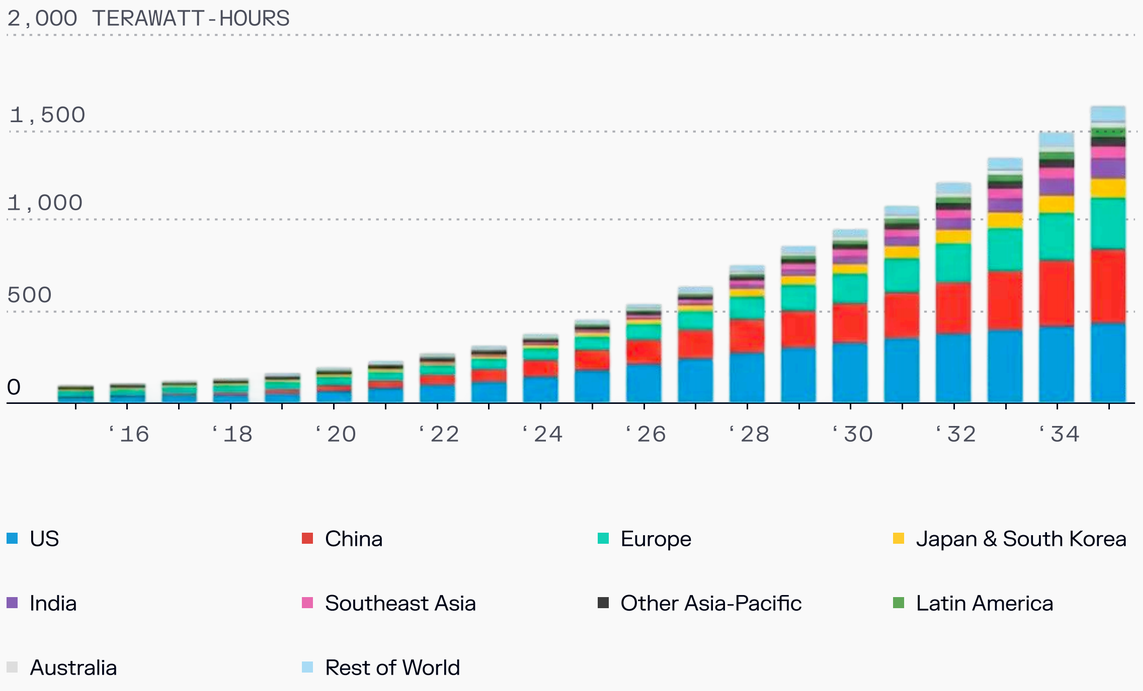
ELECTRICITY USAGE PROJECTIONS (TWH)



Source: The Financial Times, et al.

The same trend is happening outside of the US. Globally, power demand from AI data centers is projected to quadruple over the next 10 years.

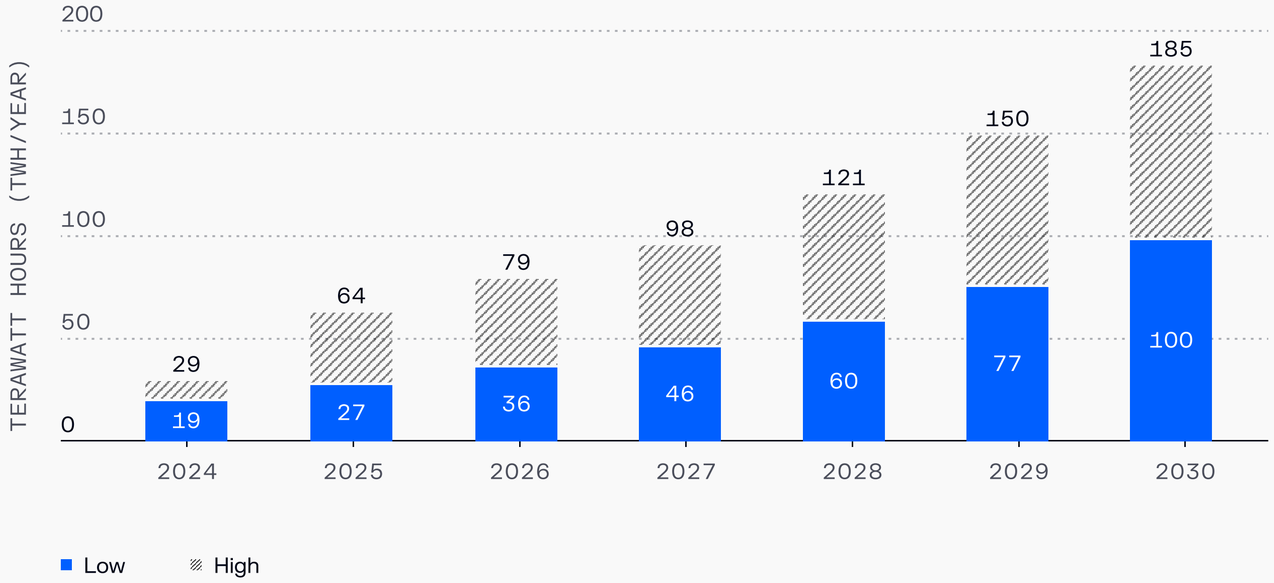
GLOBAL DATA CENTER POWER DEMAND OUTLOOK BY MARKET



Source: Bloomberg

At the same time, the ongoing adoption of EVs is also driving energy demand growth. By 2030, EVs alone could account for between 2.5 - 4.6% of total power demand, around the same time that data centers are projected to reach 10% of total demand.

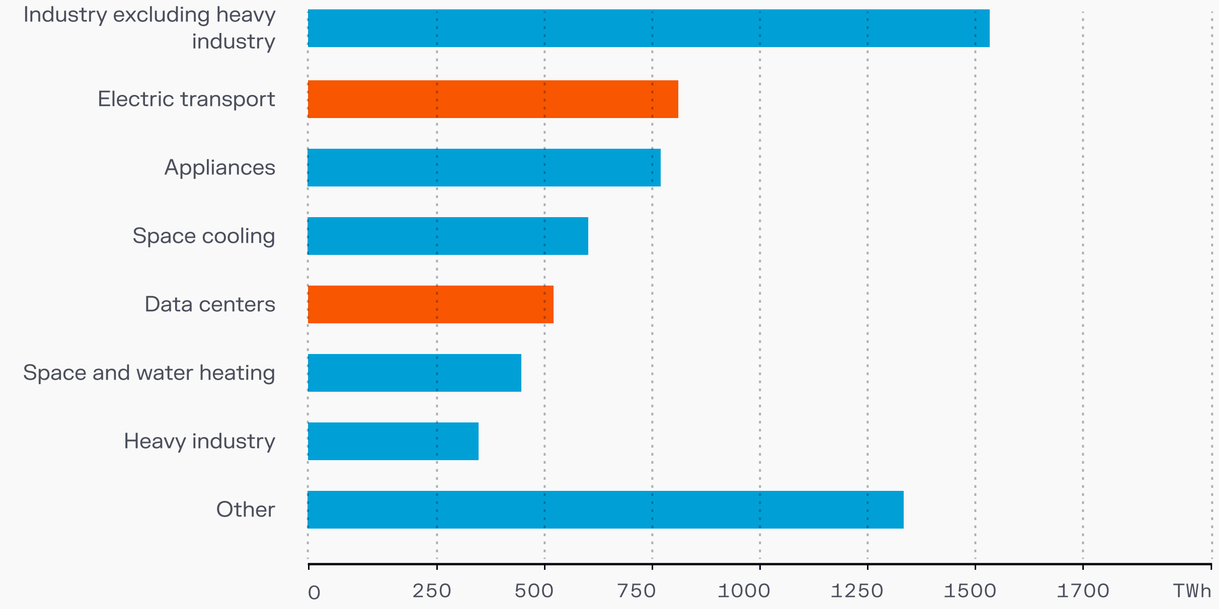
Forecast electricity demand from passenger EVs in the US from 2024 to 2030



Source: BNEF, RaboResearch 2024, National Renewable Energy Laboratory

However, energy demand growth from EVs alone could actually exceed AI-driven growth over the coming decade.

Increase in eletricity demand by sector, Base Case, 2024-2030



Source: IEA

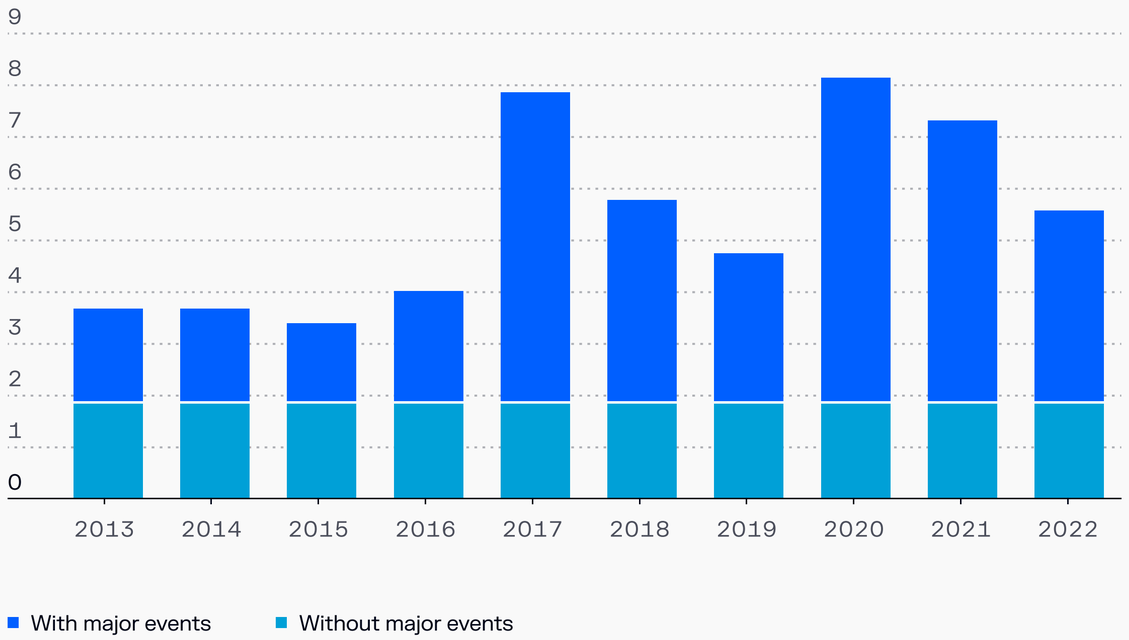
Meanwhile, the US electric grid is aging and grid failure rates are slowly rising.

Power interruptions in the US are becoming more common, mostly due to a combination of extreme weather events and the age of the grid.

Over 70% of the US grid is more than 25 years old. 80% of all major US power outages reported between 2000 and 2023 were due to weather.

Average annual total of electric power interruptions (2013-2022)

NUMBER OF HOURS PER CUSTOMER

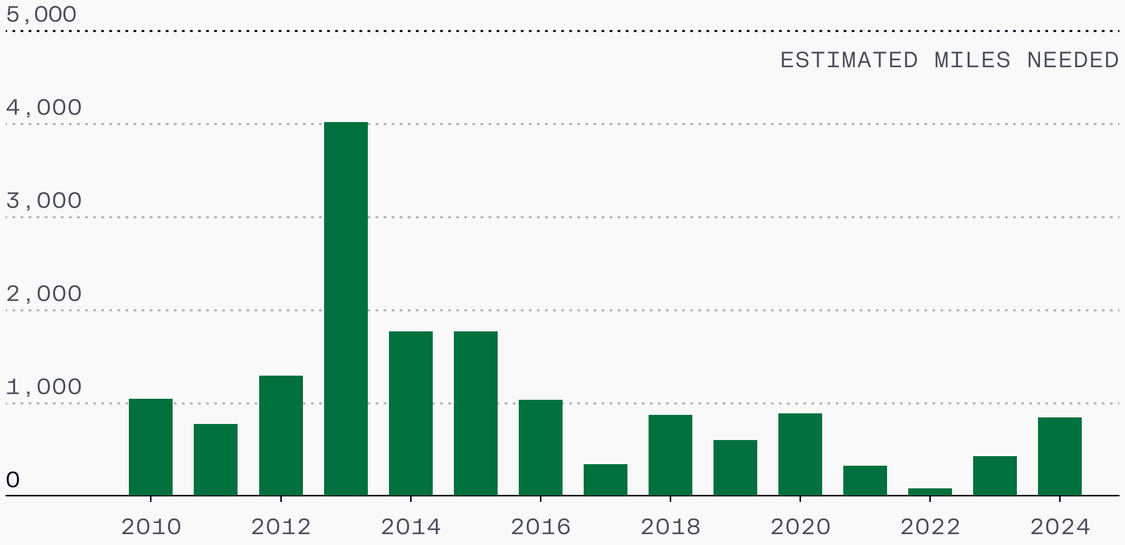


Source: IEA

The grid is the biggest bottleneck to bringing new power online. New transmission line permitting takes four years on average to secure, and shortages in large electric transformers are causing prices and lead times to skyrocket.

In other words, even if energy generation can accelerate enough to service increased demand, transmission will remain a serious obstacle.

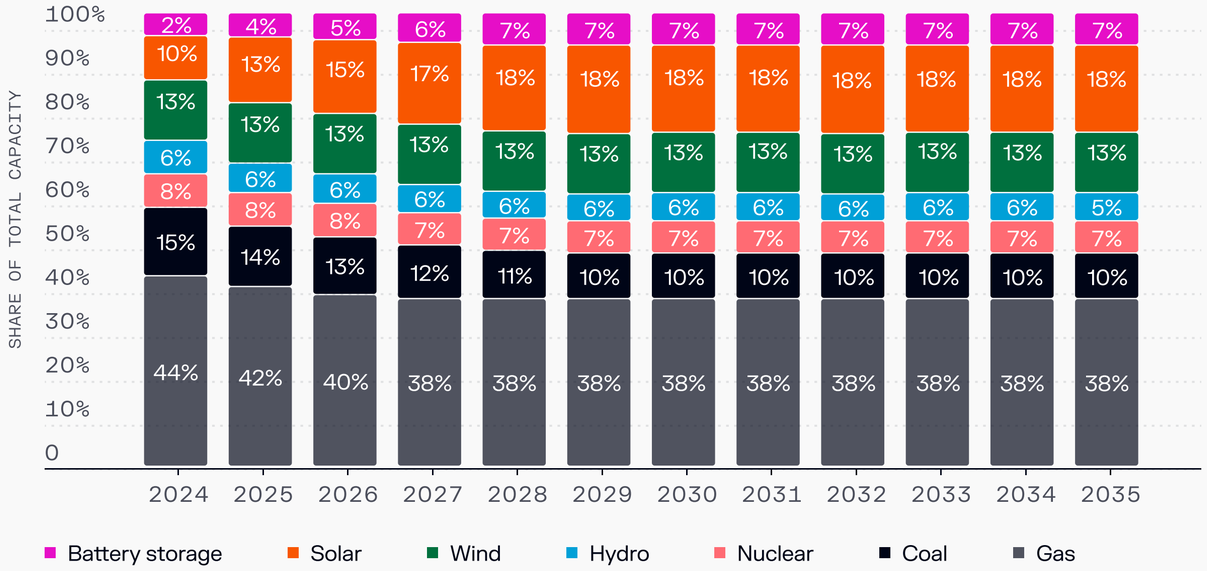
Miles of high-voltage transmission lines added per year in the US



Source: Financial Times

At about 56% of the US energy mix in 2025, fossil fuels remain the main source of American energy. However, this share is slowly declining and it projected to fall to 48% by 2035.

Projected US power source capacity by source

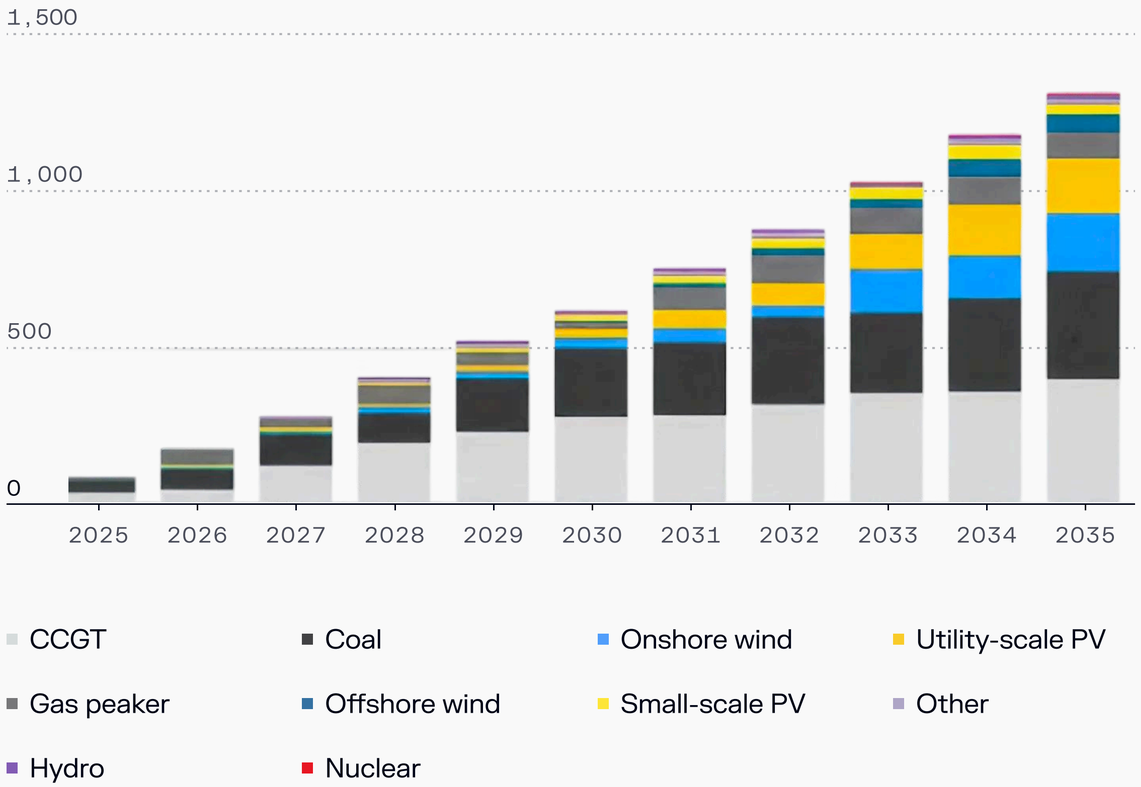


Source: Reuters

Much of the net-new energy needed to supply data center expansion, though, will likely come from fossil fuels like gas and coal.

Gas and coal will fuel most new power demand for AI

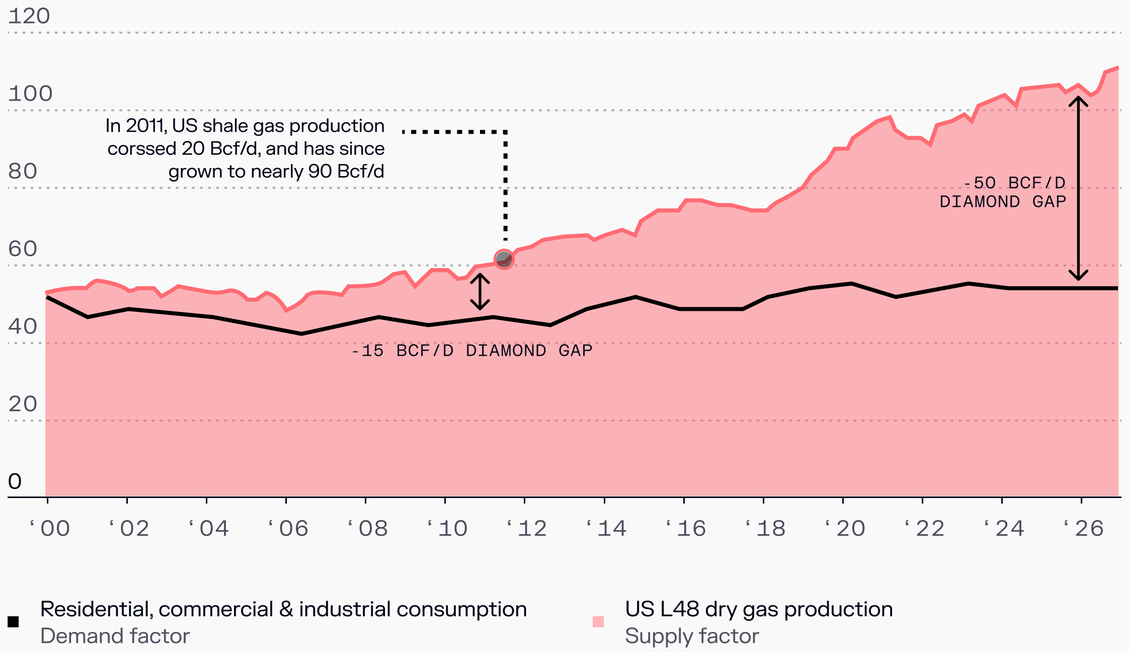
INCREMENTAL GENERATION NEEDED TO MEET DATA-CENTER DEMAND



Source: Financial Times

However, the overall gap between domestic natural gas supply and demand growth outside of generating electricity continues to grow, indicating that gas is not a growth industry outside of generating electricity.

US domestic natural gas supply and demand growth (Bcf/d)

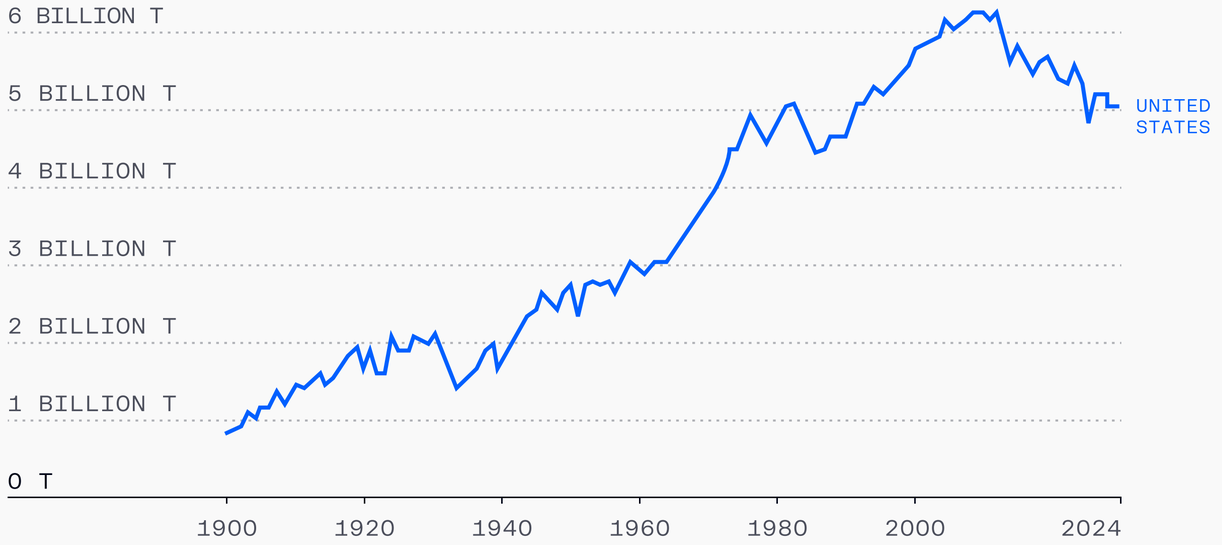


Source: Bloomberg, EIA, S&P Global, HTM Energy Research BrainScout, HTM Energy Partners; Note: Includes oil and gas upstream and midstream consumption, fuel gas, and pipeline losses.

Despite the continued importance of fossil fuels in the US economy, total carbon emissions are down from a peak of 6.1 billion tonnes in 2007 to 4.9 billion tonnes in 2024.

Annual CO_2 emissions

CARBON DIOXIDE (CO_2) EMISSIONS FROM FOSSIL FUELS AND INDUSTRY[1]. LAND-USE CHANGE EMISSIONS[2] ARE NOT INCLUDED

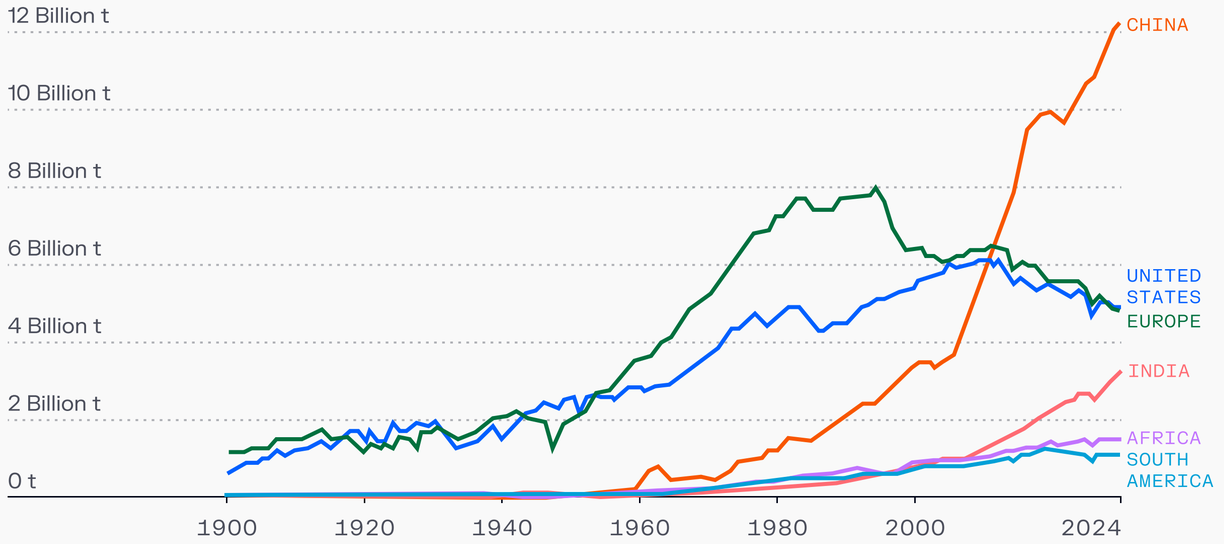


Source: Global Carbon Budget

However, China is rapidly increasing its carbon emissions, and now exceeds the US and Europe combined.

Annual CO_2 emissions

CARBON DIOXIDE (CO_2) EMISSIONS FROM FOSSIL FUELS AND INDUSTRY[1]. LAND-USE CHANGE EMISSIONS[2] ARE NOT INCLUDED

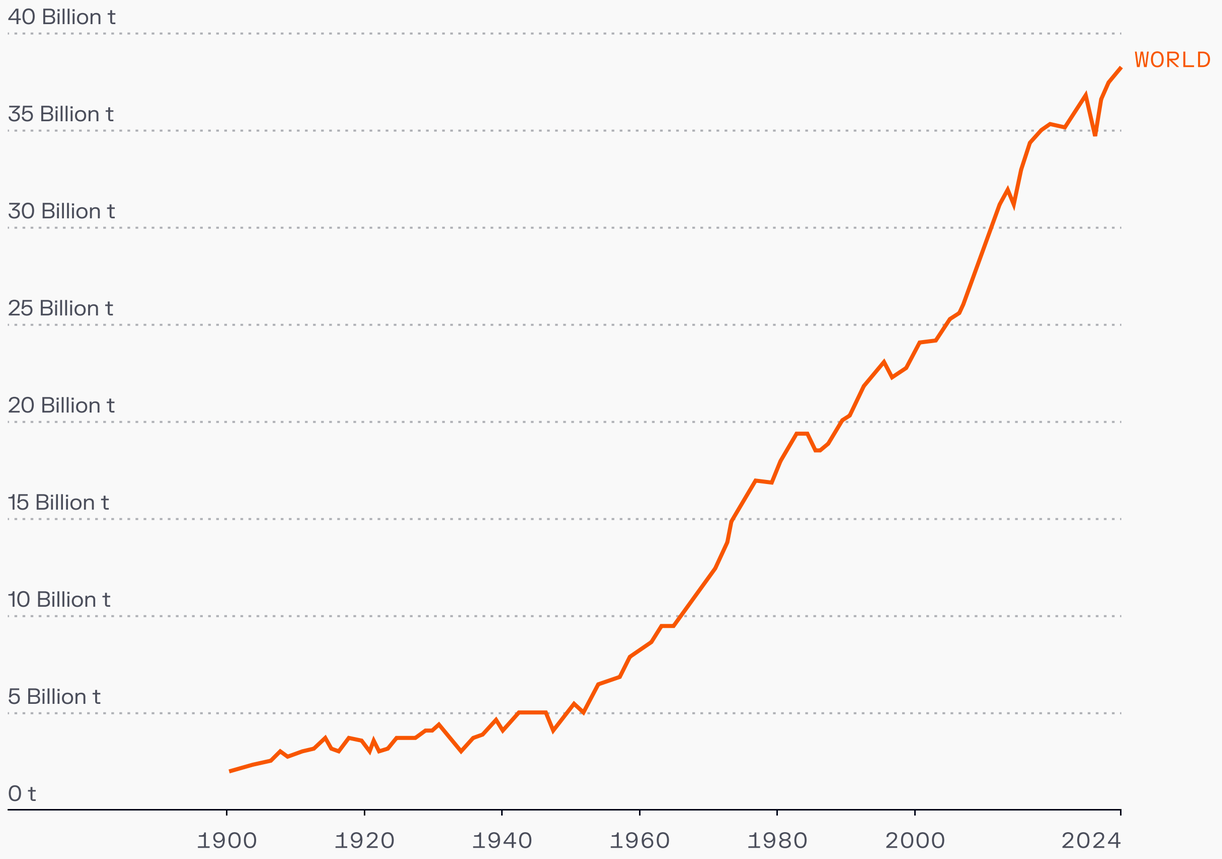


Source: Global Carbon Budget

Even with declines in the US and Europe, carbon emissions continue to rise globally in the aggregate.

Annual CO_2 emissions

CARBON DIOXIDE (CO_2) EMISSIONS FROM FOSSIL FUELS AND INDUSTRY. LAND-USE CHANGE EMISSIONS ARE NOT INCLUDED

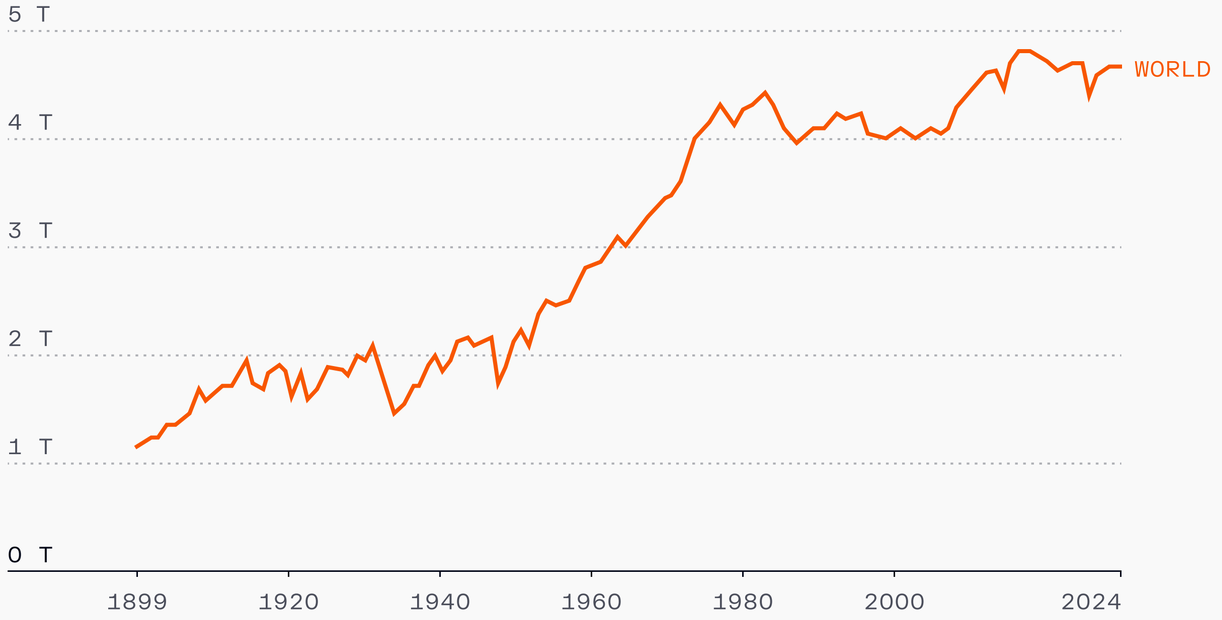


Source: Global Carbon Budget

Nevertheless, emissions per capita peaked back in 2011, which could serve as a leading indicator of total emissions as population growth decelerates.

CO_2 emissions per capita

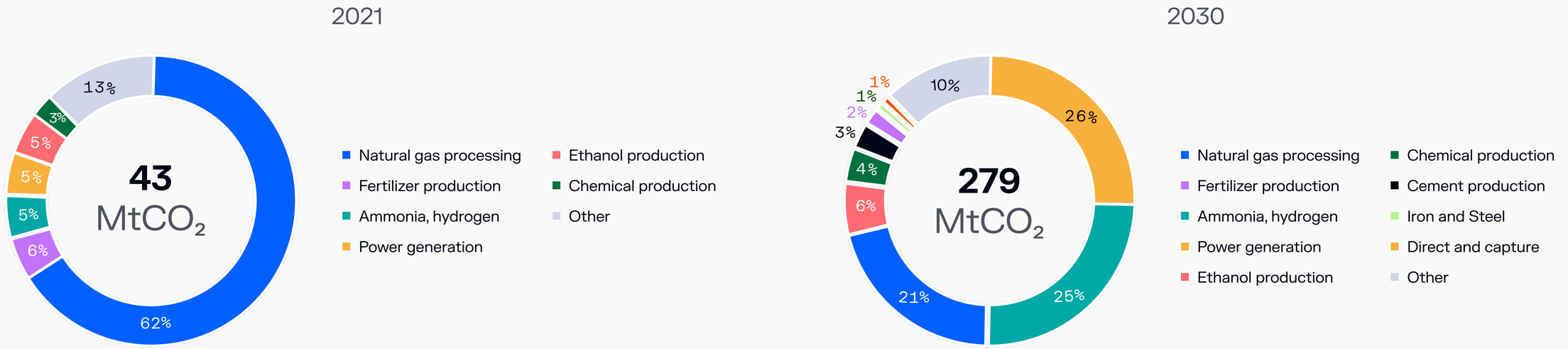
CARBON DIOXIDE (CO_2) EMISSIONS FROM BURNING FOSSIL FUELS AND INDUSTRIAL PROCESSES. THIS INCLUDES EMISSIONS FROM TRANSPORT, ELECTRICITY GENERATION, AND HEATING, BUT NOT LAND-USE CHANGE.



Source: Global Carbon Budget

Meanwhile, global carbon capture capacity is rapidly scaling, and is expected to increase from 43 million tons annually in 2021 to 279 million tons by 2030.

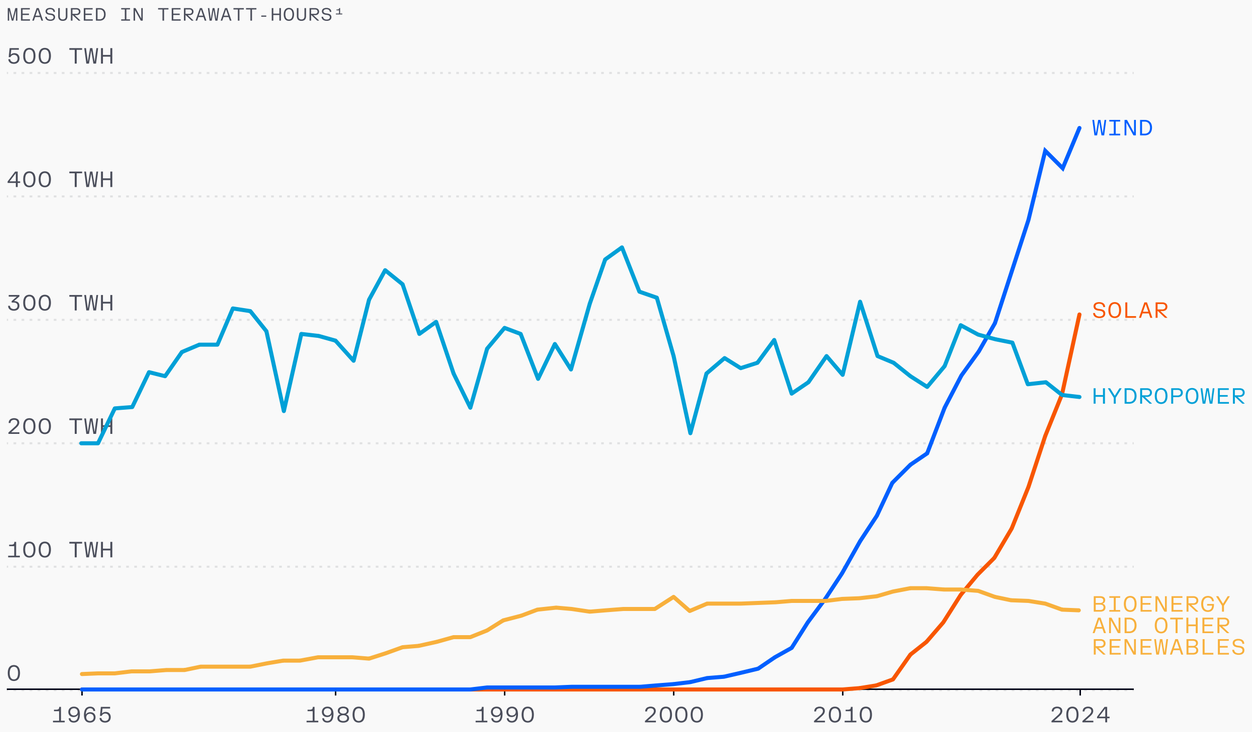
Global carbon capture capacity by source



Source: Bloomberg NEF

In the US, renewable energy growth is being driven by a surge in wind and solar power. From 2000 to 2024, wind power in the US grew from less than 6 TWh to 453 TWh, an over 75x increase. Solar's growth has been even more rapid, from just 0.5 TWh in 2000 to 303 TWh in 2024 – over 600x growth in less than 25 years.

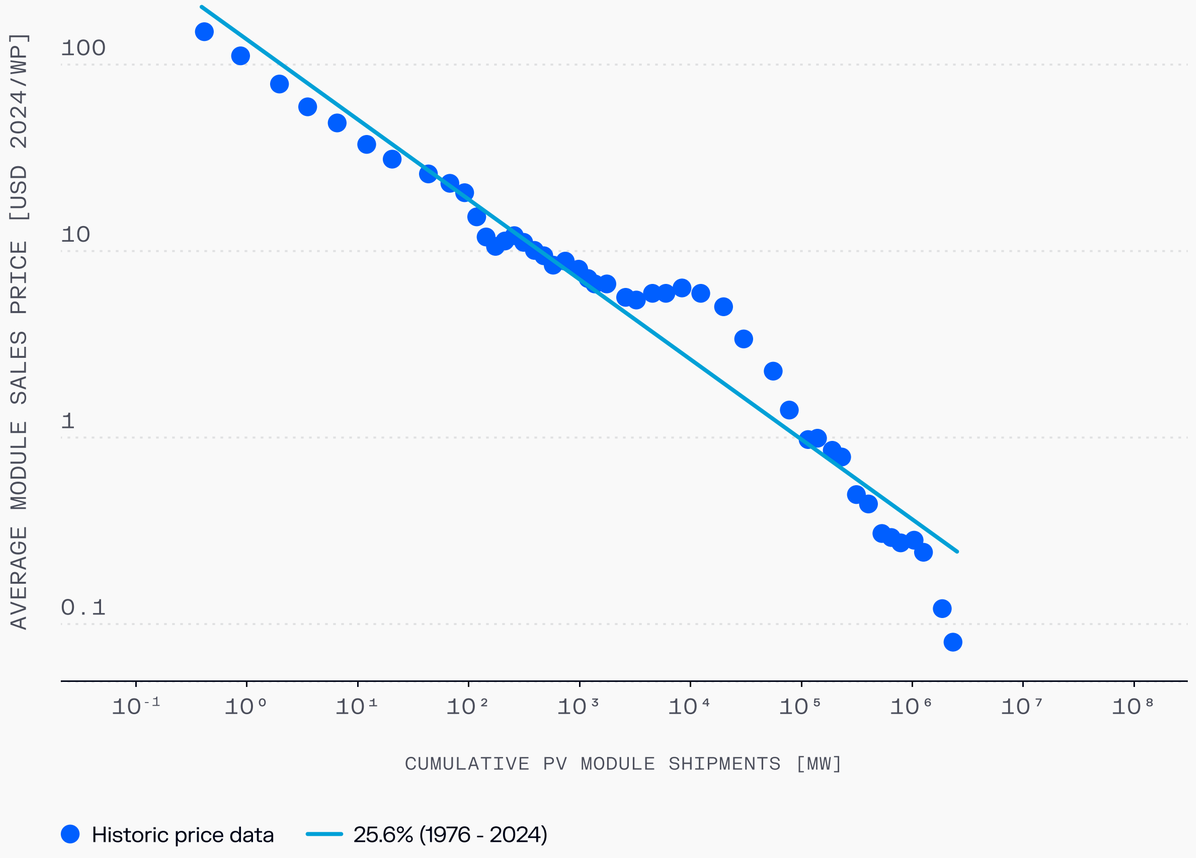
Modern renewable electricity generation by source, United States



Source: Ember; Energy Institute - Statistical Review of Word Energy (2025)

One driver of solar is the cost. For nearly 50 years, solar module prices have fallen by ~26% every time cumulative production doubled.

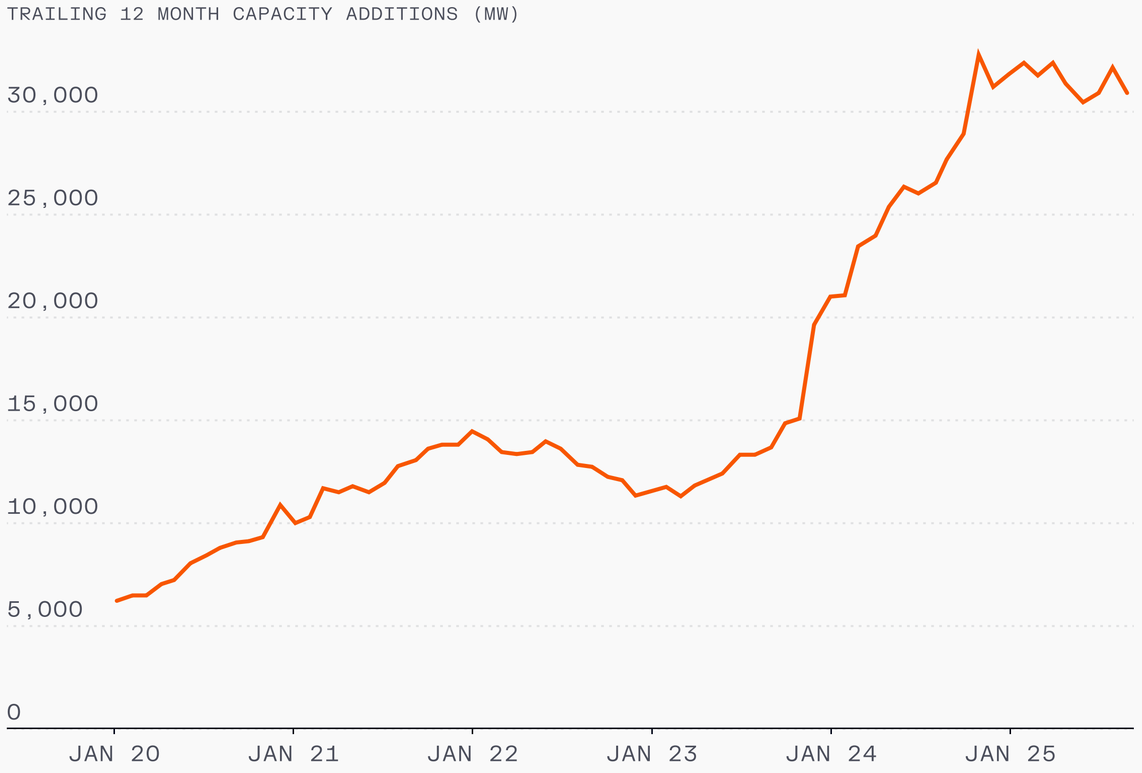
Learning curve for module price as a function of cumulative shipments



Source: LevelTen

This is leading to significant increases in solar capacity additions taking place.

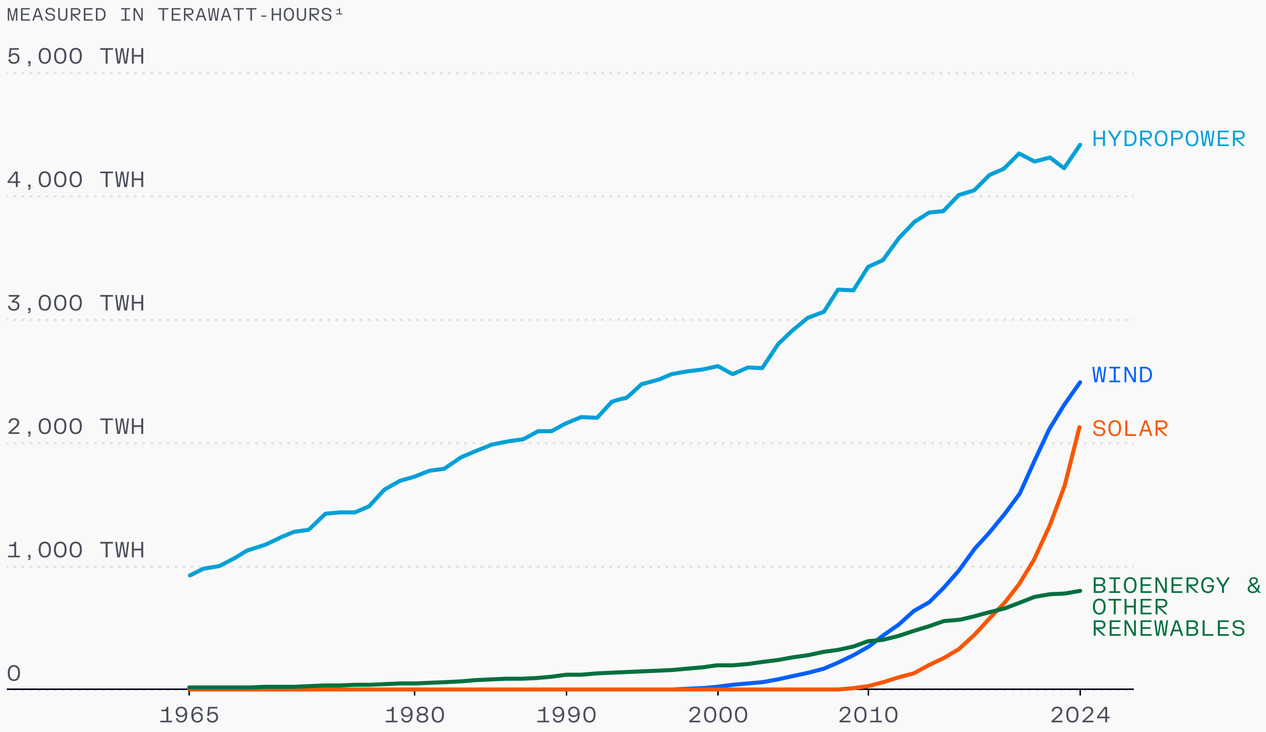
US utility-scale solar capacity additions



Source: Cleanview

Globally, hydropower is a critical piece of the puzzle and is the leading renewable source, although wind and solar are the fastest-growing.

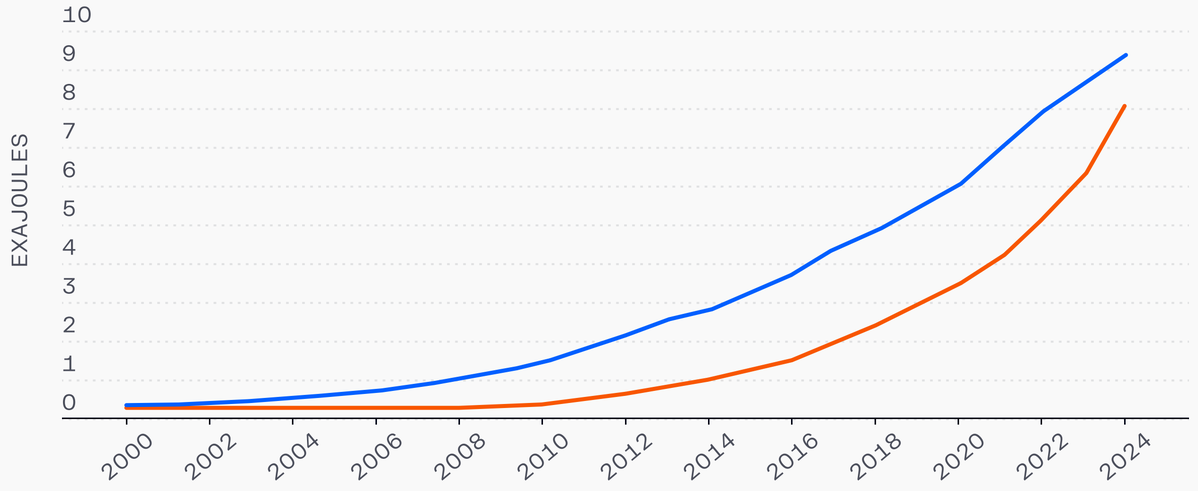
Modern renewable electricity generation by source, World



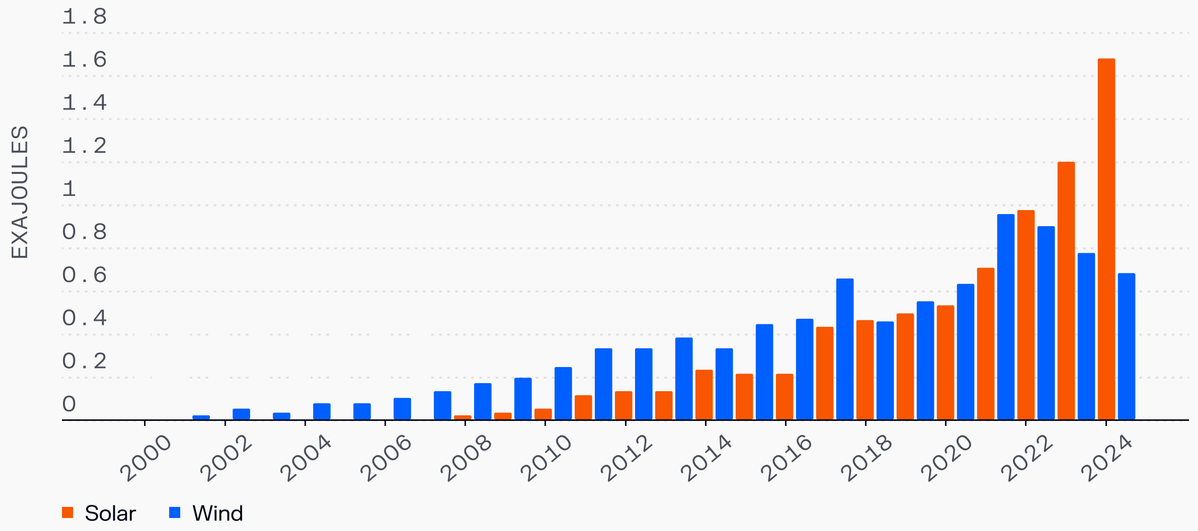
Source: Energy Institute - Statistical Review of Word Energy (2025)

Wind and solar consumption are growing as quickly as production, though wind's growth has started to decline.

Global consumption of solar & wind power since 2000



Annual change in global solar & wind consumption



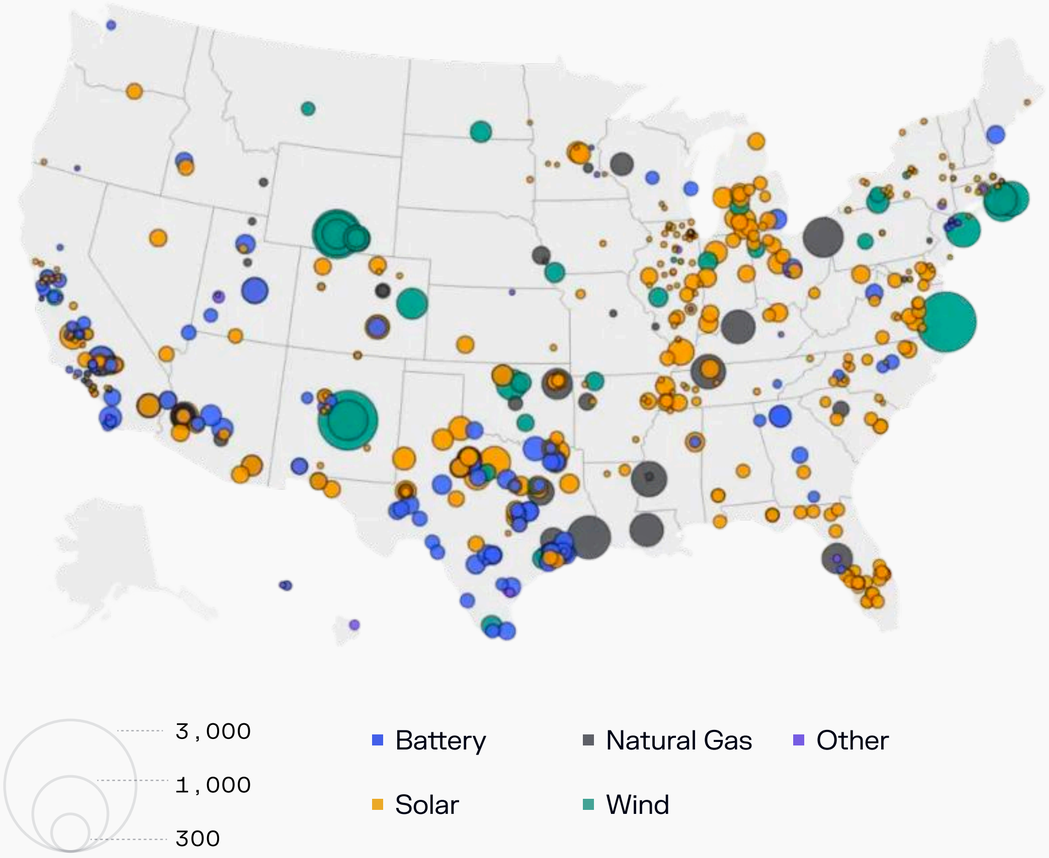
Source: Reuters; Energy Institute

US wind capacity additions have declined by 74% since their peak in October 2021.

US utility-scale solar capacity additions

Source: Cleanview

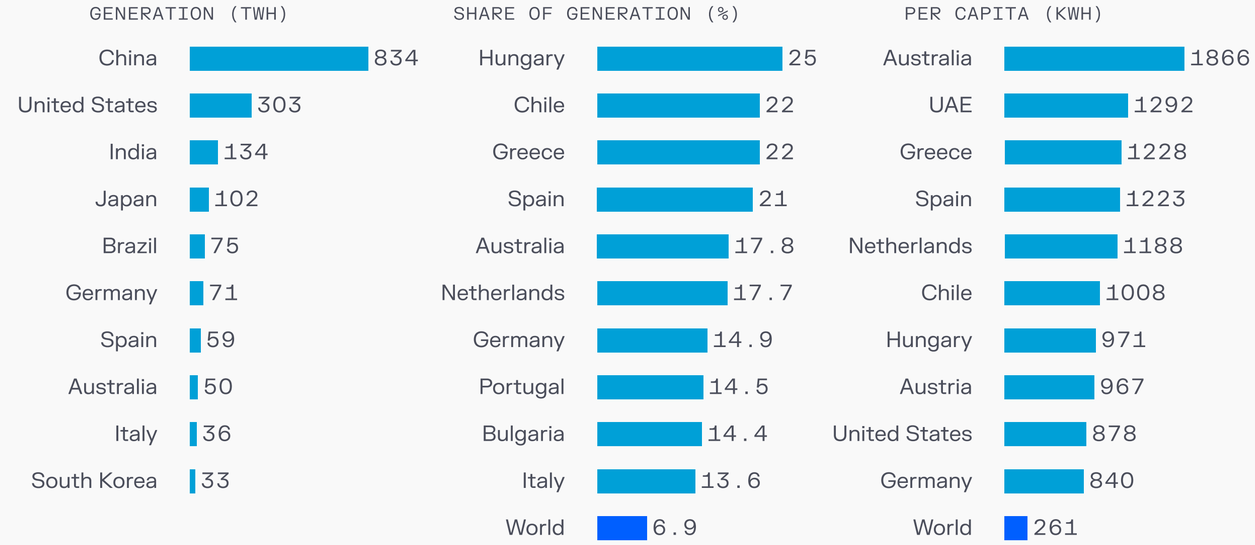
In the US more broadly, there is a broad swath of energy projects under production, though solar has the highest number of active projects under construction.



Source: Cleanview

China is by far the leader in solar, with 834 TWh as of 2024, compared to the US at 303 TWh.

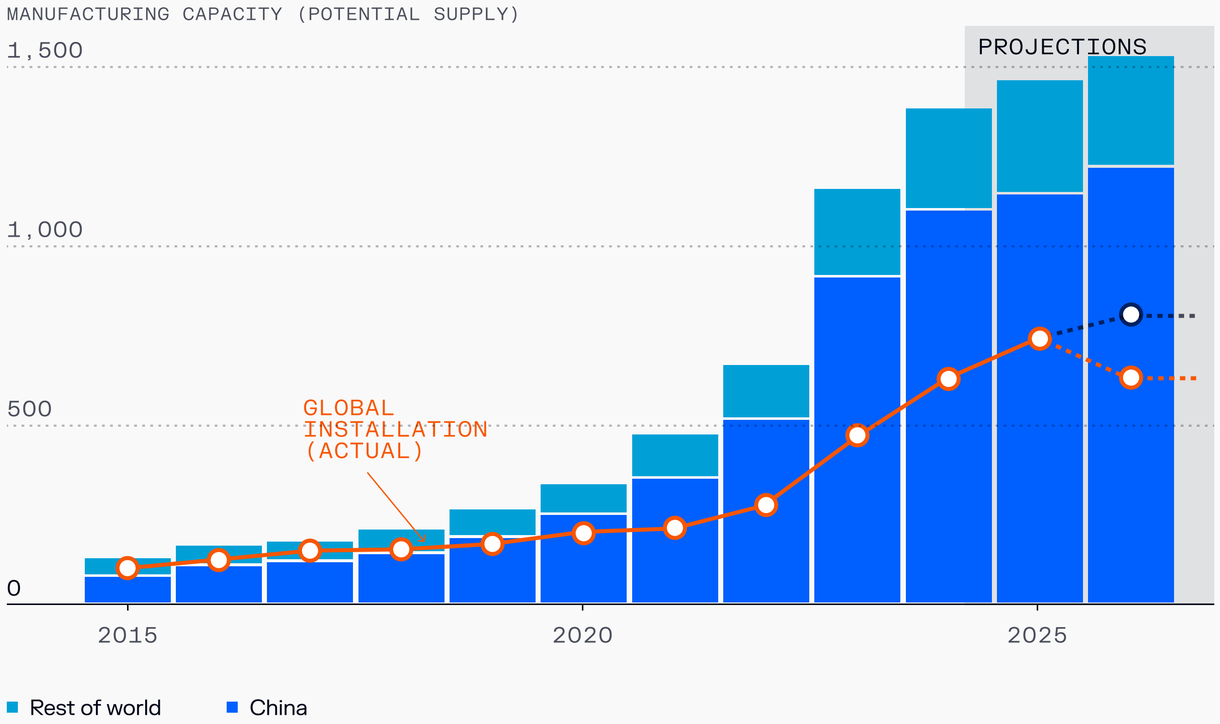
Solar: 2024 global electricity rankings



Source: Ember; Graphic only includes countries with source generation above 5 TWh; where 2024 data is not available, 2023 is used

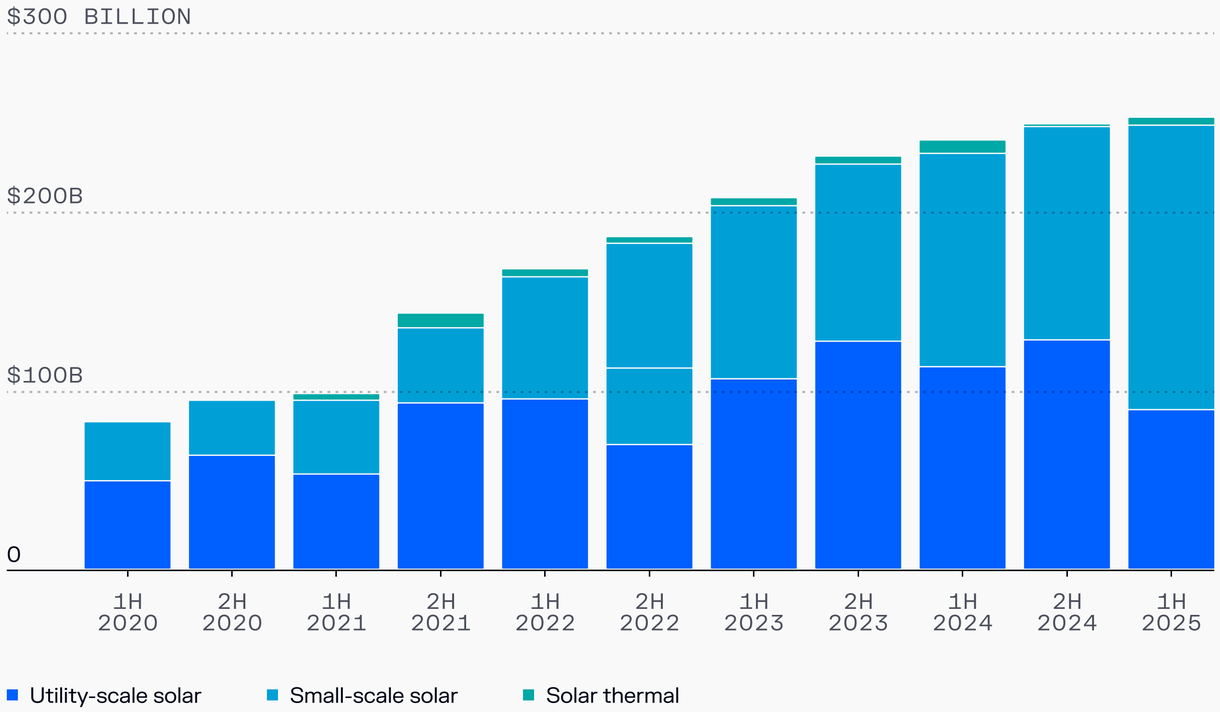
In fact, China is the majority of solar PV manufacturing capacity globally.

Solar PV modules, GW



Source: Compound

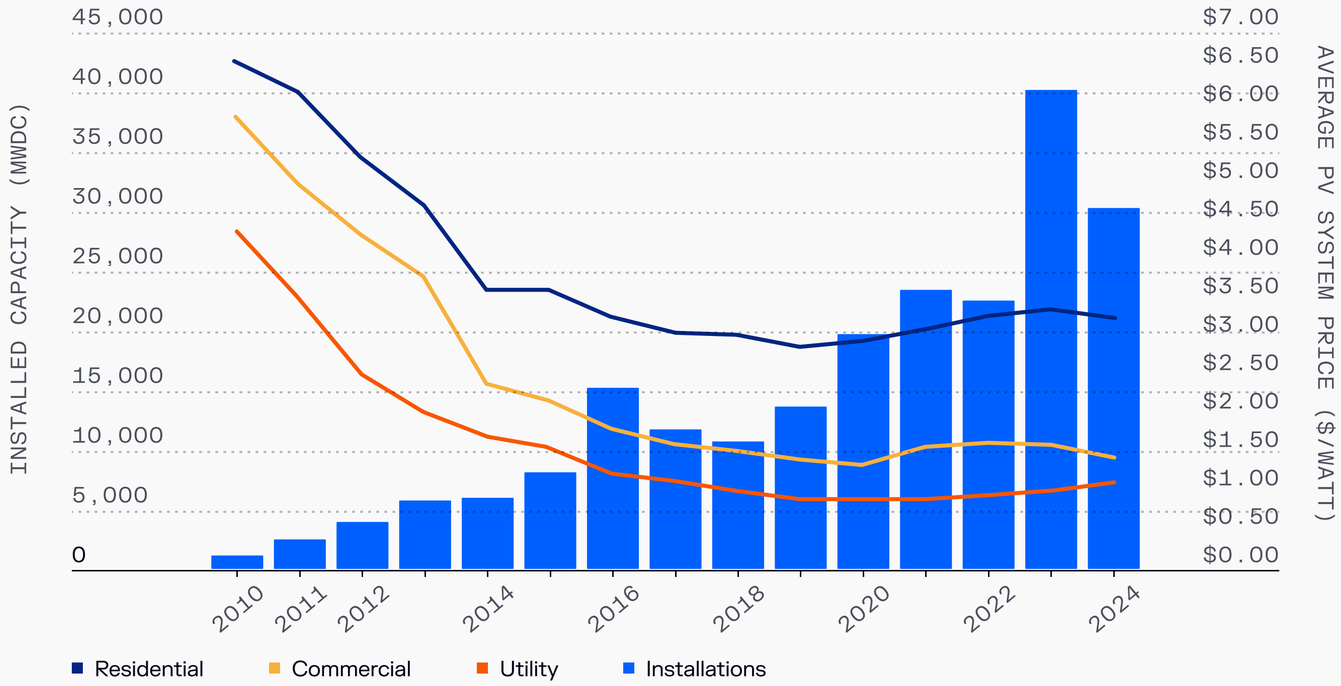
Globally, investment in small-scale solar has overtaken investment in grid-scale solar.



Source: BloombergNEF

The US is ramping up solar deployment, driven by decreasing costs.

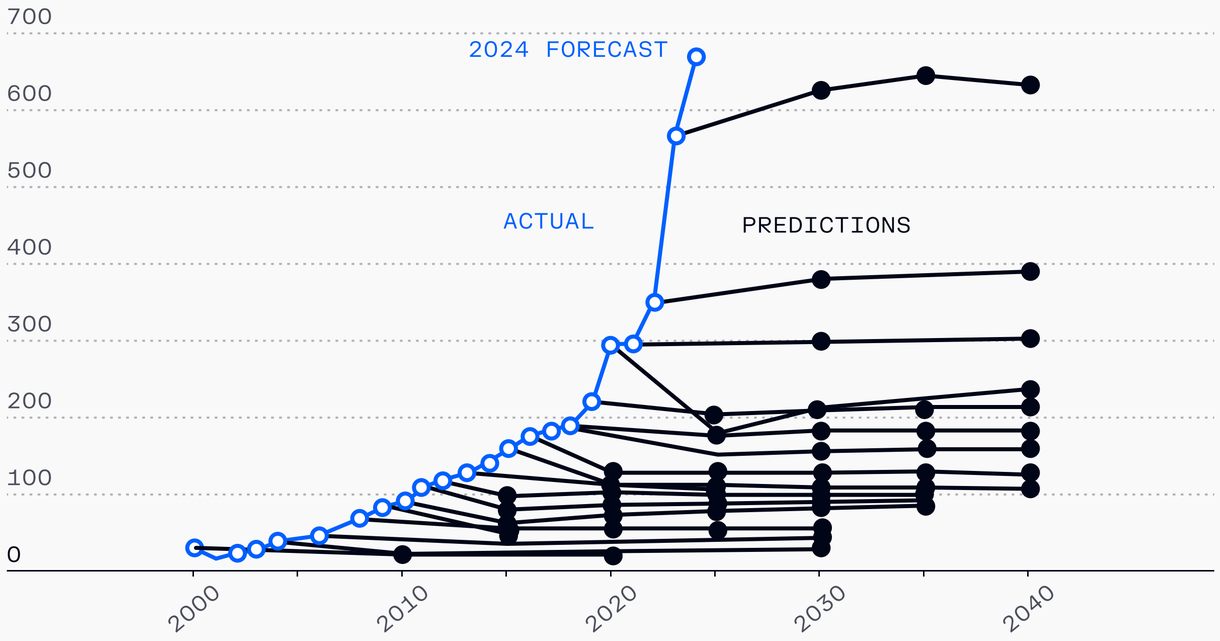
U.S. Solar PV Pricing Trends & Deployment Growth



Source: SEIA/ Wood Mackenzie Power & Renewables U.S. Solar Market Insight Q4 2024

The story of global renewable energy capacity is one of continuously exceeding expectations, where each incremental annual forecast consistently under-predict the volume of actual capacity being added each year.

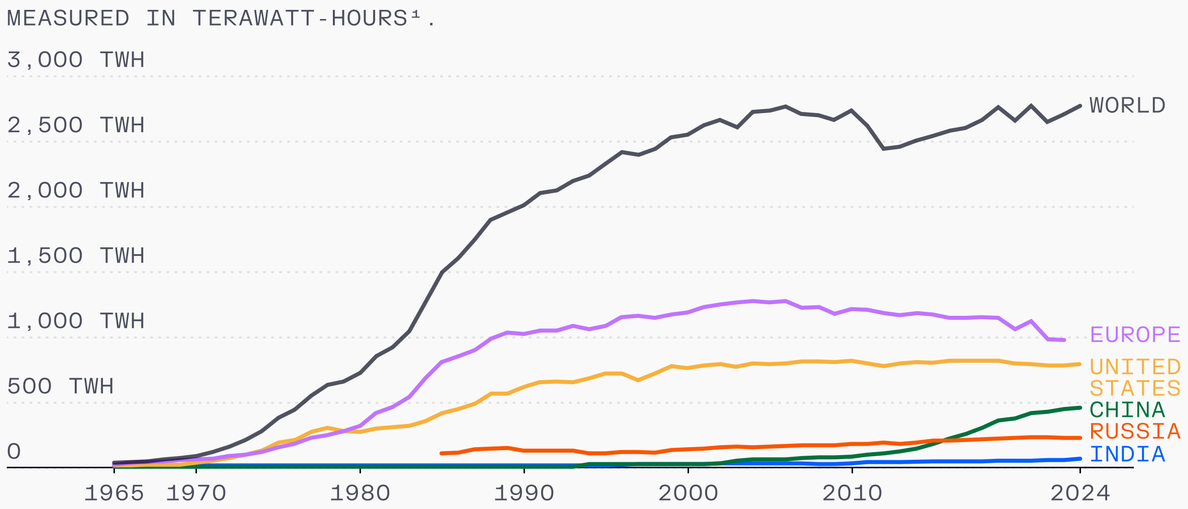
Global renewable energy*, capacity added each year, GW



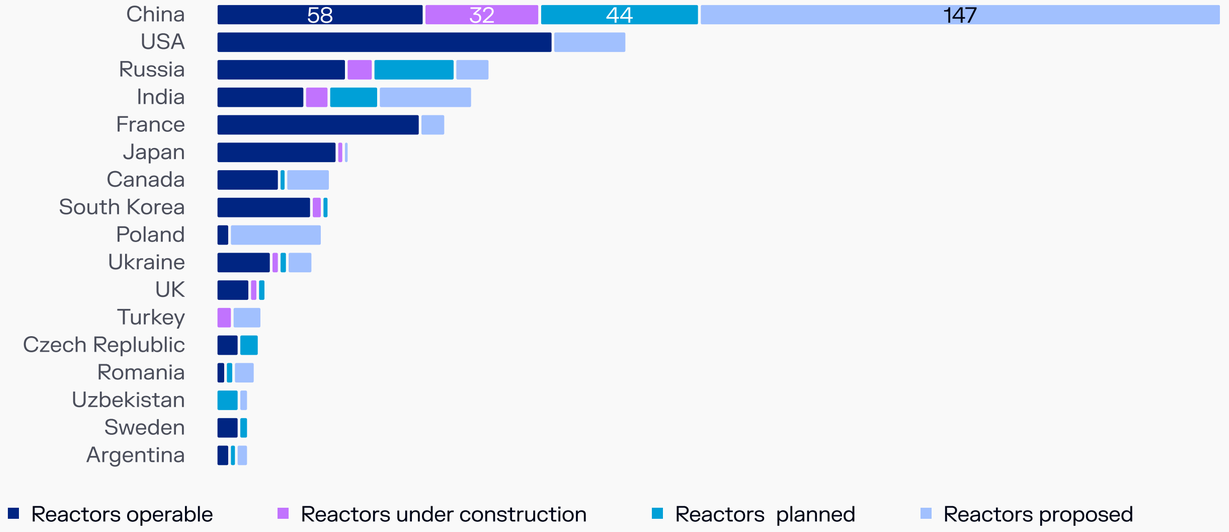
*Source: IEA; *includes solar, wind, hydropower, bioenergy, geothermal, and marine; +Existing-policies scenario, lower-end estimates*

Globally, nuclear power generation is growing after decades of stagnation, led by growth in China.

Nuclear power generation

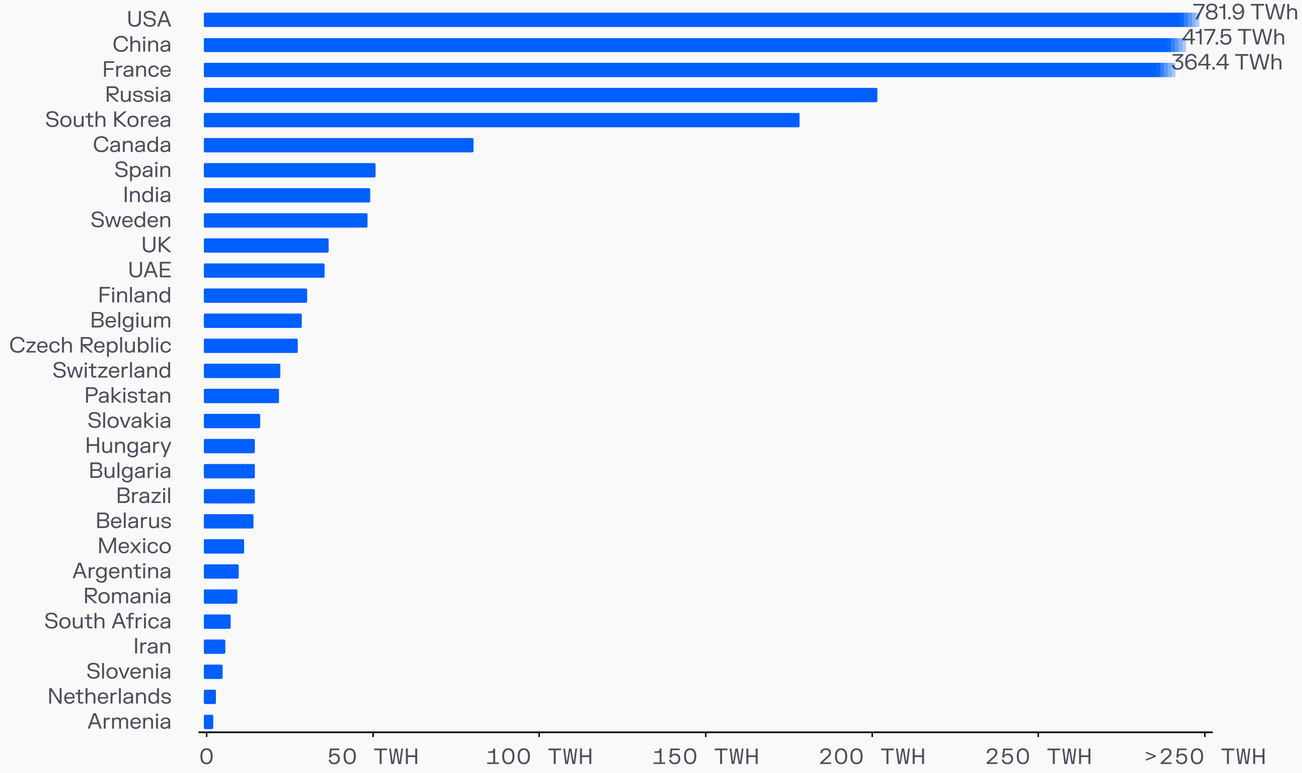


Number of reactors proposed, planned and being built across the globe, July 2025



Source: Ember, Energy institute, Our World in Data; World Nuclear Association, World Economic Forum

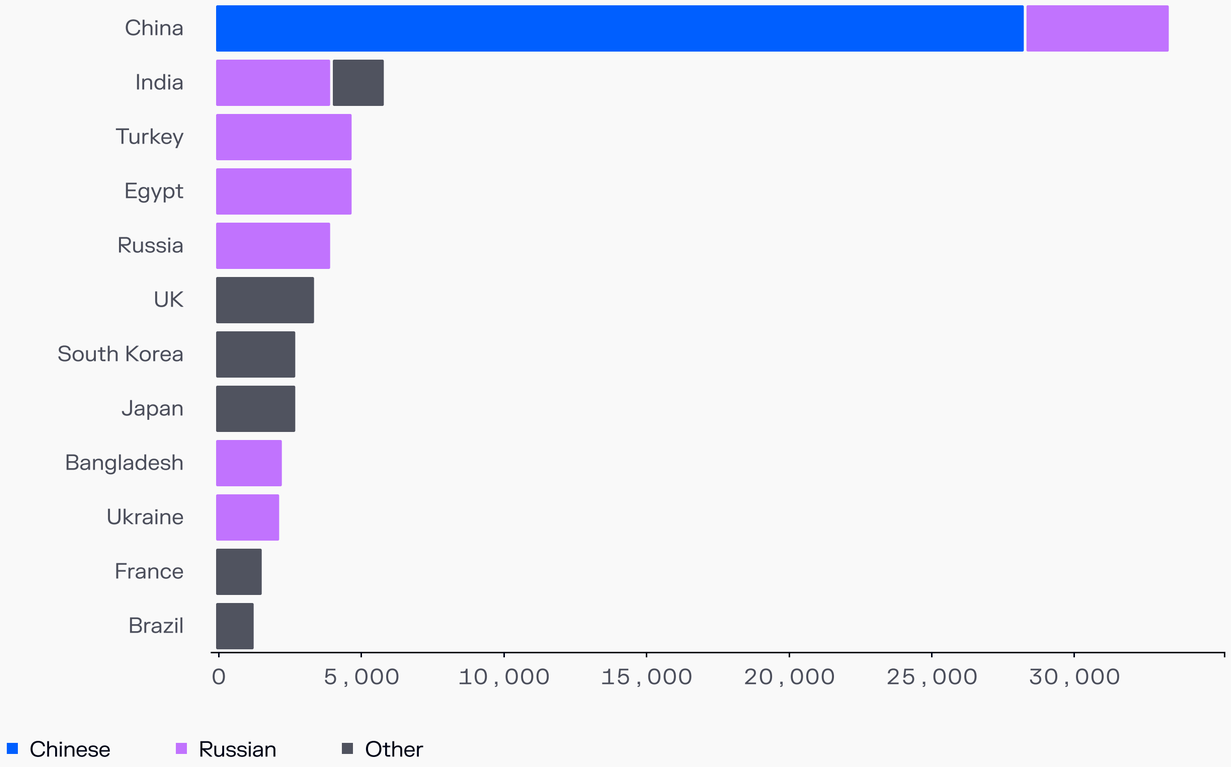
As of 2024, the US led in terms of total nuclear power generation, followed closely by China and then France.



Source: World Nuclear Association, IAEA PRIS,

But as of January 2025, the vast majority of the nuclear power capacity currently under construction globally was in China.

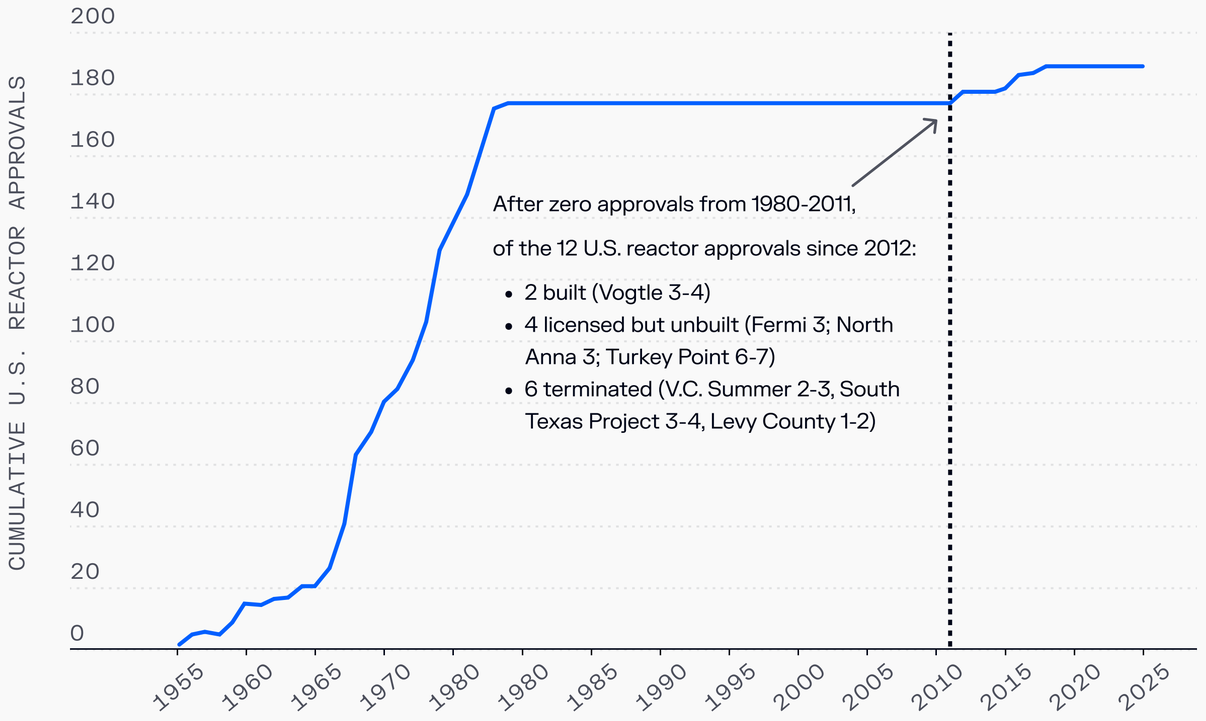
Nuclear power capacity under construction by region and national origin of technology, in gigawatts



Source: IEA; Semafor

The US has not been building new nuclear reactors for decades.

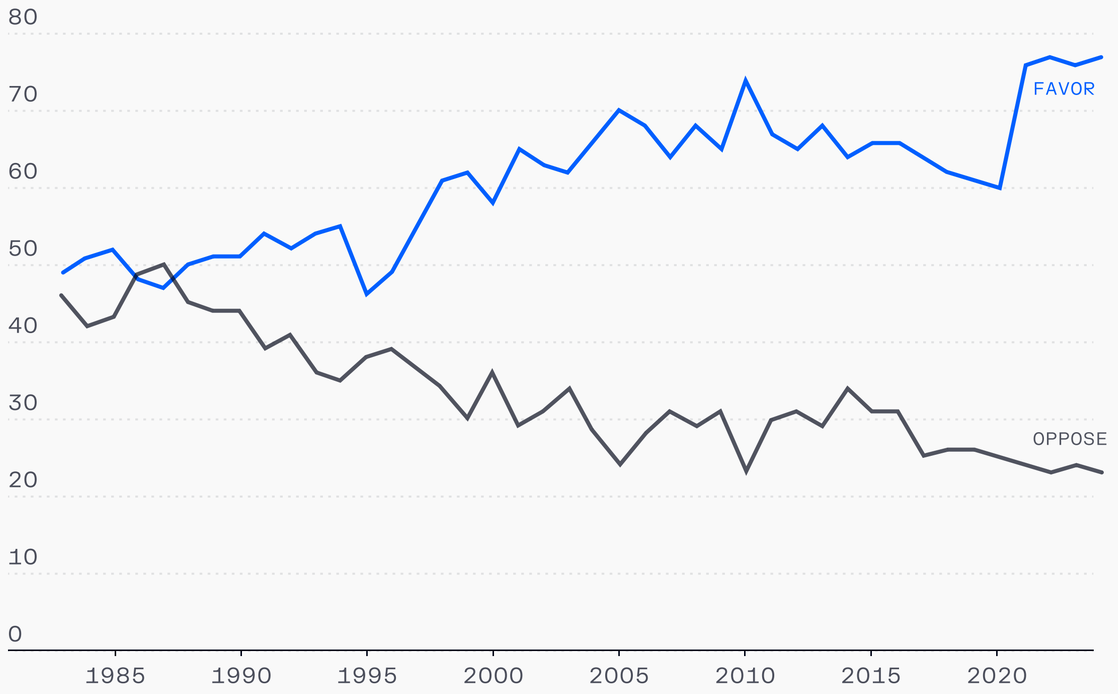
U.S. Nuclear Reactor Unit Approvals



Source: EIA

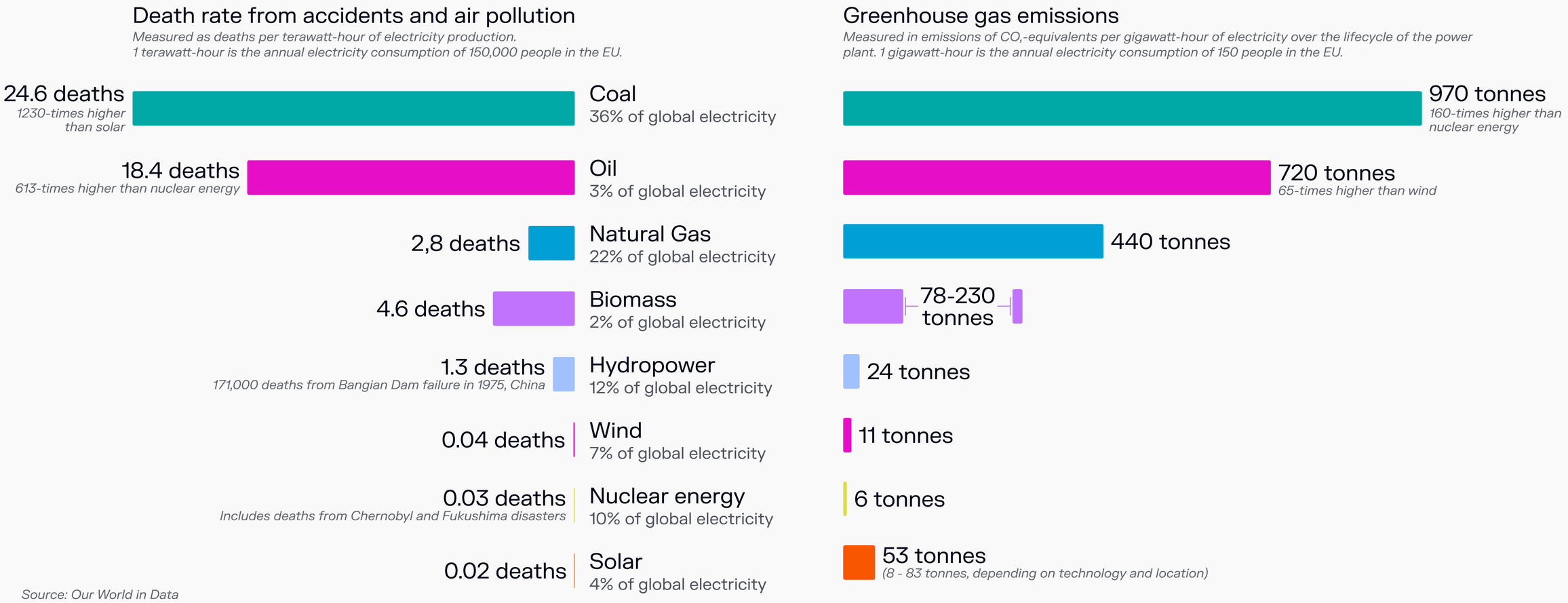
This is despite large and growing public support for the use of nuclear energy, which the majority in the US has supported since 1990.

Support for / opposition towards the use of nuclear energy for electricity in the USA, 1983-2024 (%)



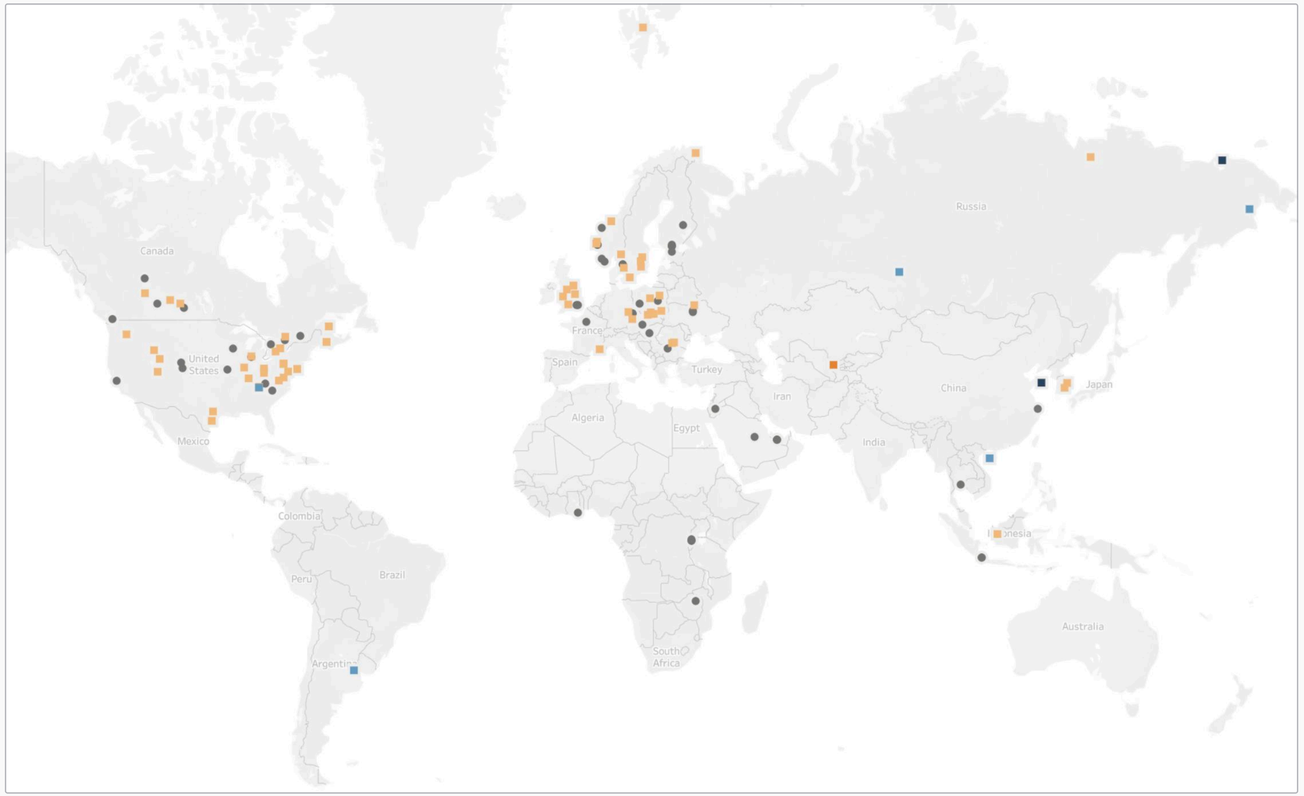
Source: Bisconti Research; World Nuclear Association

And despite the fact that nuclear is one of the safest and cleanest forms of energy.



Source: Our World in Data

Small nuclear reactors (SMRs) are one potential path to nuclear revival being embraced in Europe and the US. However, as of 2025, none of them were commercially operable.

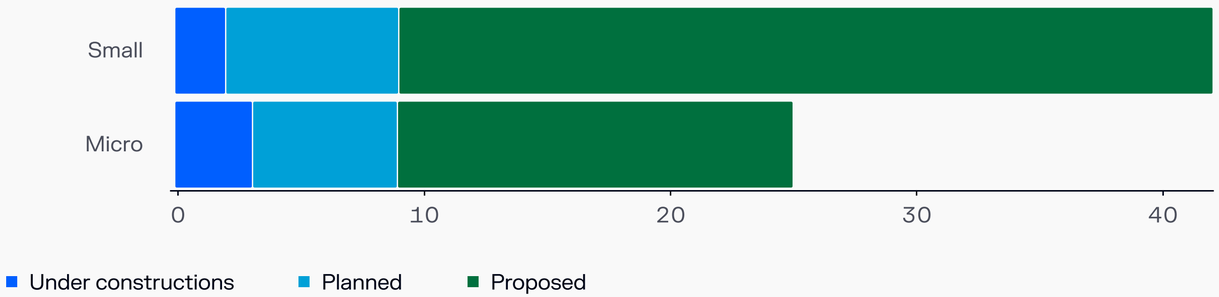


- Operable
- Under construction
- Pre-investments
- FID
- N/A

Source: World Nuclear Association; Operable = connected to the grid; Under construction = first concrete poured (or keel layed for floating plants); FID = final investment decision made, decision to proceed; Pre-investment = project identification, feasibility studies, economic appraisal

As the regulatory environment continues to change, the number of small and micro reactor projects in the US has a significant proposal backlog.

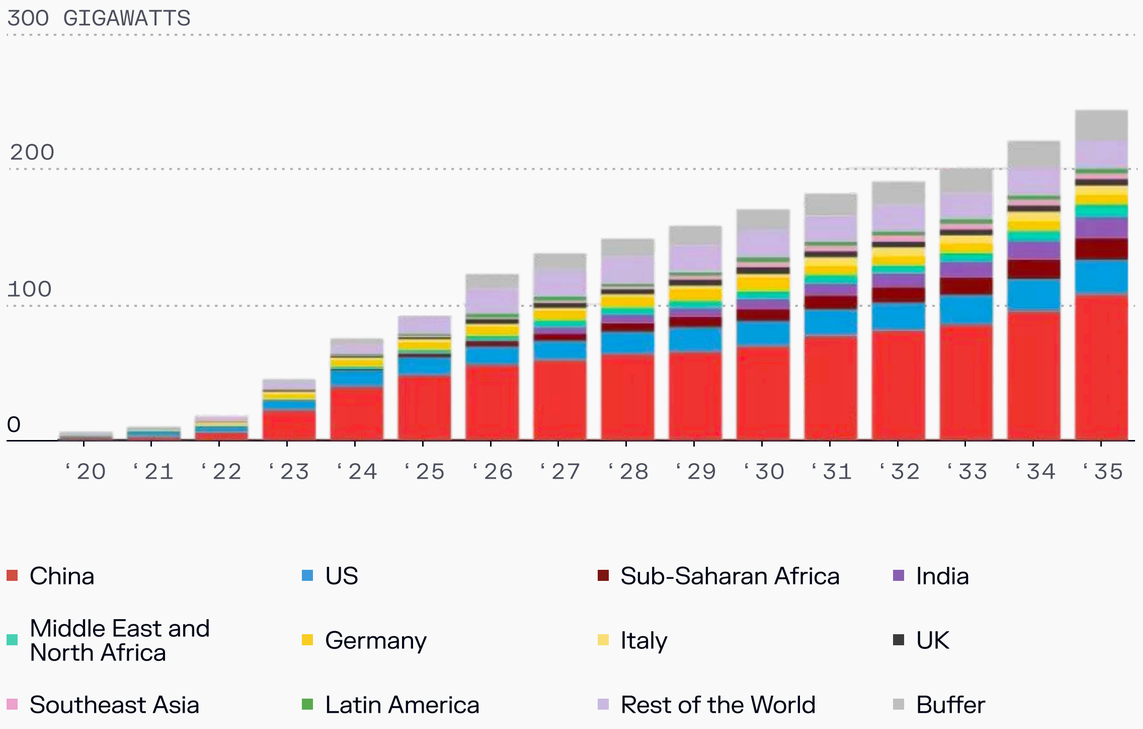
Next-generation small and micro reactor projects in the US



Source: Nuclear Energy Institute figures retrieved on Oct. 24; Note: A proposed project is one for which a reactor developer, government agency or other potential owner has proposed one or more reactors at an estimated site or identified a reactor design. Planned projects are in more formal development and may be a part of a public integrated resource plan or have suppliers contracted.

92 gigawatts of global energy storage was added in 2025, up 23% YoY. China accounted for 50% of the buildout, followed by the US at 14%.

Global annual energy storage additions

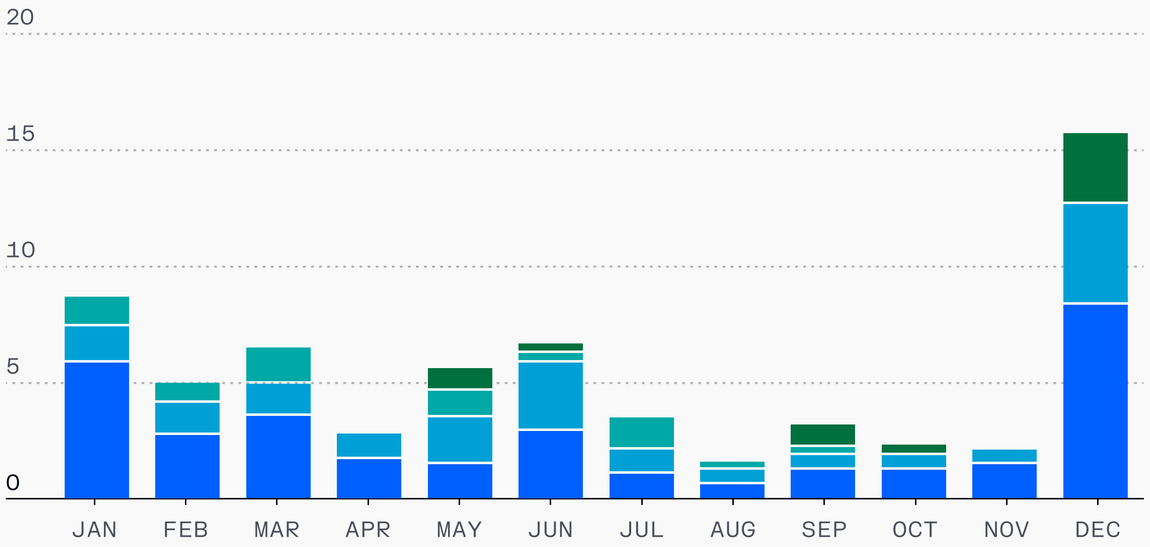


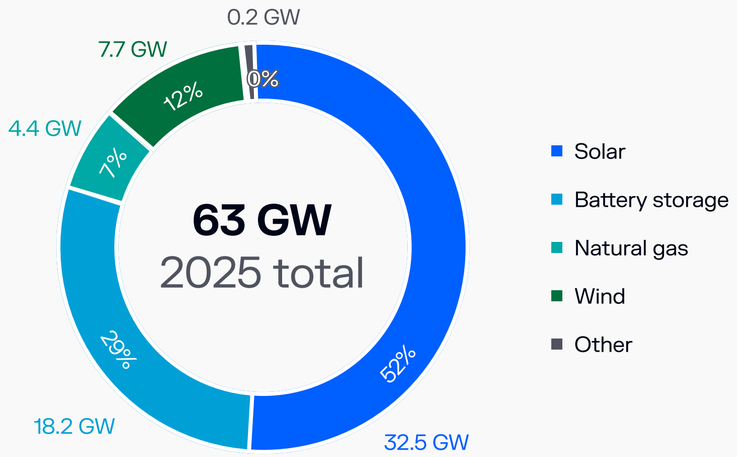
Source: BloombergNEF

In the US, solar accounts for the majority of planned grid-scale capacity additions, followed by wind and natural gas.

U.S. planned utility-scale electric-generating capacity additions (2025)

GIGAWATTS (GW)

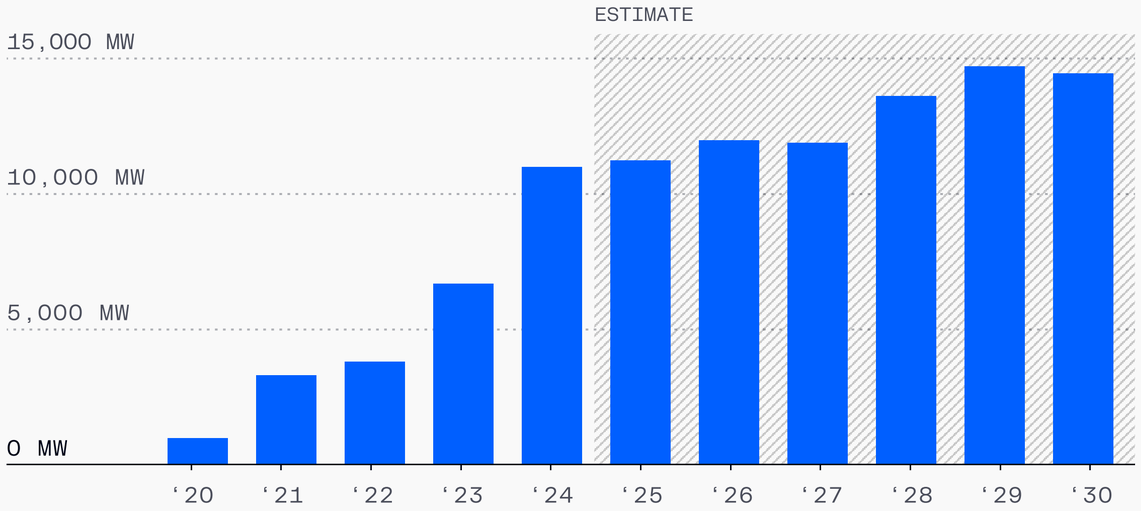




Source: EIA

The US is projected to add almost 67 GW of new utility-scale batteries over the next five years, which will triple its battery capacity.

Annual utility-scale battery additions, in megawatts

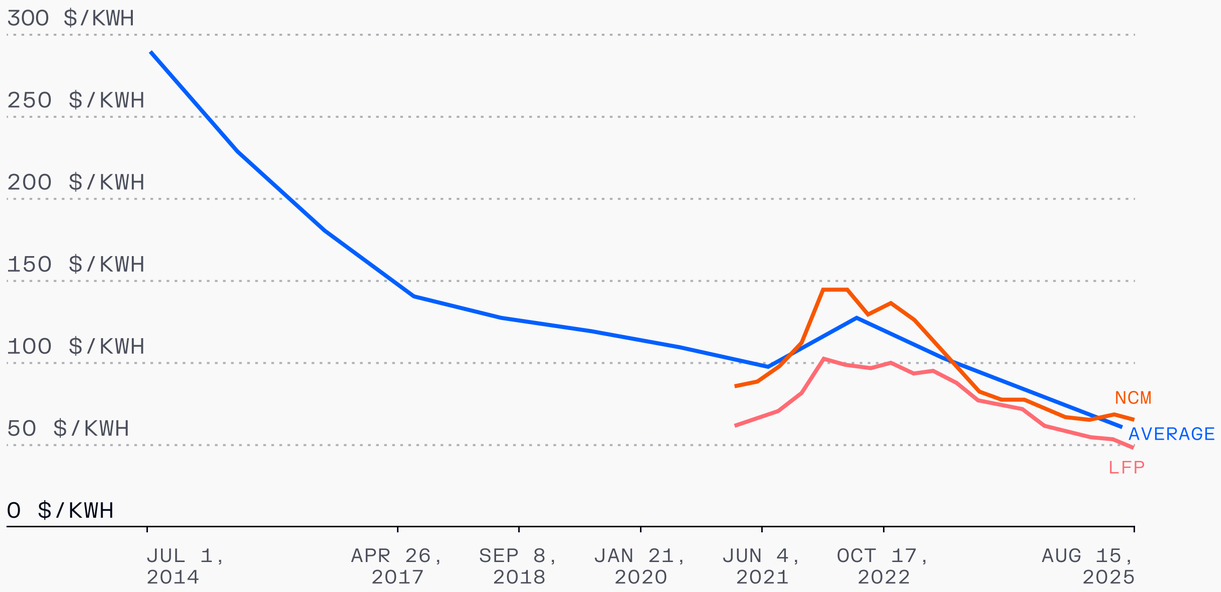


Source: BloombergNEF, Canaray Media

The battery boom has been driven by a steep decline in the price of lithium-ion battery cells.

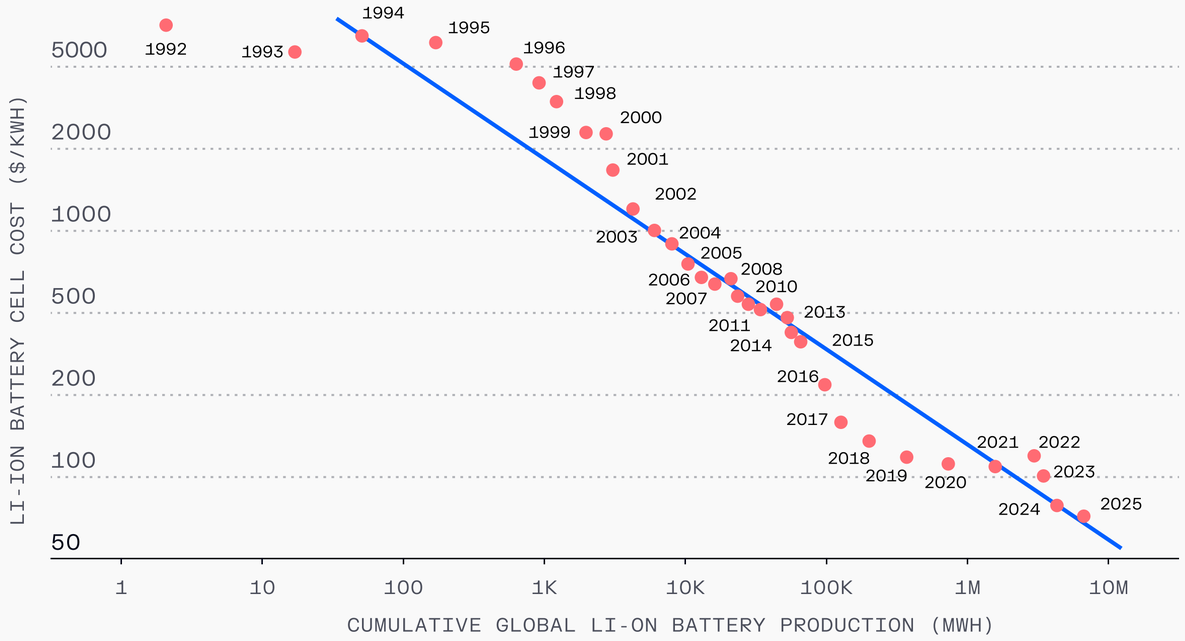
This, coupled with the aging and overtaxed grid, has led to growing interest in decentralized, behind the meter batteries that reduce reliance on the grid for end consumers.

Lithium-ion battery cell price



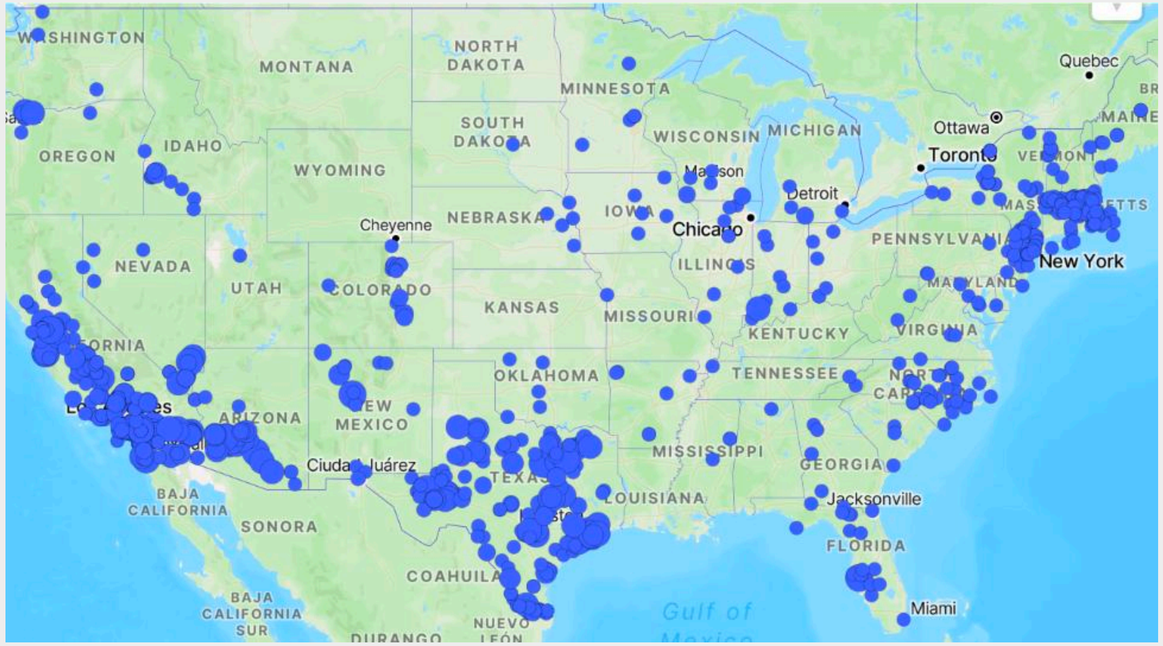
Source: Benchmark Mineral Intelligence; Average price of battery cells[1] per kilowatt-hour[2] in US dollars, not adjusted for inflation. The data includes an annual average and quarterly average prices of different lithium-ion battery[3] chemistries commonly used in electric vehicles and renewable energy storage.

Cost has, in large part, been driven down as a function of battery production volumes increasing.



Source: Casey Handmer

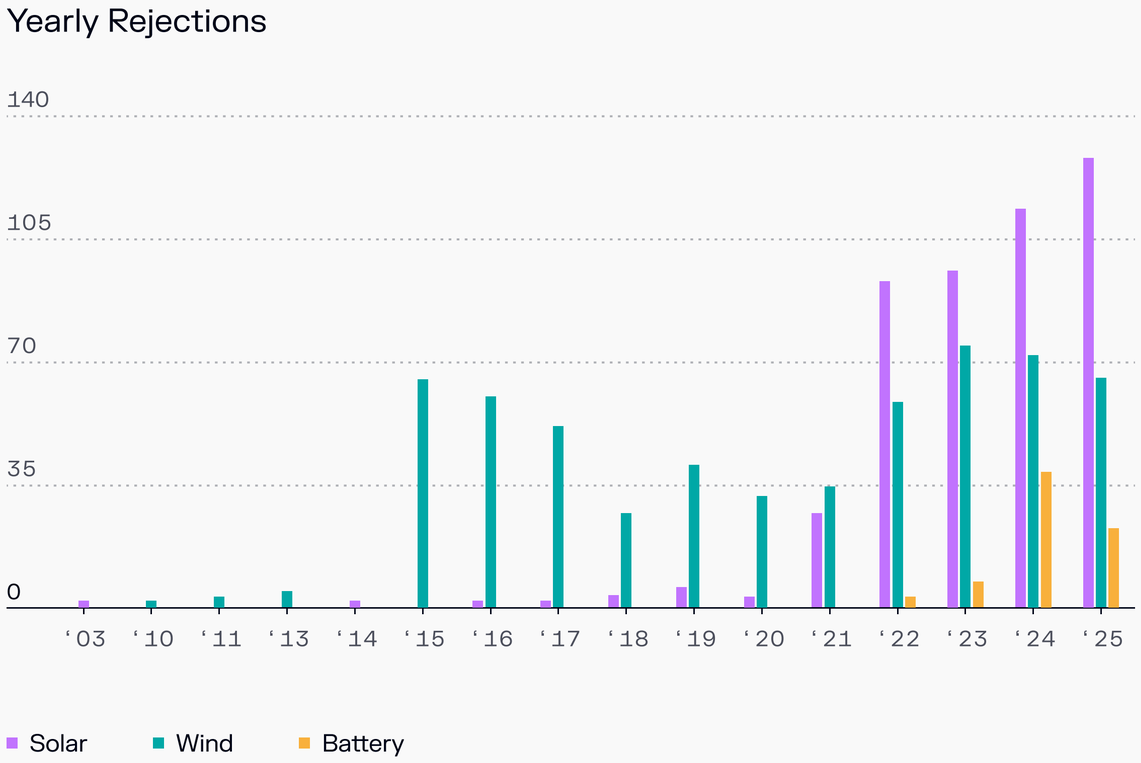
In Q2 2025, developers added almost 5K megawatts of storage capacity to the US grid. California, Arizona, and Texas – leading utilizers of solar power – accounted for 75% of that.



Map of Utility-Scale Battery Projects in the US, 2025

Source: Cleanview

However, battery storage projects (and renewables as a whole) are facing increasing opposition. One database records that 52 communities globally chose to reject battery projects in 2025.



Source: Robert Bryce's Renewable Rejection Database

Some of this opposition is coming from fear of fire risk. Batteries can overheat and cause a chain reaction known as thermal runway.

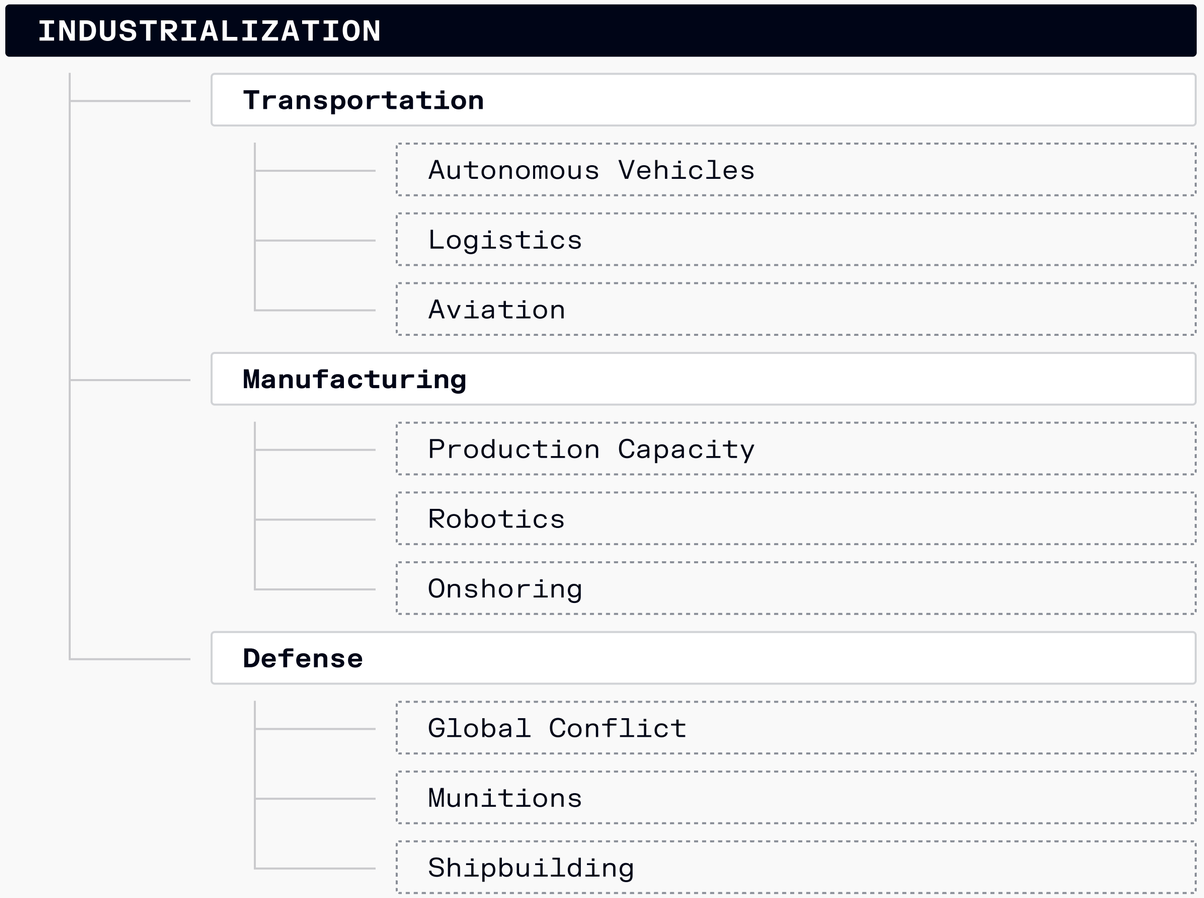
A major fire at a 750 megawatt facility in Moss Landing, California, led to the evacuation of 1.5K residents in January 2025. One nearby city council banned large-scale battery storage facilities.

Image of the fire at Moss Landing battery storage facility in January 2025.

Source: Robert Bryce

Industrialization

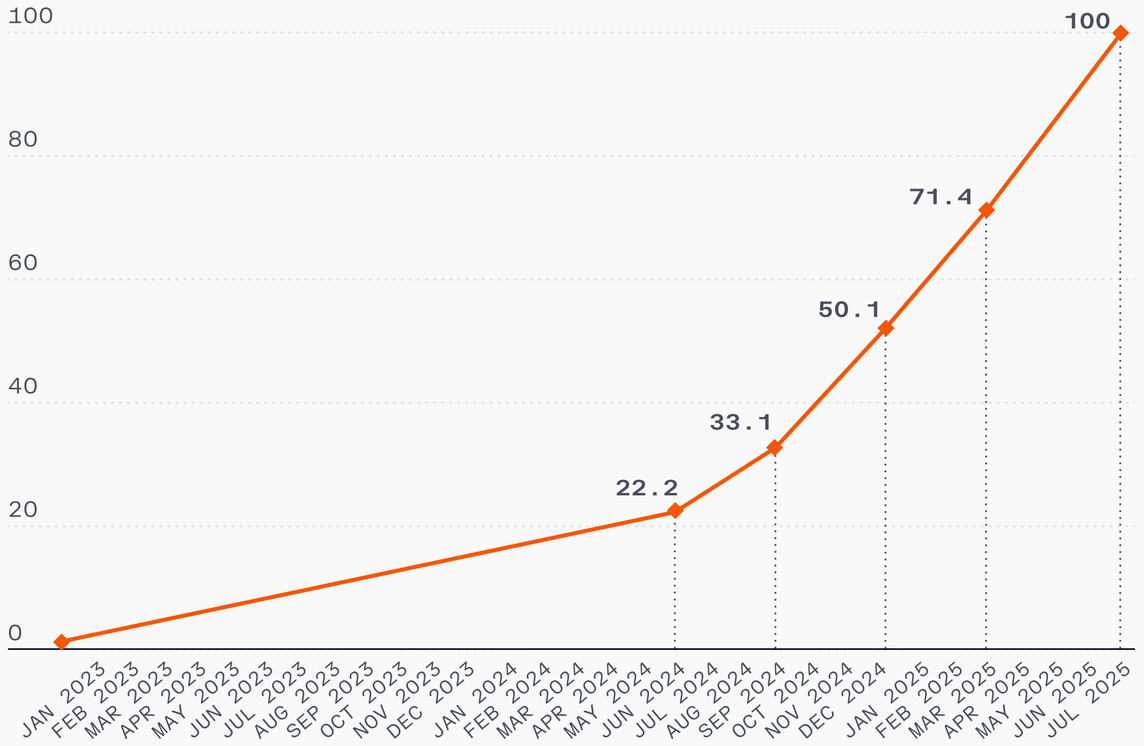
Transportation
Manufacturing
Defense


INDUSTRIALIZATION
Transportation
Autonomous Vehicles
Logistics
Aviation
Manufacturing
Production Capacity
Robotics
Onshoring
Defense
Global Conflict
Munitions
Shipbuilding

Transportation: Autonomy Across Air, Land, and Sea

In July 2025, Waymo became the first autonomous taxi service to reach 100 million miles driven.

Waymo Driverless Miles (in Millions) Across Operational Cities

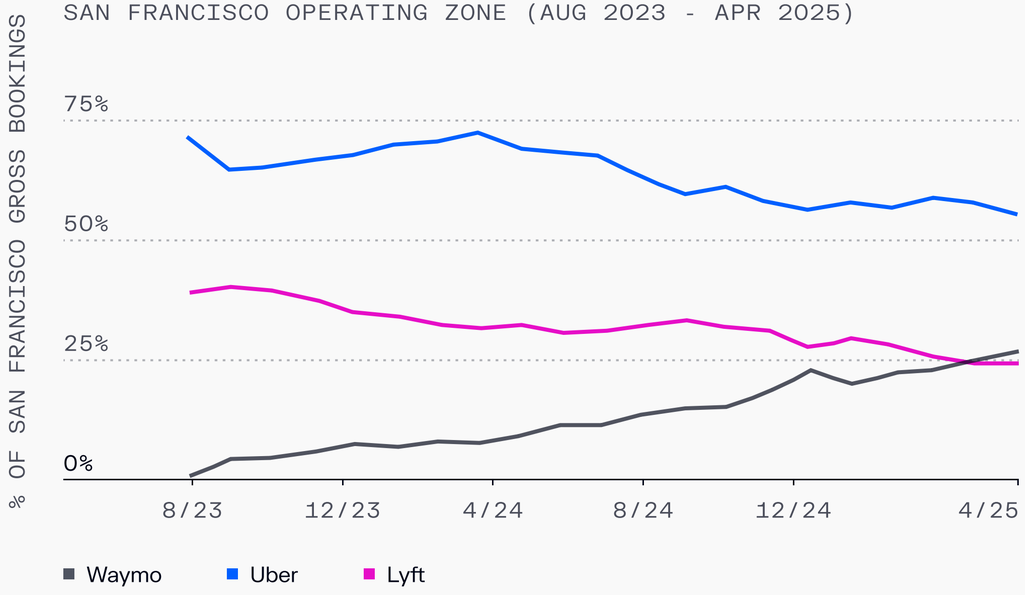


Source: Waymo, various reports, compiled by The Driverless Digest by Harry Campbell

Over the course of 2025, Waymo surpassed traditional ride-share service Lyft in San Francisco, and reached 5-10%+ market share in major cities.

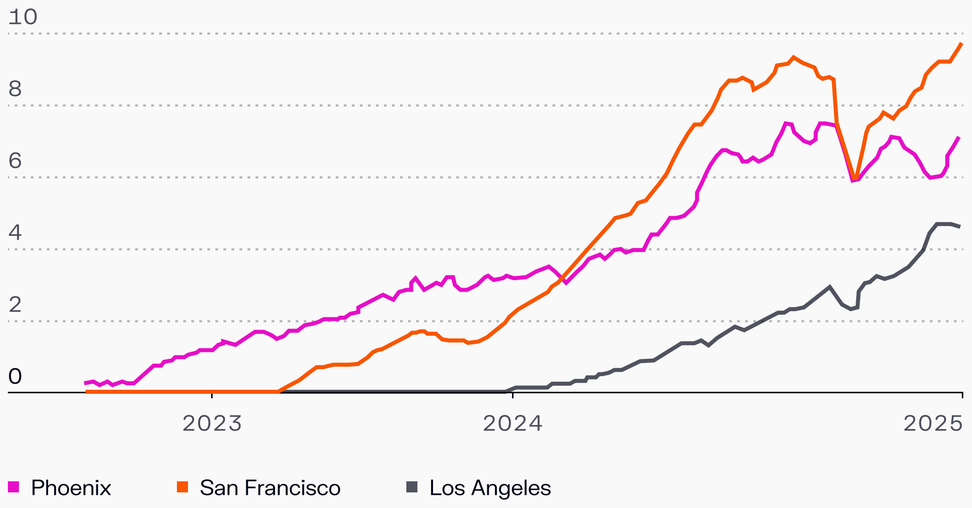
Estimated Market Share (Gross Bookings)

SAN FRANCISCO OPERATING ZONE (AUG 2023 - APR 2025)



Waymo, % of ride-sharing market*

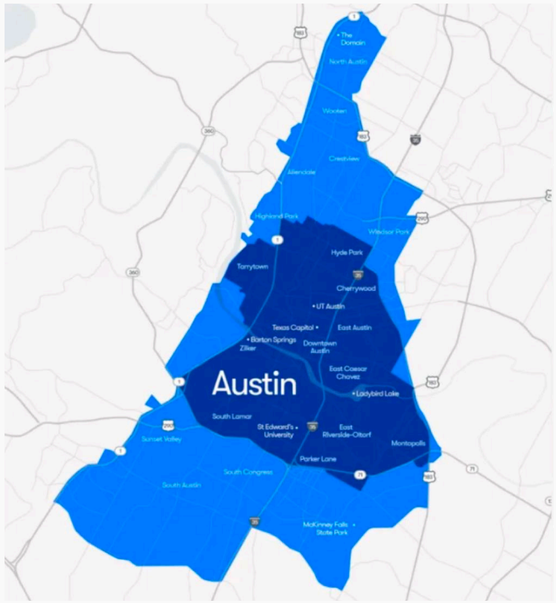
SELECTED US CITIES



*Source: Waymo, various reports, including Tech Brew, Fast Company, YipitData, etc. Charts calculated with different methodologies in terms of gross bookings vs. total ride counts. Data derived from USA-user email receipt panel composed of >1mm monthly transacting USA email accounts from all available domains. Paid rides only. Numbers are estimates due to sample size. *Ride-sharing market share calculated as a % among Uber, Lyft, Waymo*

In Austin, for example, Waymo launched having completed 50M autonomous miles.
In comparison, Tesla's robotaxi service launched with 15K autonomous miles.

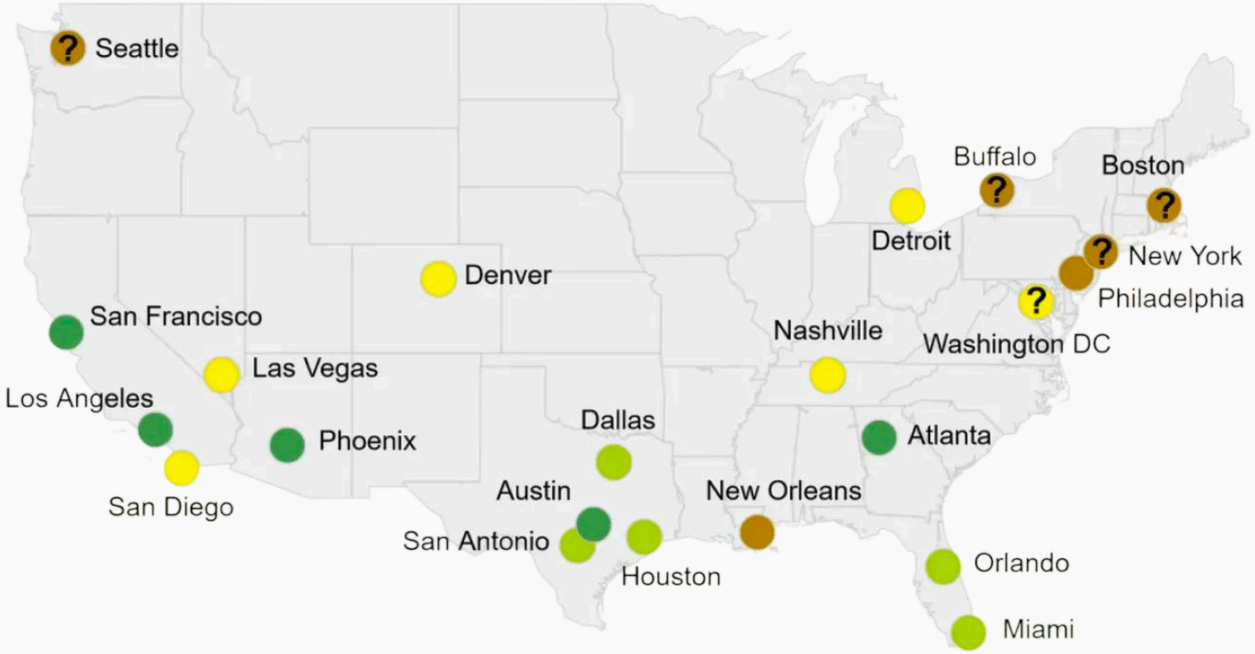
Tesla had 0.12 vehicles per square mile



Waymo had 1.1 vehicles per square mile

Source: Waymo and Tesla reporting; Reuters, estimations from Electrek

As of November 2025, Waymo had plans to expand to 15 additional cities over the course of 2026, expecting to be completing 1 million trips per week by the end of the year.

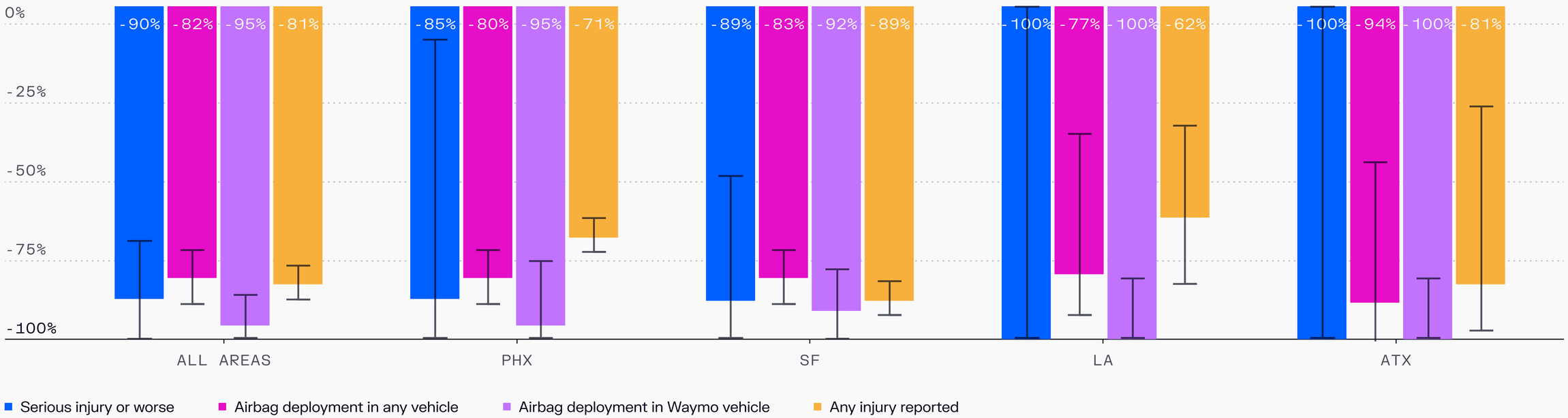


Source: Understanding AI

Waymo's safety record indicates a material reduction across different markets in terms of serious injury, and airbag deployment.

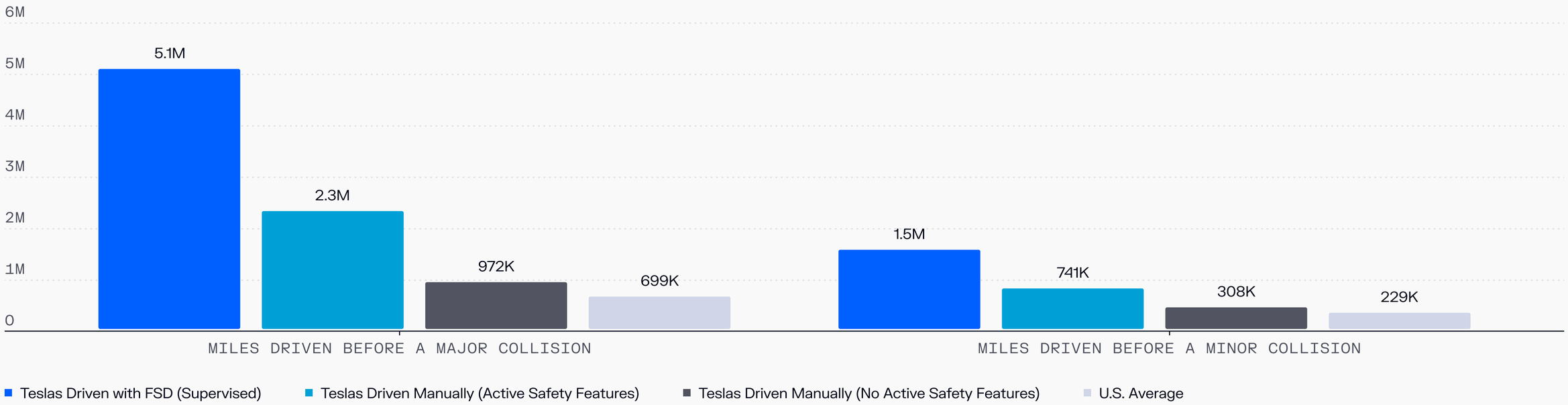
Waymo crash rate percent difference to benchmark

PERCENT DIFFERENCE TO BENCHMARK



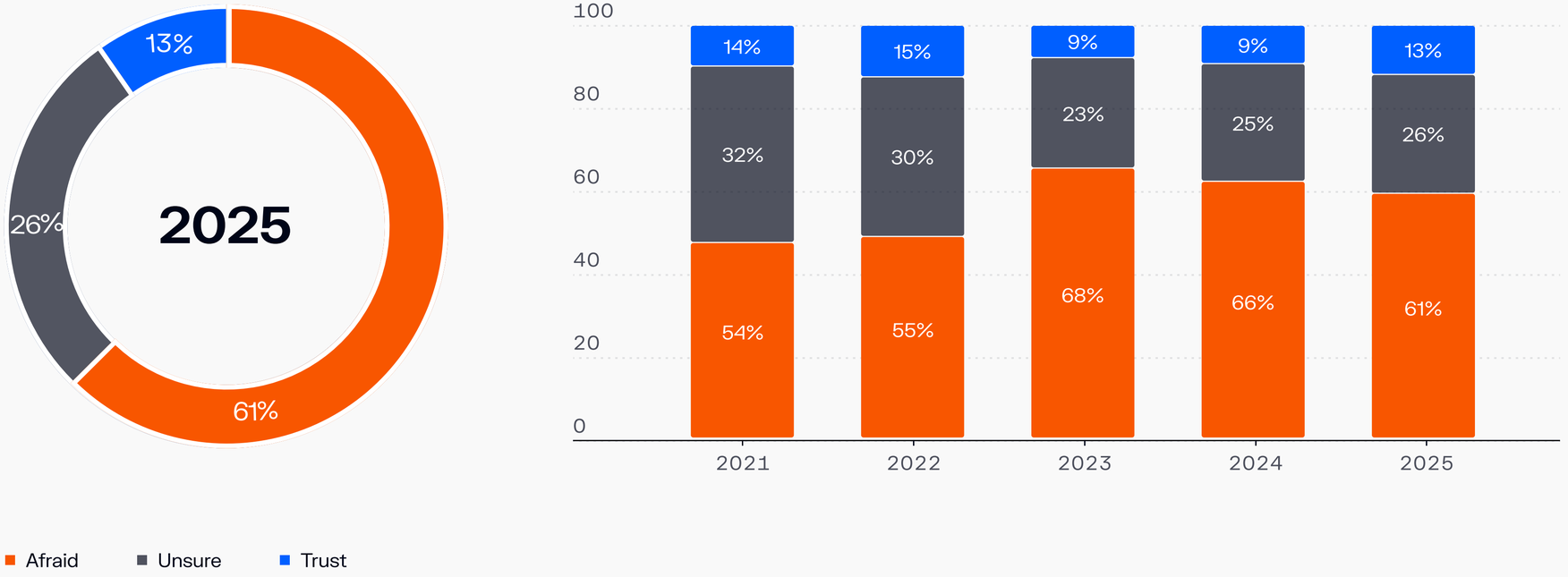
Source: Waymo

Tesla's Robotaxi offering is too early for definitive safety evaluation, but Tesla claims that its Full-Self Driving (FSD) product drives an expected 6-7x more mileage before an accident occurs compared to human operators



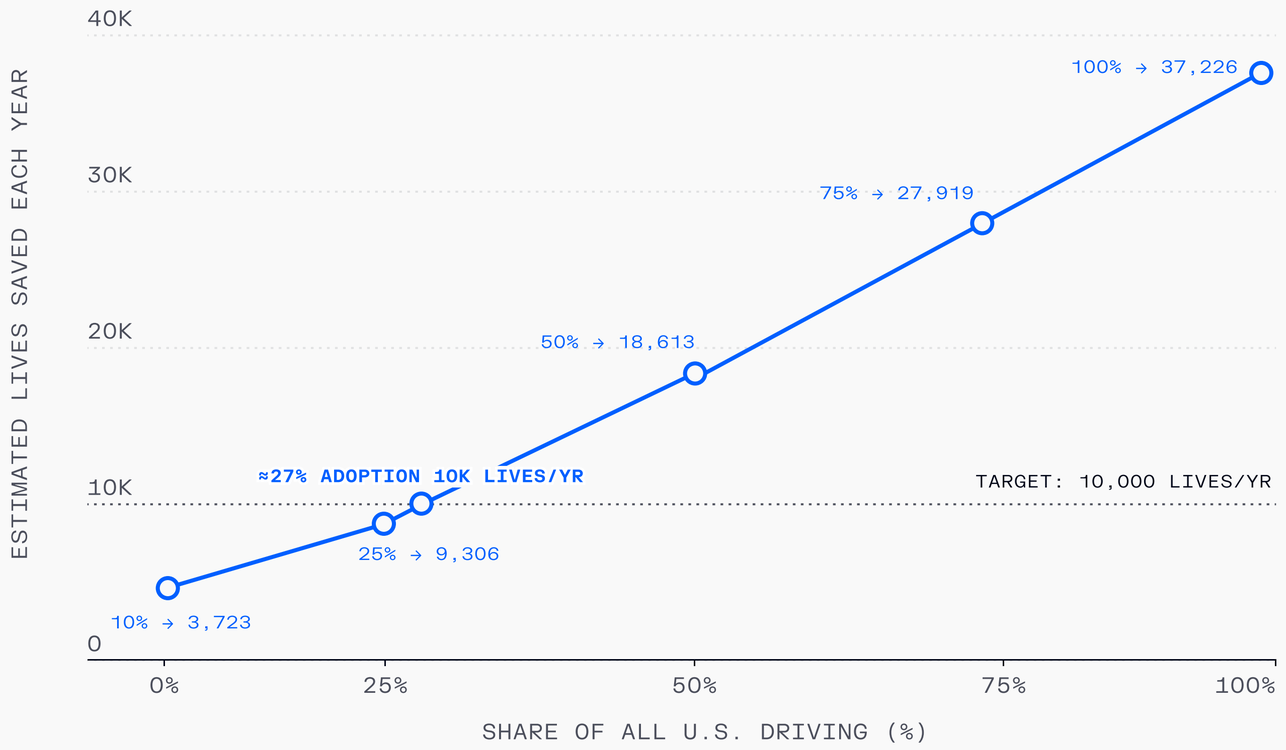
Source: Tesla reporting

Despite safety benefits and increased adoption, general sentiment towards AVs remains relatively skeptical. The % of respondents to a 2025 survey in the US who trust AVs only increased from 9% to 13% compared to the prior year.



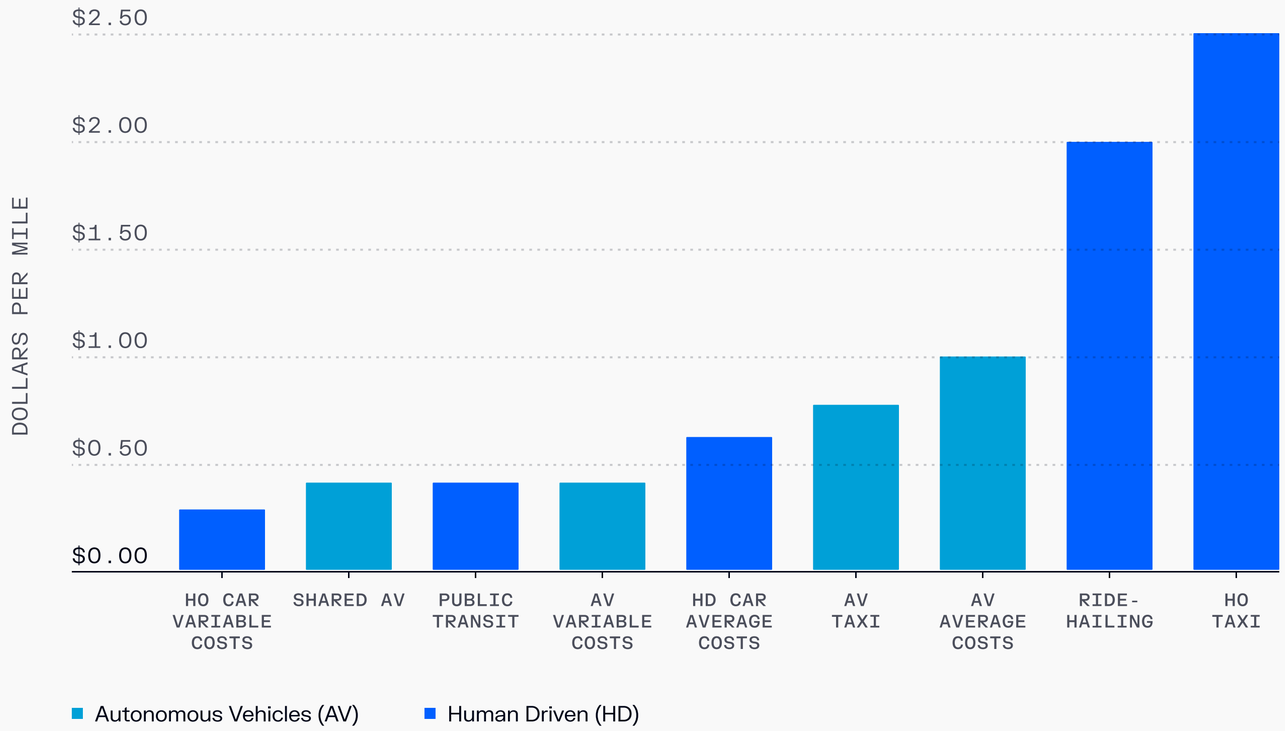
Source: AAA survey

The safety benefits of AVs will eventually win out. If all US vehicles operated at the safety levels of a Waymo, it would prevent ~ 37K deaths per year and save ~$1T in societal costs.



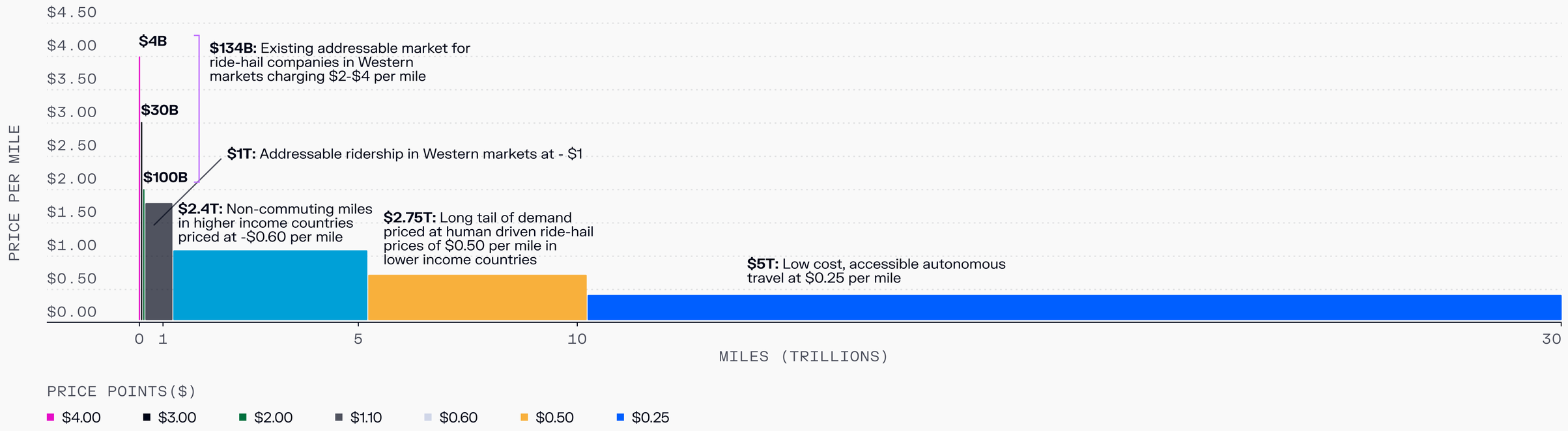
Source: Waymo reporting; Jon Slotkin analysis

Today, autonomous taxis are already estimated to be more affordable than human-operated taxis or ride-sharing.



Source: Autonomous Vehicle Implementation Predictions Implications for Transport Planning By Todd Litman; Victoria Transport Policy Institute: 17 November 2025

As AV adoption increases, the costs will decrease significantly, expanding the potential addressable market across trillions of dollars in use cases.

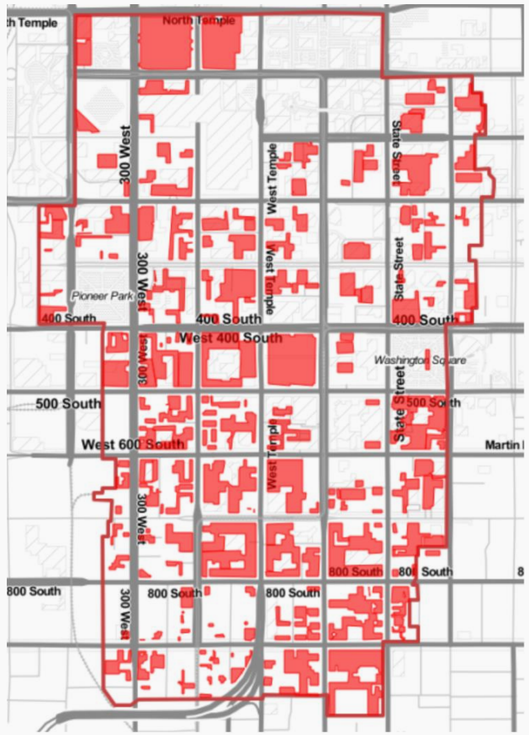


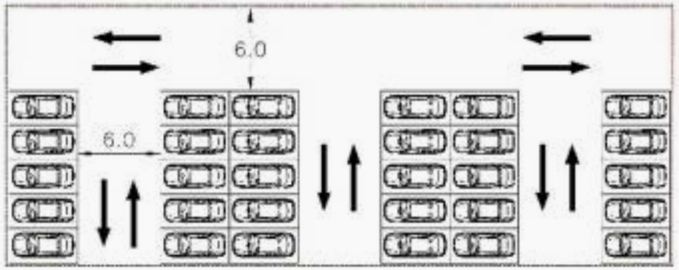
Source: ARK Investment Management LLC

Broad AV adoption would also have implications for childcare, hospitality, and land use.

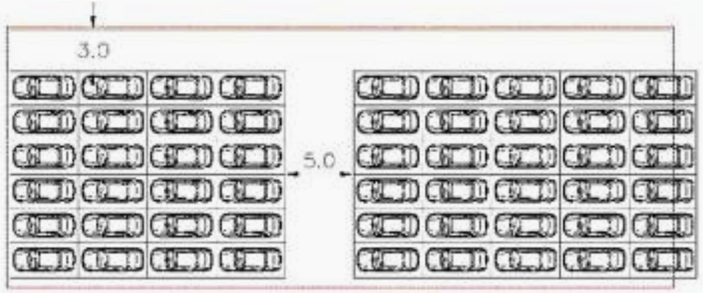
For example, U.S. cities with 1M+ people dedicate 22%+ of available land to parking space on average. AVs could free up that space by improving parking capacity by 80%.

Parking Space in Red





TRADITIONAL PARKING STRATEGY FOR HUMAN-DRIVEN VEHICLES (FOR 30 VEHICLES)

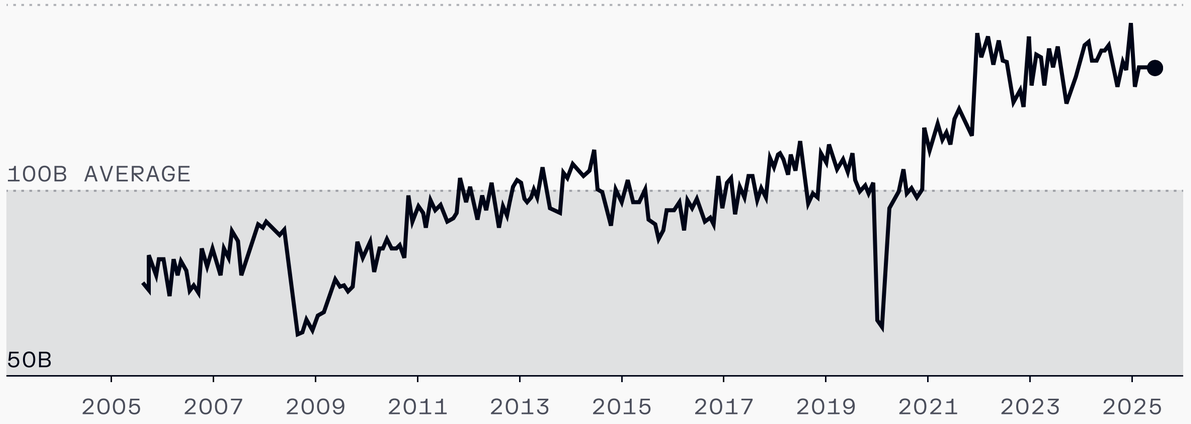


BLOCKING PARKING STRATEGY FOR AVS (54 VEHICLES ON THE SAME PARKING AREA)

Source: Thomas Carpenito and Parking Reform Network, Exploring the implications of autonomous vehicles: a comprehensive review by Kareem Othman

Freight volumes in the US have continued to rise over the last two decades.

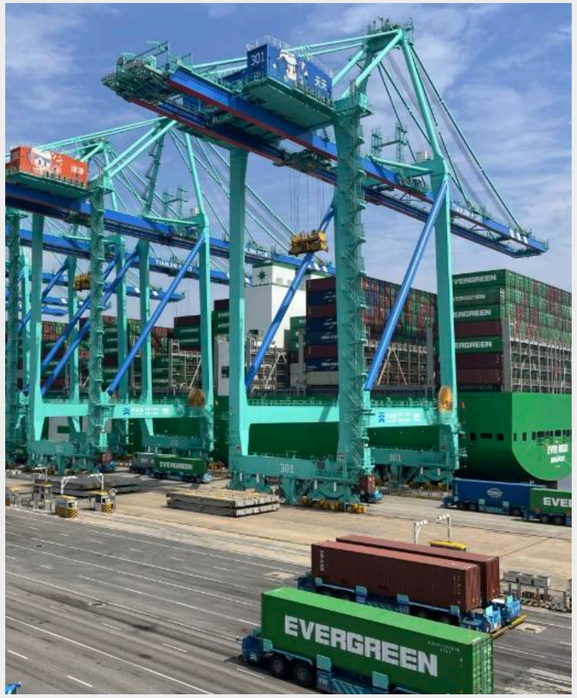
Total U.S. - North American Freight Flows



Source: US Department of Transportation Bureau of Transportation Statistics

Freight operations are becoming increasingly automated. For example, at the port of Tianjin, more than 88% of large container equipment is already automated. The Long Beach Container Terminal automated work requiring 8K jobs down to just 800.

Long Beach Container Terminal

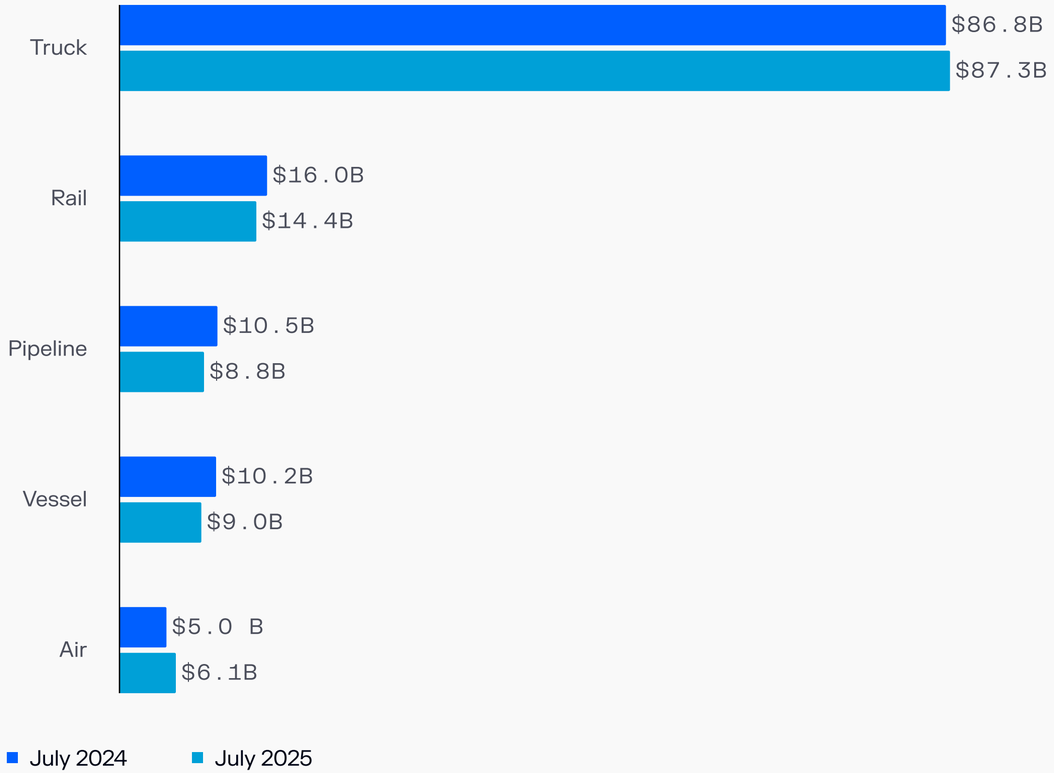


Port of Tianjin

Source: Wall Street Journal; CBS / LA News

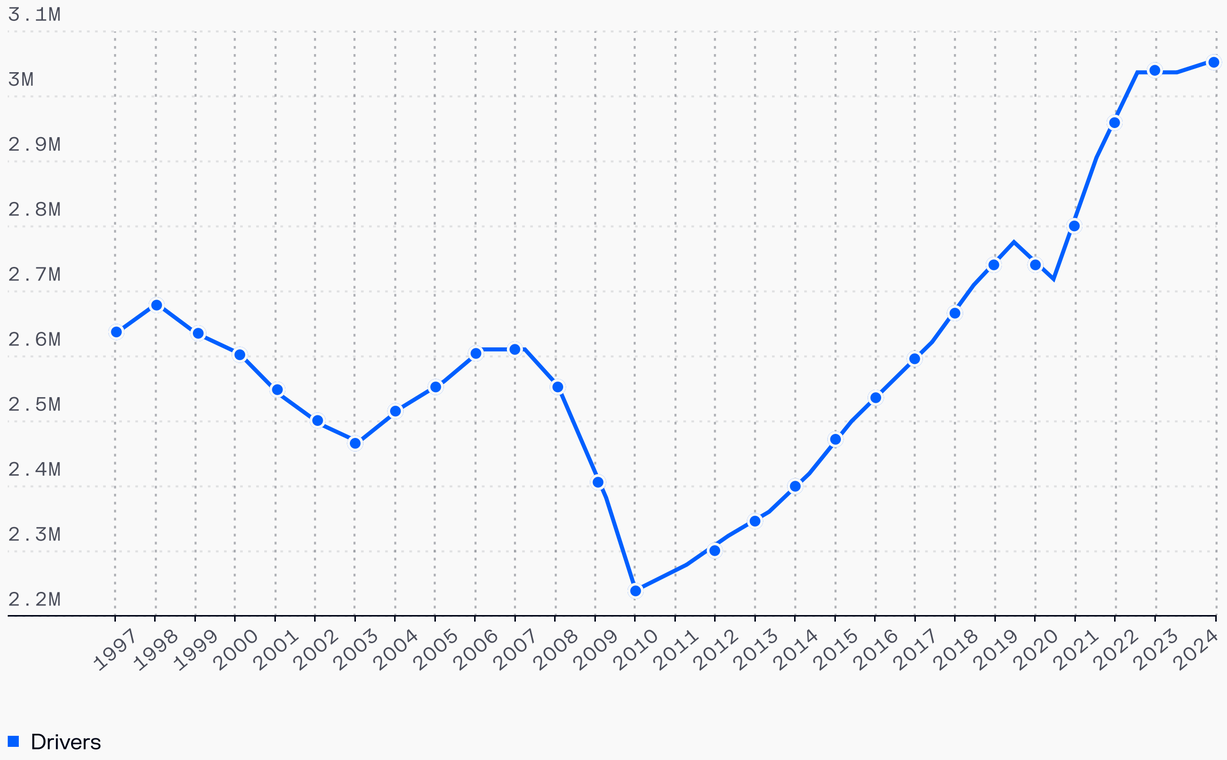
While the vast majority of international overseas freight is via ocean freight, domestic freight, in particular, relies heavily on trucking.

North American Freight by Mode



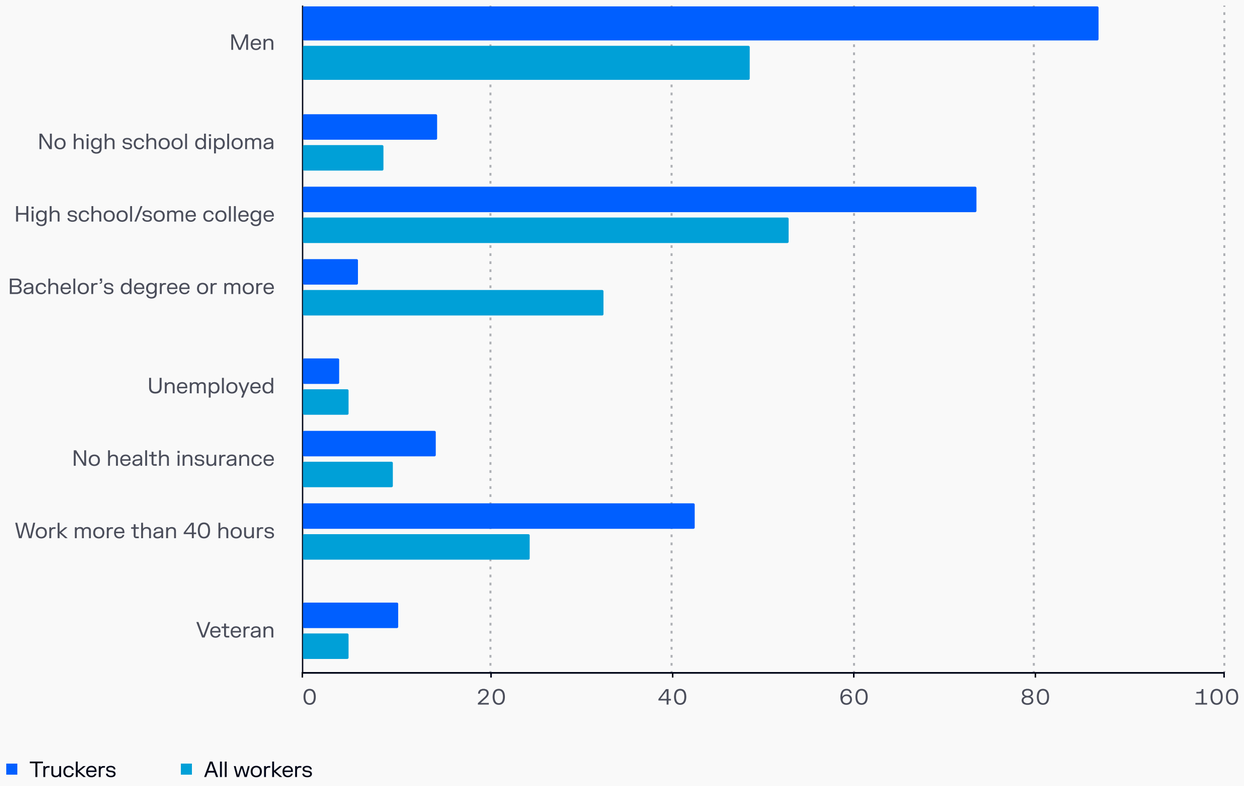
Source: US Department of Transportation Bureau of Transportation Statistics

After a dip during the Great Financial Crisis, the number of truck drivers in the US has risen fairly consistently for the last 15 years.



Source: Consumer Shield

Truck drivers are, typically, men without a college education.



Source: US Census Bureau

In fact, truck driving is the most common job for employed men between the ages of 25 to 34 without a four-year college degree.

Men

Occupation	Number
Driver/Sales workers and truck drivers	624,894
Construction laborers	395,914
Laborers and freight, stock and material movers, hand	385,314
First-line supervisors of sales workers	362,319
Chefs and cooks	344,751
Managers, NEC (including postmasters)	269,912
Retail salespersons	261,740
Carpenters	241,657
Automotive service technicians and mechanics	238,989
Electricians	227,662

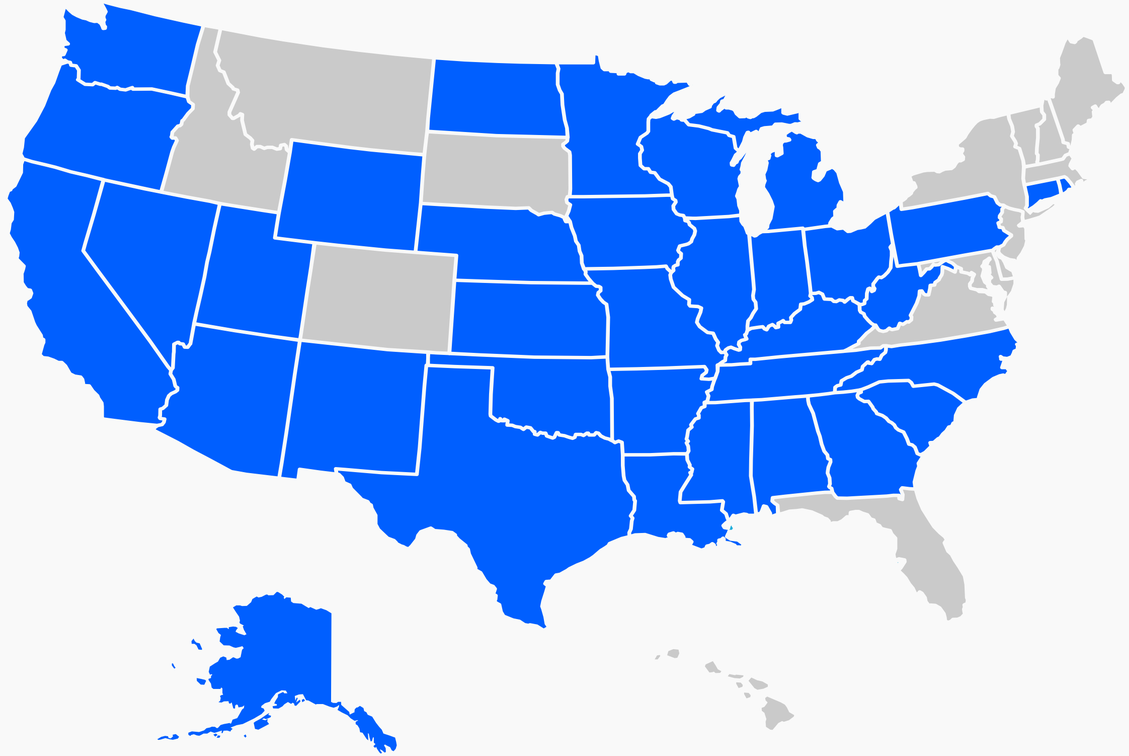
Women

Occupation	Number
Customer service representatives	334,064
Nursing, psychiatric and home health aides	288,439
First-line supervisors of sales workers	269,789
Cashiers	243,109
Waiters and waitresses	233,897
Secretaries and administrative assistants	202,397
Retail salespersons	200,229
Receptionists and information clerks	199,779
Registered nurses	164,008
Maids and housekeeping cleaners	161,200

Source: Pew Research Center; Note: Reflects adults who have some college education (including associate degree), those with a high school diploma only and those who did not graduate high school.

In 35 of 52 US states and territories, transportation is the first or second most common job for all employed men; representing ~18% of all employed men.

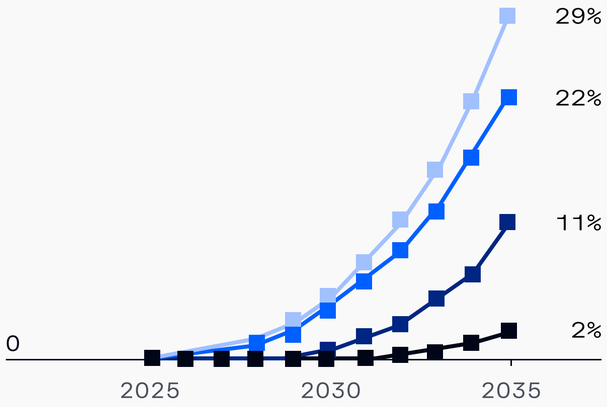
States where Transportation is the first or second most common job for employed men



Source: US Census Bureau

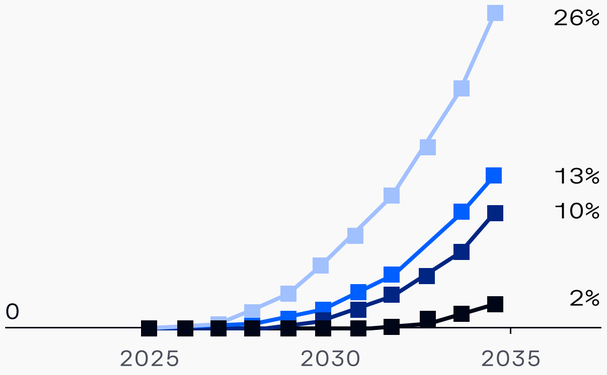
Autonomous trucking adoption is beginning to take hold in various markets at different rates depending on individual market variables. However, adoption is still early, with leading vendors like Aurora having completed ~20K driverless miles.

United States



USA leads AD truck adoption thanks to strong TCO benefits, significant driver shortages and long freight distances.

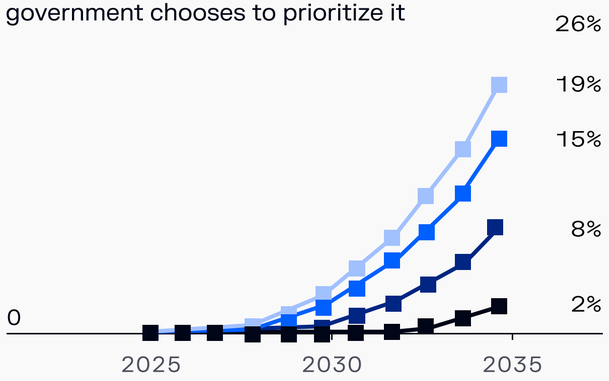
Europe



Europe sees high TCO benefits but faces slower adoption due to cross-border regulatory hurdles and operational complexity.

China

Adoption could follow a similar speed to USA and Europe if the government chooses to prioritize it



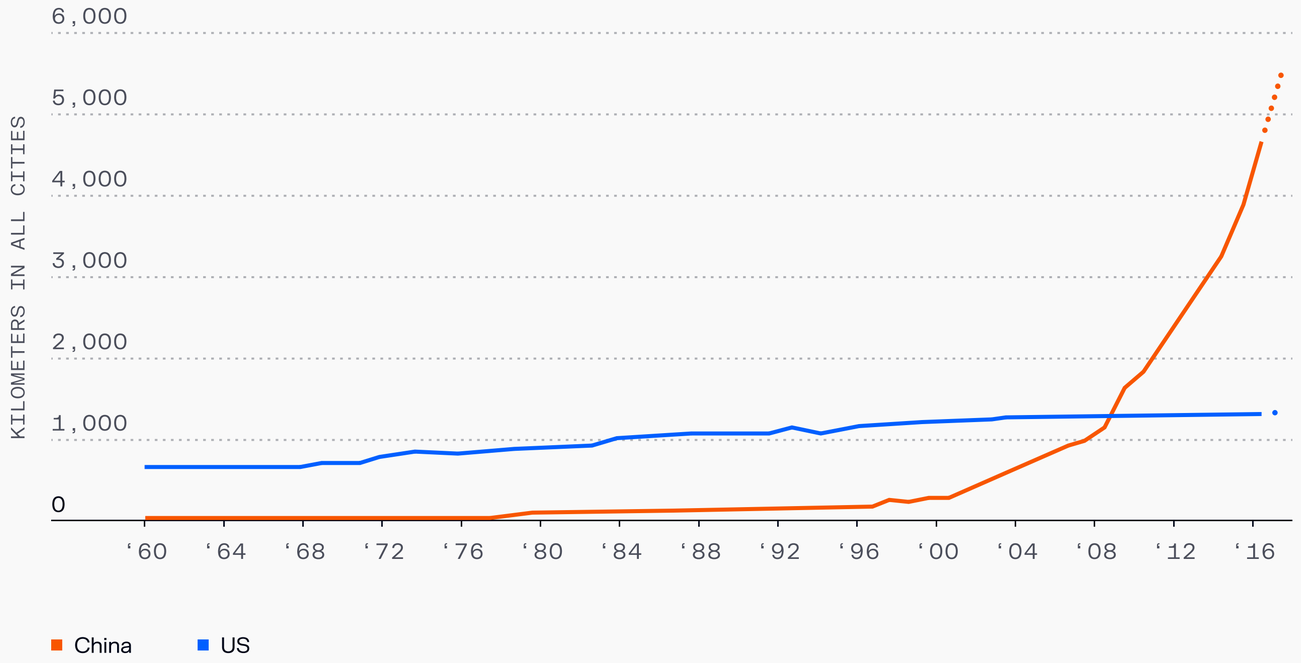
China lags in adoption due to lower TCO benefits and higher upfront investment.

■ Distribution ■ Mid-distance P2P ■ Long-haul ■ Mid-distance H2H

Source: World Economic Forum; Boston Consulting Group

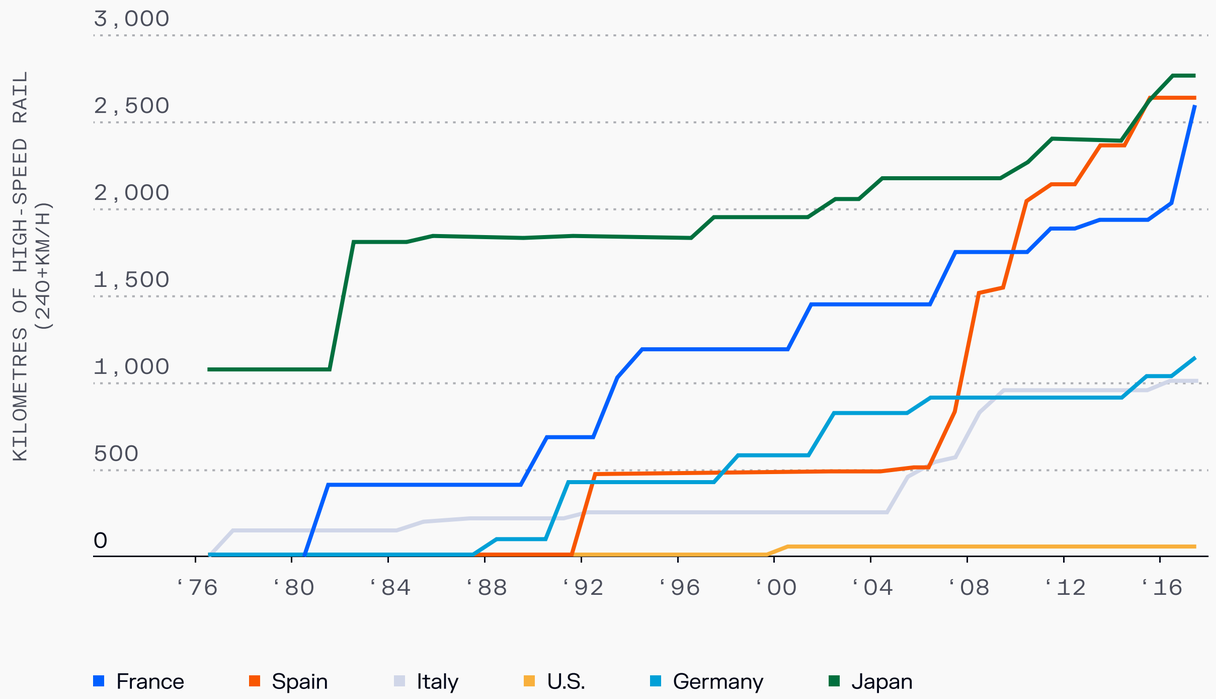
High-speed rail is another category where China has materially surpassed anything the US is doing.

Total kilometers of rail rapid transit



Source: The Transport Politic

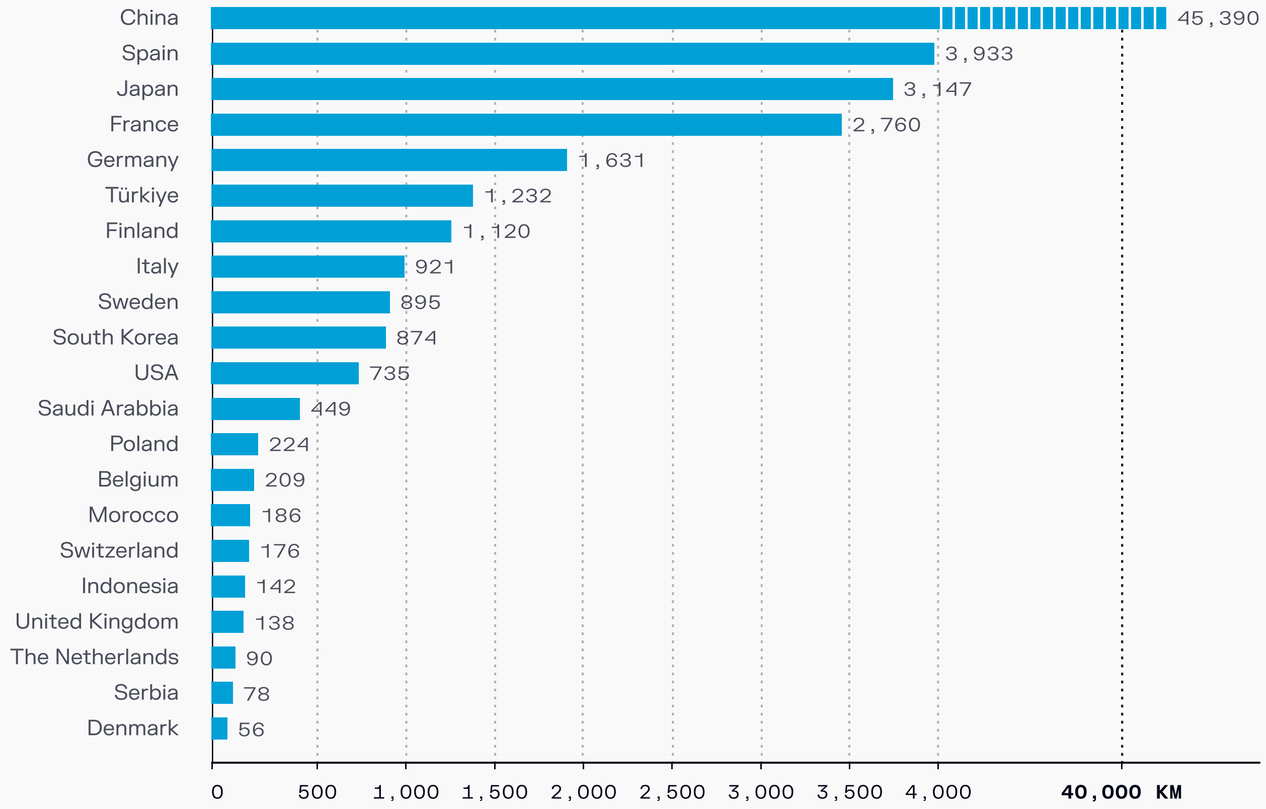
In fact, most countries have materially surpassed the US in terms of kilometers of rail that has been built.



Source: The Transport Politic

China has built 10x more high-speed rail lines than any other country.

Length of the high-speed network in commercial operation by country



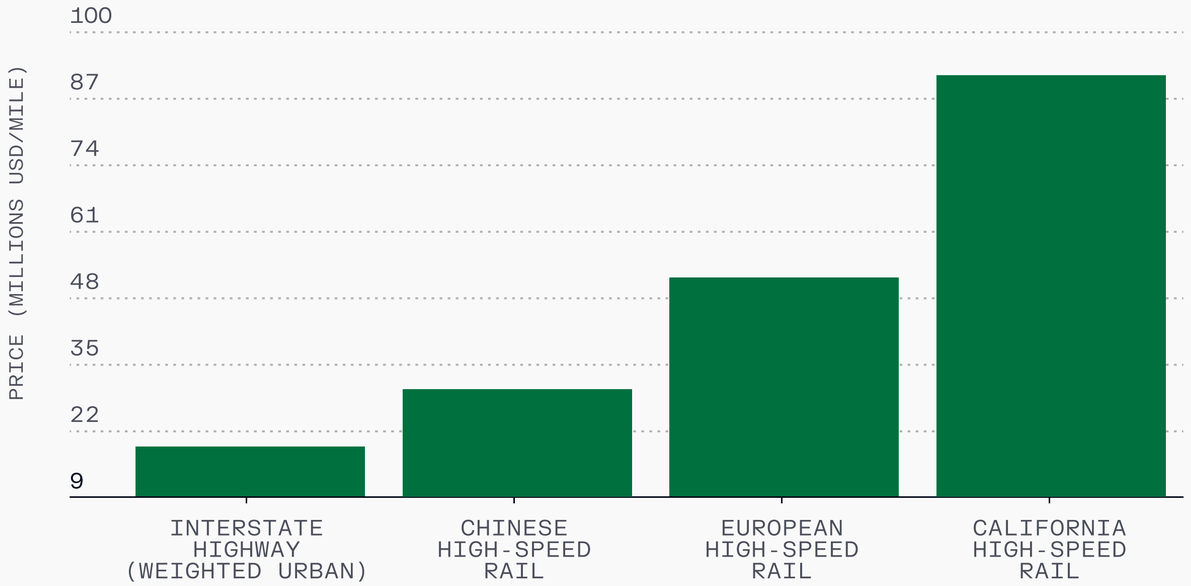
Source: International Union of Railways

China has built over 61x more high-speed rail lines than the US.

Source: International Union of Railways

The core driver of this deficiency in the US is the immense cost of building anything relative to comparable projects in other countries or eras.

Cost of construction



Source: Glimpse From The Globe

Just one example of a cost barrier in high-speed rail is the construction of tunnels.

The original NYC subway in 1904 took 4 years to open 28 stations and cost ~$1.7 billion in 2025 dollars.

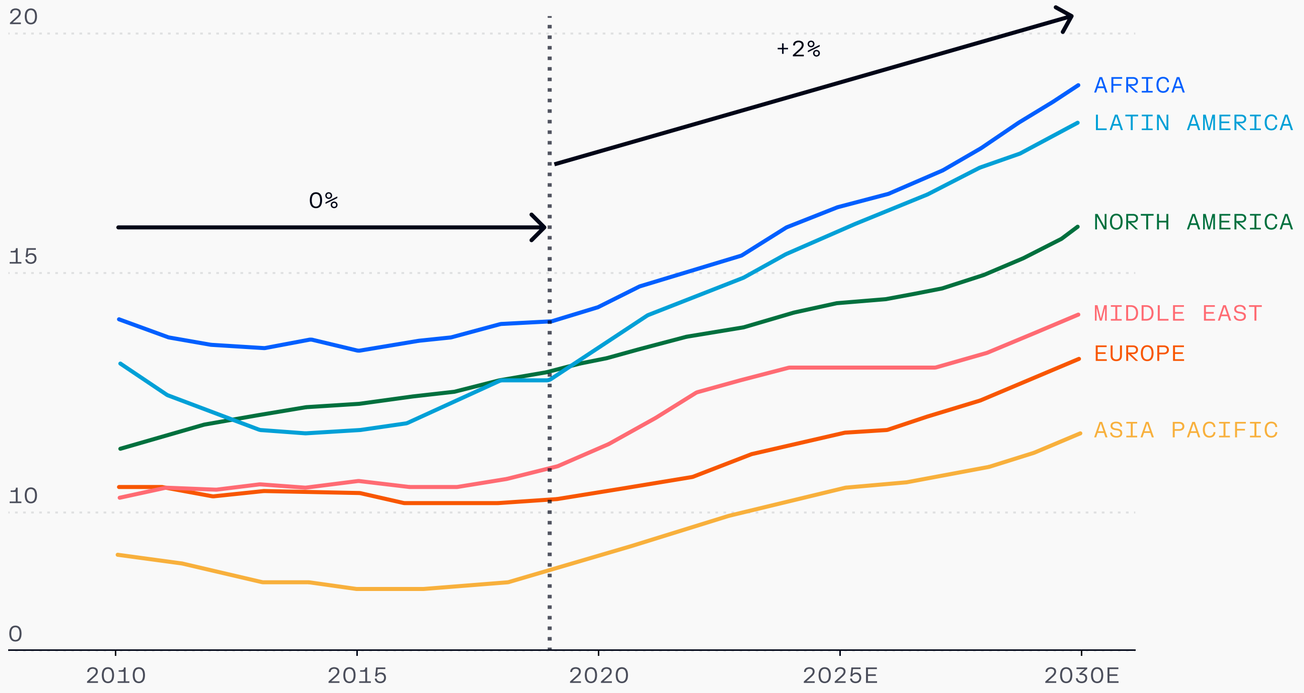
In 2007, NYC started building just 3 new stations. It took 10 years and cost $4.4 billion.

Building the original 28 stations of the NYC subway with the cost structure of today **would take 93 years to complete and cost $41 billion.**

Source: New York Public Library; Metropolitan Transportation Authority of the State of New York

Since 2020, average passenger fleet age globally has risen by ~2% due to delayed aircraft deliveries, enhanced maintenance practices that keep planes running longer, and faster fleet growth than anticipated.

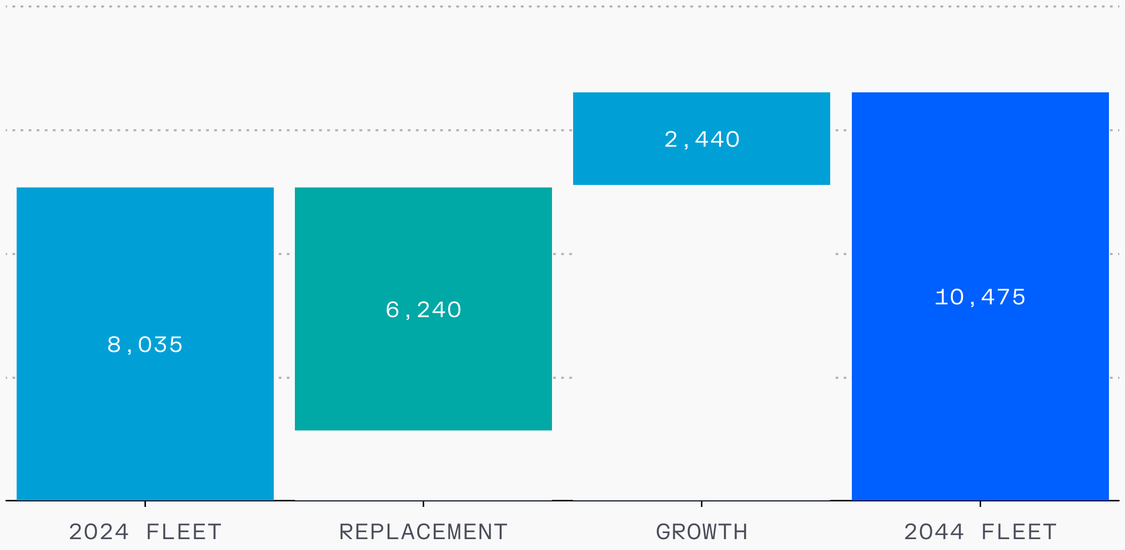
Average Passenger Fleet Age By Region (Years)



Source: Boston Consulting Group

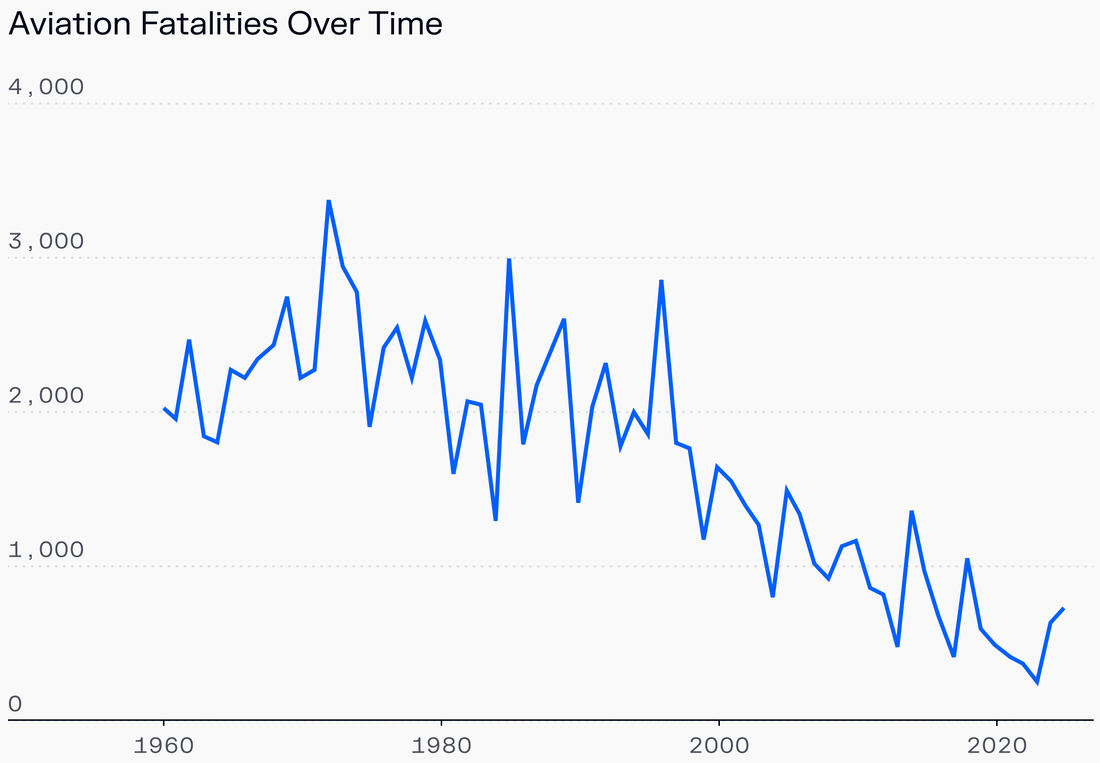
As a result of increasingly older fleets, large replacement rates are planned over the next 20 years. For example, Boeing expects to replace over 75% of its fleet.

Deliveries



Source: Boeing

Despite aging fleets and highly publicized mechanical failures, like the Boeing 737 Max incidents, aviation fatalities have continued to trend down.

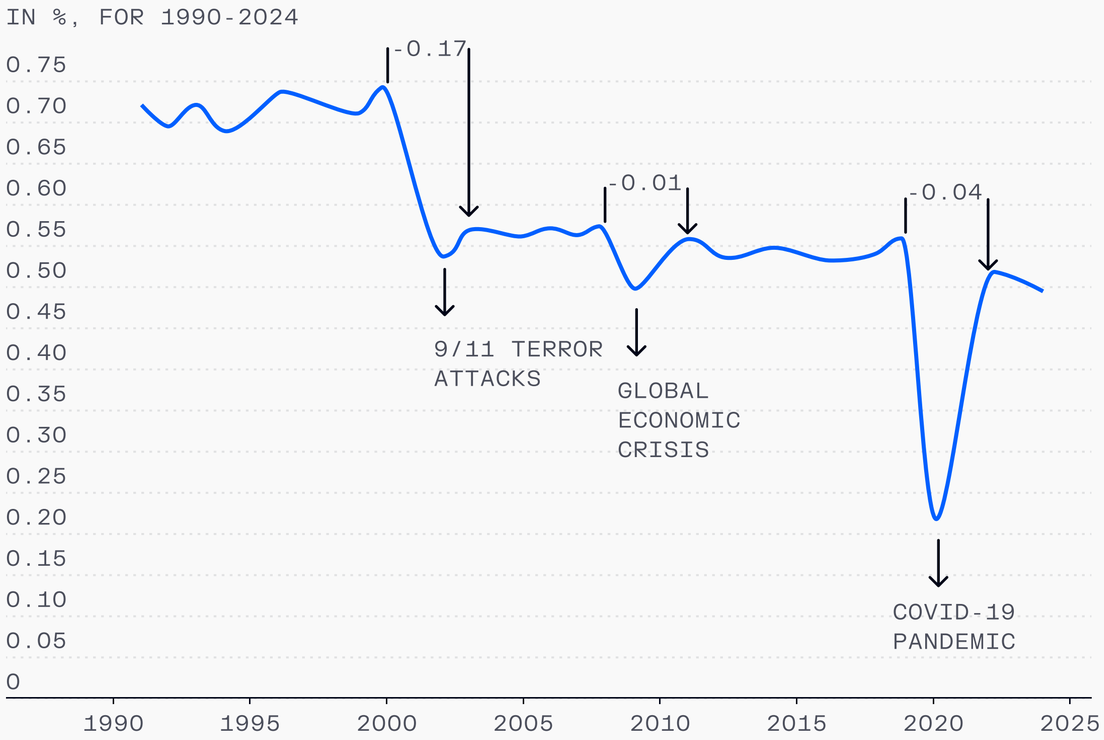


Source: Bureau of Aircraft Accidents Archives

However, after meaningful economic events, the aviation industry typically returns smaller than it was before.

From 1990 to 2024, the aviation industry lost the equivalent of $70 billion in 2024 dollars.

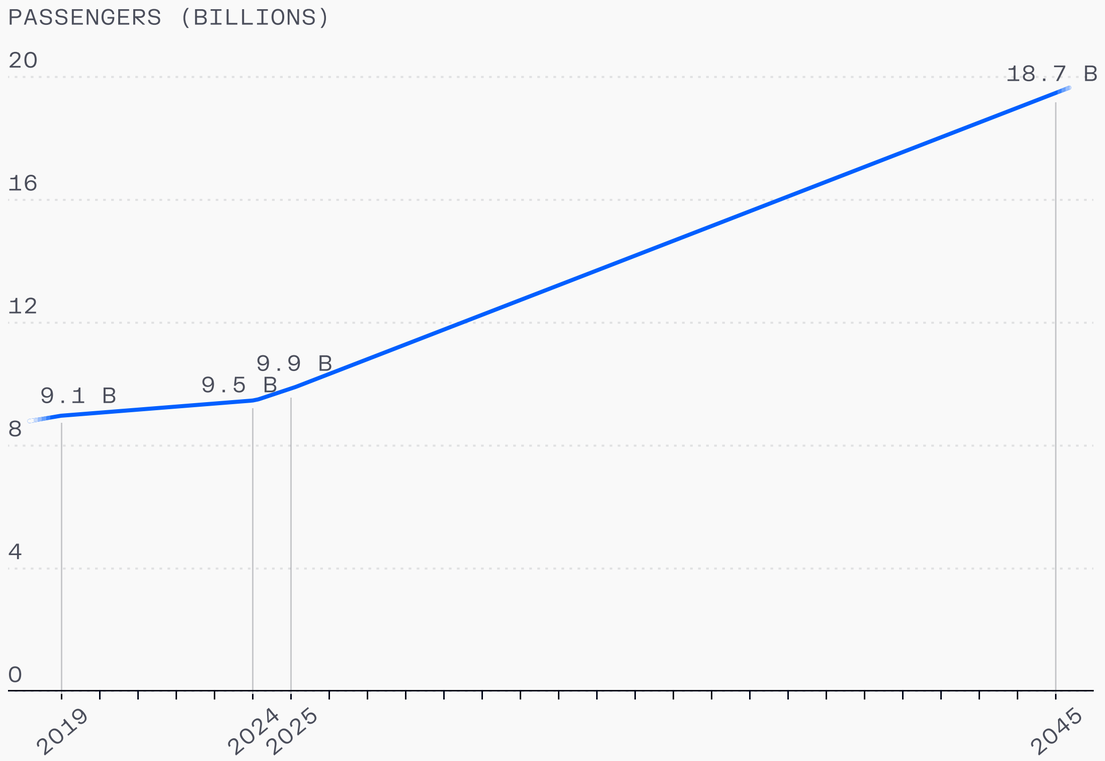
US airline domestic passenger revenue relative to GDP



Source: Oliver Wyman

One potential opportunity for renewed growth in the airline industry is supersonic travel.

Global Passenger Travel Growth



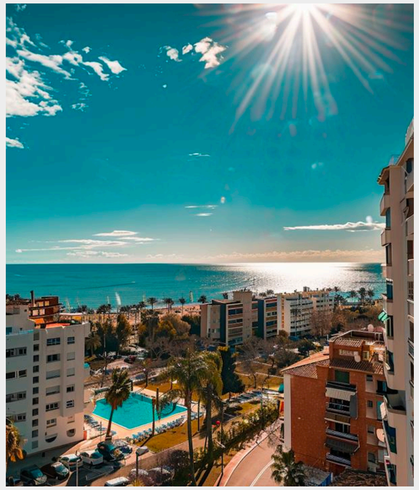
Source: Boom Supersonic

Startups like Boom Supersonic are hoping to offer dramatically faster flights, for which there is high consumer demand.

Washington D.C. → London

3H 55M

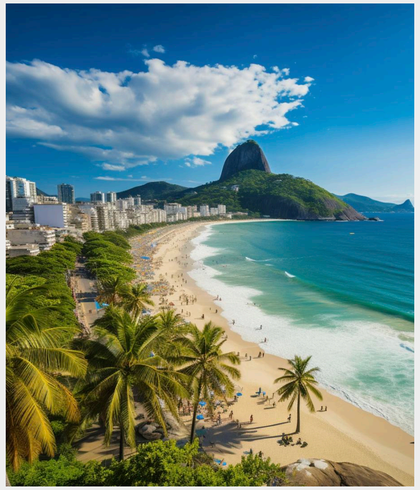
INSTEAD OF 6H 45M



Tokyo → Honolulu

3H 50M

INSTEAD OF 6H 45M



London → Miami

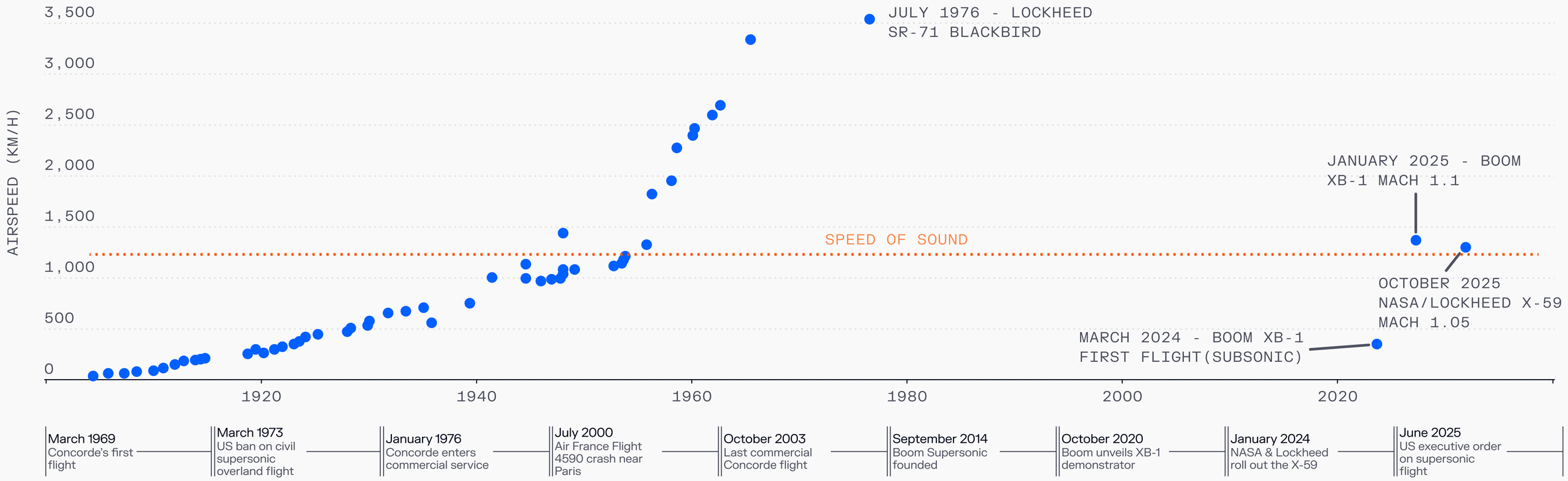
4H 40M

INSTEAD OF 9H 10M

Source: Boom Supersonic

97%	are interested in flying supersonic for long haul international trips
92%	believe that supersonic air travel will be commercially available in the next 10 years
87%	are interested in switching from their preferred airline in order to gain access to supersonic travel

After air speed records peaked in 1976, companies have been rebuilding back to supersonic speeds, first with Boom and then with NASA and Lockheed.



Source: Wikimedia Commons

Beyond supersonic advances, drone delivery has also made strides in the last decade to become a common part of logistics in the US.

2013

Amazon CEO Jeff Bezos announces plans for Amazon Prime Air, a drone delivery service, sparking widespread interest in drone delivery.

2016

Alphabet's subsidiary, Wing, launches a pilot drone program in Australia, delivering small packages to homes in a suburb of Canberra.
Zipline begins delivering medical supplies via drones in Rwanda, showcasing the potential for drones to provide life-saving services in remote areas.

2019

UPS receives FAA approval to operate a fleet of drones for package delivery in the US, marking a significant milestone for commercial drone delivery.

2020

COVID-19 pandemic accelerates interest in contactless delivery methods, leading to increased investment and experimentation in drone delivery solutions.

2021

Drone delivery services expand globally with companies like DHL, FedEx, and JD.com conducting trials and launching commercial operations in various countries.

2022

Regulatory frameworks for drone delivery continue to evolve, with governments worldwide adapting regulations to accommodate the growing industry while addressing safety and privacy concerns.

2023

Technological advancements in drone technology, including larger payload capacities, longer flight times, and improved navigation systems, further enhance the feasibility and efficiency of drone delivery services.

2024

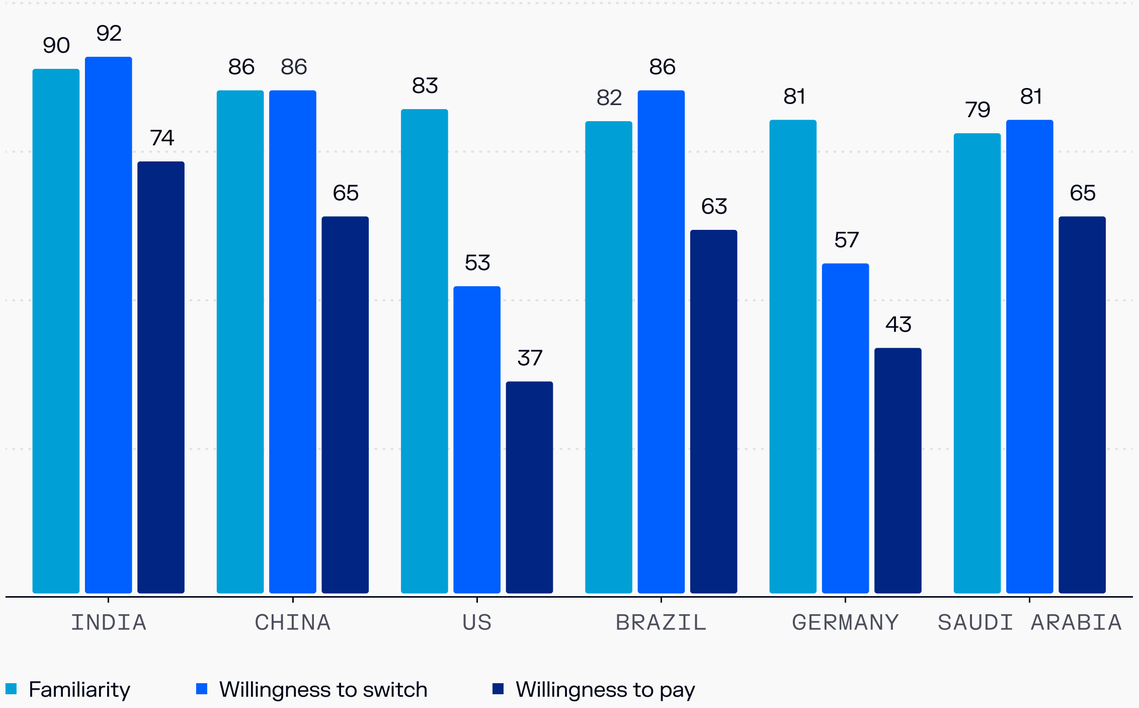
Drone delivery becomes increasingly integrated into supply chain logistics, with drones having a clear upcoming role in widespread last-mile deliveries for e-commerce, healthcare, and humanitarian aid.

Source: PwC

Internationally, consumer sentiment about drone delivery is already quite positive.

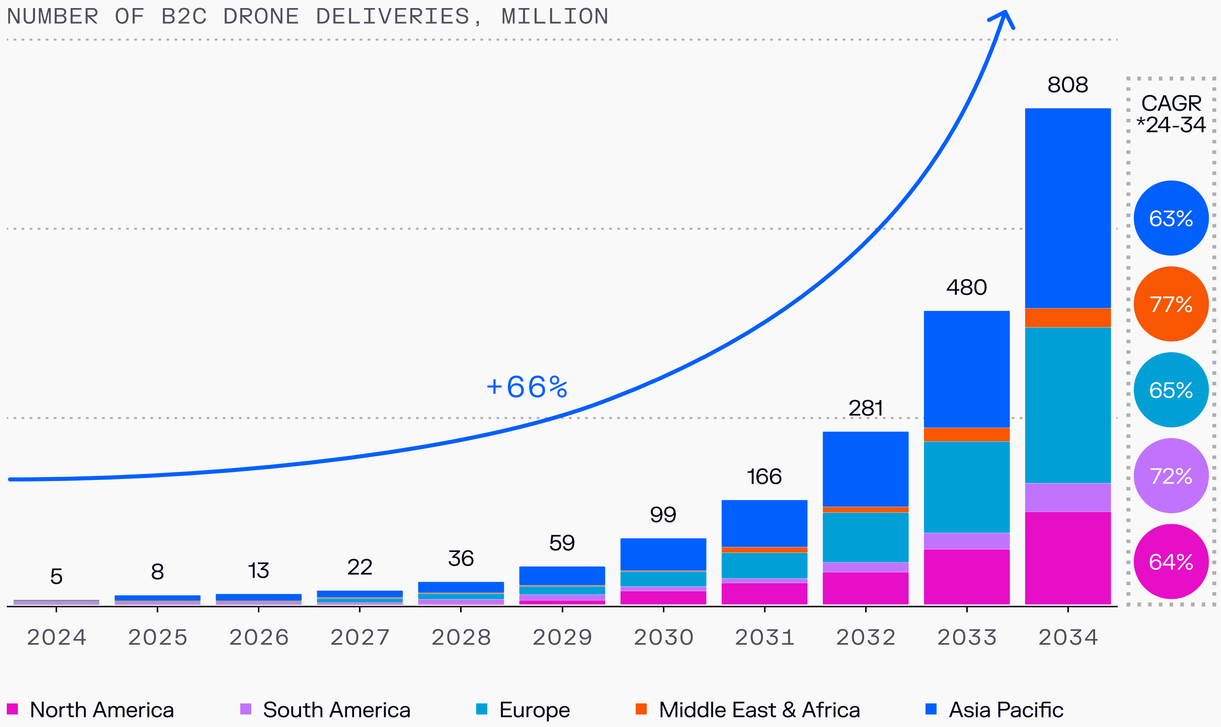
Familiarity with and openness to drone deliveries,

% OF RESPONDENTS



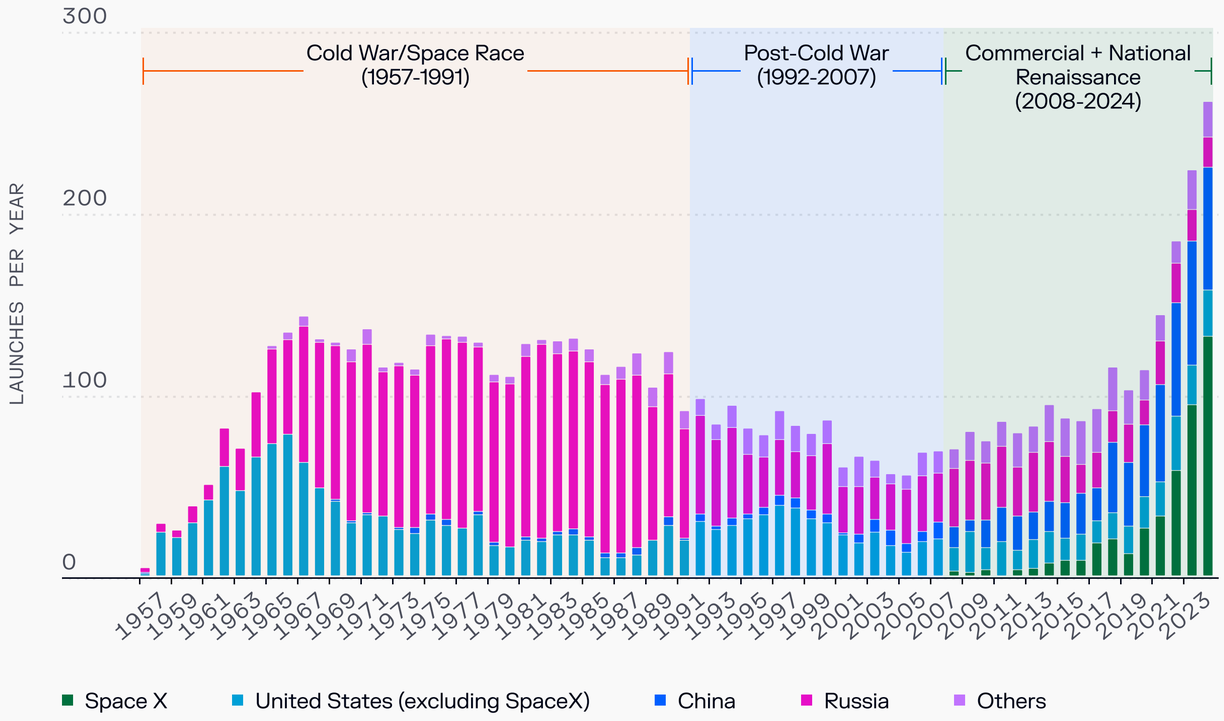
Source: McKinsey Advanced Air Mobility Consumer Pulse (n = 3000)

The volume of drone deliveries is expected to grow 10x from 2024 to reach over 50 million deliveries by 2029.



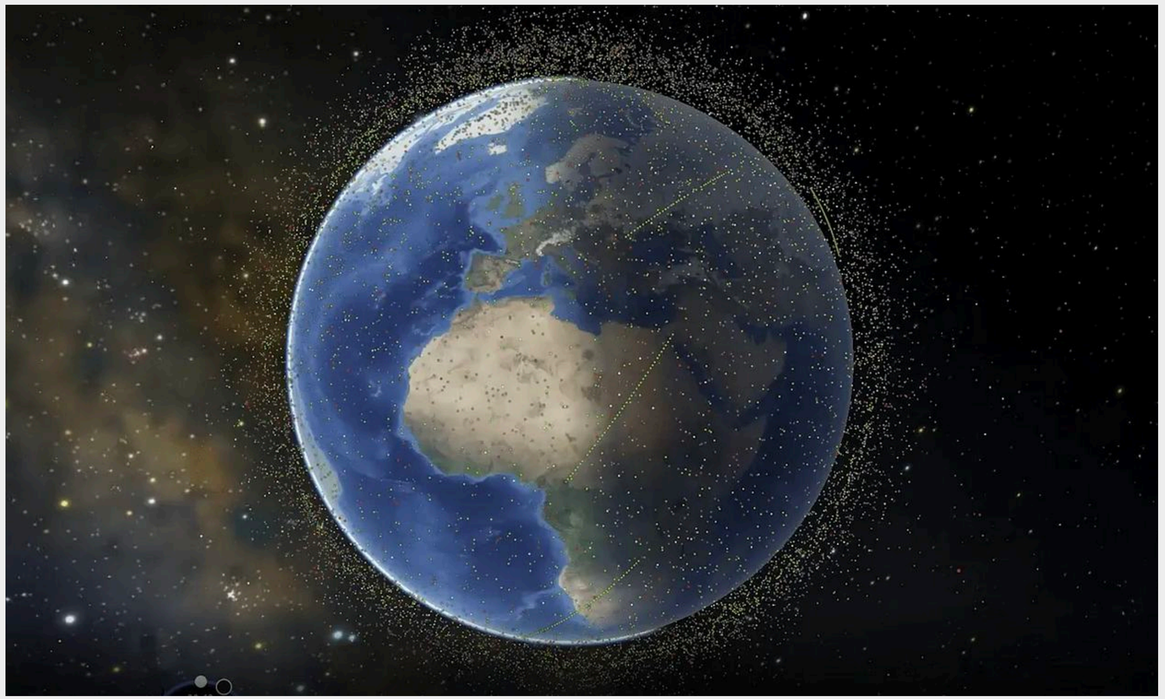
Source: PwC

Meanwhile, further from the ground, orbital deliveries via rocket launches have increased dramatically during a commercial and national satellite renaissance.



Note: Orbital launches from other celestial bodies than Earth are not included (e.g., Apollo LM ascents from the Moon's surface).
Source: SpaceX public announcements (1/25), Space Stats (3/25), USA Federal Aviation Administration

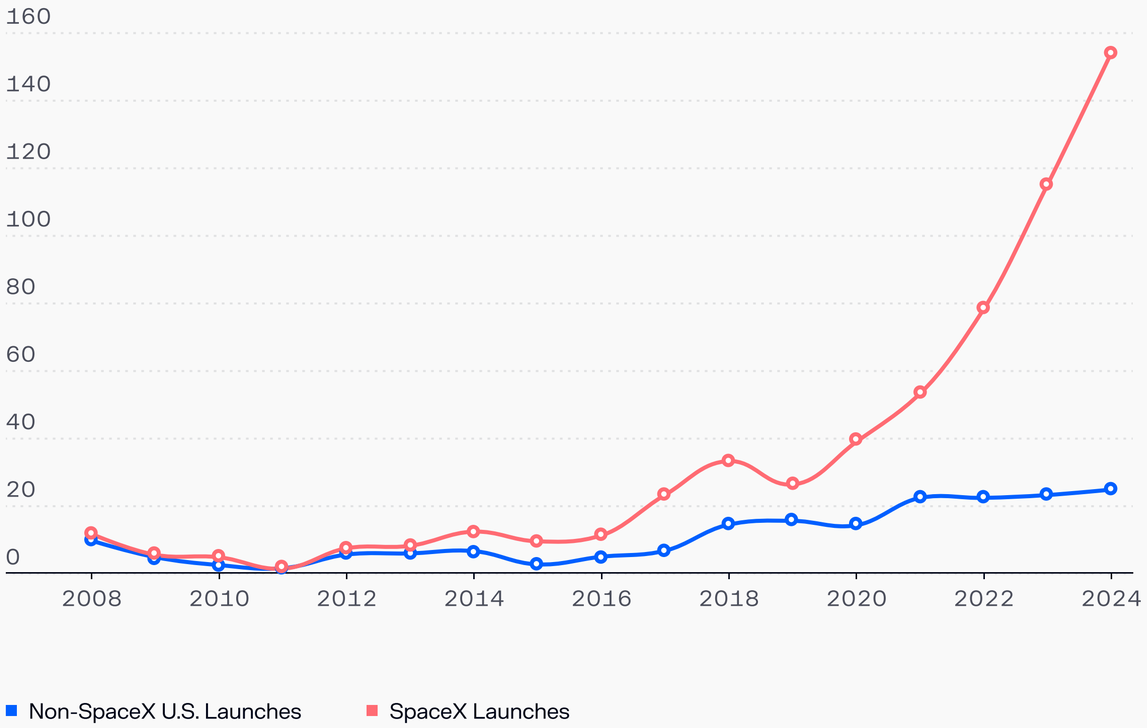
As of May 2025, there were an estimated 12,149 active satellites in various earth orbits.



Rendering of satellites in low earth orbit (LEO), geostationary orbit (GEO) and medium Earth orbit (MEO)

Source: Nano Avionics

SpaceX is, far and away, the most active launch provider in the market, launching 43 times in Q3 2025 alone.



Source: Motley Fool; Bryce Tech

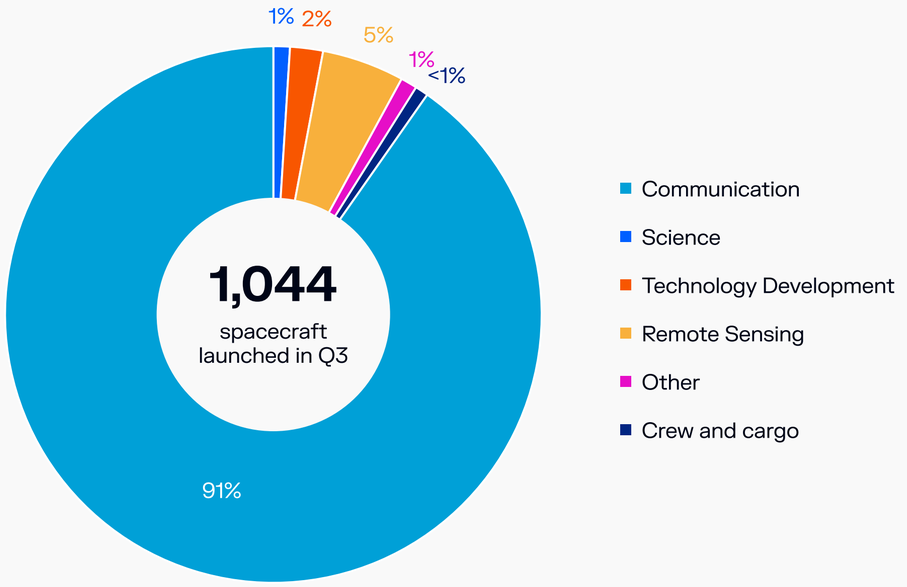
43 Launches Each — SPACEX

17 Launches Each — CASC

6 Launches Each — ROSCOSMOS

The majority of spacecraft being launched are communications related.

For example, in Q3 2025, 91% of the spacecraft launched were communications related.

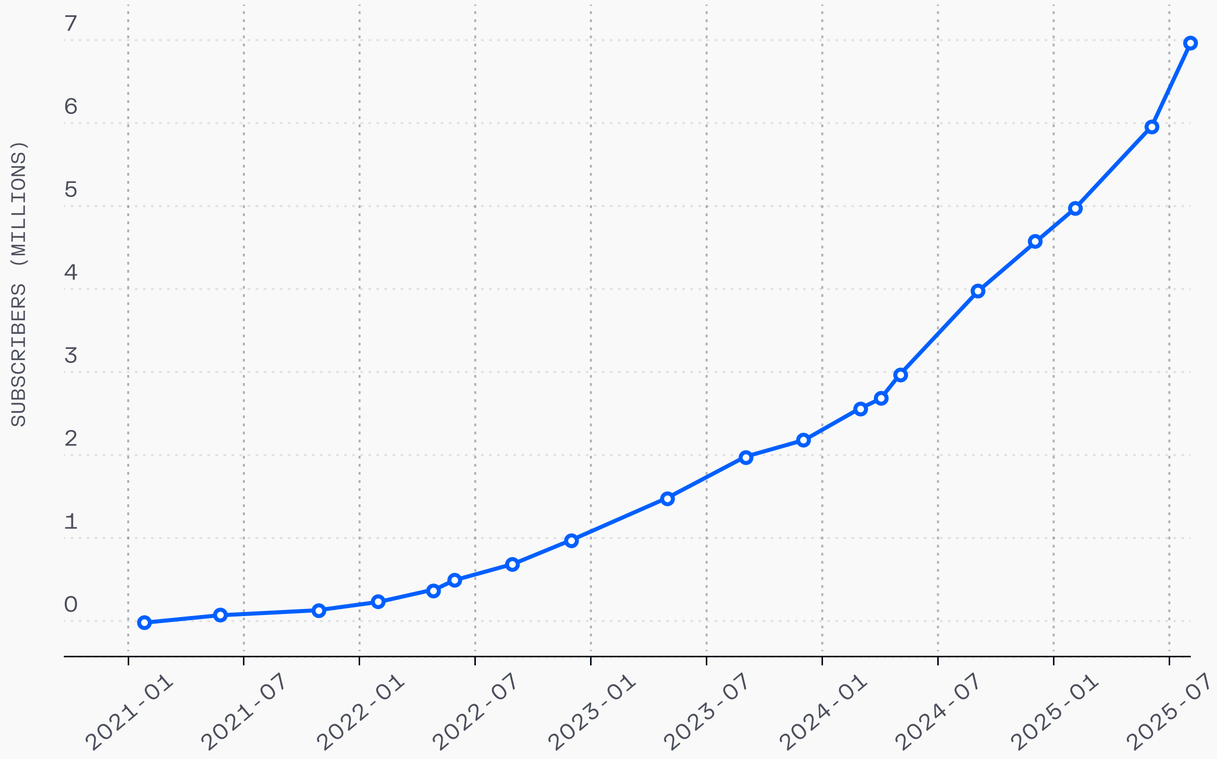


Source: Bryce Tech

Starlink satellites now make up the majority of satellites in low Earth orbit, with over 8,700 Starlink satellites active and in orbit as of October 2025. SpaceX has been approved by the Federal Communications Commission (FCC) to fly up to 12,000 satellites, and SpaceX has said it aspires to eventually fly over 42,000.

Starlink serves more than 7 million subscribers after launching in 2021.

Starlink Subscribers Over Time (Feb 2021 - Aug 2025)



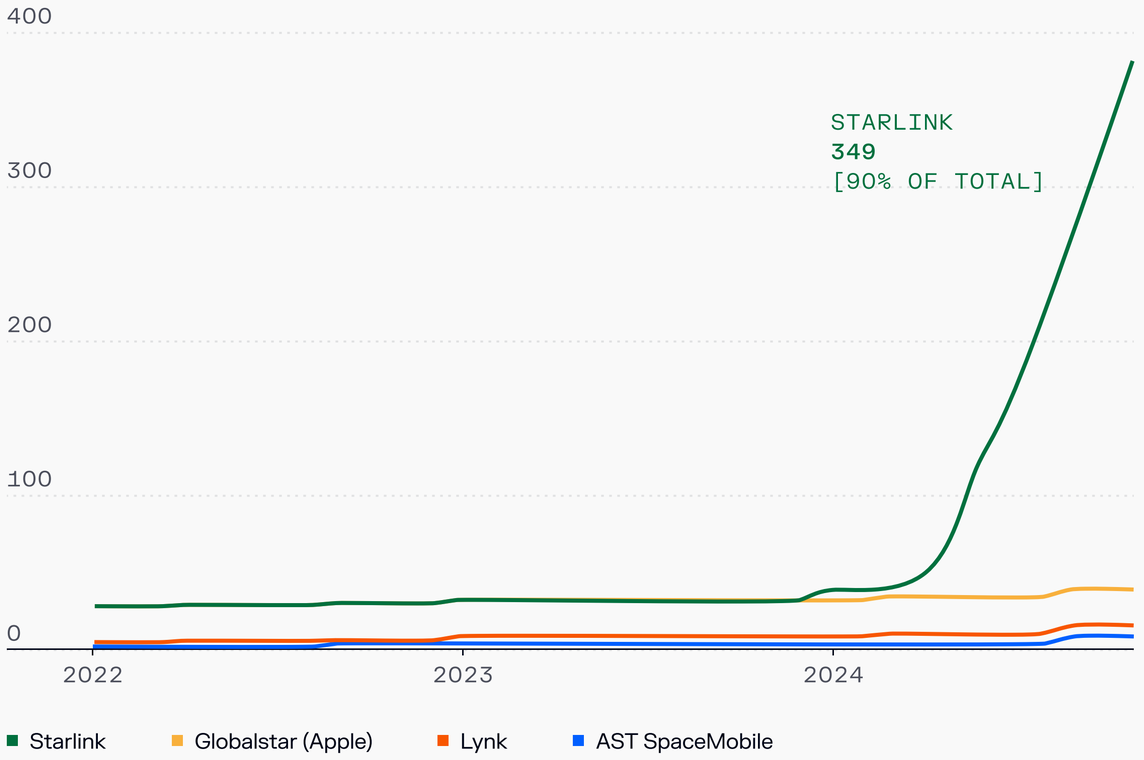
Source: Nature, Space.com

Globalstar, used by Apple for satellite connectivity on iPhones, utilizes 24 satellites, compared to over 8,700 Starlink satellites. As of 2025, Starlink satellites service customers using T-Mobile.

Other phone manufacturers and cell service providers have not signed with a satellite service provider, leaving the opportunity for ongoing competition.

Starlink dominates satellite direct-to-device (D2D) launches

GLOBAL LAUNCHES OF D2D CAPABLE SATELLITES, STARLINK, AST SPACEMOBILE, LYNK, GLOBALSTAR*

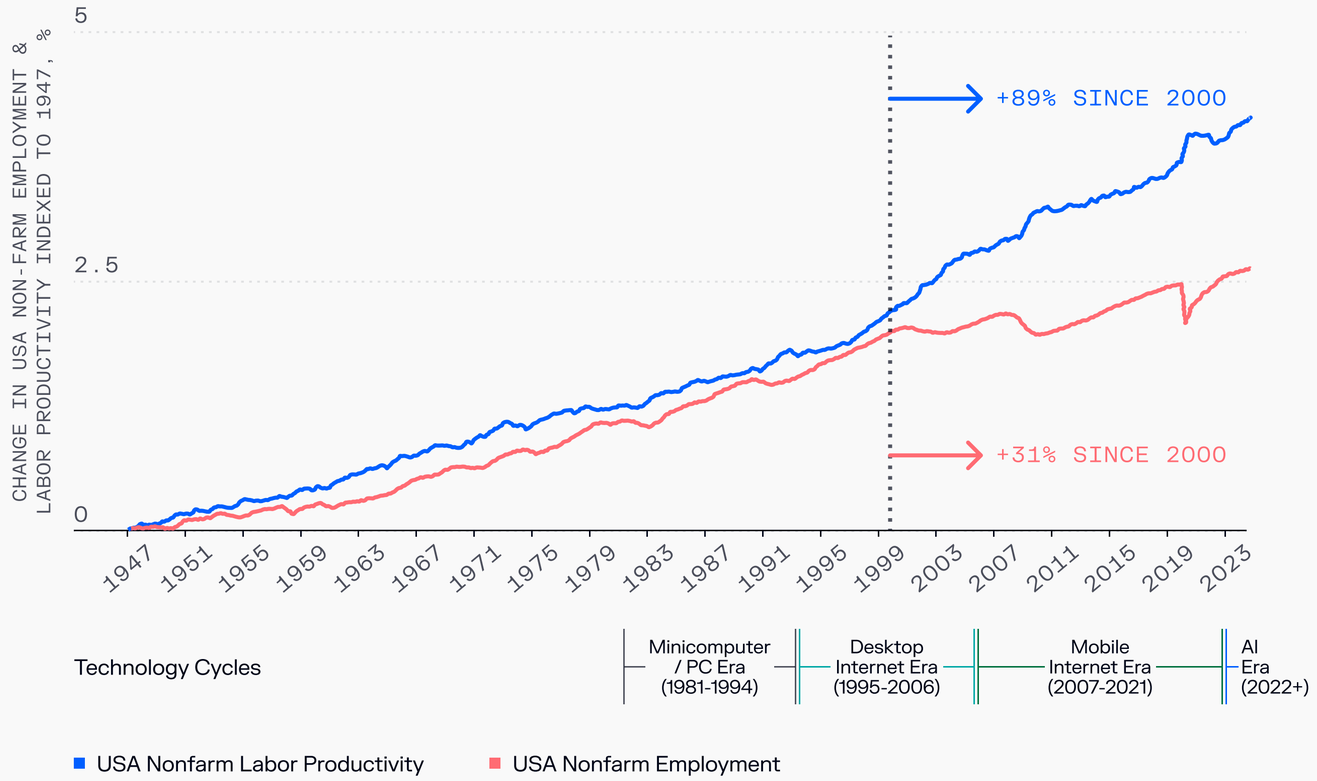


Source: satnews; Chart includes test satellites for Lynk and AST SpaceMobile. Globalstar count includes only those satellites used by Apple.

Manufacturing: Shifts Across Human and Robotic Labor

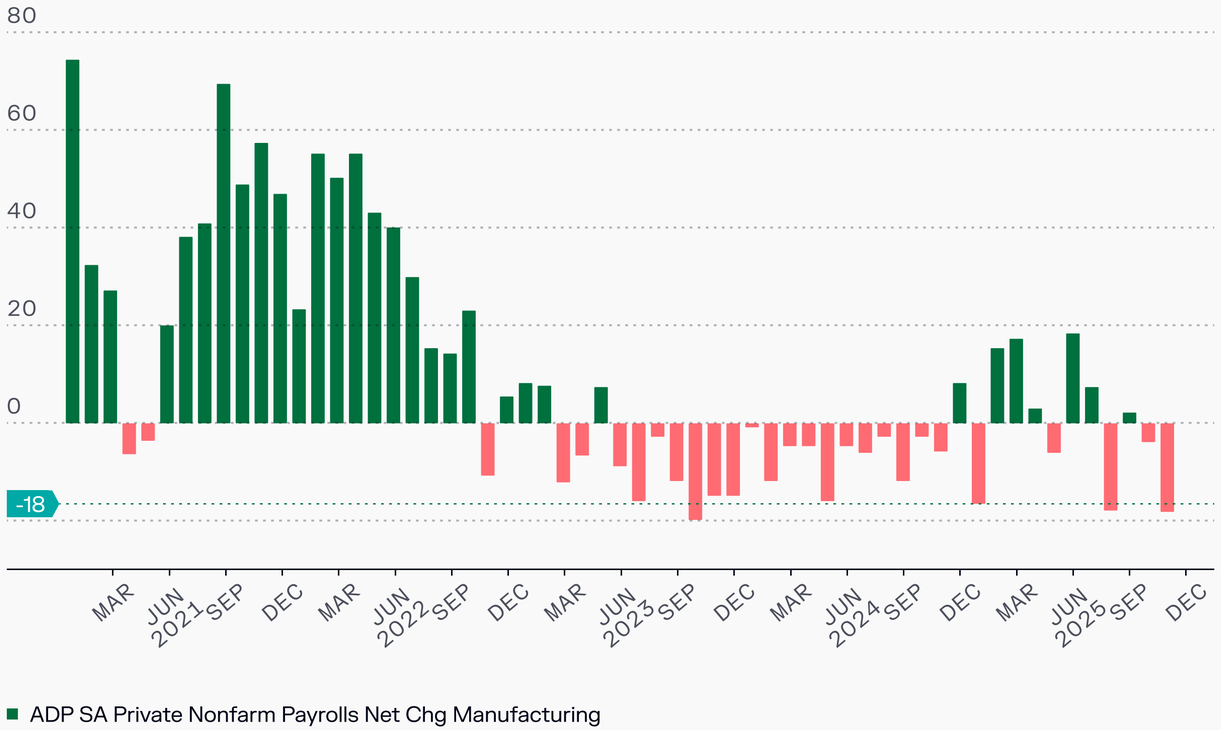
Despite increasing productivity in manufacturing and other non-farm operations in the US, the number of people employed in these industries has risen more slowly.

Relative Change in USA Non-Farm Employment & Labor Productivity



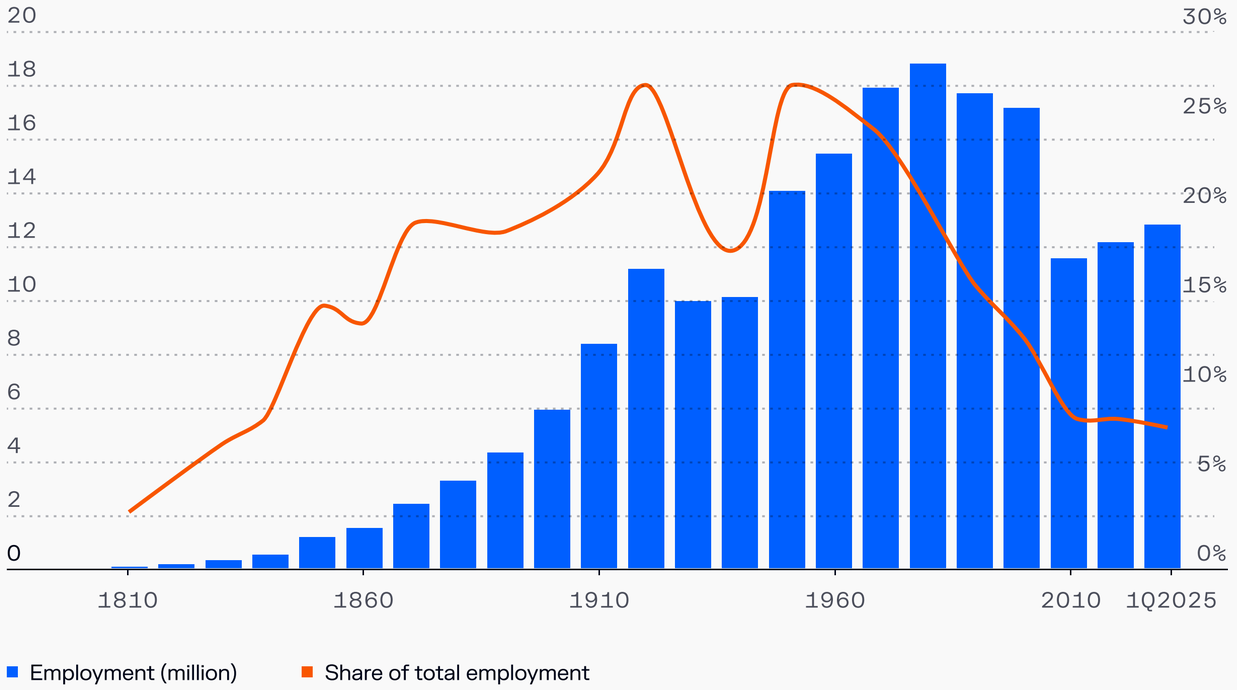
Source: Federal Reserve Bank of St. Louis; This chart defines the start of the PC Era as 1981 (launch of IBM PC), the start of the desktop internet era as 1995 (Netscape's IPO), the start of the mobile internet era as 2007 (the launch of Apple's iPhone), the start of the AI Era as 2022 (the public launch of ChatGPT).

Manufacturing employment in the US continued to fall in the last three years, with over 12 months of consecutive decline in 2023-2024.



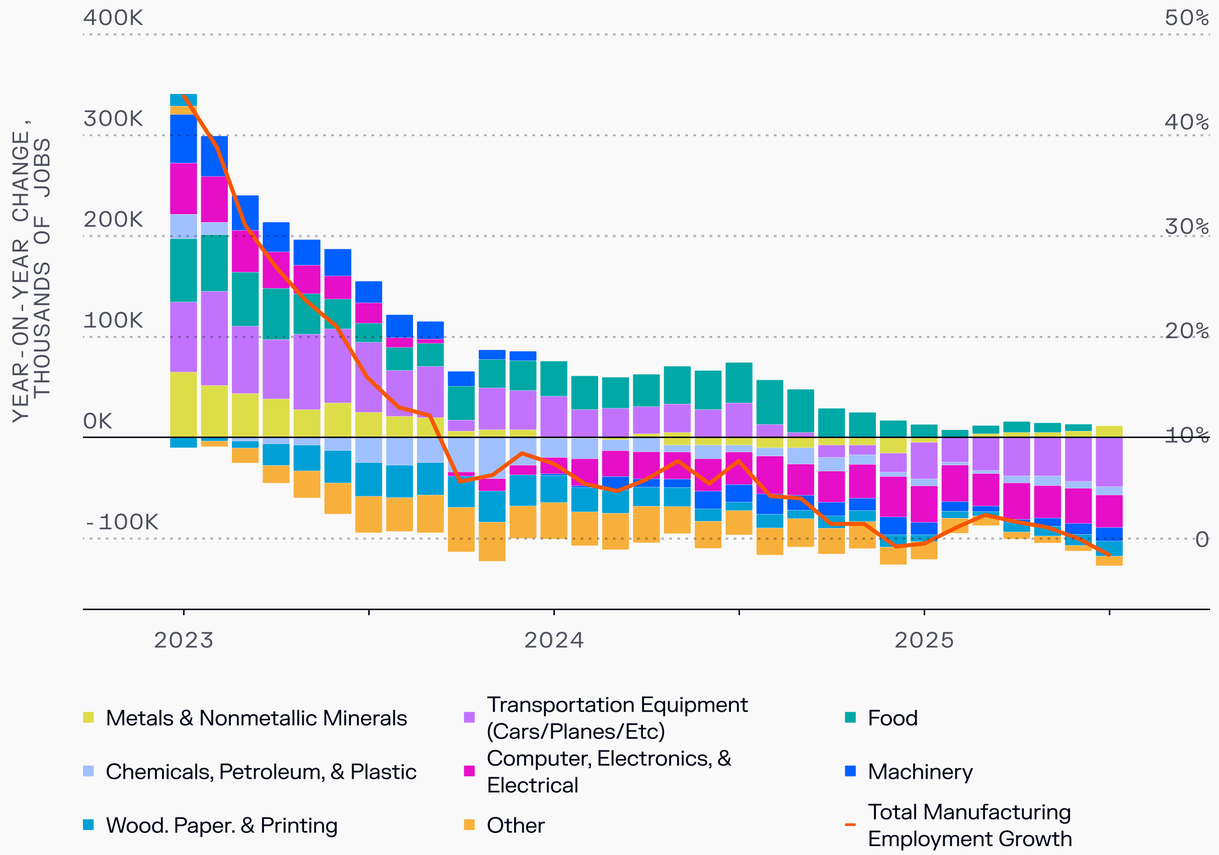
Source: Bloomberg

Manufacturing employment as a share of total employment has been consistently declining in the US since the 1980s



Source: US Census Bureau, Stanley Lebergott (NBER)

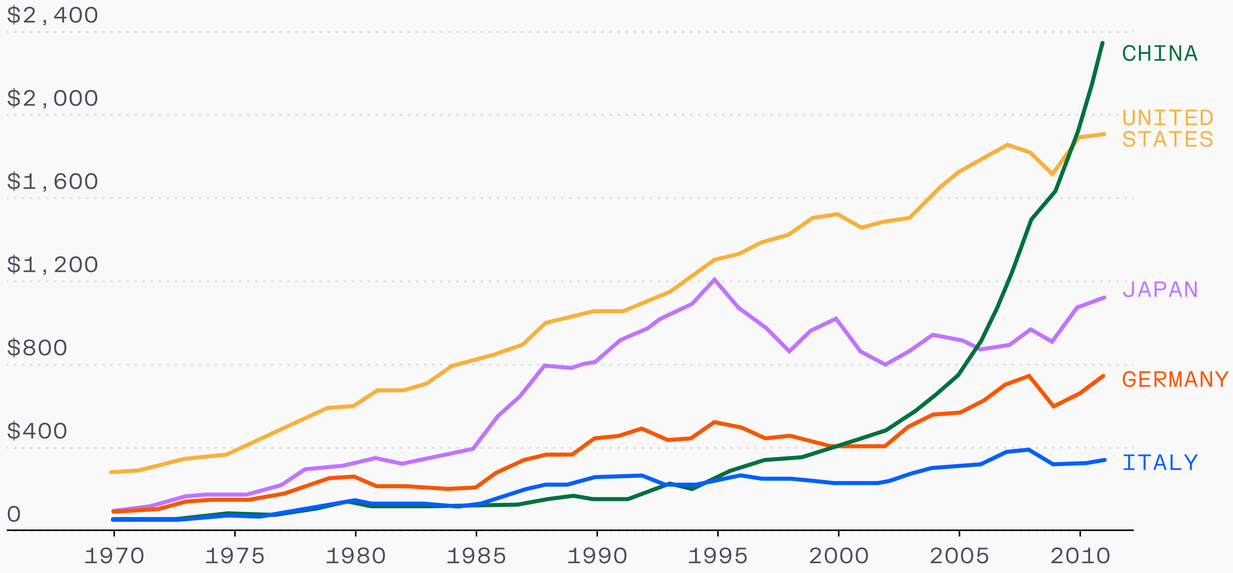
That decline occurred across categories outside small incremental growth in food and mining. From July 2024 to July 2025, the US lost 100K manufacturing jobs.



Source: Bureau of Labor Statistics via Joseph Politano

Like many other industrial categories, the notable trend over the last several decades has been the rapid rise of China, which overtook the US in manufacturing output in the early 2010s.

Manufacturing Output, Top 5 Countries (billions)

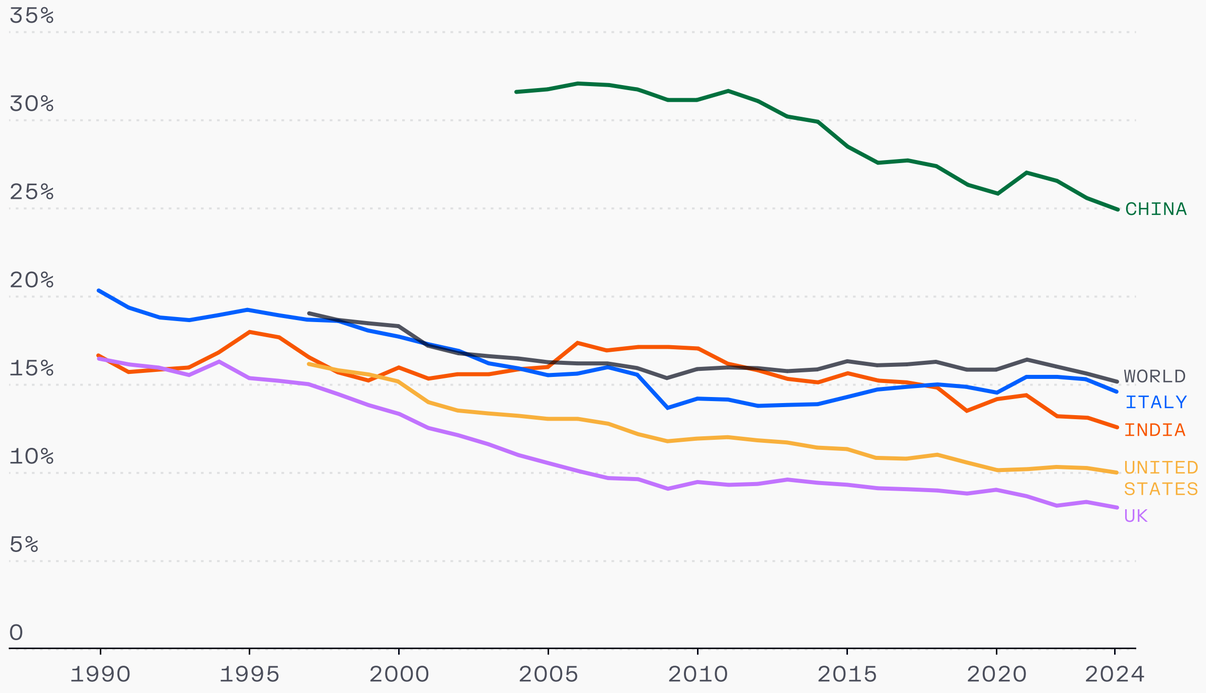


Source: United Nations; measured in 2011 US Dollars

However, the broader trend is the increasing decline in manufacturing as a percentage of GDP across countries, including China.

Share of manufacturing in gross domestic product (GDP), 1990 to 2024

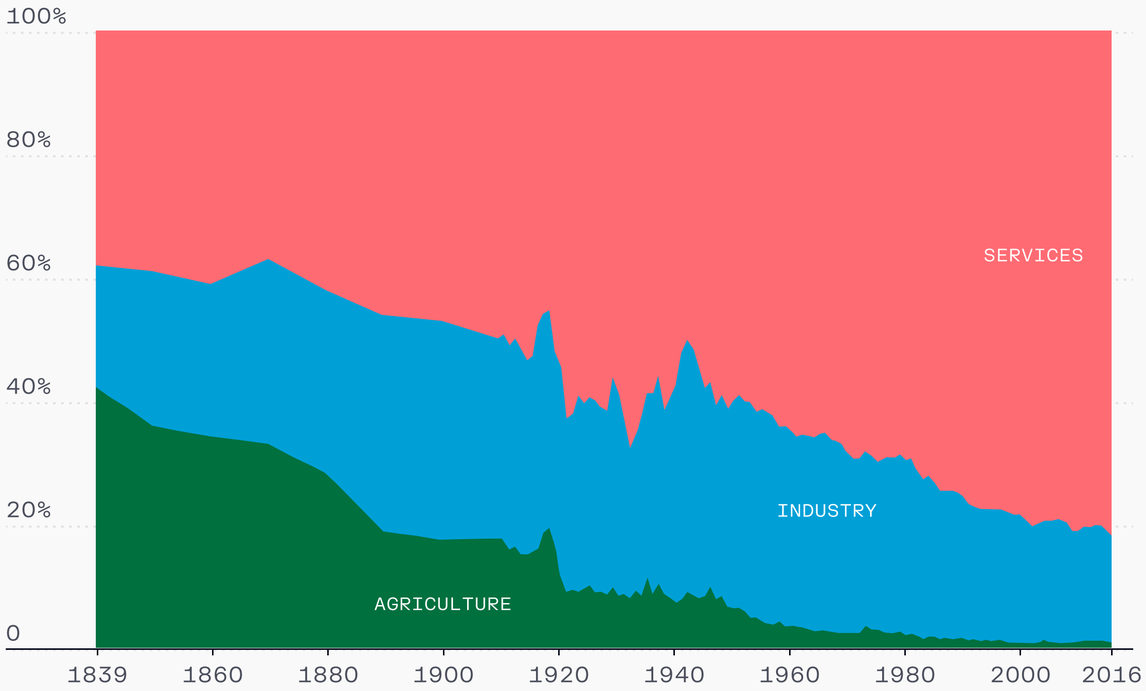
MANUFACTURING COMPRISES UNITS ENGAGED IN THE PHYSICAL, OR CHEMICAL TRANSFORMATION OF MATERIALS, SUBSTANCES, OR COMPONENTS INTO NEW PRODUCTS.



Source: World Bank and OECD national accounts (2025)

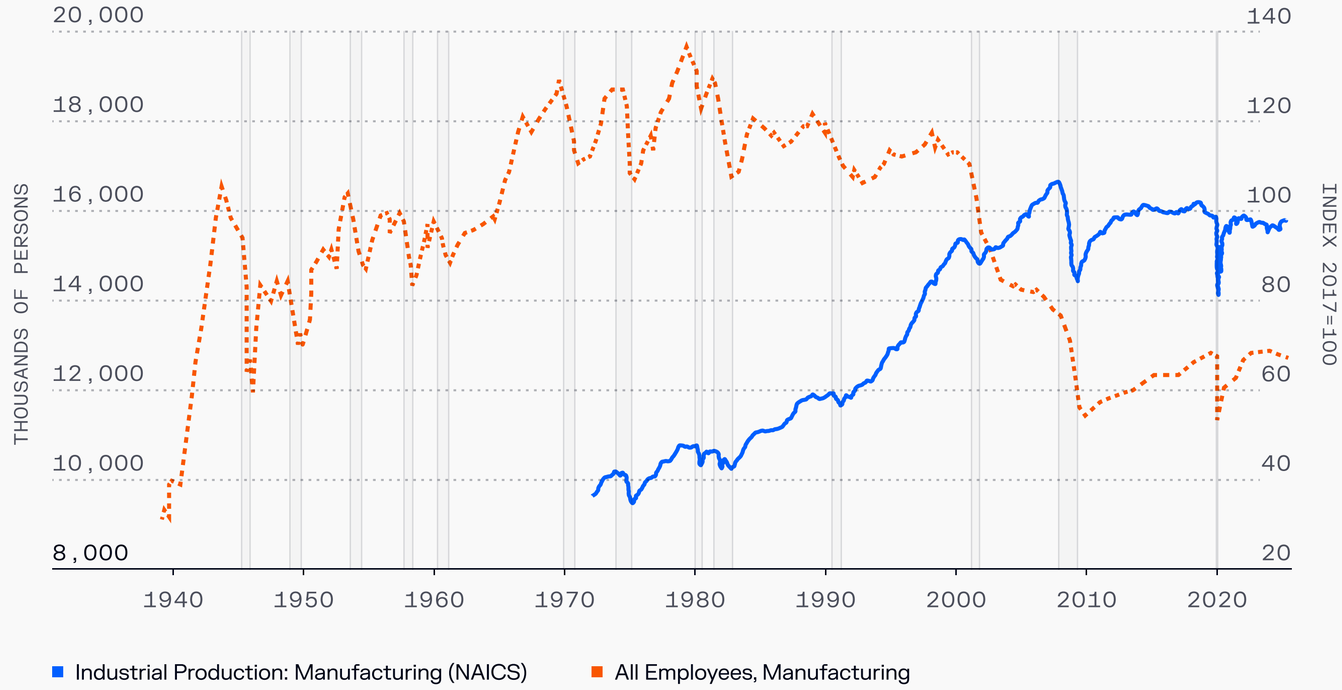
Industry, including manufacturing, mining, construction, and utilities has increasingly declined, giving way to a growing service economy.

Distribution of GDP by economic sector in the US



Source: Herrendorf

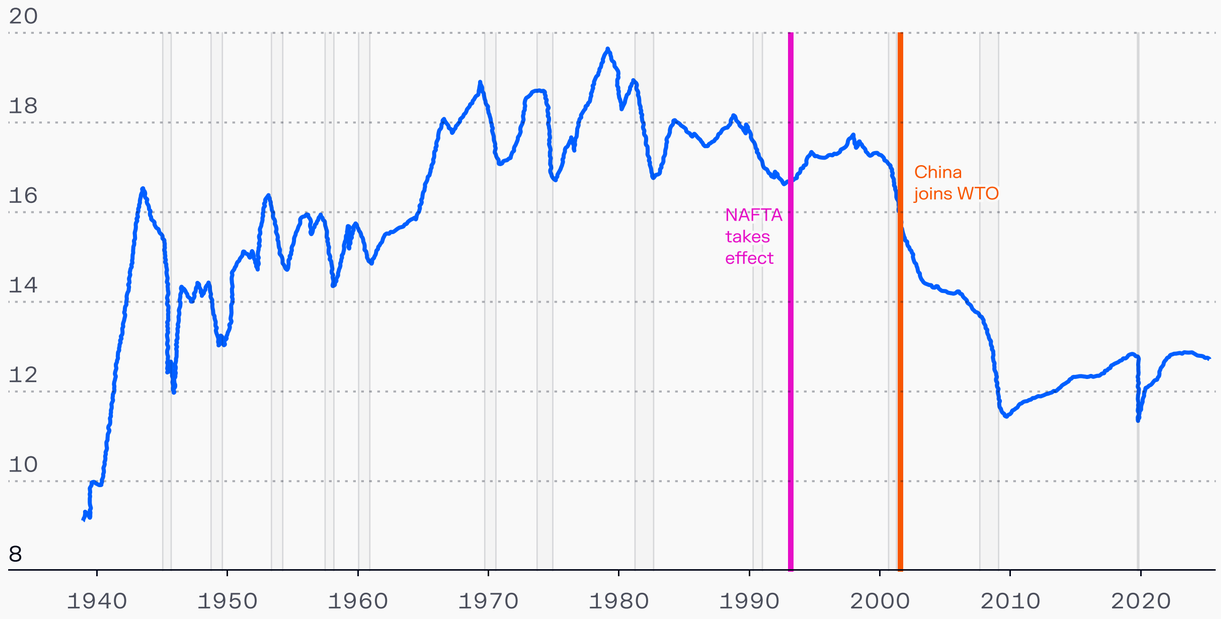
In the early 2000s, manufacturing underwent what's been called the "productivity puzzle." While manufacturing employment dropped dramatically, productivity continued to rise until the financial crisis where, post-recovery, it plateaued.



Source: Board of Governors of the Federal Reserve System (US); US Bureau of Labor Statistics via FRED; Shaded areas represent recessions

One key driver in the employment reduction came from offshoring through geopolitical events like NAFTA taking effect and China joining the WTO.

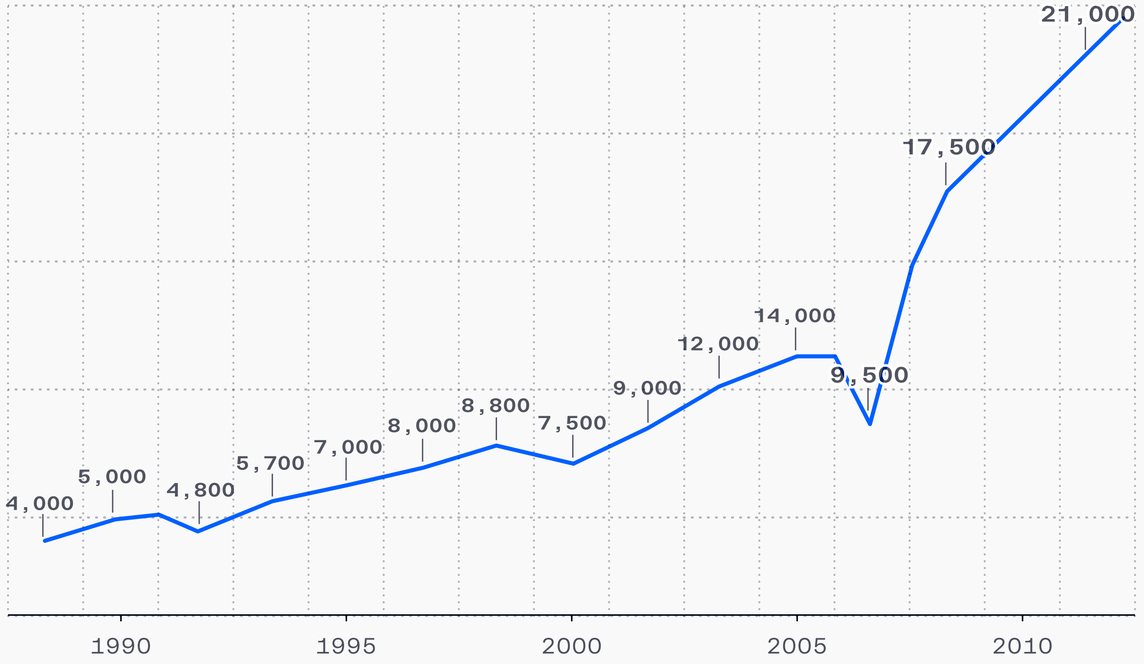
Manufacturing Employment (in millions; seasonally adjusted)



Source: Bureau of Labor Statistics

Another driver of the manufacturing puzzle was the adoption of industrial robotics in the US, helping support manufacturing productivity.

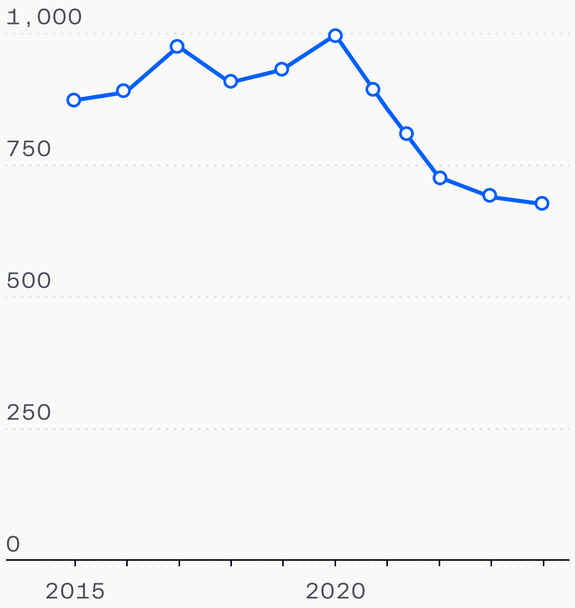
Annual US Robot Shipments



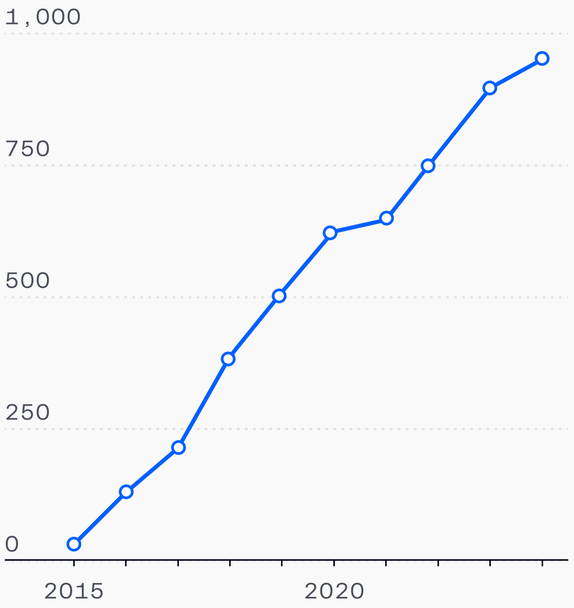
Source: Robotics Tomorrow

One use case for robotics has been ecommerce, where companies like Amazon have seen per facility headcount decline for the last several years, while package handling volumes continue to increase. 75% of Amazon's global deliveries are assisted in some way by robotics.

Number of Amazon employees, per facility



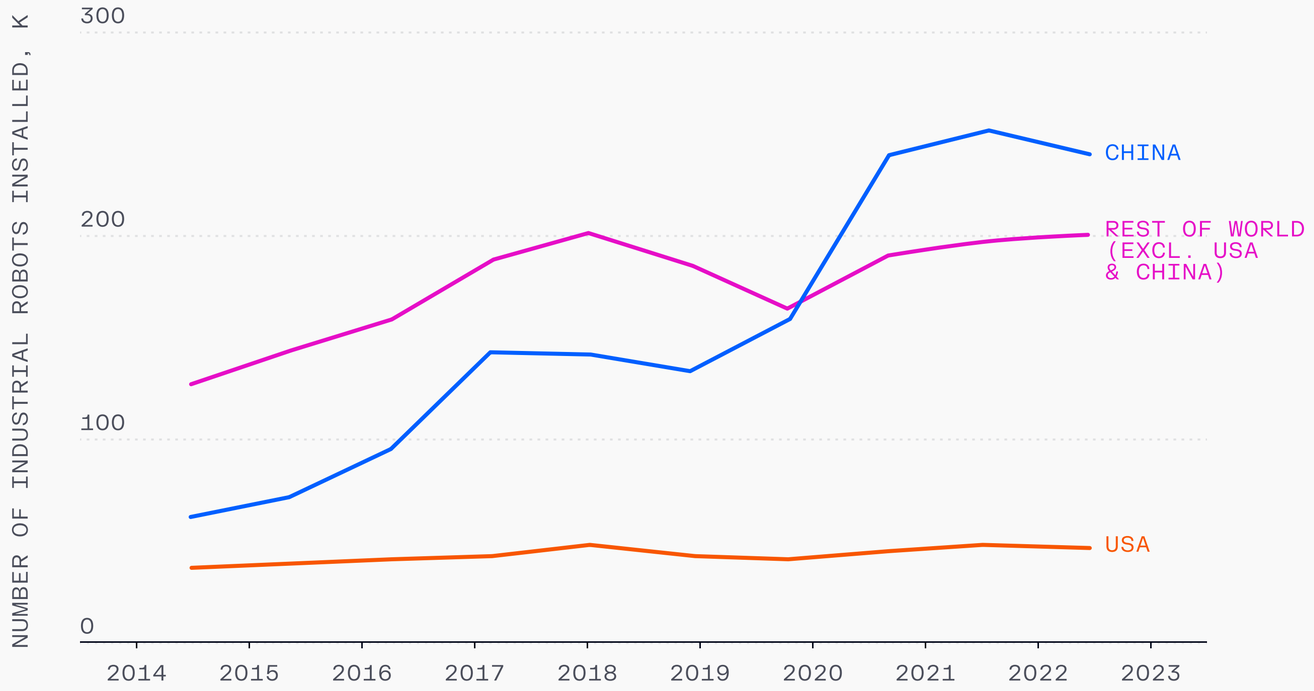
Packages handled by Amazon end-to-end, per employee



Sources: WSJ analysis of data from the company (employees), MWPVL International (facilities) and ShipMatrix (packages); Note: Includes employees at Amazon corporate offices. Employee and facility figures are global; package figures are for U.S. shipments only.

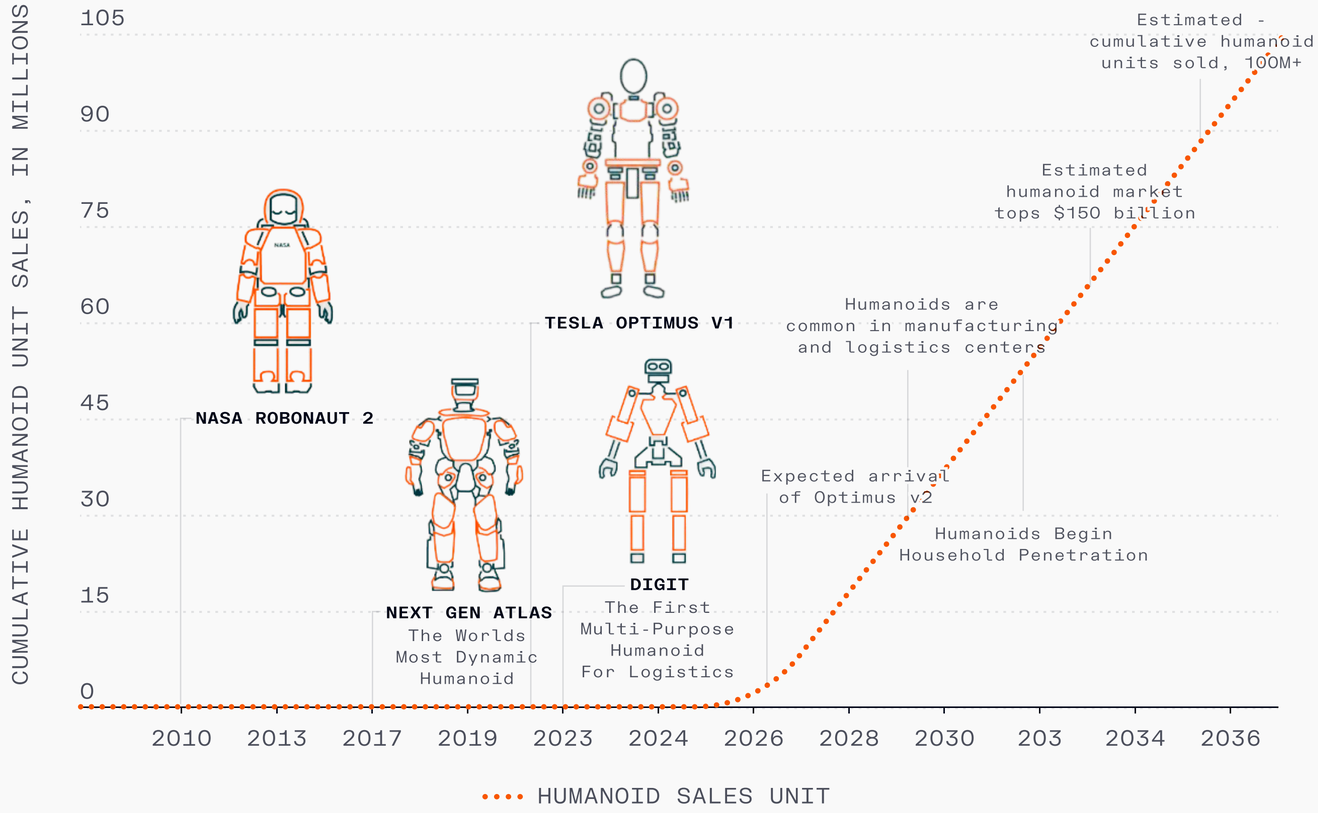
However, US robotics adoption has been eclipsed by China. In 2020, China surpassed the rest of the world combined for the number of industrial robots installed. Meanwhile, 90% of factories in the US still operate without robots.

Number of Industrial Robots Installed



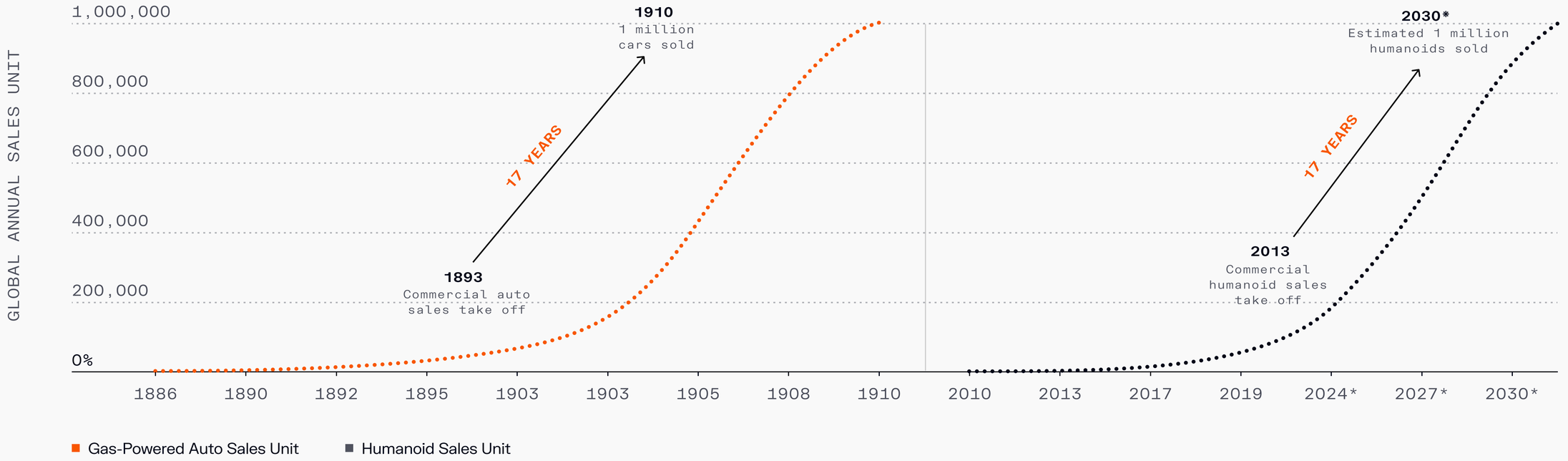
Source: International Federation of Robotics (IFR) (2024)

Going forward, the humanoid robotic market represents a sizable opportunity; estimated by some to be capable of generating $150B in revenue across 100M+ units.



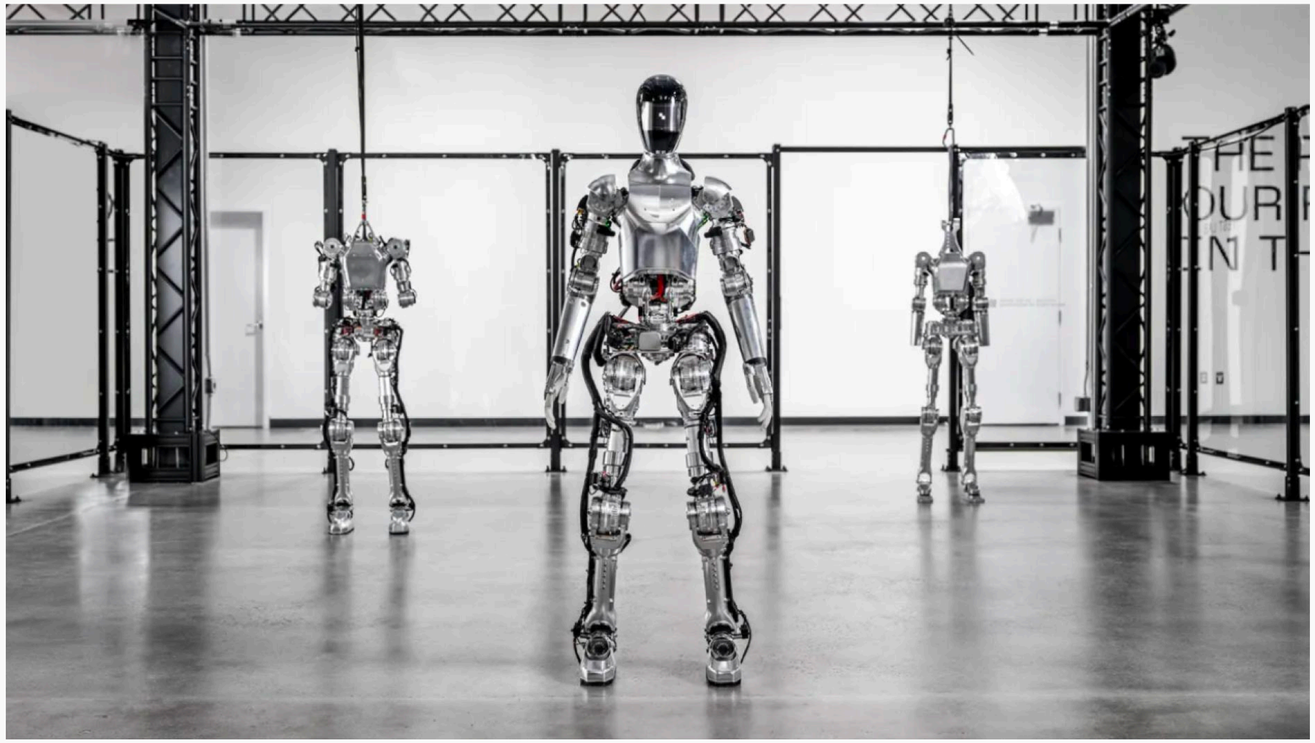
*Source: *indicates Global X forecast; 2010-2023 Global X ETFs estimates with information derived from: Goldman Sachs. (2022, November 15). Humanoid Robots: Sooner Than You Might Think. Science Robotics. (2017, December 20). Humanoid robotics - History, current state of the art, and challenges. The Economic Times. (2024, January 22). Elon Musk expects 1 billion humanoid robots by 2040s. University of Groningen. (2019). Service Robots Rising.*

Some estimates of humanoid robotic penetration appear comparable to early adoptions rates of the automobile.



Source: Global X ETFs with information derived from: Strategy + Business. (2023, August 15). Boston Dynamics wants to change the world with its state-of-the-art robots. Whisbi. (2022, February 1). The history of car sales.

However, humanoid robotics are not without risk. For example, one robotics company, Figure AI, was recently sued by a whistleblower, stating the company was disregarding safety requirements for a robot that could “fracture a human skull.”



Source: Figure AI

Across the board, automation is expected to drive meaningfully positive impacts, particularly around speed of production, delivery, and production capacity.

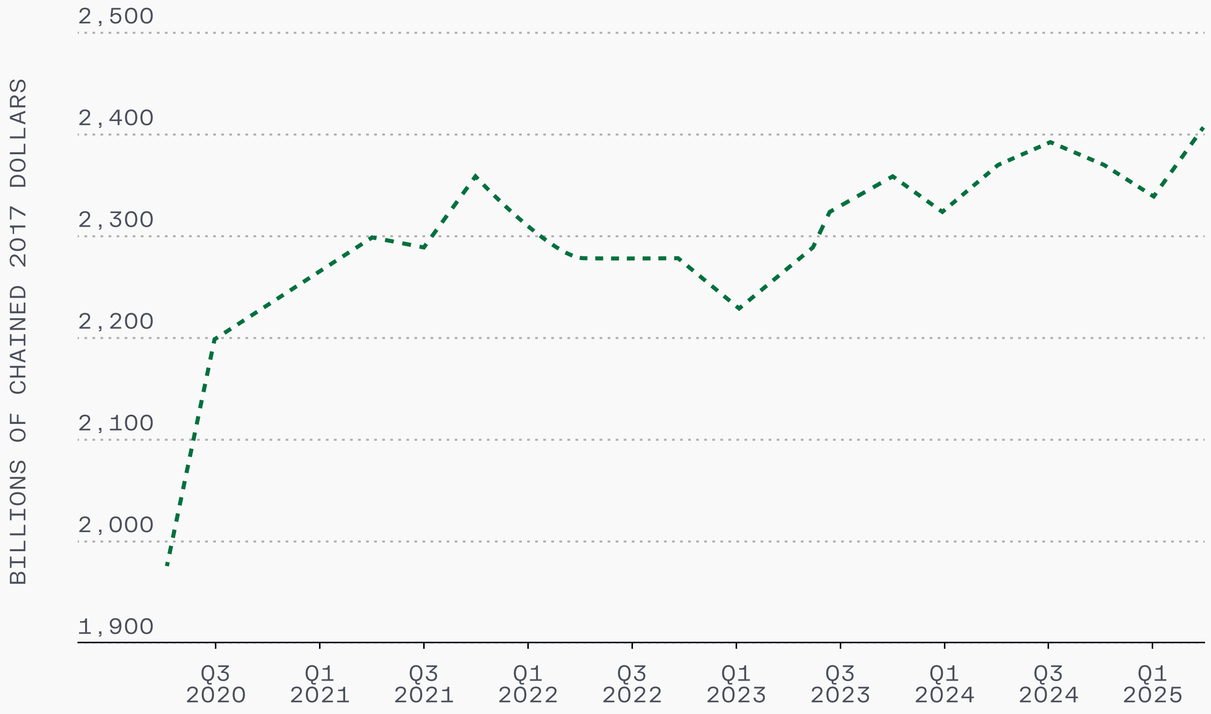
Impact of automation, by type

% OF RESPONDENTS

Source: McKinsey Global Industrial Robotics Survey, 65 senior leaders and executives in automotive; food and beverage; life sciences, healthcare, and pharmaceuticals; logistics and fulfillment; and retail and consumer goods sectors, August 2022

As a result of automation, reshoring, and geopolitically-constrained supply chains, inflation-adjusted economic output produced by US manufacturing has continued to rise in a post-COVID recovery, though slowly.

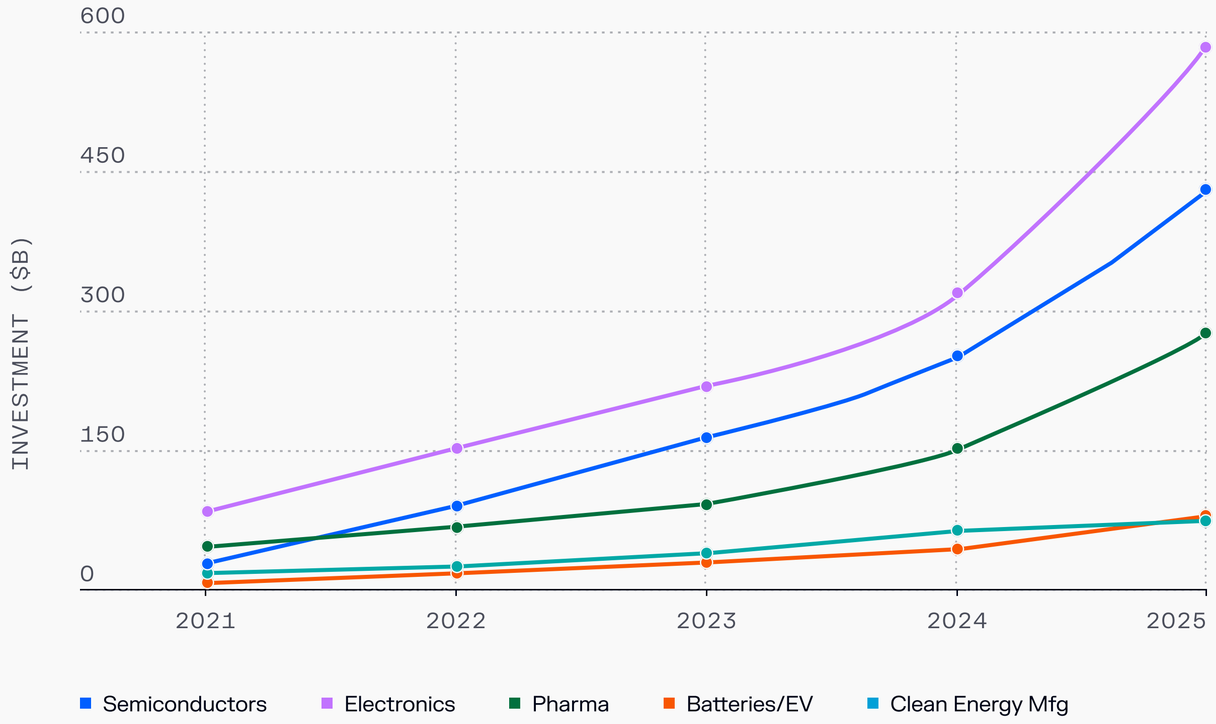
Manufacturing Value Added



Source: US Bureau of Economic Analysis via FRED

In addition, private capital commitments have continued to rise across critical industries like semiconductors and energy.

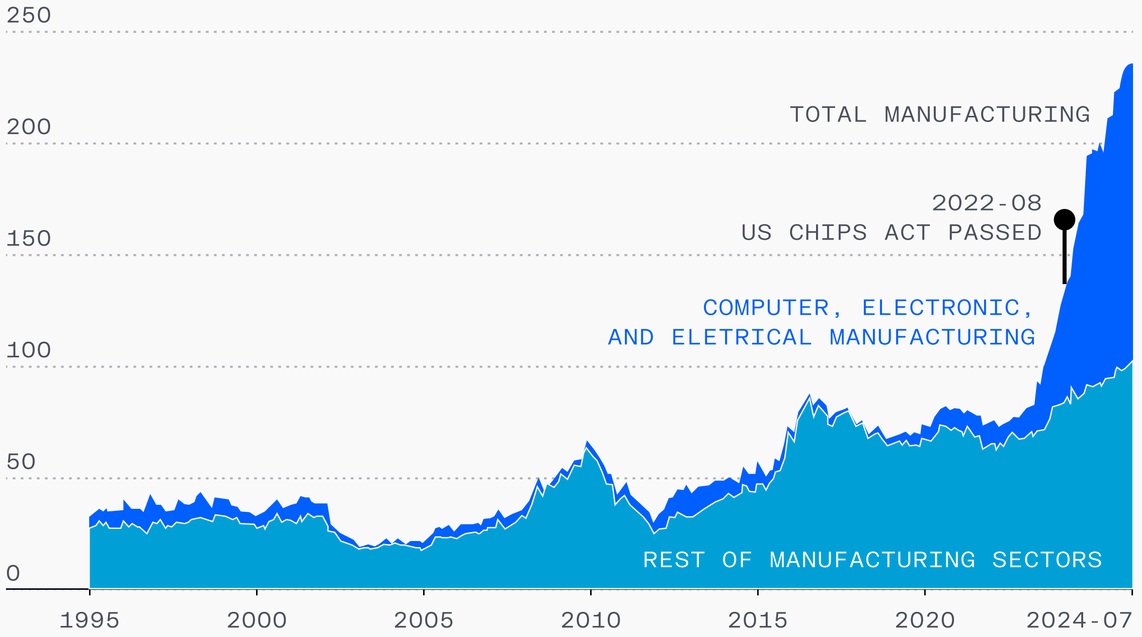
Private manufacturing investment announcements by sector



Source: JP Morgan, company announcements, Semiconductor Industry Association, Clean Investment Monitor, ACP

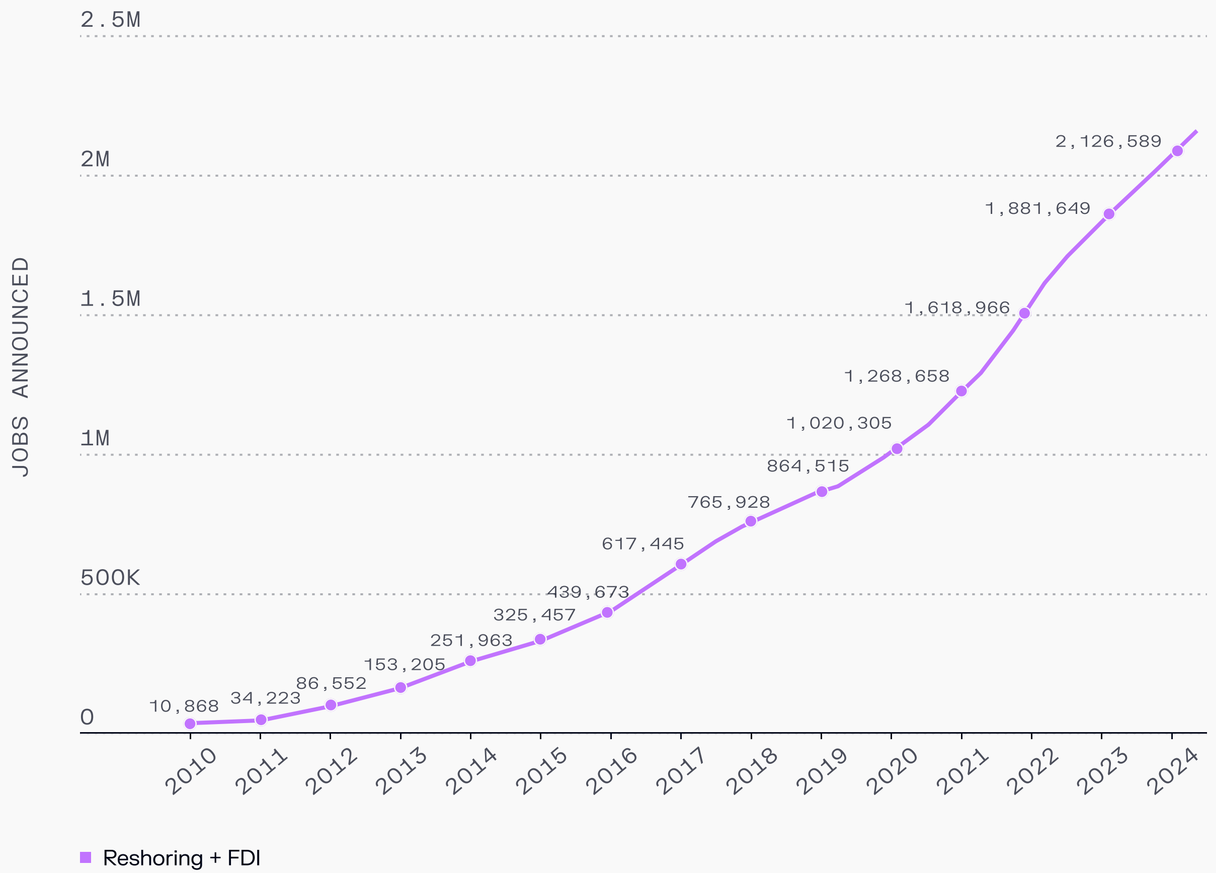
In particular, semiconductor manufacturing has driven an outsized portion of manufacturing investment like construction spending, spurred by policies like the US CHIPS Act.

Value of private construction put in place for manufacturing monthly at a seasonally adjusted, annualized rate (Billion US$)



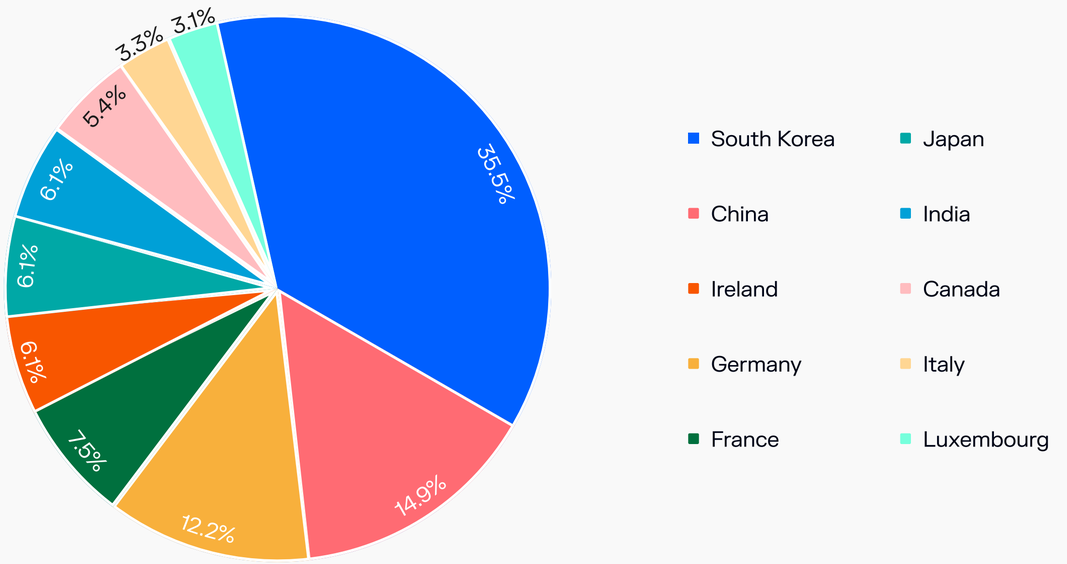
Source: US Census

US jobs coming from reshoring and foreign direct investment (FDI) have continued to rise significantly over the last several years.



Source: Reshoring Initiative Annual Report

In particular, jobs are being reshored from countries like South Korea and China in particular, partly as a result of deglobalization.

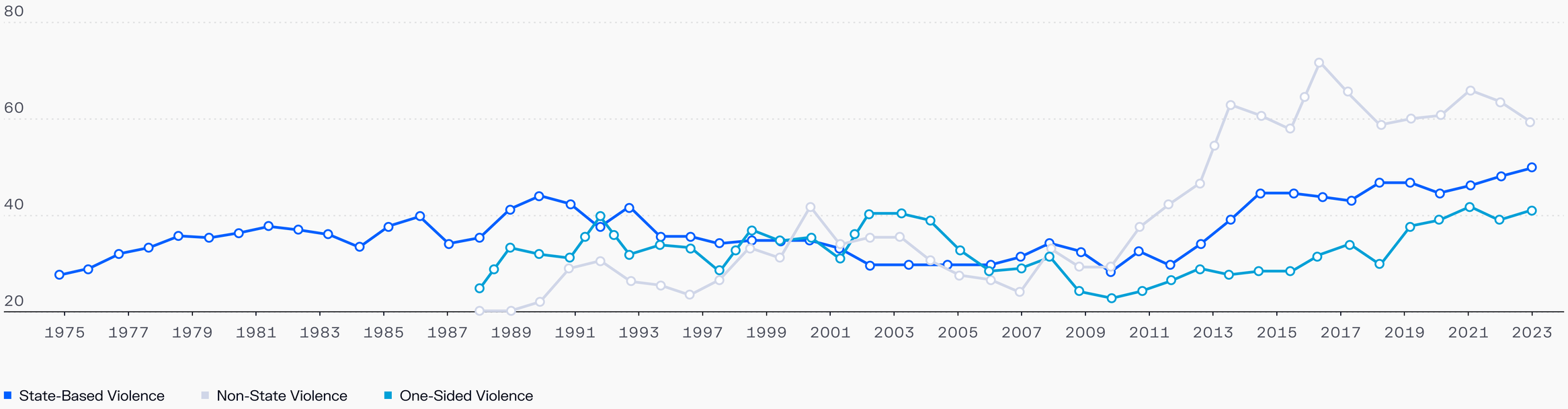


Source: Reshoring Initiative Annual Report

Defense: The Rise of Global Conflict & The Assets To Respond

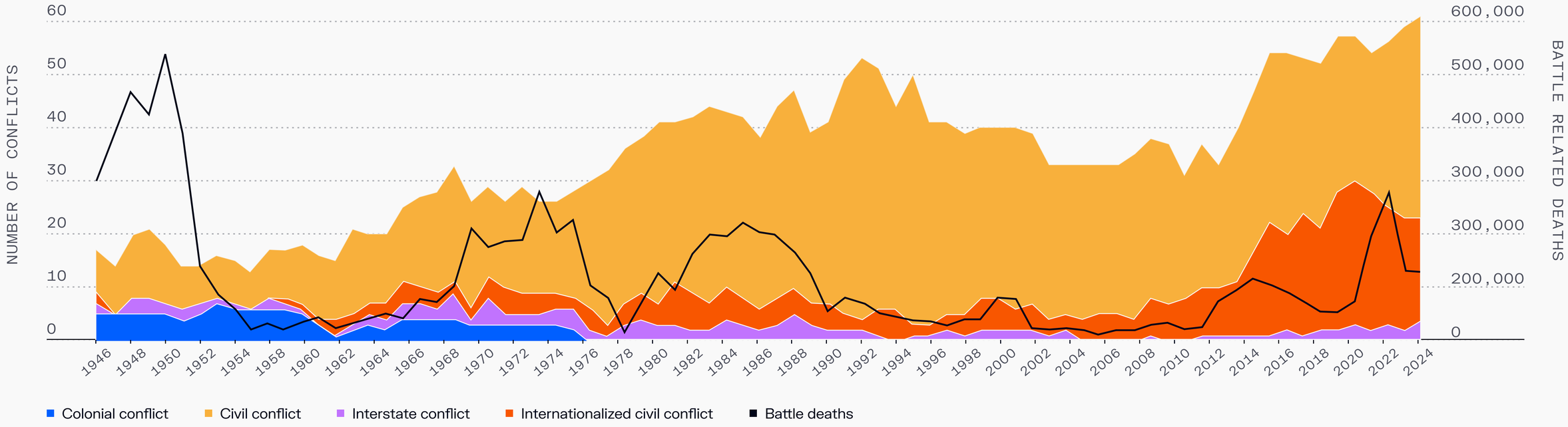
Global conflict is reaching levels that haven't been seen in over 50 years.

Number of Conflicts (1975-2024)



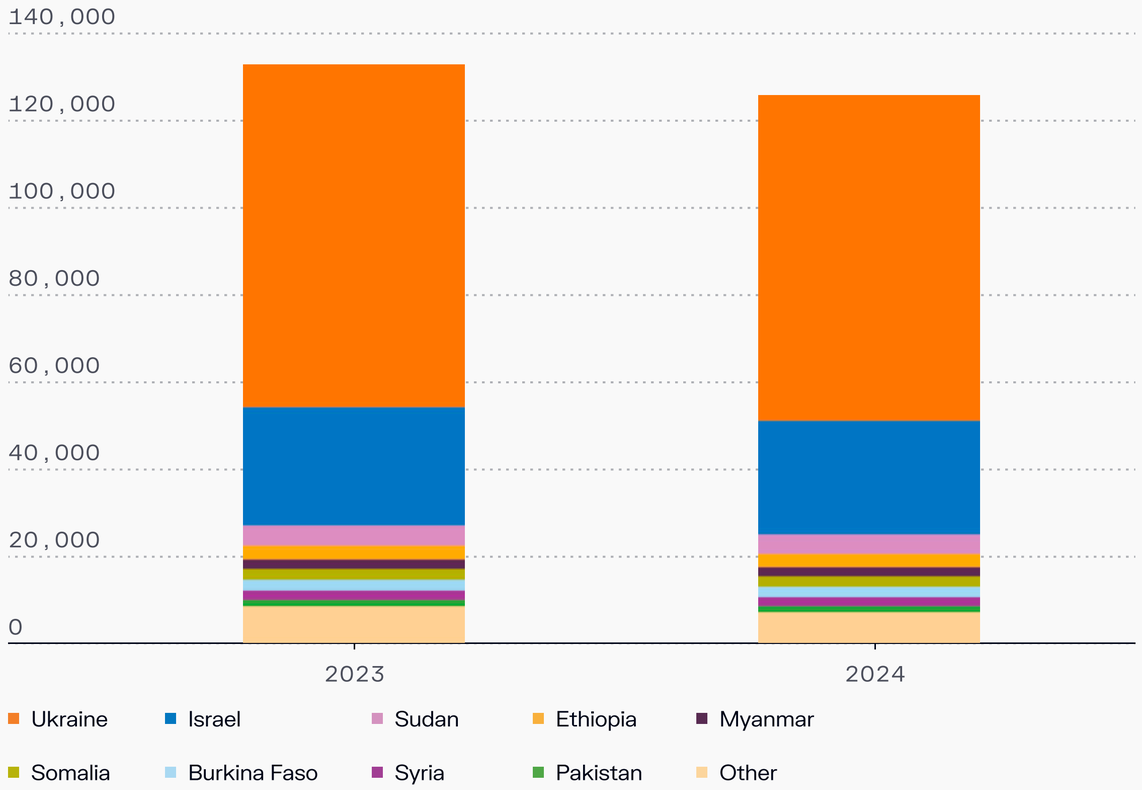
Source: Uppsala Conflict Data Program Department of Peace and Conflict Research

Battle-related deaths are reaching comparable highs to the 1970s and 1980s, but the number of conflicts across both civil and internationalized civil conflicts are dramatically higher than have been seen since World War II.



Source: Lacina and Gleditsch Battle Death Datasets (2005), UCDP/PRIO Armed Conflict Dataset, and UCDP Battle-Related Deaths Dataset (Pettersson et al, 2025). Data includes number of state-based armed conflicts by conflict type, 1946-2024.

Ukraine and Israel, in particular, drove an outsized portion of the battle-related deaths over the course of 2023 and 2024.



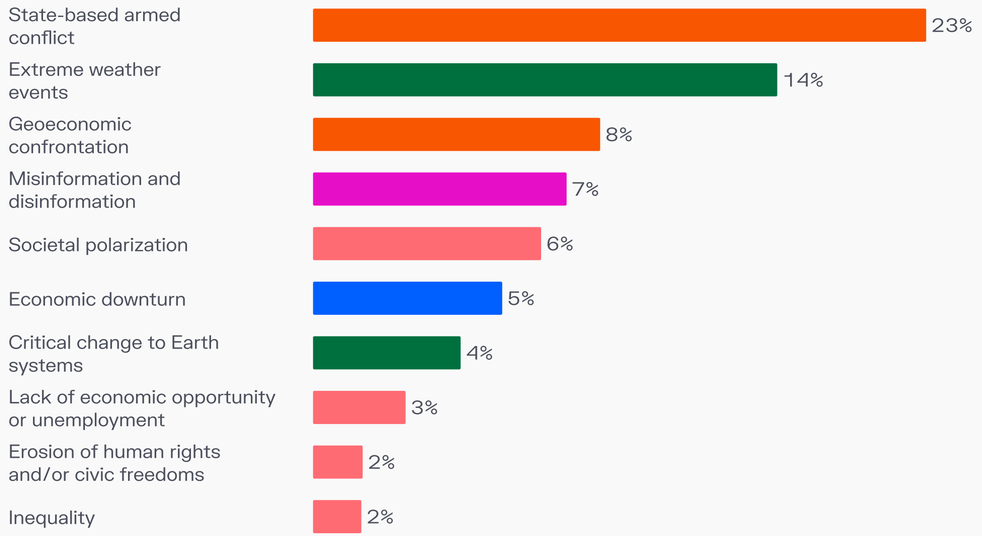
Source: UCDP Battle-Related Deaths Dataset (Pettersson et al, 2025).

In 2019, none of the top 10 global risks included conflict. By 2025, almost 33% of respondents saw some kind of geopolitical conflict as the most likely global risk.

Top Global Risks, 2019

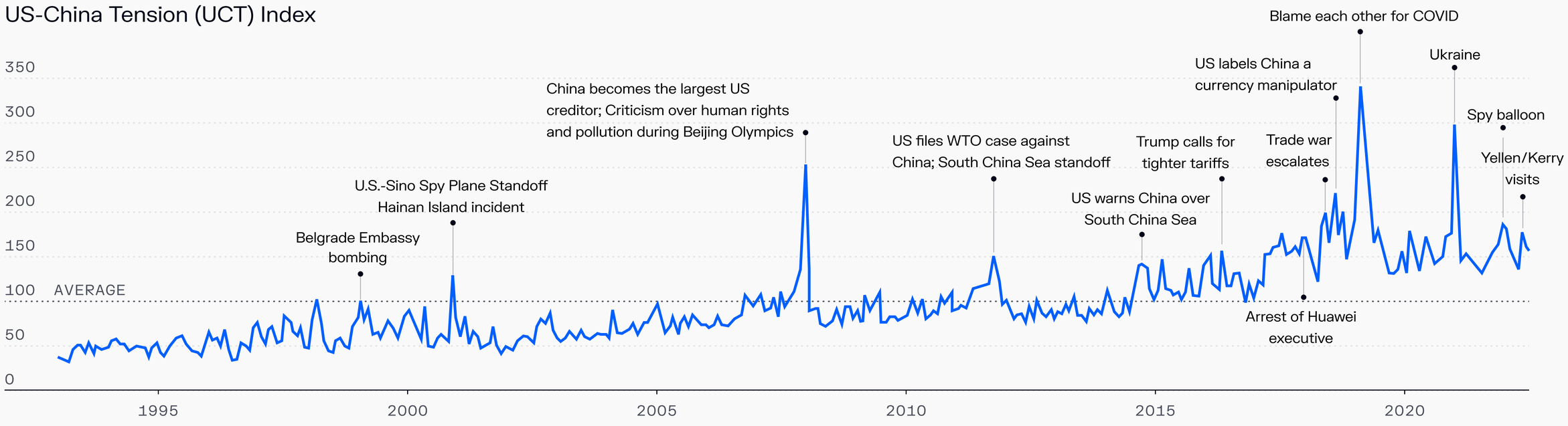
1. Extreme weather events
2. Failure of climate-change mitigation and adaptation
3. Natural disasters
4. Data Fraud or theft
5. Cyber-attacks
6. Man-made environmental disasters
7. Large-scale involuntary migration
8. Biodiversity loss and ecosystem collapse
9. Water crises
10. Asset bubbles in a major economy

Top Global Risks, 2025



Source: World Economic Forum Global Risks Perception Survey 2018-2019, 2024-2025

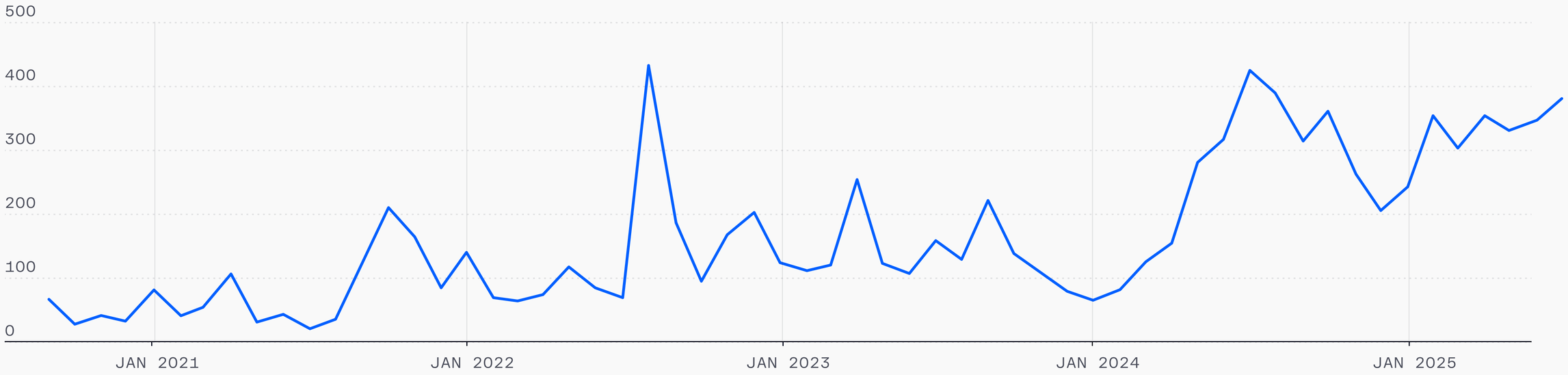
US-China conflict is the most formidable threat to global stability.



Source: Economic Policy Uncertainty; The U.S.-China Tension (UCT) index constructed by John Rogers, Bo Sun, and Tony Sun (2024). Monthly data normalized to have an average of 100 over the 1993-2024 sample.

Chinese violations of the air defense identification zone (ADIZ) around Taiwan continue to increase.

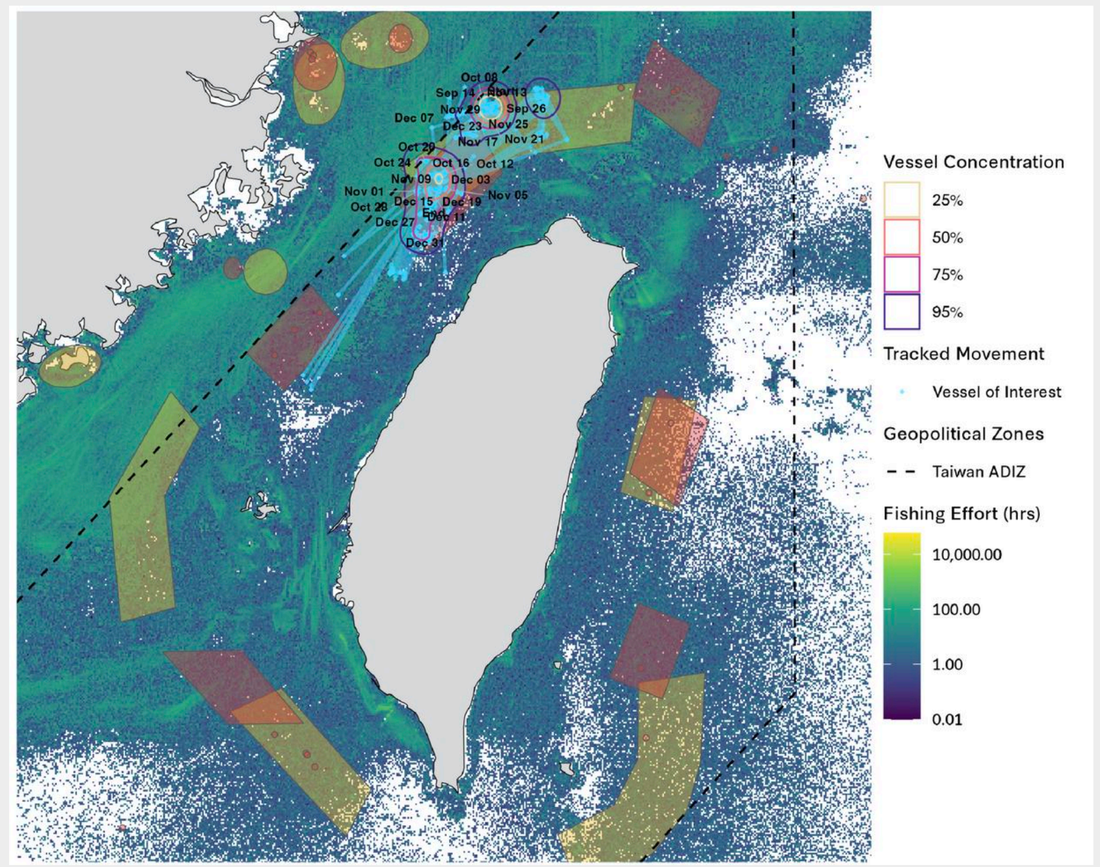
Chinese ADIZ Violations Over Time



Source: Center for Strategic and International Studies, China Power Project via Gerald C. Brown and Ben Lewis

China is increasingly using maritime militia, presented as "fishing" vessels, to project power around Taiwan.

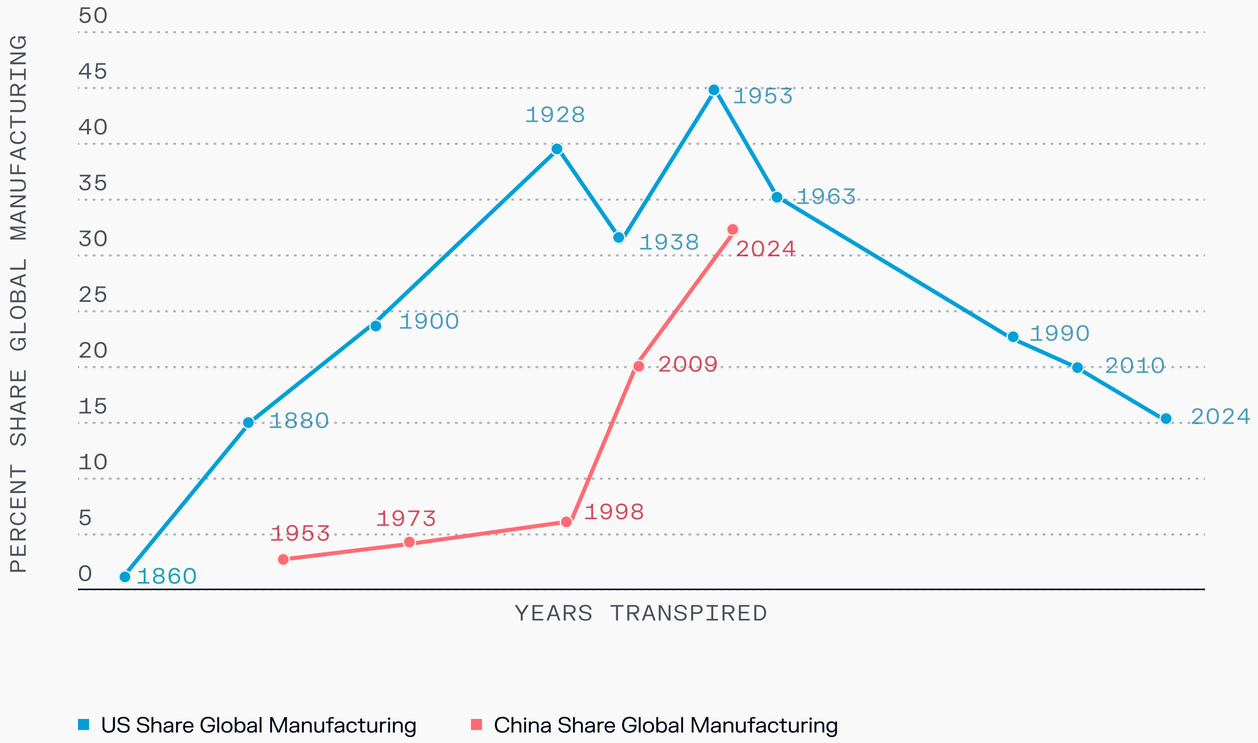
This makes the US Indo-Pacific Command (INDOPACOM) an increasingly critical conflict surface area, reinforcing the need for long-range and maritime capabilities over more traditional land-based European systems and counter insurgency platforms.



Visual representation of vessel movement data around Taiwan

Source: AIS data from General Atomics' Optix and Joint Sword A & B polygon data. The CSIS Futures Lab calculated KDEs from the AIS data.

The US peaked in terms of global manufacturing share in the 1950s; China has been on a comparable rise of the last 25 years.



Source: for 1750-1980, Paul Bairoch; for 1990-2024, UNIDO. China is represented on a 70 year lag relative to US data

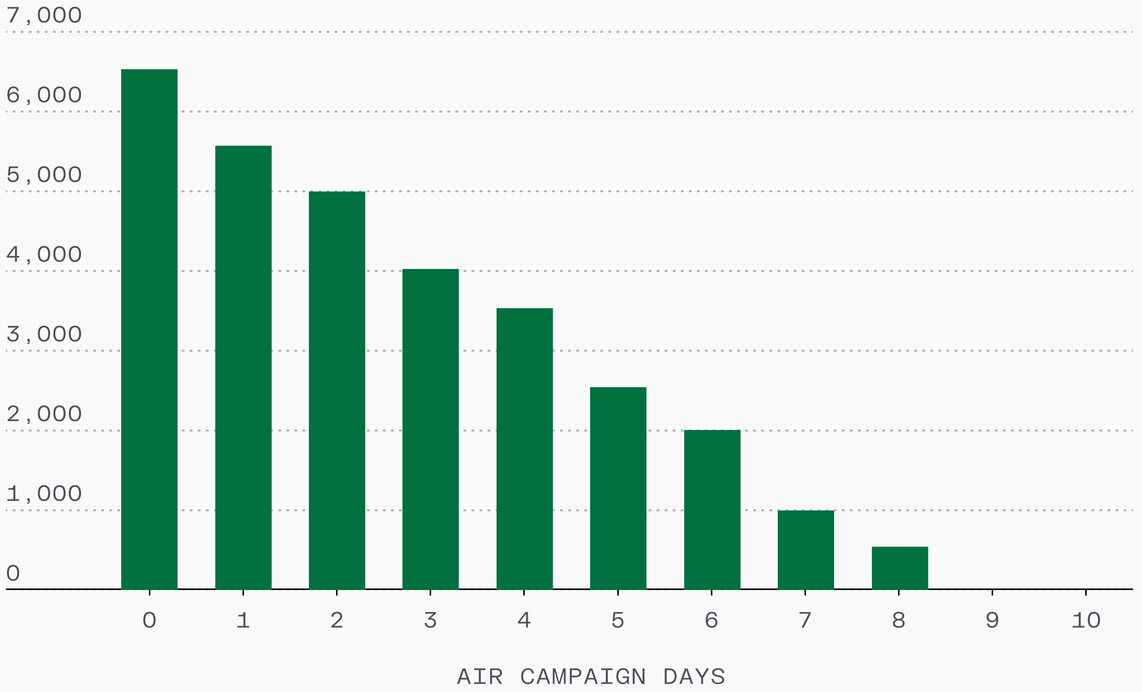
Unfortunately, America's rapid deindustrialization has resulted in critically low levels in its munitions arsenal.

System	Manufacturer	Status of Production Line	Status of U.S. Inventory
Javelin Anti-Armor Systems	Raytheon/Lockheed Martin	Active	Low
Stinger anti-aircraft systems	Raytheon	Semi-active	Low
155 mm howitzers	BAE Systems & others	Semi-active	Low
155 mm artillery rounds	General Dynamics & others	Active	Low
Excalibur precision-guided 155 mm rounds	Raytheon	Active	Medium
Counter-artillery radars	Raytheon	Active	Low
M113 armored personnel vehicles	BAE Systems	Closed	Medium
105 mm howitzers	Rock Island Arsenal	Closed	Medium
105 mm artillery rounds	BAE Systems & others	Active	High
Harpoon coastal defense systems	Boeing	Active	Medium
High Mobility Artillery Rocket Systems (HIMARS)	Lockheed Martin	Active	Medium
Small arms ammunition	Various manufacturers	Active	High

Source: CSIS estimates; "Fact Sheet on U.S. Security Assistance to Ukraine," U.S. Department of Defense, January 6, 2023; and Mark Cancian, "Is the United States Running Out of Weapons to Send to Ukraine?," CSIS Commentary, September 16, 2022. Data through January 6, 2023.

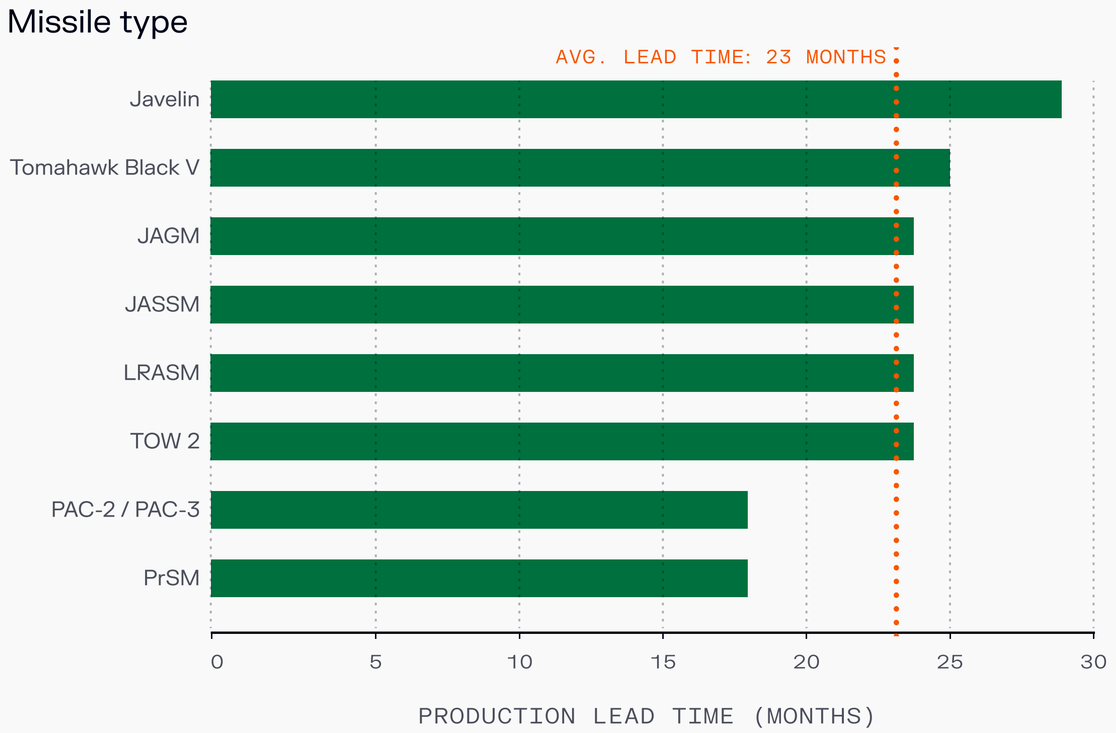
For example, in a hypothetical air campaign over Taiwan, the US's arsenal of long-range missiles could be completely depleted in about eight days.

Inventory of JASSM, JASSM-ER, LRASM



Source: Mark A. Gunzinger, "Affordable Mass: The Need for a Cost-Effective PGM Mix for Great Power Conflict," Mitchell Institute for Aerospace Studies, November 2021

In addition, our ability to replenish our arsenal is riddled with supply chain delays that would further exacerbate munitions shortages.



Source: U.S. Department of Defense data from "DoD Budget Request," Under Secretary of Defense (Comptroller); and author interviews with multiple individuals in the U.S. government and defense industry.

As a result, the US would struggle to replace the majority of its munitions sooner than five years in any given conflict.

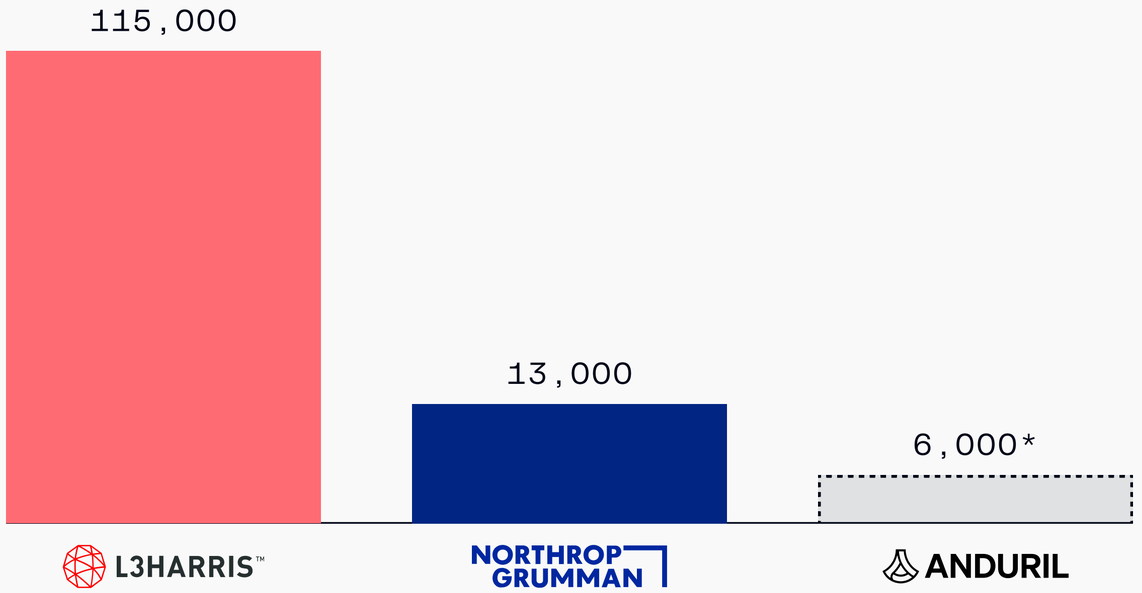
	Number transferred to Ukraine	Production rate (year)	Manufacturing lead time (months)	Production time (months)	Total time to rebuild (months)
155 mm ammunition (recent rate)	1,074,000	93,000	Inventory rebuild not possible because of U.S. training requirements		
155 mm ammunition (surge rate)	1,074,000	240,000	12-18	44	59 (5 YEARS)
155 mm precision munition—Excalibur (recent rate)	5,200	1,000	22	56	84 (7 YEARS)
155 mm precision munition—Excalibur (surge rate)	5,200	2,400	22	23	48 (4 YEARS)
Javelin (recent rate)	8,500	1,000	24	12	149 (~8 YEARS)
Javelin (surge rate)	8,500	2,100	24	12	56 (~5.5 YEARS)
HIMARS (recent rate)	20	20	26	12	37 (3 YEARS)
HIMARS (surge rate)	20	72+	26	5	30 (2.5 YEARS)
GMLRS (recent rate)	“Thousands”	5,000	17+	?	?
GMLRS (surge rate)	“Thousands”	10,000+	26	?	?
Stinger (recent rate)	1,600	100?	24+	192	216 (18 YEARS)
Stinger (historical rate)	1,600	350?	24+	55	79 (65 YEARS)

■ Unlikely to rebuild inventories within 5 years ■ Inventory replacement within five years at low risk ■ Rebuilding timeline unclear but substantial risk of low inventories and long replacement cycles

Source: Center For Strategic International Studies; Rebuilding U.S. Inventories: Six Critical Systems by Mark F. Cancian

One crucial bottleneck is the production of solid rocket motors (SRMs). The US only has two established SRM vendors and one emerging vendor.

Annual SRM Production



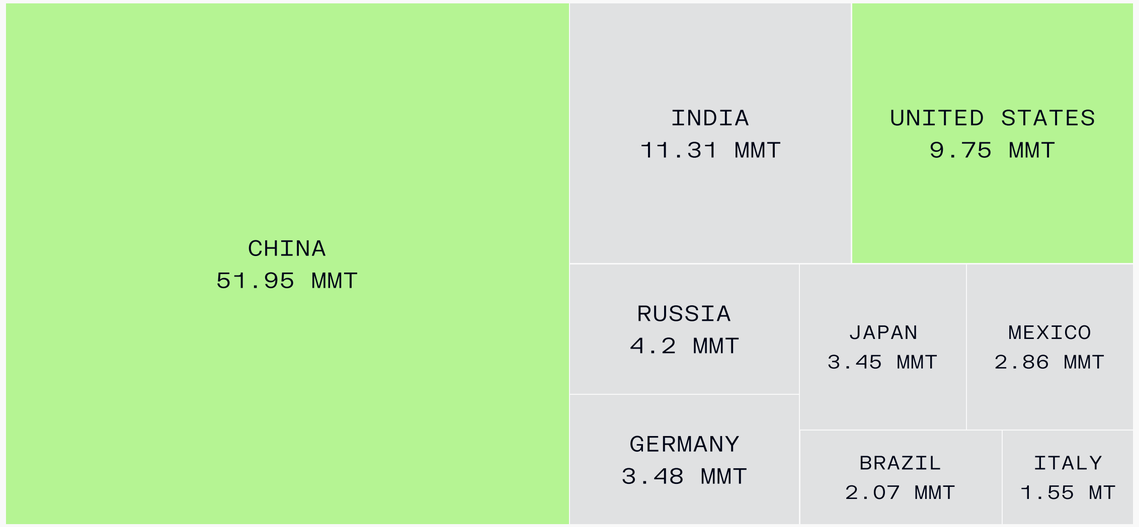
*Source: Reuters, Inside Defense. *Note: Projected capacity by end of 2026.*

China has built dominant industrial capacity, particularly in casting and forging required for ships' hulls, missile bodies, etc.

China produces more casted products than the next nine countries combined and 5x the capacity of the US.

Casting Production by Country

IN MILLION METRIC TONS (MMT)



Source: Center For Strategic & International Studies; The U.S. Defense Industrial Base Is Not Prepared for a Possible Conflict with China; data quality across countries has been opaque post-COVID, but individual country data points represent directionally similar volumes, if not more tipped in China's direction

China has maintained a more operational state-of-the-art arsenal compared to the US, with 100% of its capacity operational compared to 45% for the US.

China

Missile Name	Class	Range	Status
DF-11	SRBM	280 - 300 KM	Operational
DF-12 / M20	SRBM	280 KM	Operational
DF-15	SRBM	600 KM	Operational
DF-16	SRBM	800-1,000 KM	Operational
DF-17	HGV	1,800-2,500 KM	Operational
DF-21	MRBM	2,150 KM	Operational
DF-26	IRBM	4,000 KM	Operational
DF-31	IRBM	7,000-11,700 KM	Operational
DF-4	IRBM/ICBM	4,500-5,500 KM	Operational
DF-41	ICBM	12,000-15,000 KM	Operational
DF-5	ICBM	13,000 KM	Operational
HN 1	Cruise Missile	50-650 KM	Operational
HN 2	Cruise Missile	1,400-1,800 KM	Operational
HN 3	Cruise Missile	3,000 KM	Operational
JL-2	SLBM	8,000-9,000 KM	Operational
YJ-18	Cruise Missile	220-540 KM	Operational
		Operational	**100%**

Source: Center For Strategic & International Studies Missile Defense Project

United States

Missile Name	Class	Range	Status
ALCM	ALCM	950-2,500 KM	Operational
ATACMS	SRBM	165-300 KM	Operational
FGM-148 Javelin	ATGM	2.5-4.5 KM	Operational
Harpoon	ASCM	90-240 KM	Operational
Hellfire	ASM	7-11 KM	Operational
JASSM / JASSM ER	ALCM	370-1,000 KM	Operational
Lance	SRBM	130 KM	Obsolete
Minuteman I	ICBM	10,000 KM	Obsolete
Minuteman II	ICBM	12,500 KM	Obsolete
Minuteman III	ICBM	13,000 KM	Operational
Peacekeeper	ICBM	9,600 KM	Obsolete
Pershing 1	SRBM	740 KM	Obsolete
Pershing 2	MRBM	1,700 KM	Obsolete
SM-62 Snark	ICBM	10,186 KM	Obsolete
SM-65 Atlas	ICBM	14,000 KM	Obsolete
SM-78 Jupiter	MRBM	2,400 KM	Obsolete
Titan I	ICBM	10,000 KM	Obsolete
Titan II	ICBM	15,000 KM	Obsolete
Tomahawk	Cruise Missile	1,250-2,500 KM	Operational
Trident D5	SLBM	12,000 KM	Operational
		Operational	**45%**

China is also rapidly growing missile production capacity. One investigation found that 60% of 136 facilities connected to Chinese missile production have showed signs of expansion adding 2 million square meters between 2020 and 2025.

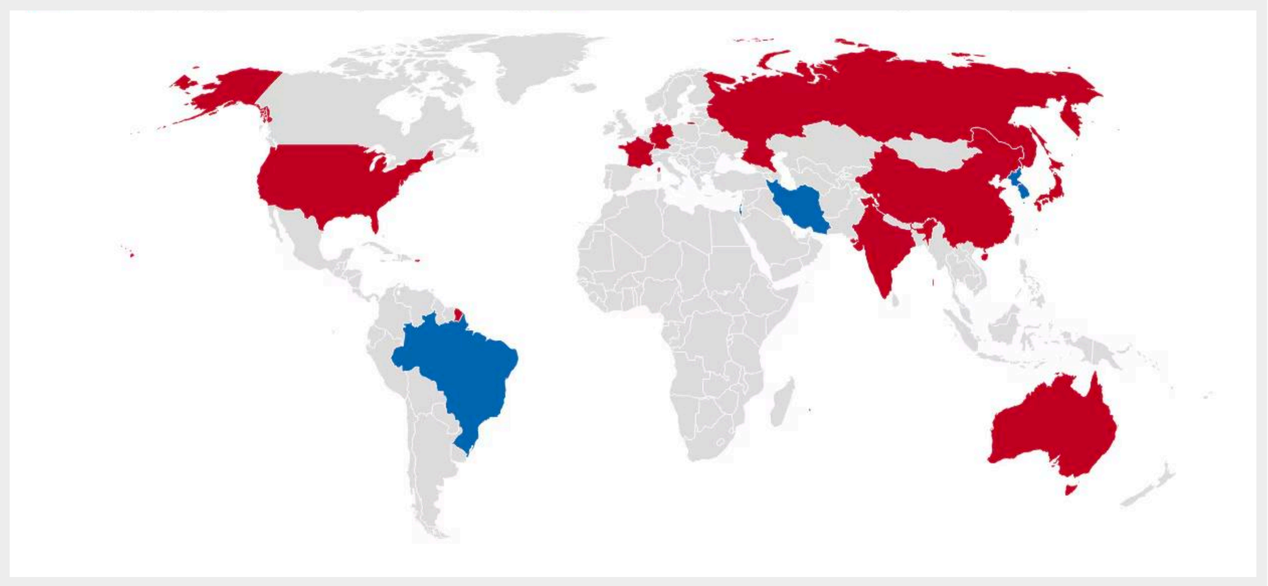
Satellite imagery of Chinese missile site expansion

Satellite imagery of Chinese missile site expansion

Source: CNN; RBC-Ukraine

China, the US, Australia, Japan, and India are among the countries leading development of more advanced hypersonic weapons.

Global Hypersonic Weapons Development



■ Developing hypersonic weapons technology ■ Conducted research or testing related systems

Source: US Congressional Research Service

The US has been transitioning its naval fleet to emphasize (1) smaller surface and amphibious ships, and (2) significantly more unmanned vehicles

	2016	2023	Change
Ballistic missile submarines (SSBNs)	12	12	0
Attack submarines (SSNs)	66	66	0
Aircraft carriers (CVNs)	12	12	0
Large surface combatants (i.e., cruisers, destroyers)	104	87	-17
Small surface combatants	52	73	21
Larger amphibious ships	38	31	-7
Smaller amphibious ships	0	18	18
Combat Logistics Force (CLF) ships	34	46	12
Command and support ships	37	36	-1
Subtotal battle force ships (i.e., manned ships)	**355**	**381**	**26**
LUSV and MUSV (Large and Medium Unmanned Surface Vehicles)	0	78	78
XLUUV Extra Large Unmanned Underwater Vehicles	0	56	56
Subtotal large unmanned vehicles	**0**	**134**	**134**

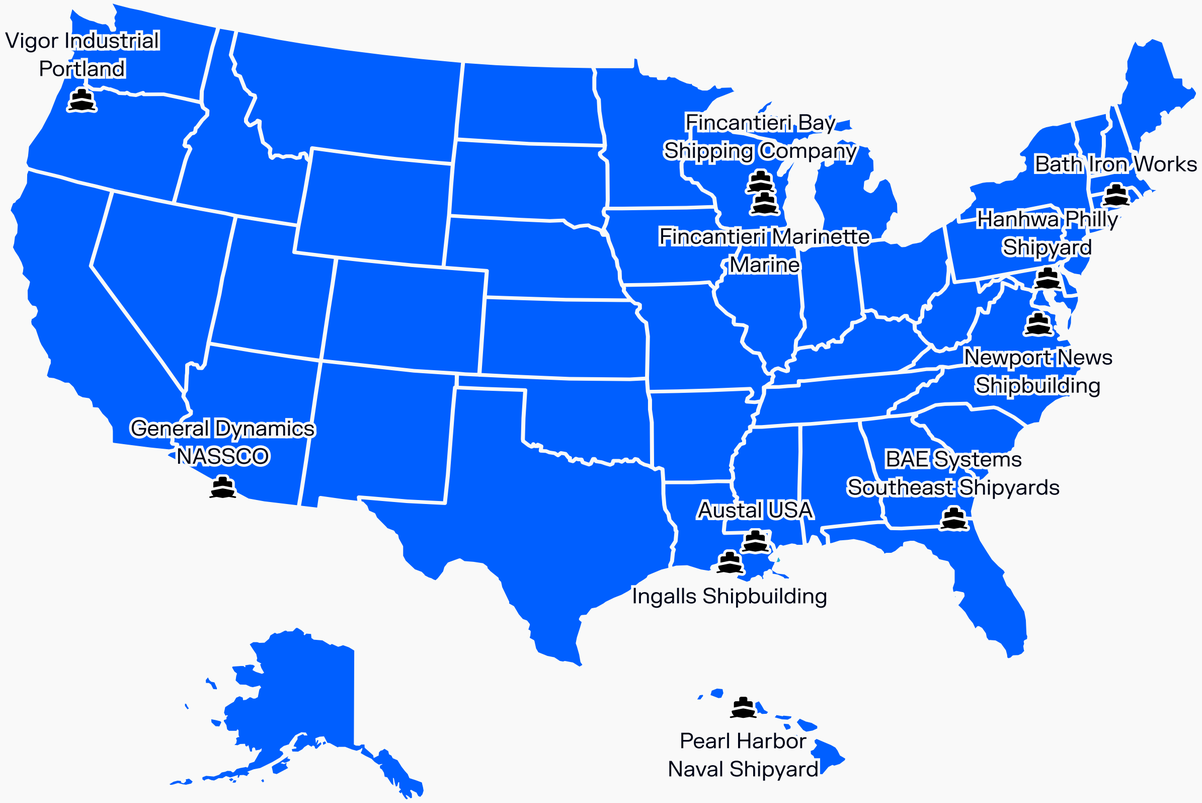
Source: US Congress; Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress; March 2025

However, shipbuilding capacity in the US has been significantly constrained given limited shipyard capacity, particularly in comparison to China.

	Fleet	Shipbuilding	Shipbuilding Workforce	Mariners/ Seafarers
United States	<200 U.S Flag Oceangoing Vessels	<5 Orders (2023)	<153,000 U.S. Workers	<12,000 Merchant Mariners
V.S.				
China	>7,000 Chinese Flag Oceangoing Vessels	>1,700 Orders (2023)	>600,000 Chinese Workers	>1.7 Million Seafarers

Source: Global Maritime Hub

The 10 major shipyards in the US only produce ~0.04% of global output.



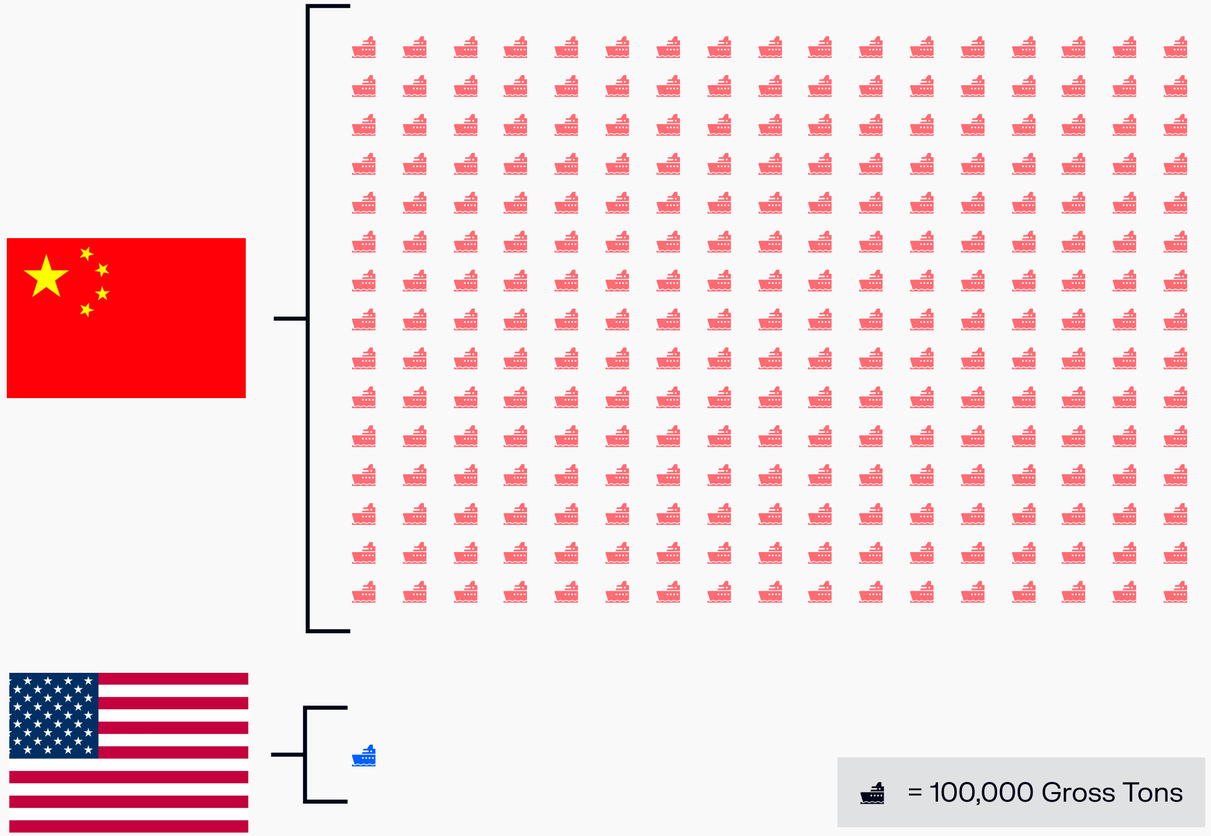
Source: Marine Insight, Bloomsbury Intelligence & Security Institute

Meanwhile, just one of China's 13 major shipyards has more capacity than the entire US.

In addition, China is planning to increase its shipbuilding capacity by 80% by 2027.

Source: Pan Asian Marine Co., The Lowy Institute

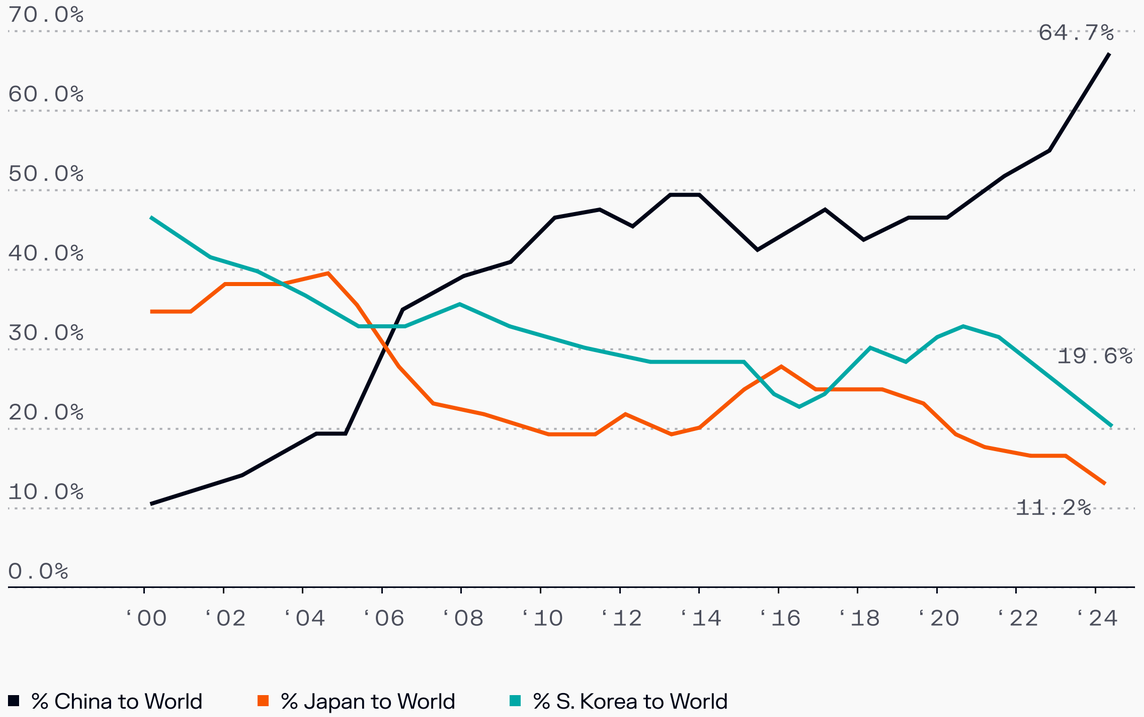
Already, China's overall shipbuilding capacity has grown to 200x that of the US.



Source: The US Office of Naval Intelligence

China has become the dominant shipbuilding power globally; growing from ~10% of global orderbook share in 2000 to over 60% by 2024.

Orderbook Share of major shipbuilding countries

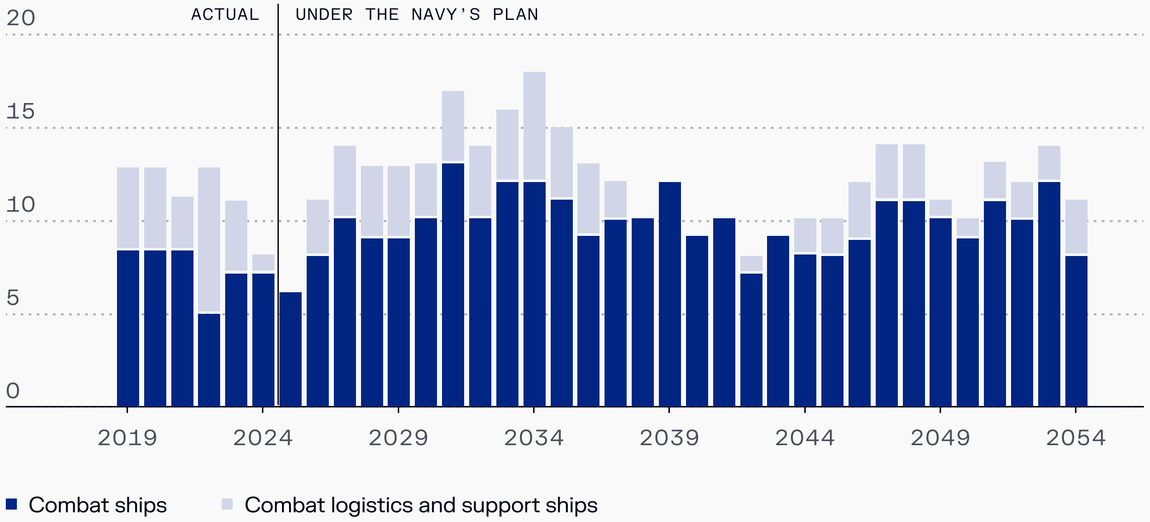


Source: Intermodal and Clarksons Research

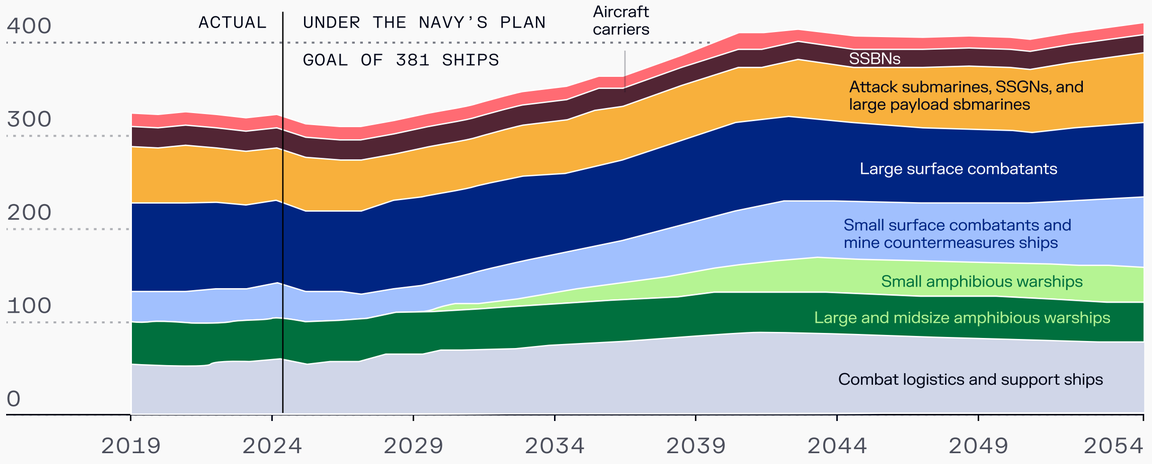
In addition to new shipbuilding capacity, the US Navy is 20 years behind on maintenance work, forcing them to decommission viable ships.

As a result, even as the Navy attempts to purchase 364 ships over the next 30 years, it would only increase its fleet from 296 to 390 total.

Purchases



Inventories



Source: Center For Strategic & International Studies; Congressional Budget Office

Planned shipyard development and expansion in the US over the next five years is expected to reach over $200 billion, both domestically and via allies.

Solano Shipyard
NORTHERN CALIFORNIA

Port Alpha
LOCATION TBD

Project Maeve
PENSACOLA, FL

Hanwha Ocean
PHILADELPHIA, PA

Austal USA
MOBILE, AL

Source: California Forever, Saronic, WUWF, Jobs With DOD, Alabama Life, Congress.gov; several images represent artistic renderings vs. live images.

Medicine & Healthcare

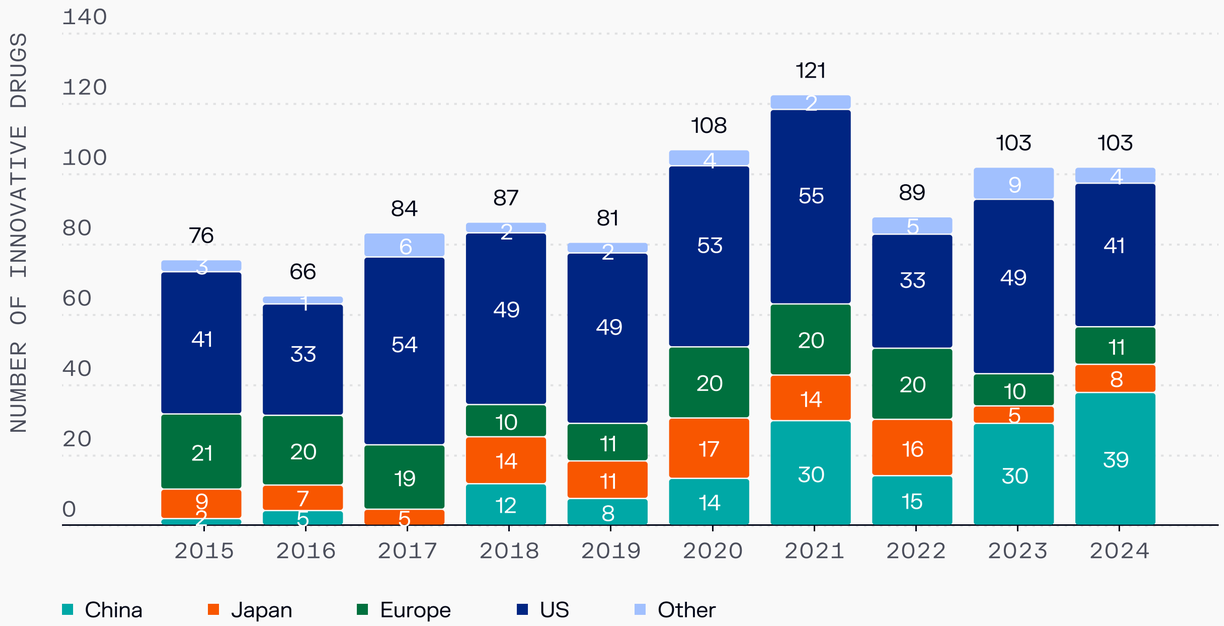
Biotech Manufacturing
Shift From Pharmaceuticals to Biologics
Human Augmentation
Healthcare

- **MEDICINE & HEALTHCARE**
  - **Biotech Manufacturing**
    - Current Capacity
    - Alternative Approaches
  - **Shift from Pharma to Biologics**
    - GLP-1s
    - Breakthrough Biologics
  - **Human Augmentation**
    - Gene Therapies
    - Longevity
    - Brain-Computer Interfaces
  - **Healthcare**
    - State of Healthcare
    - Chronic & Communicable Diseases
    - AI For Medicine

Biotech Manufacturing: Current Capacity, Alternative Approaches

While the US remains the global leader in first approvals of new drugs, China's new drug development and approval is rapidly catching up, with only 5% fewer new approvals in 2024.

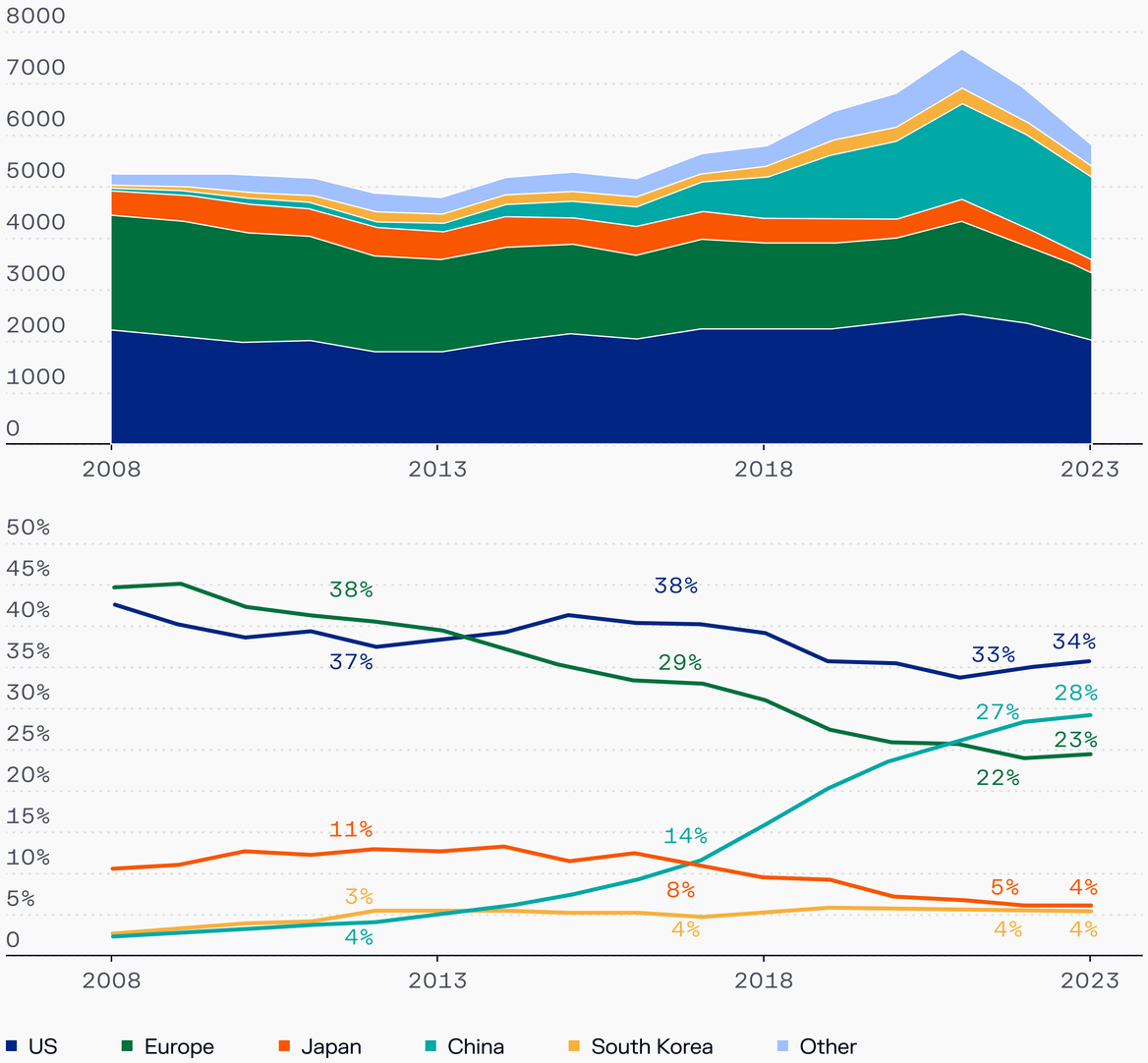
Regional distribution of first global approvals of innovative drugs (2015-2024)



Source: "The rise of China's pharmaceutical industry from 2015–2024: a decade of innovation," Nature

This trend is supported by an increase in trials of drugs developed by companies headquartered in China, which now comprise 28% of new drug trial starts.

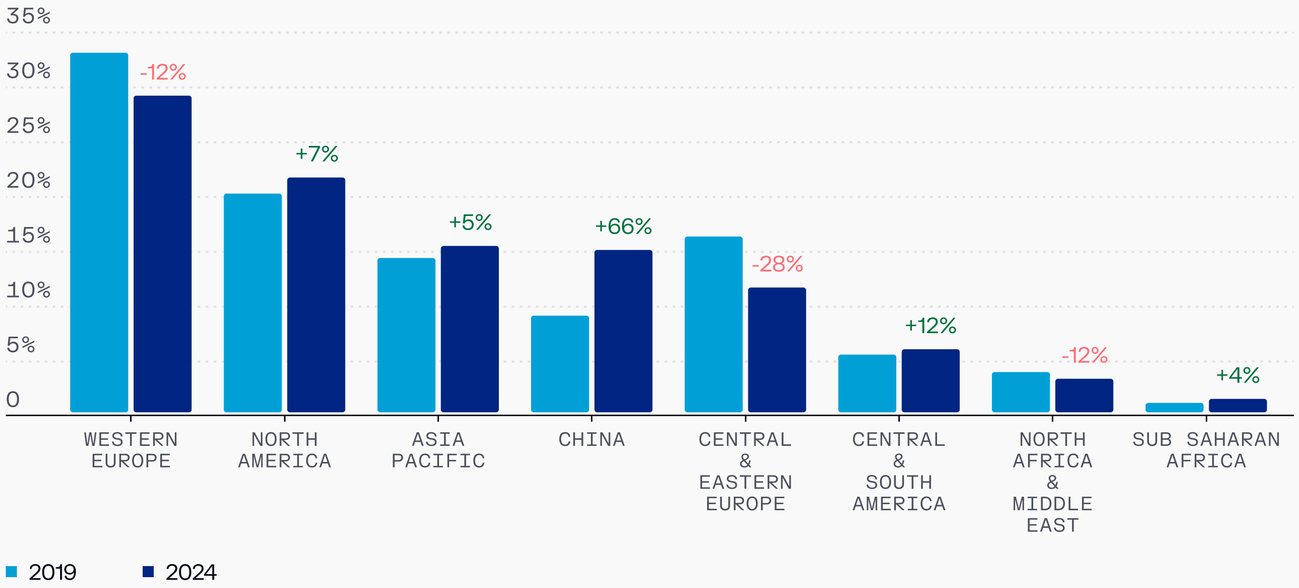
Number of Phase I to III trial starts based on company headquarters location, 2008-2023



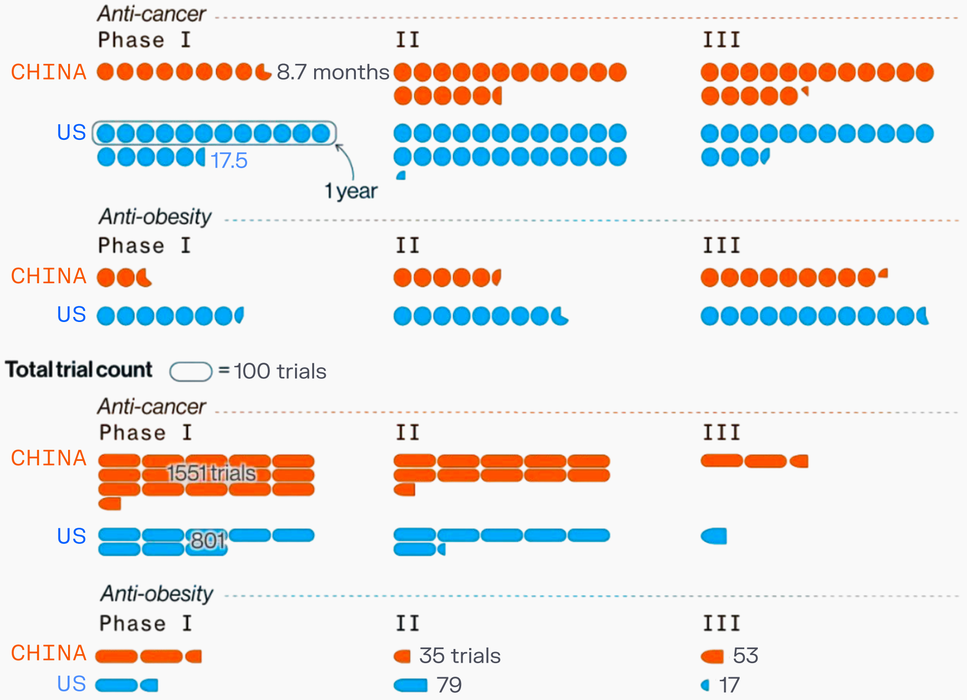
Source: Citeline Trialtrove, IQVIA Institute

This increase in China-based trials is emphasized in the share of total global pharmaceutical trials taking place in China versus other nations, given faster recruitment timelines and different regulatory requirements.

Country utilization as percent of trial country-uses 2019 and 2024



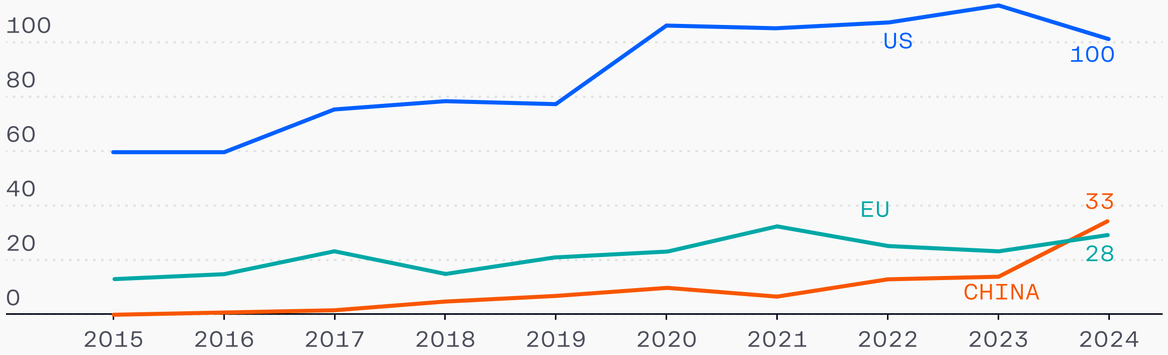
Median time to recruit patients for trials ○ = 1 MONTH



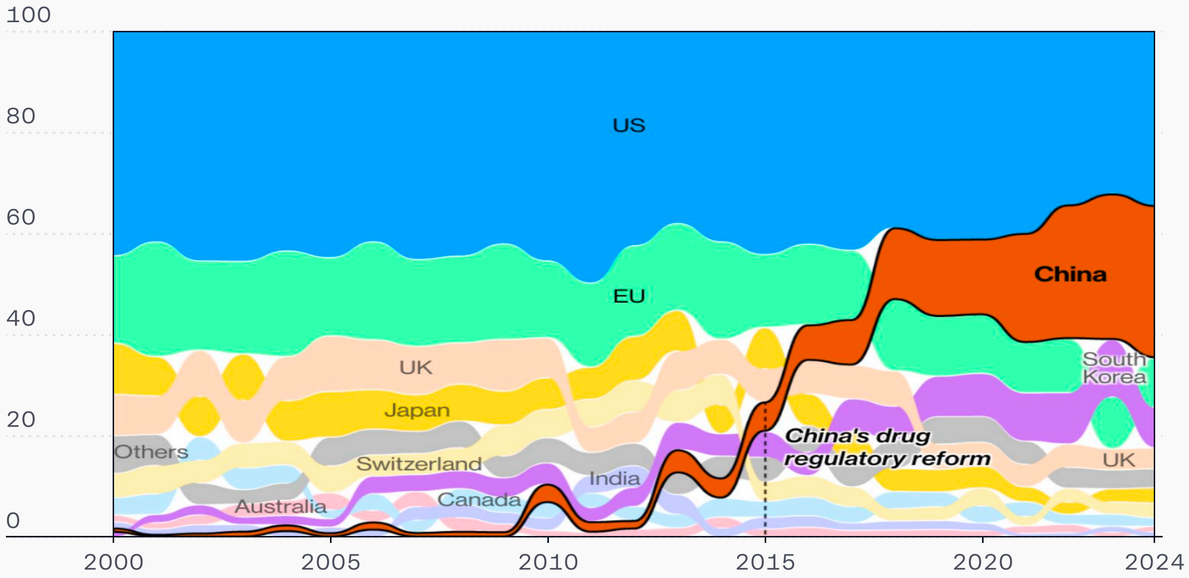
Source: Citeline Trailtrove, IQVIA Institute, Norstella; Note: Trials were industry sponsored, interventional, Phase II to III studies. Trials with no country reported were excluded. Each trial-country instance was counted and the total was aggregated to region level to determine the share of global trial starts which included a country in the region. Data based on single-country trials conducted in 2020–2024.

This growth has led to China surpassing the EU in numbers of both expedited drug review approvals from regulators and in innovative drugs entering development.

Annual number of innovative drugs receiving expedited reviews from top regulators



Annual share of innovative drugs entering development, by country

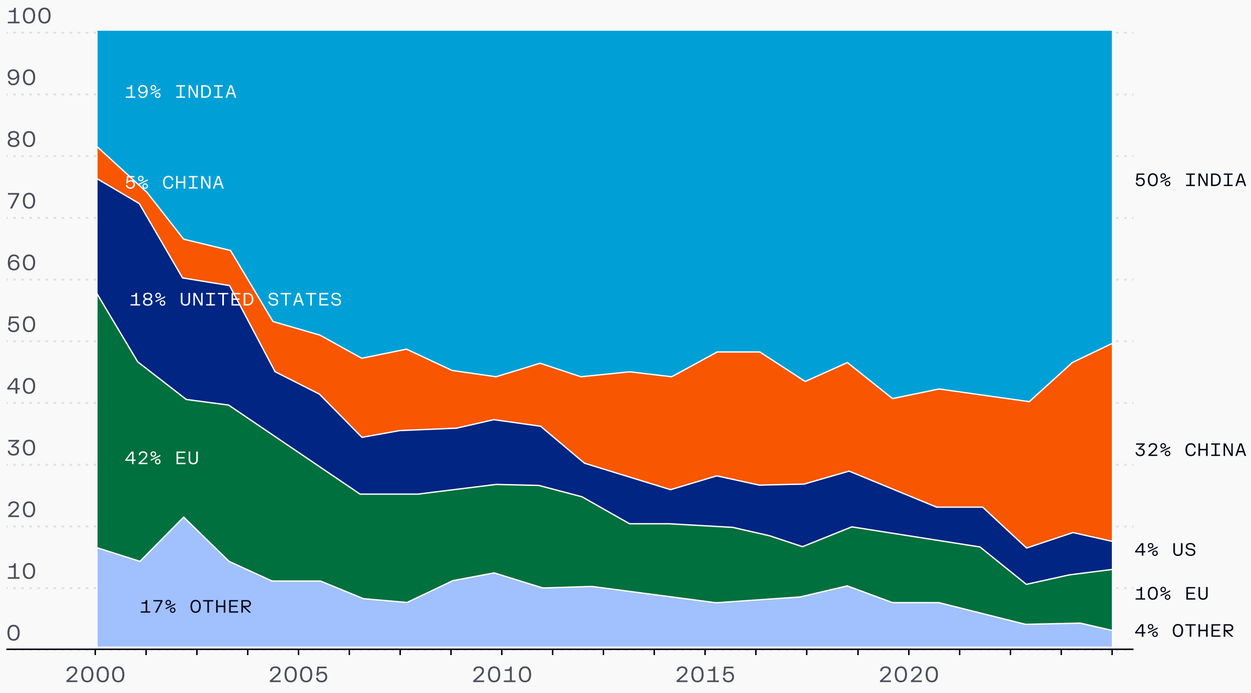


Source: Norstella data analyzed by Bloomberg; Note: Analysis is based on an innovative drug's first expedited review designation granted by US, EU, UK, or Japan. Expedited reviews are generally granted to drugs that tackle serious diseases and show promise over existing therapies.

At the same time, China's role in global drug manufacturing has grown, making it the second largest producer of drugs after India.

Active API Drug Master Files

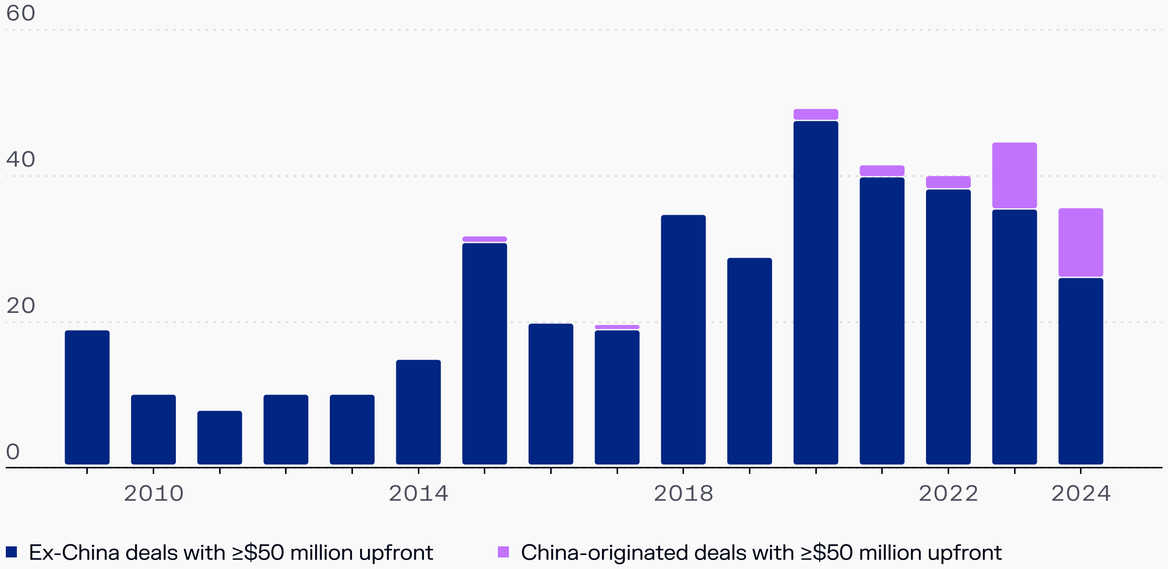
BY YEAR OF FILING AND REGION OF MANUFACTURE



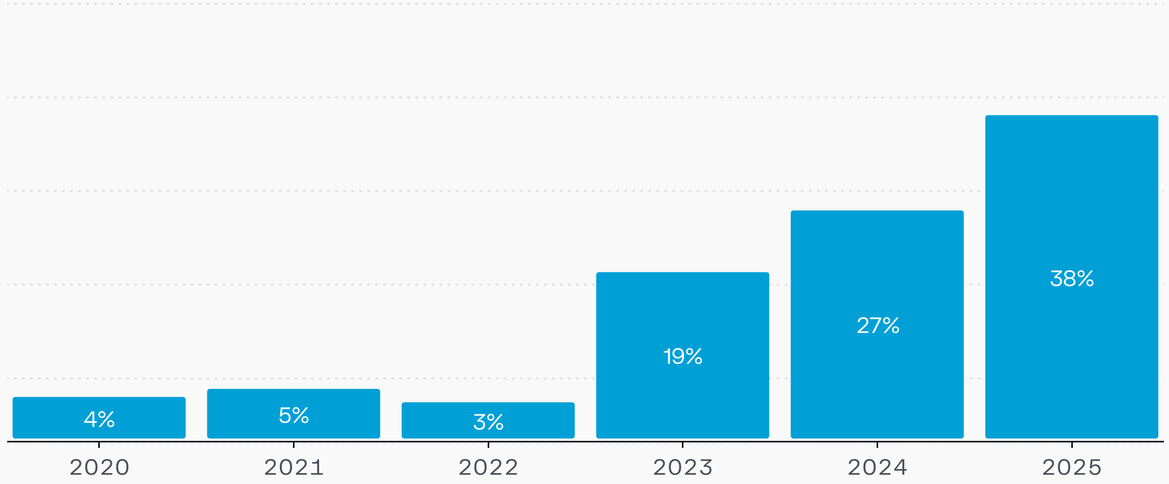
Source: Active API DMFs, by year of filing and region of manufacturer, USP Medicine Supply Map

Large pharmaceutical deals are increasingly funded by Chinese investors, with 38% of deals over $50 million originating from China in 2025.

The country is becoming a key hunting ground for novel therapies



Share of global Big Pharma deals with $50M+ upfront originating from China- Deal Count



Source: GlobalData Pharma Intelligence Center, Deals Database, DealForma; Global deals data as of Nov 26, 2024. Analysis includes R&D stage in-licensing or asset purchase deals by biopharma companies with market cap of at least $50 billion.

In efforts to remain competitive, US biotech investors are turning to alternative drug development and pharmaceutical manufacturing approaches.

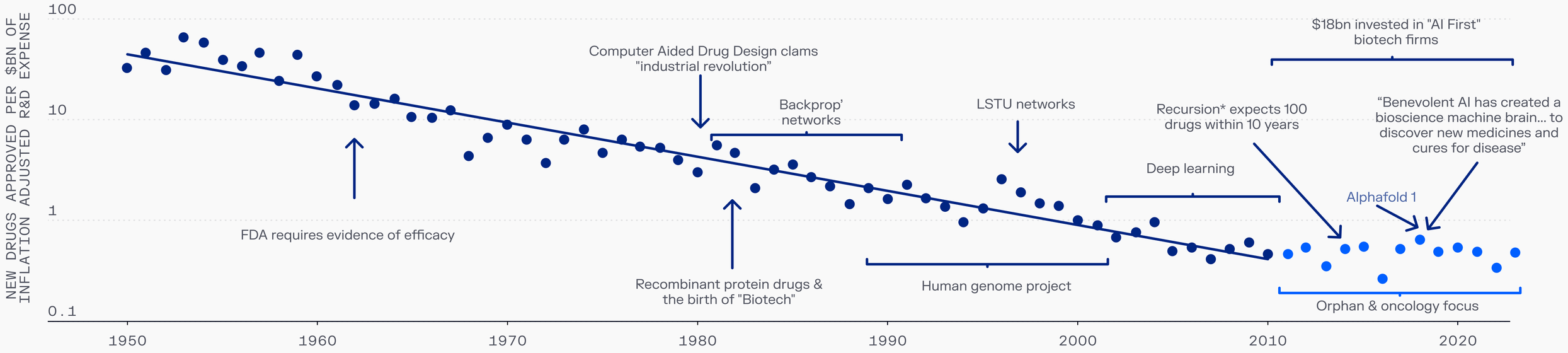
Varda offers one such approach with zero-gravity manufacturing. Varda's platform is launched into orbit, grows drug protein crystals in zero gravity, allowing for higher successful formation rates, and then returns the platform to Earth.

Varda successfully grew ritonavir on its maiden mission 2024 and launching several additional successful missions in 2025.

Varda employees inspect payload at Wendover Airport in Utah after it returns from space

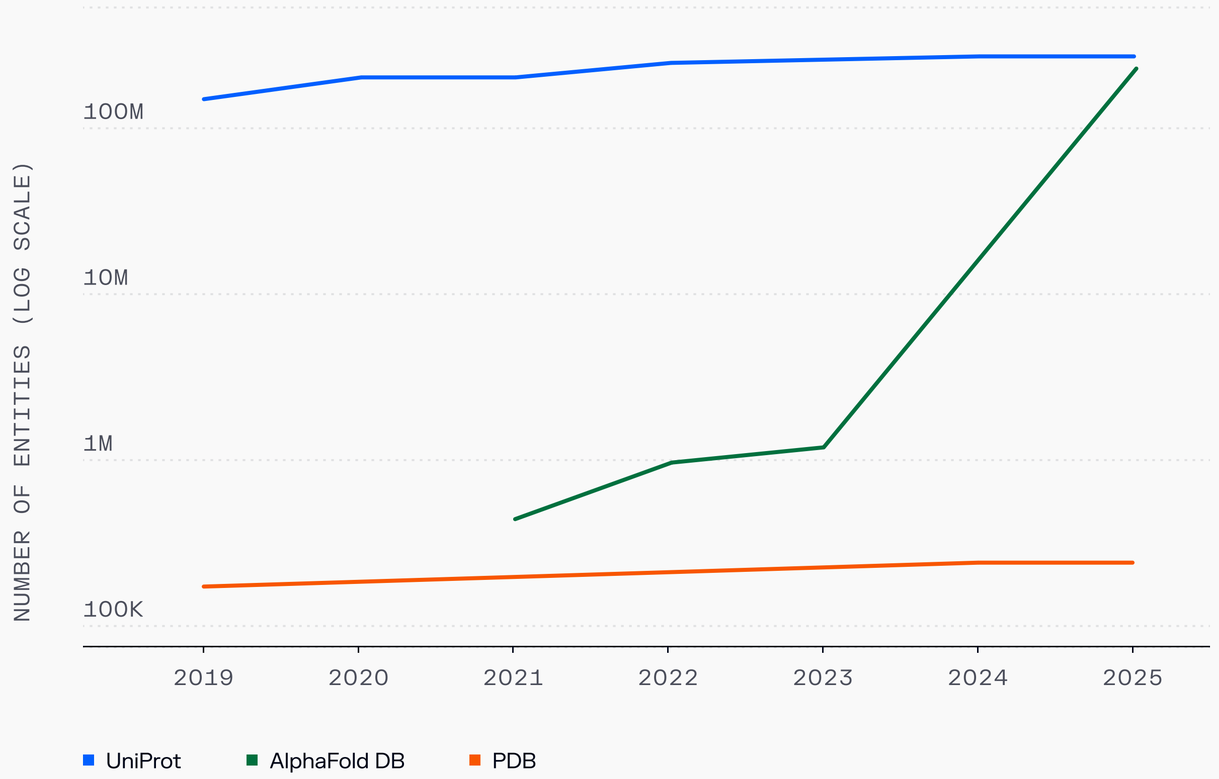
Source: The Salt Lake Tribune

Proponents of AI for drug discovery aim to reverse the “Eroome’s Law” phenomenon, which describes the rising costs of drug discovery and manufacturing.



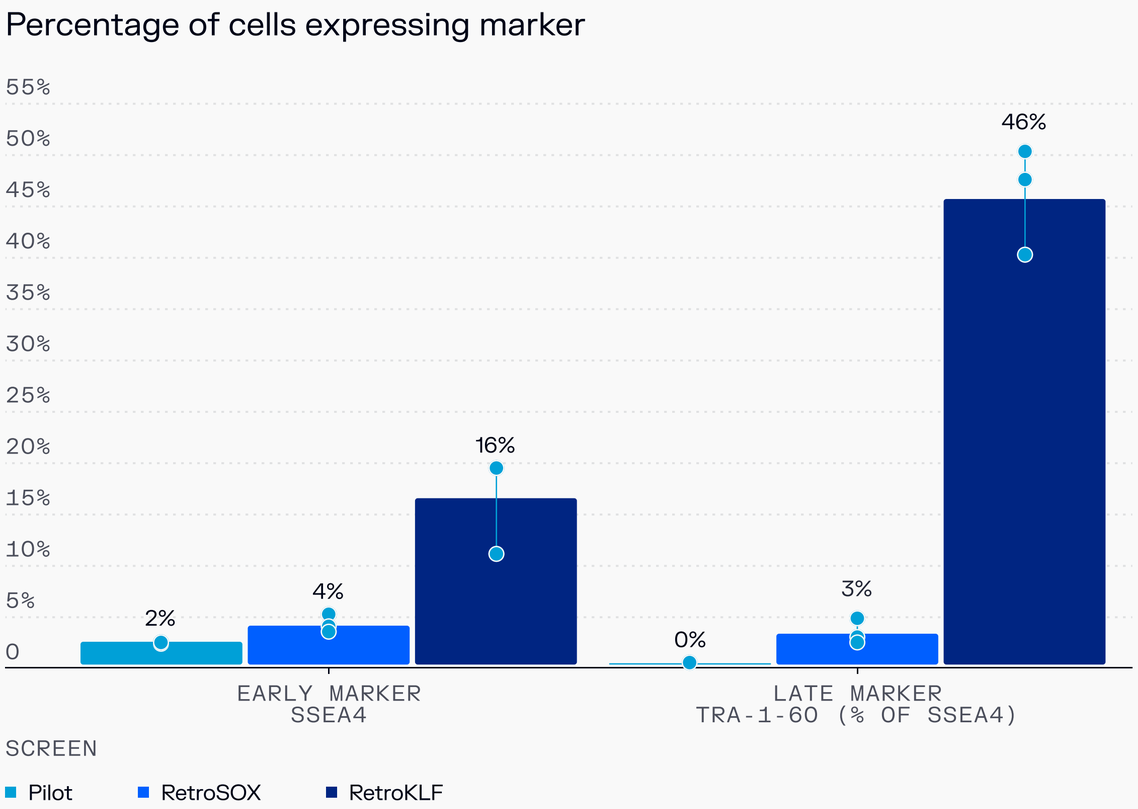
Source: Jack Scannell

Cell and protein-folding models benefit from the growth of AlphaFold DB, DeepMind's protein-folding prediction arm, which has seen a massive rise as a public protein science database.



Source: Stanford HAI Artificial Intelligence Index Report 2025

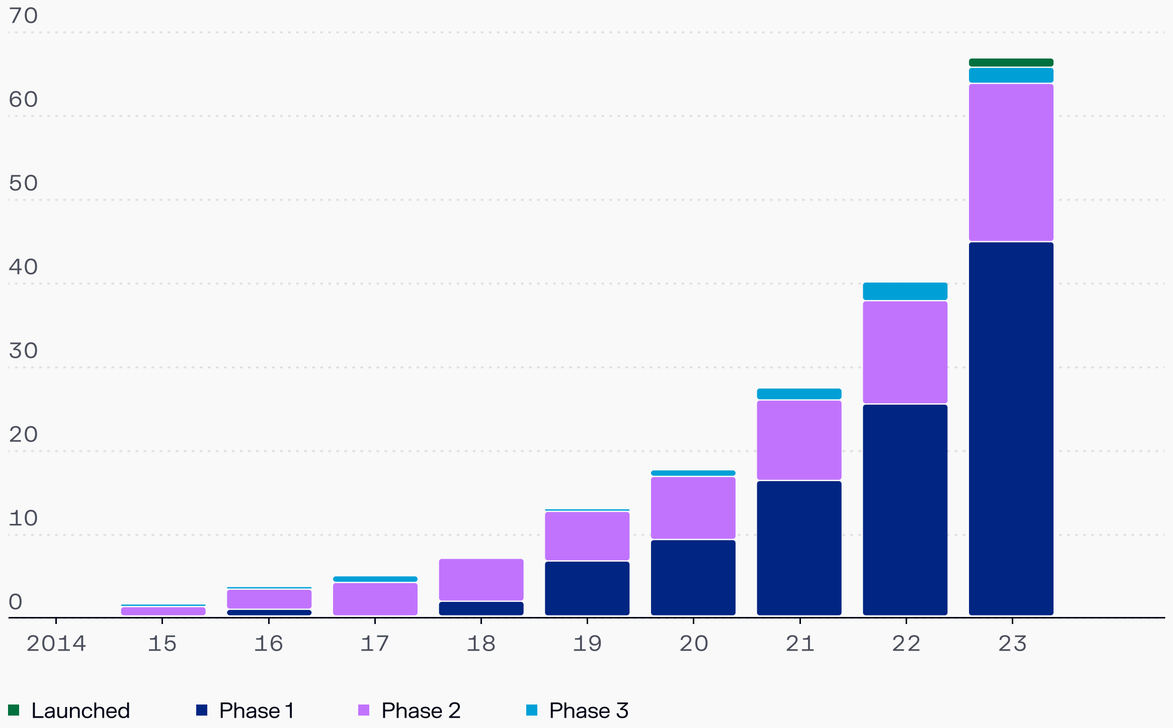
Like DeepMind, OpenAI has also turned to biology-focused modelling, building its first biology model through a partnership with Retro Biosciences. This model helped develop proteins that increase successful stem-cell reprogramming rates by 50%.



Source: OpenAI, Retro Biosciences

At the same time, few AI-discovered drugs have reach late-stage clinical trials or launched.

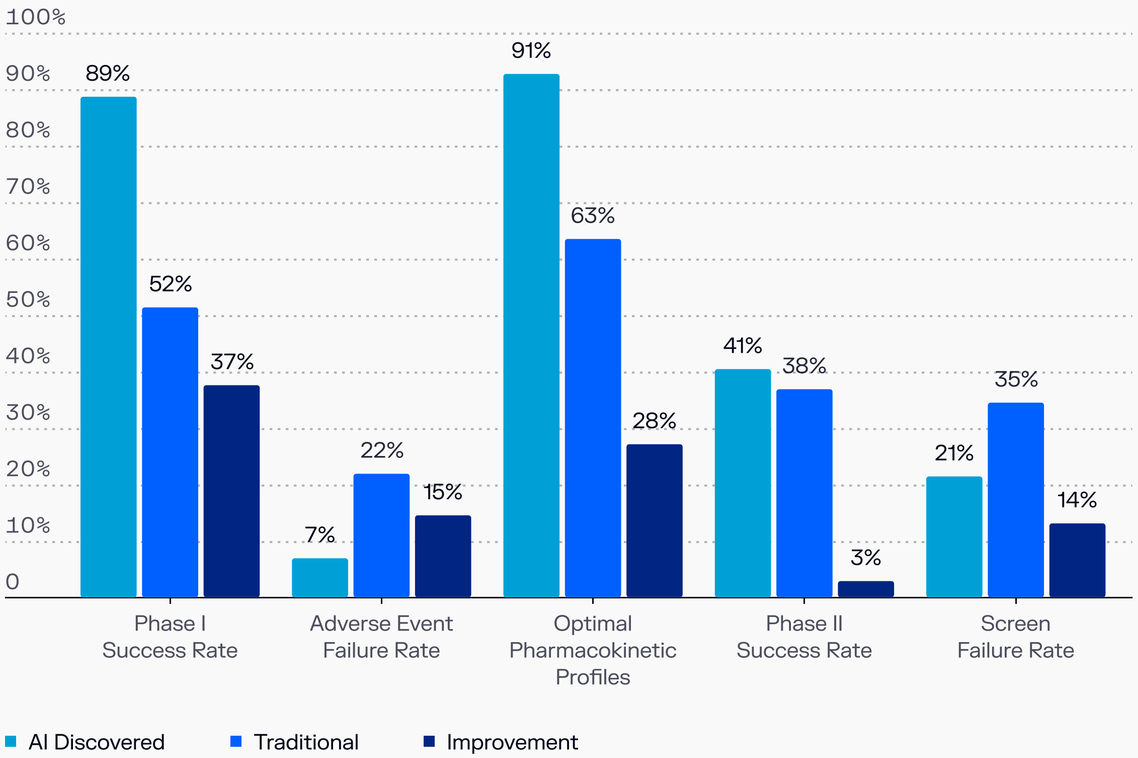
AI-discovered molecules in clinical trials*



*Source: "The Transformative Impact of Artificial Intelligence on Drug Discovery: A Technical Review"; Note: *by AI-native biotech companies*

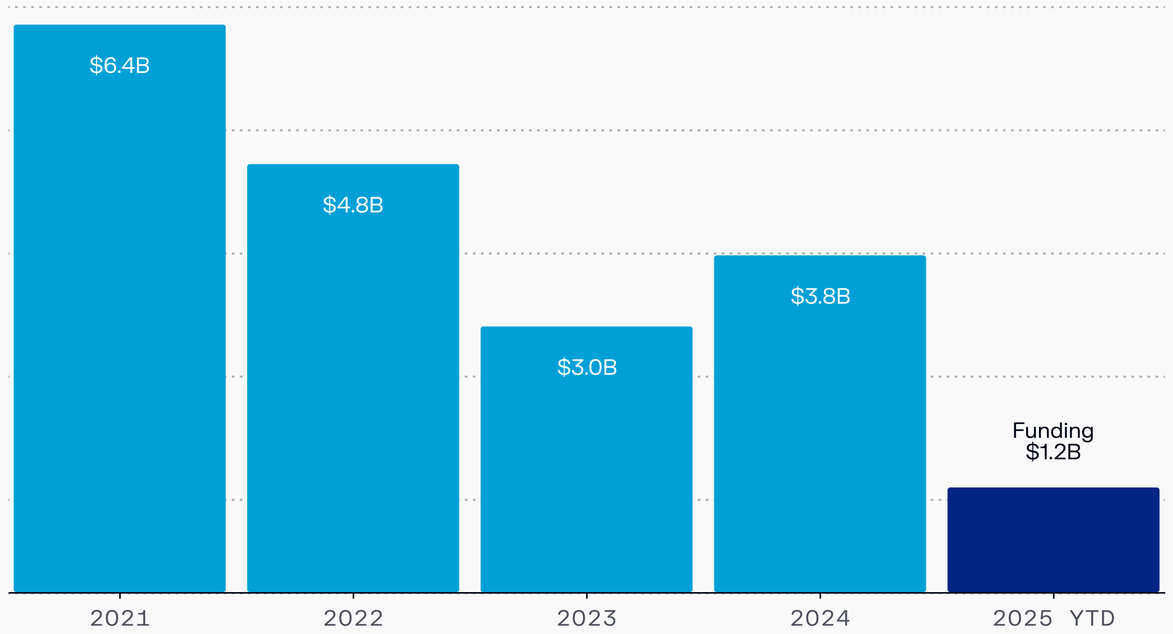
Drugs that have advanced to Phase II testing have only slightly higher success rates than traditionally developed drugs.

Parameter Improvements



Source: "How successful are AI-discovered drugs in clinical trials?" Jayatunga et al

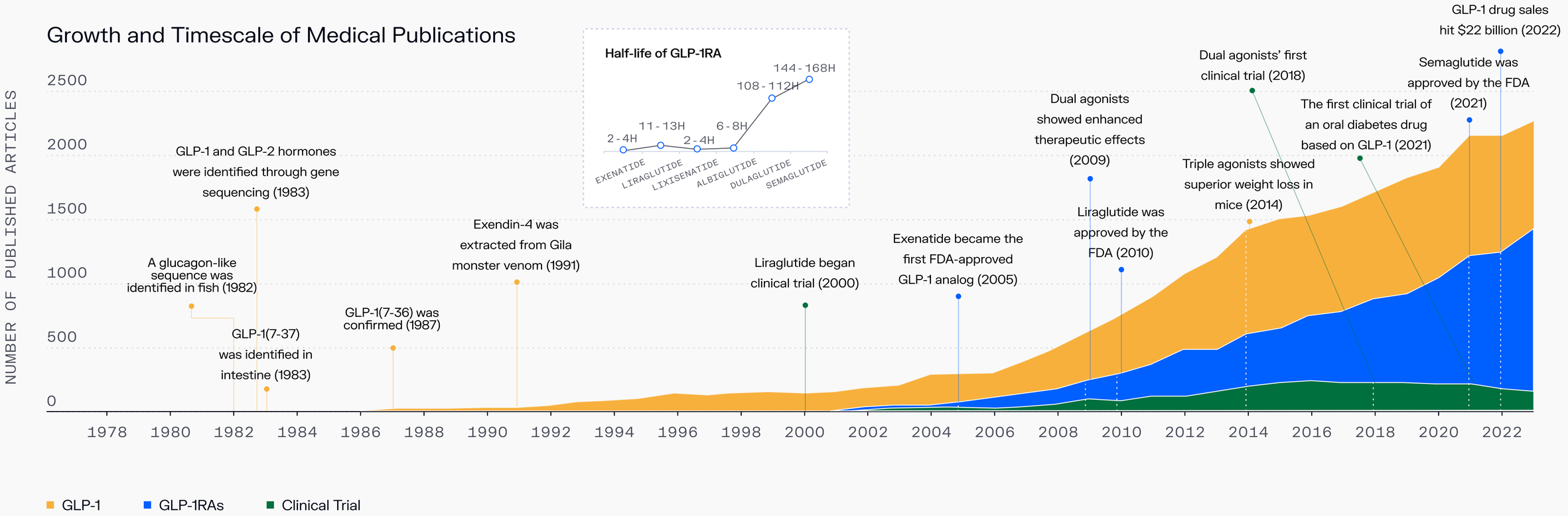
Investment in R&D for AI in drug development has failed to keep pace with overall AI investment.



Source: CB Insights via disclosed equity funding as of May 2025

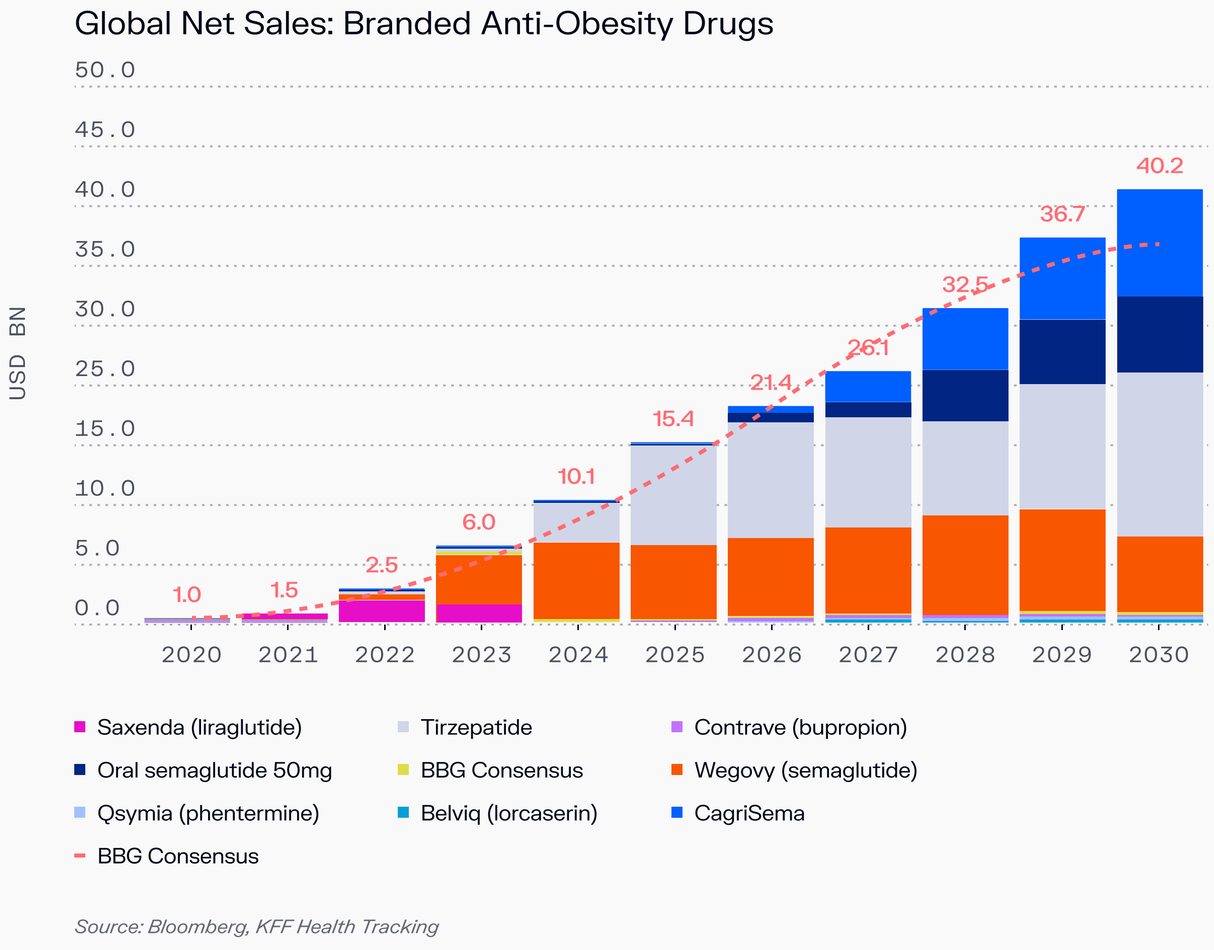
Shift From Pharmaceuticals to Biologics: GLP-1s, and Breakthrough Biologics

GLP-1s are among the most successful drugs of the 21st century, as measured both by efficacy and adoption rates.



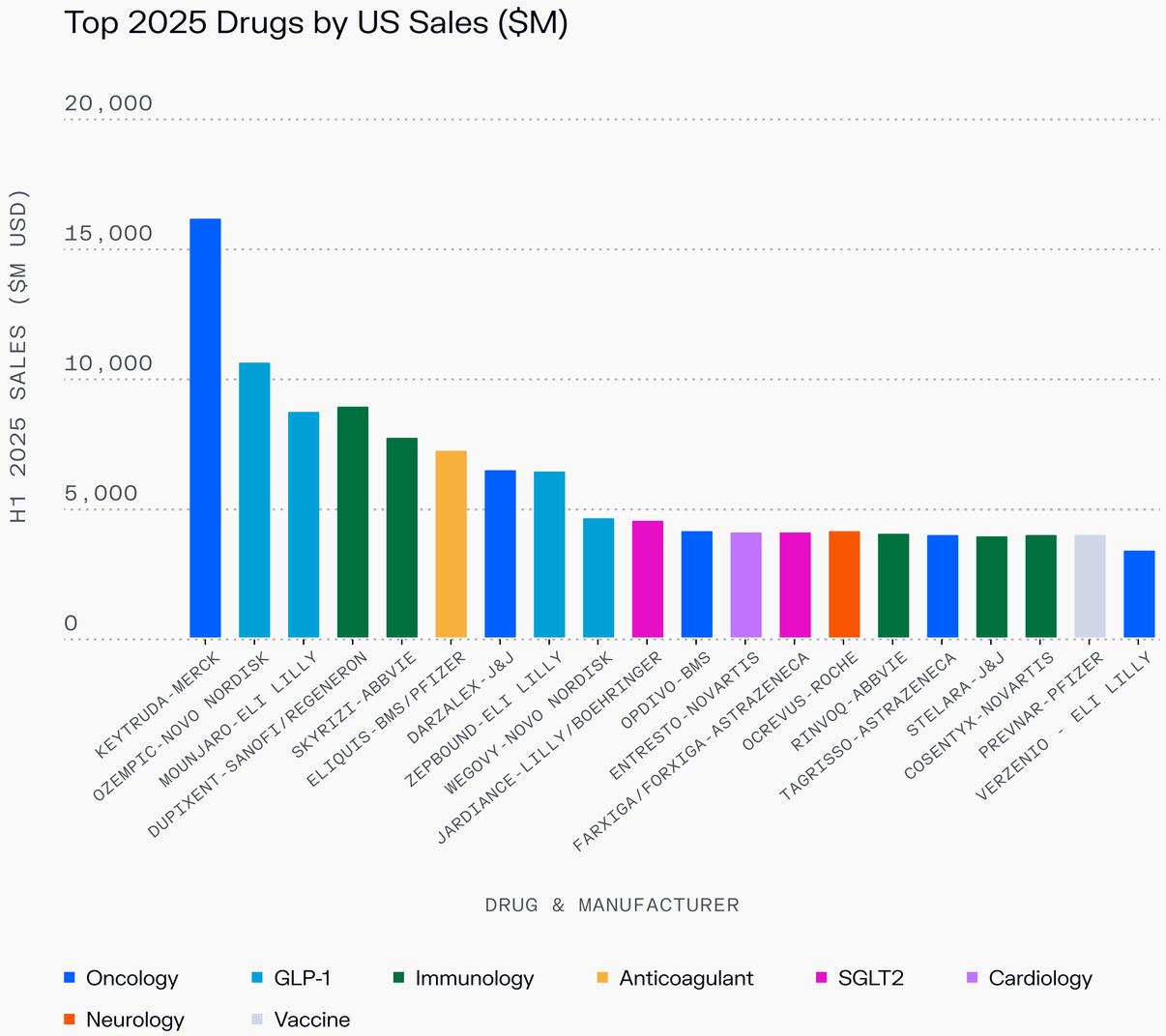
Source: Derek Thompson

The market for GLP has grown dramatically, and is predicted to continue growing at over 10% annually, with 18% of US adults now taking a GLP-1 medication of some form.



Source: Bloomberg, KFF Health Tracking

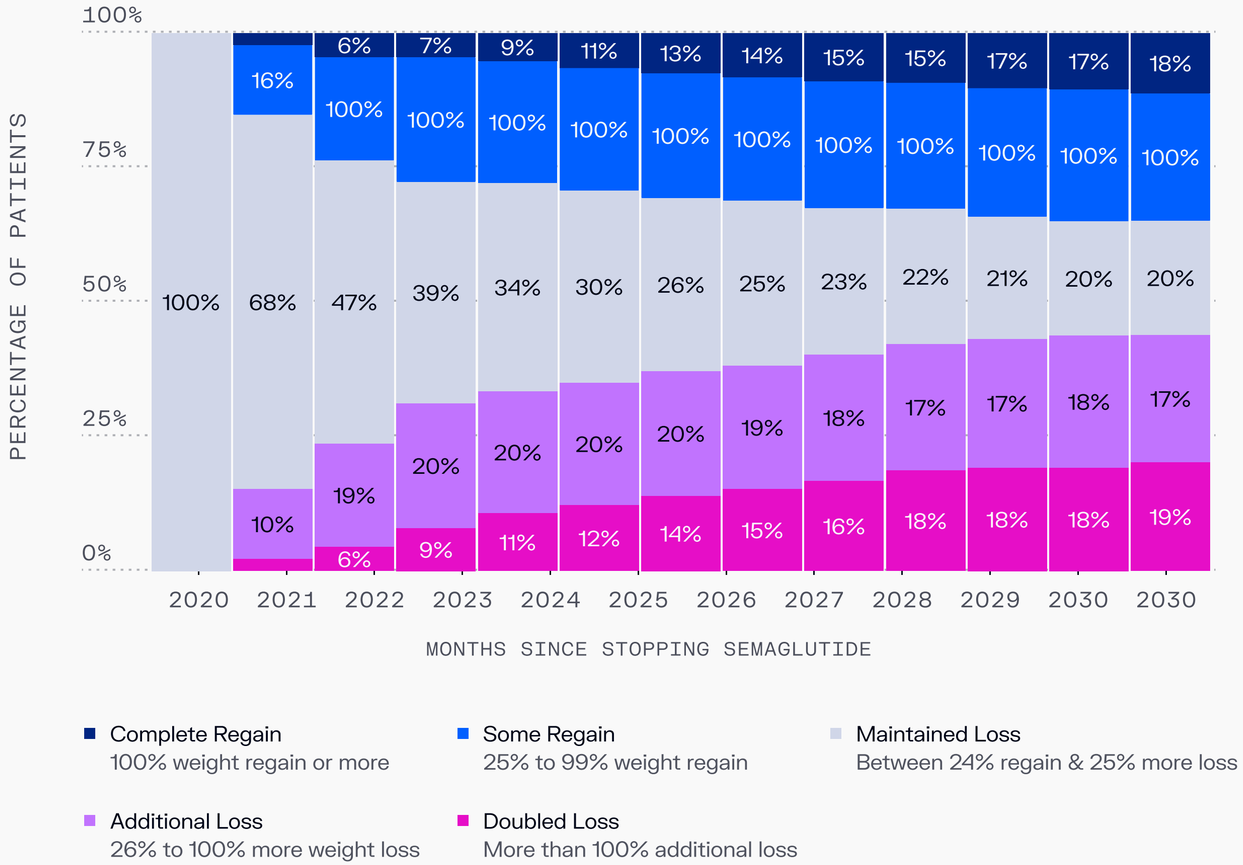
GLP-1s have become some of the highest selling drugs worldwide, and are expected to lead new prescription drug sales into 2026.



Source: Drug Discovery & Development, Evaluate 2025 Preview Report

Despite widespread popularity, many users of GLP-1s have stopped prescriptions due to intolerable side effects. The split between those who have stopped GLP-1 use that have regained weight previously lost and those that have continued to lose weight is roughly even.

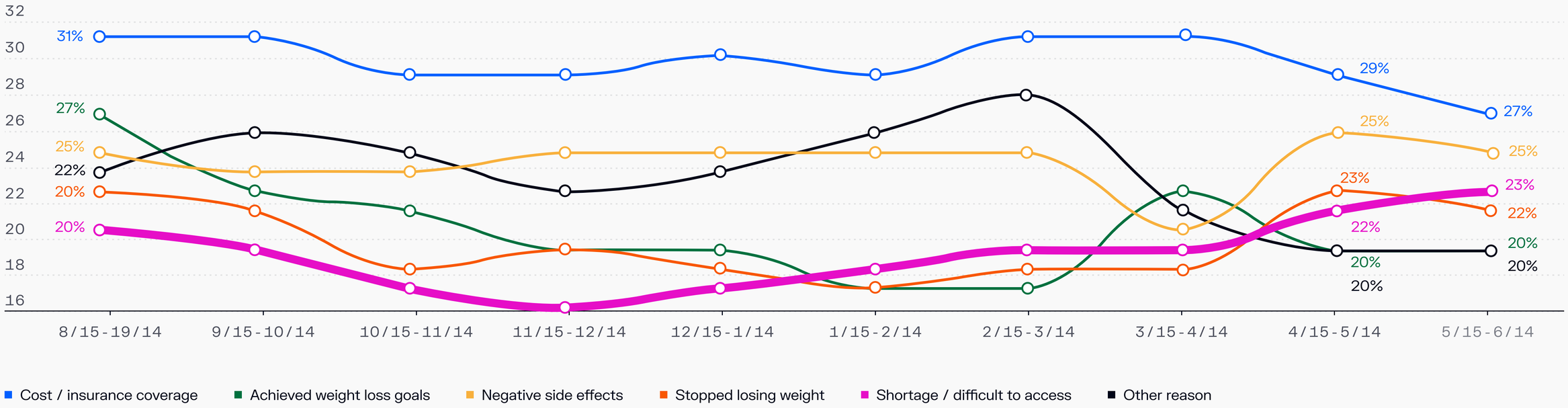
Proportion of Patients by Weight Change After Stopping Semaglutide



Source: Epic Research survey of 20,274 patients who were prescribed semaglutide and successfully lost at least five pounds while on the medication

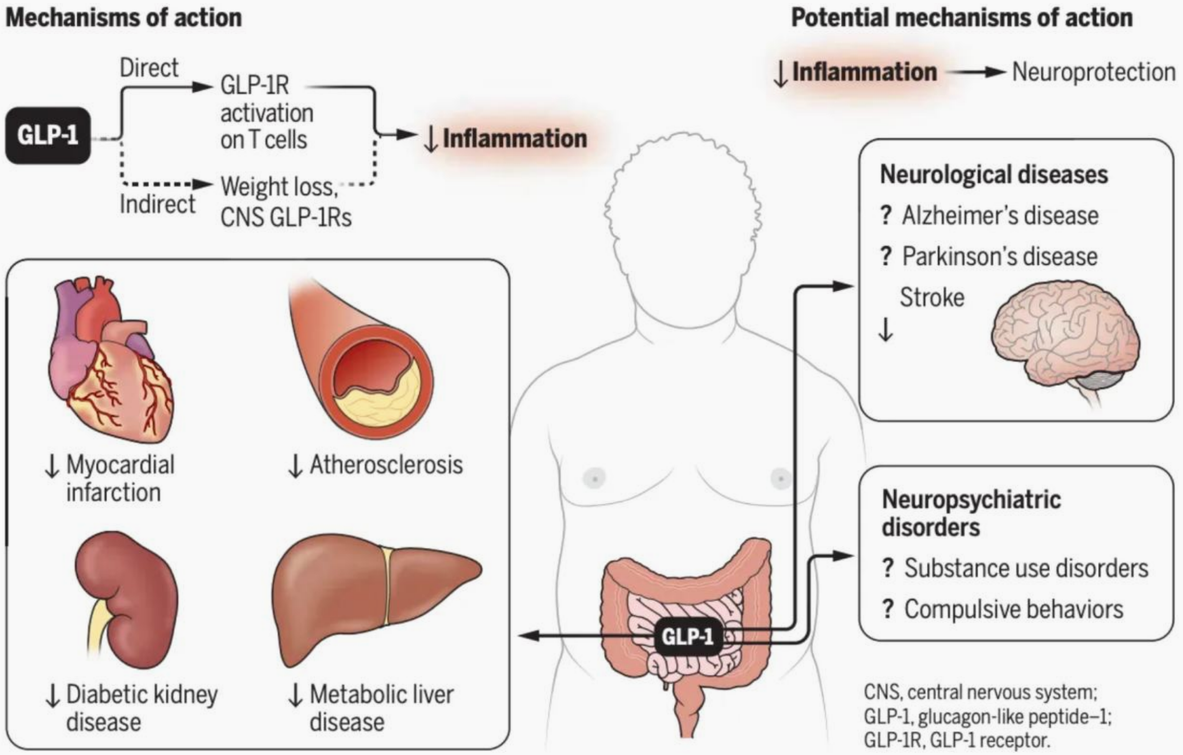
Former users report cost as one of the major blockers to continued usage, along with side effects, medication shortages, and difficulty losing weight.

If you used to take a GLP-1 medication (e.g., Ozempic, Wegovy) for weight loss but no longer do, what were your reasons for stopping? Select all that apply. (Among former GLP-1 Users)



Source: CivicScience survey of 11,222 US adult former GLP-1 users

Despite these side effects, researchers have observed unexpected benefits from GLP-1s, including decreased atherosclerosis, metabolic liver disease, Alzheimer's disease, Parkinson's disease, and substance use disorders, among other benefits.



Source: Derek Thompson

Given the significant share of the population taking the medication, GLP-1s are expected to impact the size and characteristics of the US food market.

80%

of US adults taking drugs such as Ozempic say their eating habits have changed “a lot”

51%

of Ozempic users are snacking less

44%

of Ozempic users are cooking at home more frequently

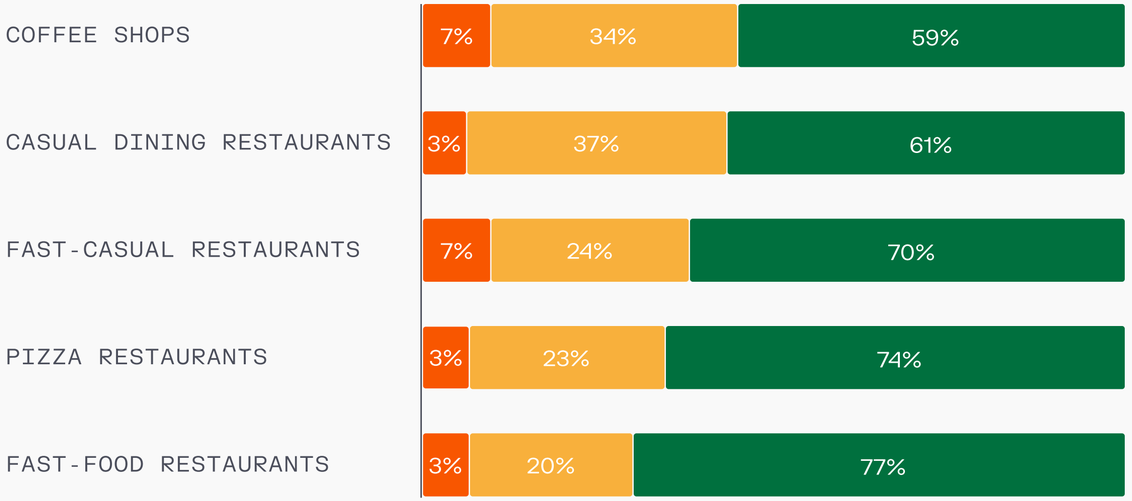
45%

of Ozempic users are using portion control as a weight loss tool

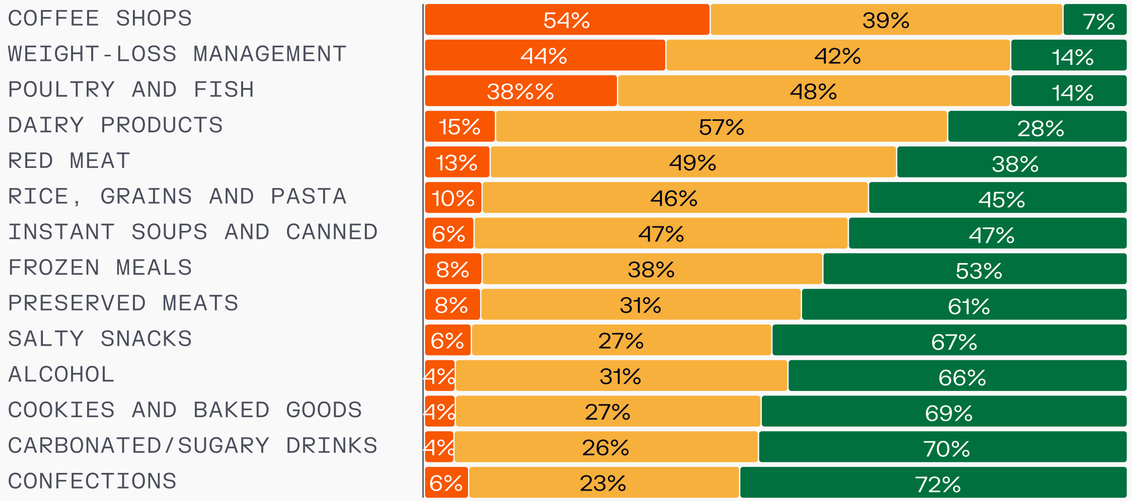
Source:”How Ozempic Users Are Changing Their Eating and Drinking Behaviors”, Morning Consult

GLP-1 users have reported eating less overall, eating out less frequently, and shifting to healthier diets.

Change in Restaurants People on Weight-Loss Drugs Visit



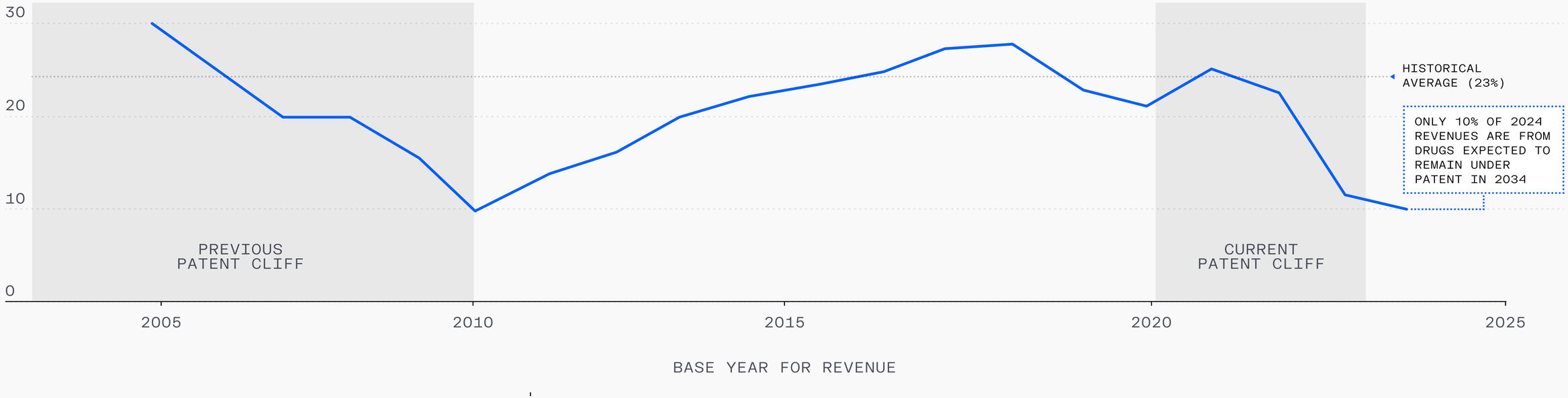
Change in Foods People on Weight-Loss Drugs Eat



Source: Morgan Stanley Research

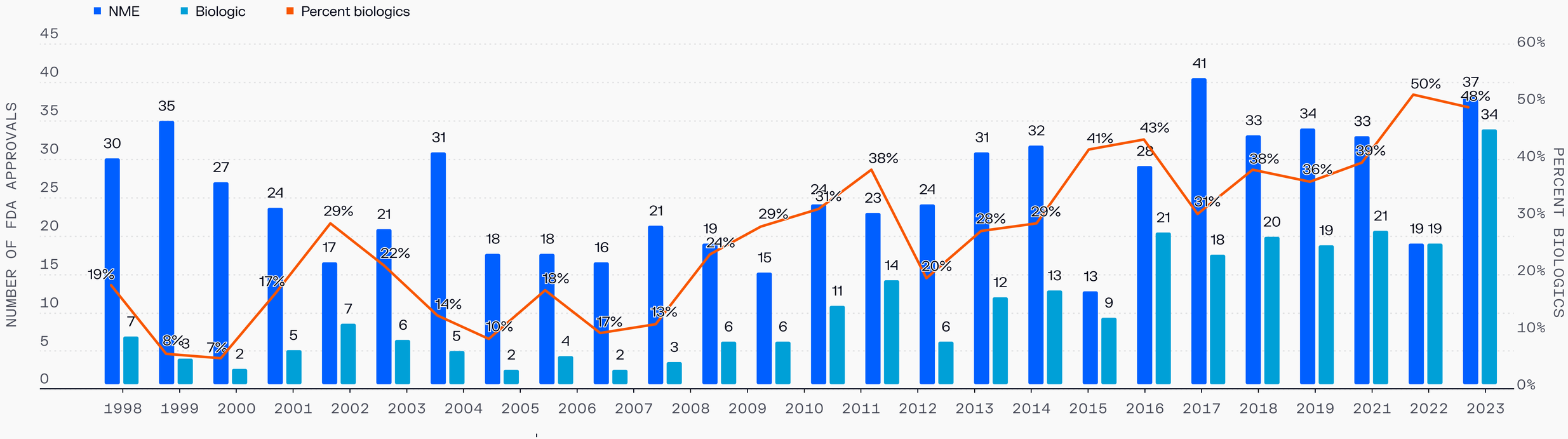
Despite the success of drugs like GLP-1s and GLP-1RAs, pharmaceutical manufacturers expect overall revenue decline as many drug patents expire. 10% of 2024 pharmaceutical revenues are expected to remain under patent in 2034.

Revenue from drugs still under patent after 10 years (%)



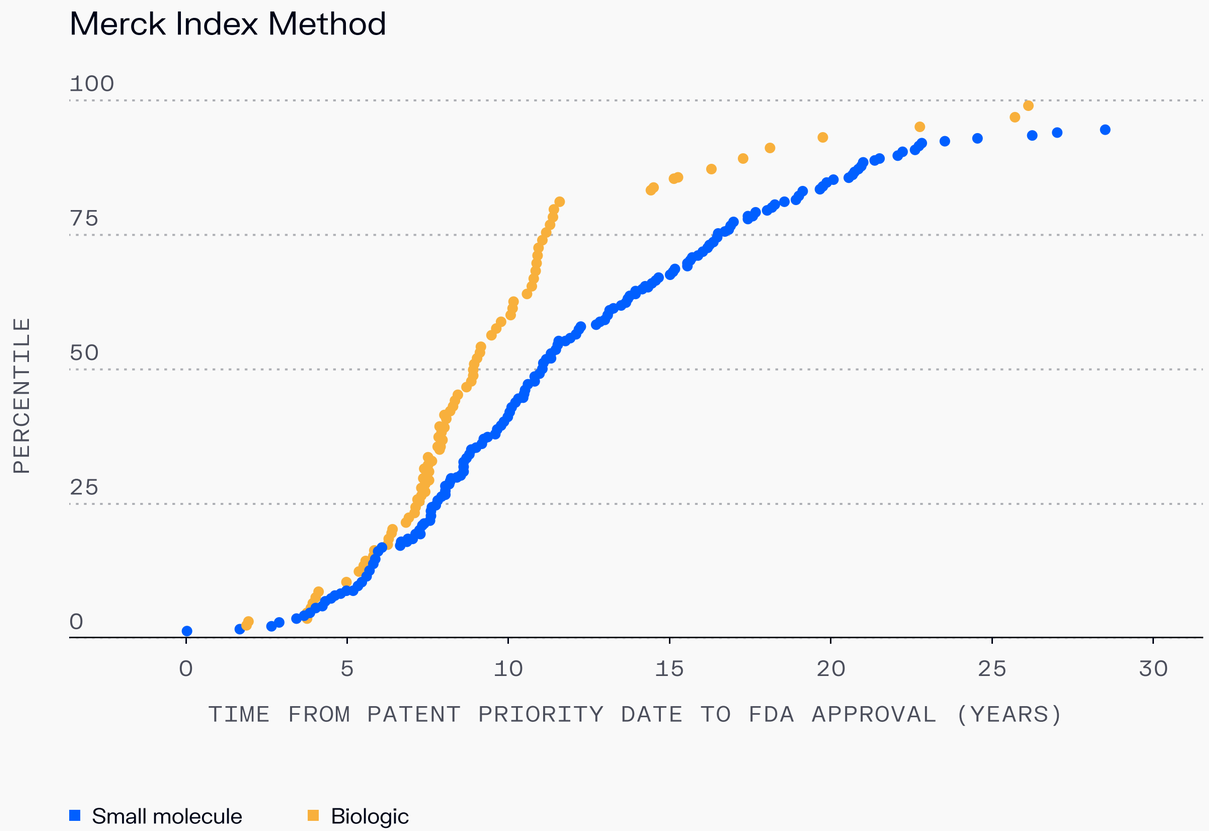
Source: BCG analysis of 20 leading pharmaceutical companies

Given the slow development timelines of traditional pharmaceuticals, drug evelopers are increasingly turning their focus to biologics (biologically derived drugs like antibody therapeutics) as opposed to smaller molecules.



Source: "Fresh from the biotech pipeline: record-breaking FDA approvals", Nature

Biologics have faster timelines to FDA approval than small molecules, but are more expensive and more challenging to develop.

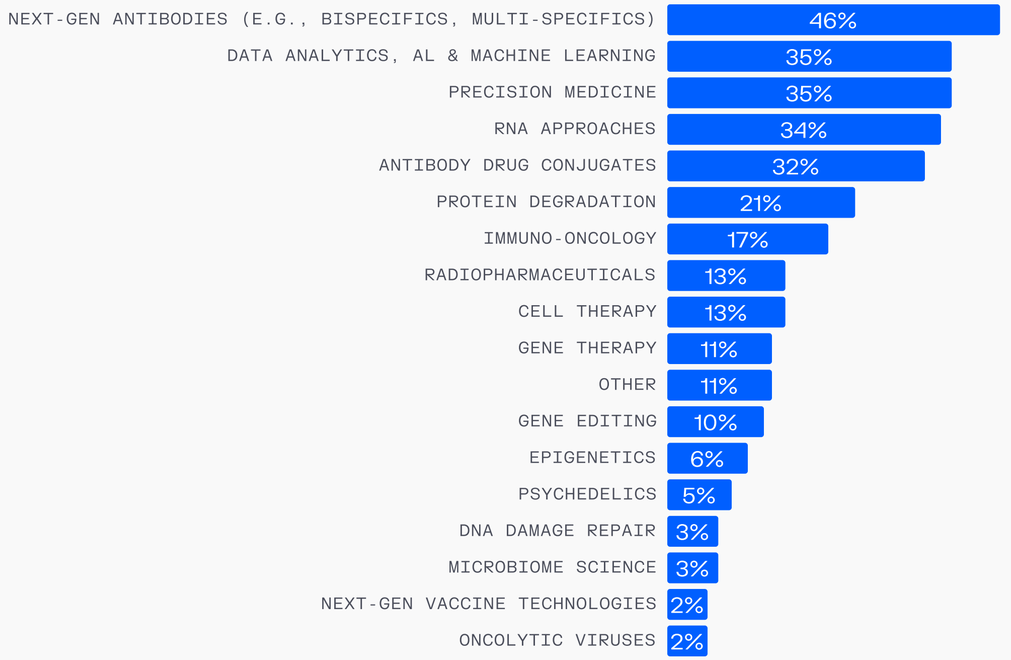


Source: "Pre-market development times for biologic versus small-molecule drugs", Nature

Biologics, including antibodies, are among the top three innovative priorities for nearly 50% of drug developers.

Q: What are your top three innovative, disruptive technological priorities for the next 12 months? (Select top three)

76% AND **53%** of large and mid-cap pharmaceutical leaders, respectively, are focused on next-generation antibodies

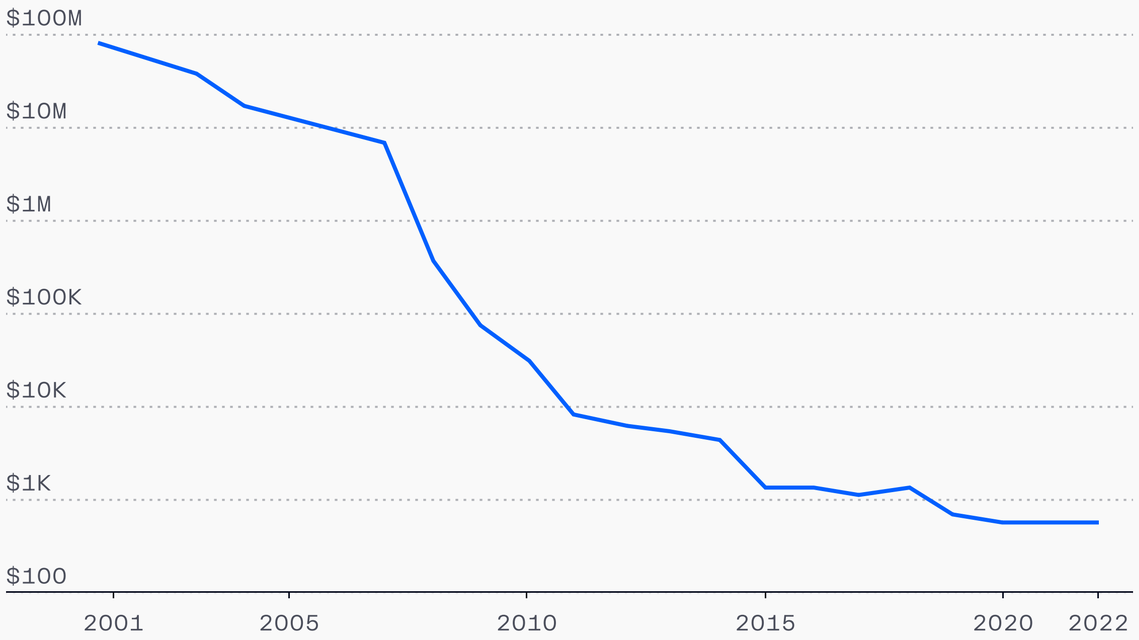


Human Augmentation: Gene Therapies, Longevity, Brain-Computer Interfaces

As the cost of genetic sequencing has fallen, genetic therapies and testing have become more approachable for both startups and establishment medicine.

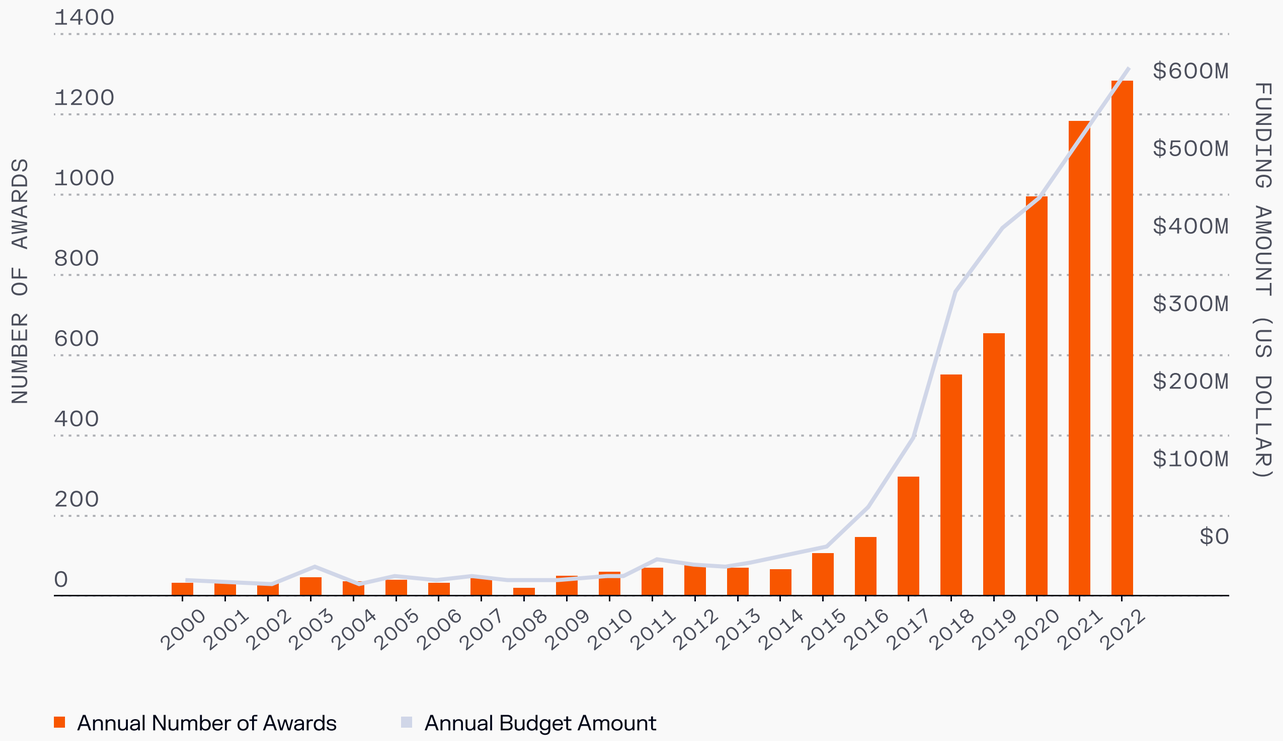
Cost of sequencing a full human genome

THE COST OF SEQUENCING THE FULL GENETIC INFORMATION OF A HUMAN, MEASURED IN US$.



Source: National Human Genome Research Institute, data is not adjusted for inflation

Federal grant awards for genetic editing research have increased 40% annually, even as public opinions on genetic editing applications are mixed.

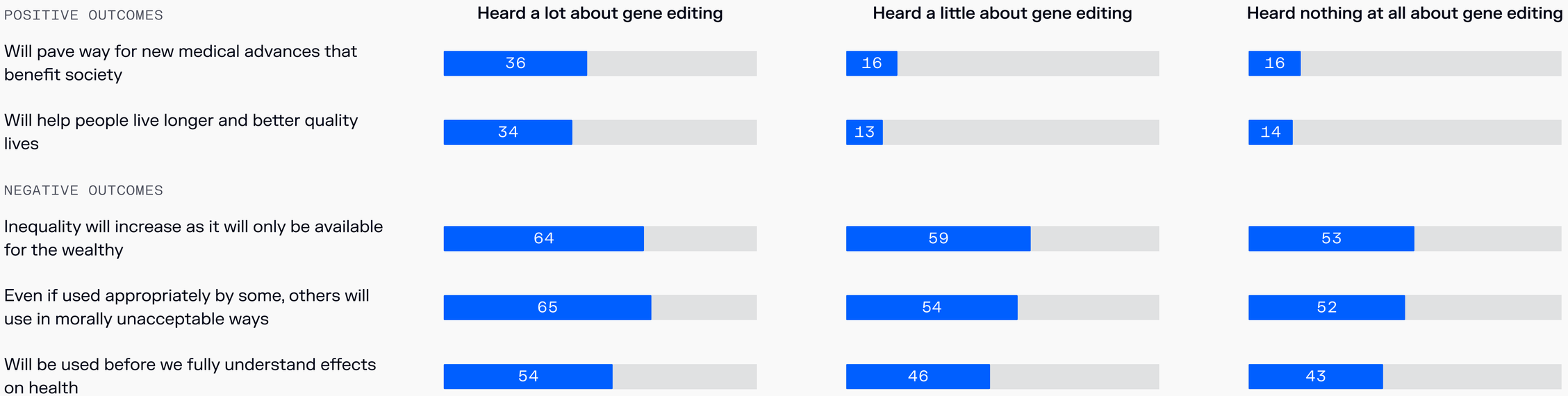


Source: Characterization of Research Support of Genome Editing Technologies and Transition to Clinical Trials, Pew Research Center

Americans lean towards feeling that embryonic testing for gene editing applications is not appropriate.

Americans who are more familiar with gene editing are more inclined to anticipate positive as well as negative effects from widespread use of gene editing

% of U.S. adults in each group who say each of the following would be very likely to occur if gene editing to change a baby's genetic characteristics becomes widely available

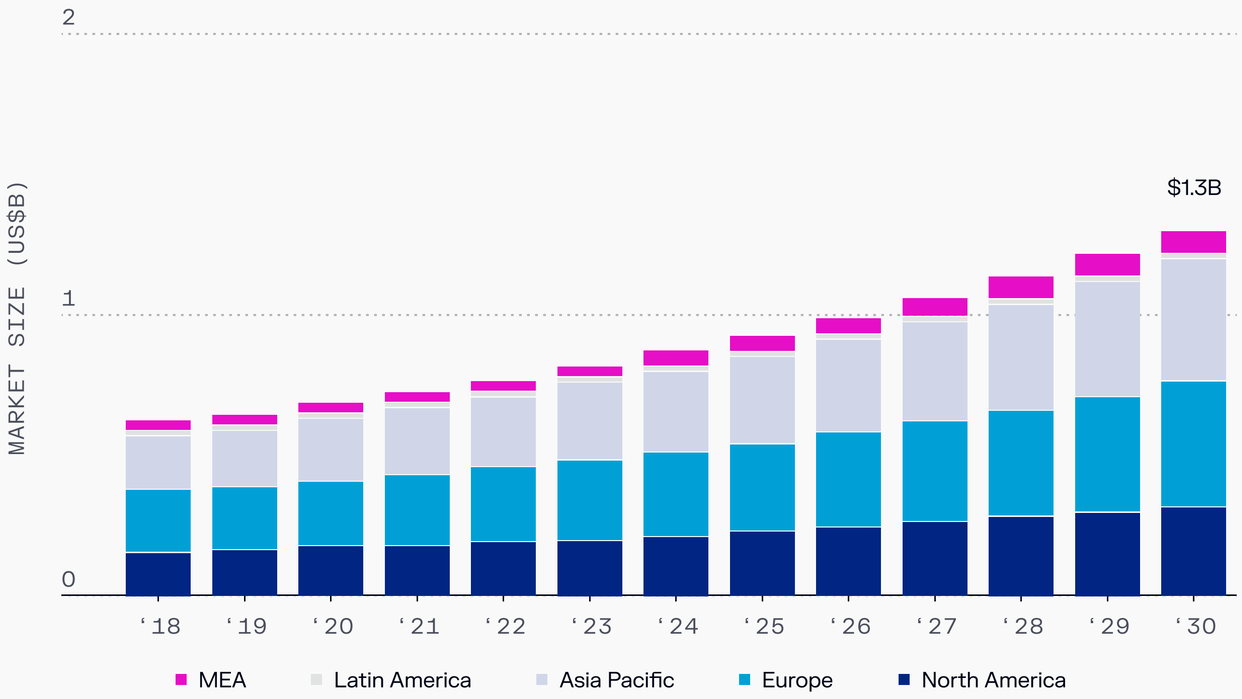


Source: Pew Research Center

Despite public uncertainty around genetic testing or selection, the genetic testing market for pre-implantation embryos is expected to grow over 10% annually through the next decade.

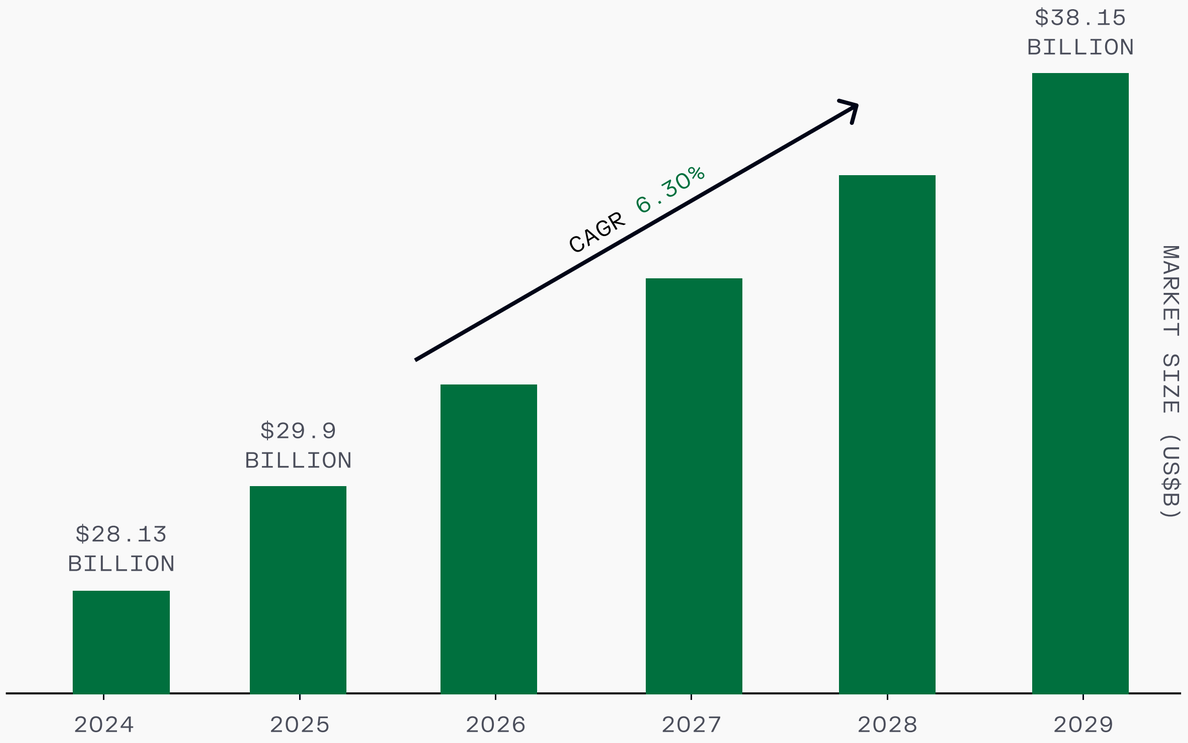
Preimplantation Genetic Testing Market

SIZE, BY REGION, 2018-2030



Source: Grand View Research

Like genetic testing and editing, funding for longevity research has continued to grow. The market is projected to reach over $38 billion by 2029.



Longevity Start-ups by Total Funding

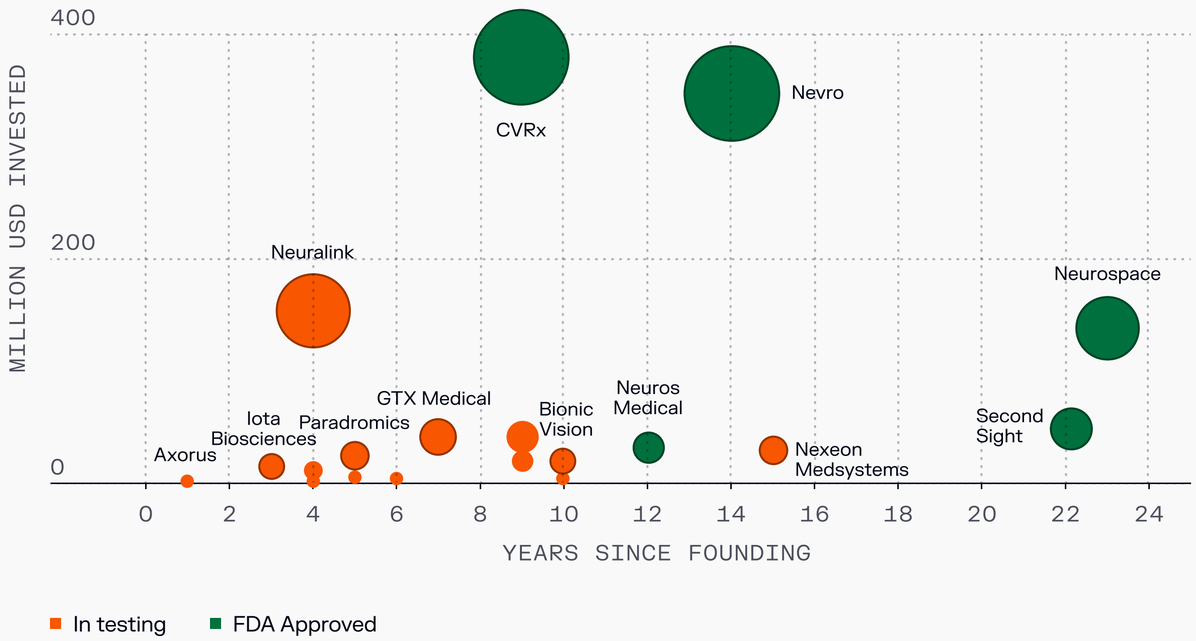
ALTOS	$5.6B
HUMAN LONGEVITY	$1+B
Insilico Medicine	$536M
Retro	$180M
Cambrian	$160M
NewLimit	$130M

Source: The Business Research Company, Longevity Investors LinkedIn

Funding for Brain Computer Interfaces (BCIs) has grown across devices for medical, research, and consumer use cases.

Funding for Invasive Neural Interfaces

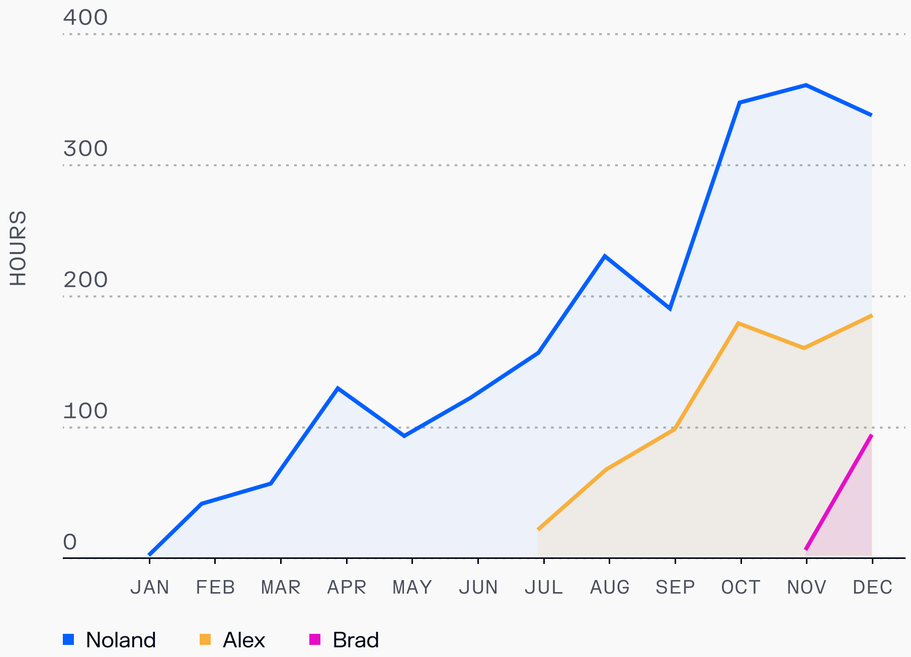
FDA APPROVAL FOR INVASIVE NEURAL INTERFACES TAKES YEARS OF PRE-CLINICAL TESTING AND CLINICAL TRIALS



*Source: From the Interface; This chart includes implanted devices that interface with the central, peripheral or autonomous nervous system. *Nexeon MedSystems was delisted from the NASDAQ, and it is not clear if the company is still operational.*

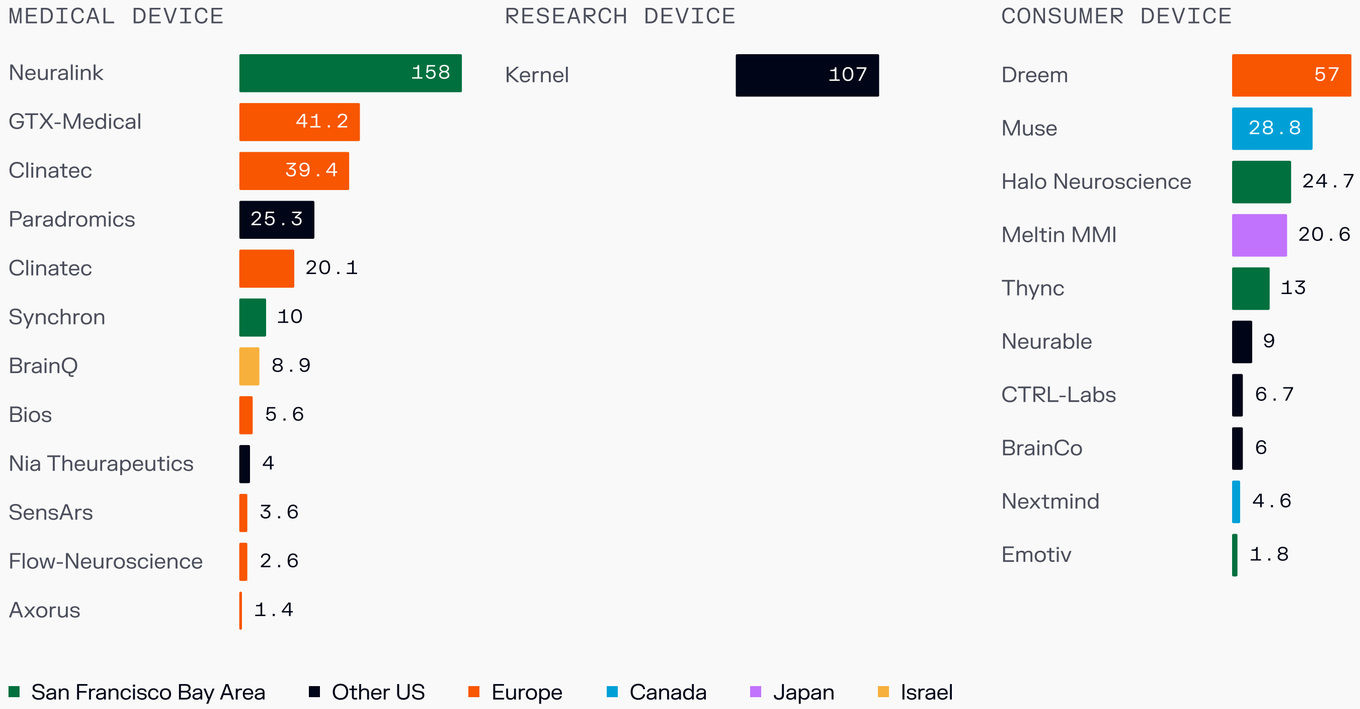
Neuralink is the most well-funded company in the BCI space, and has completed 3 BCI implants in patients, and found increases in usage over time across the board.

Monthly hours of independent BCI use in 2024



Source: Neuralink, From the Interface

Funding (Million USD) for BCI and neural interface companies since 2010

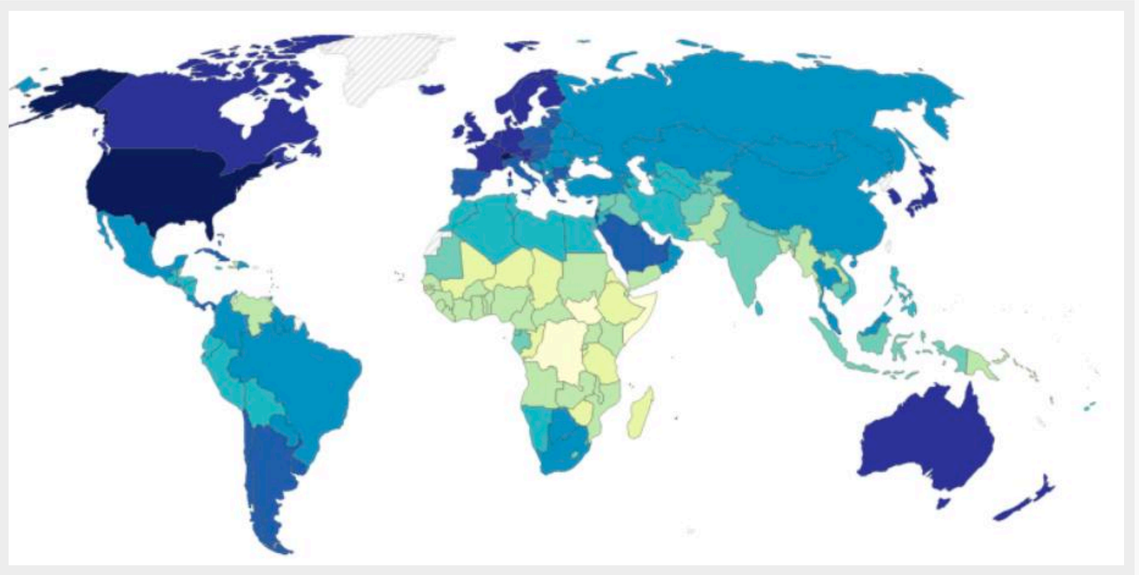


Healthcare: State of Healthcare, Chronic & Communicable Diseases, AI for Medicine

Global healthcare expenditure varies by multiple orders of magnitude. Total spending per person is higher in the US than in any other country.

Total health spending per person, 2023

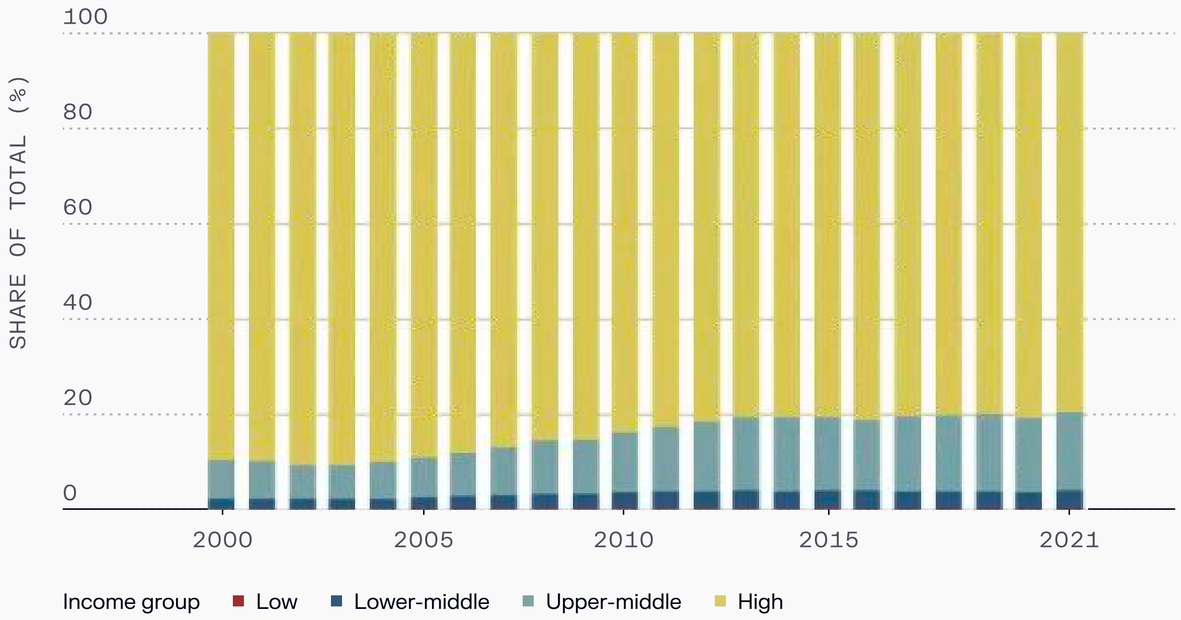
THE SUM OF PUBLIC AND PRIVATE ANNUAL HEALTH EXPENDITURE PER PERSON. THIS DATA IS ADJUSTED FOR DIFFERENCES IN LIVING COSTS BETWEEN COUNTRIES, BUT IT IS NOT ADJUSTED FOR INFLATION



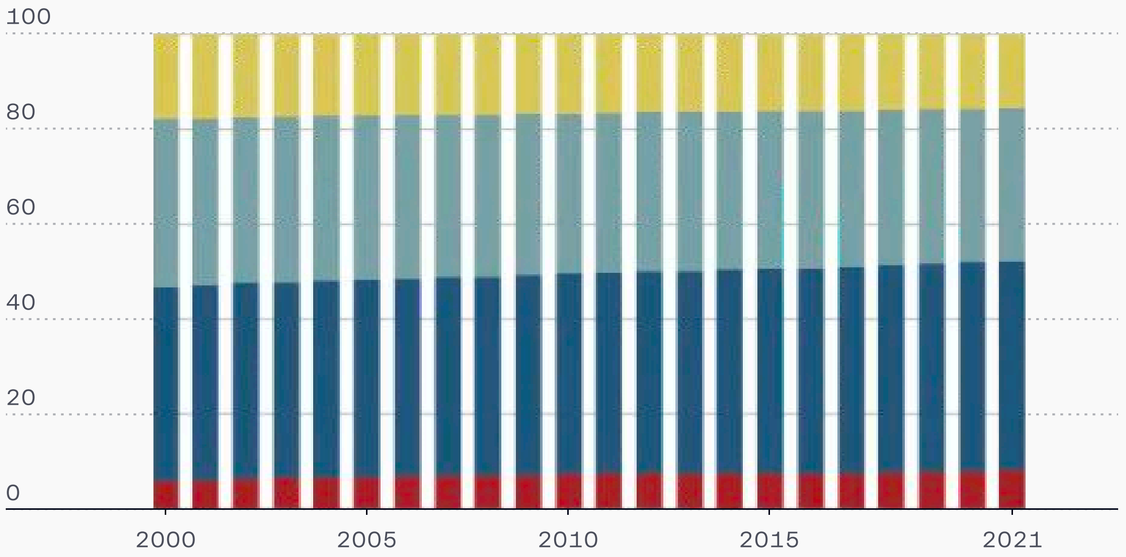
Source: WHO Global Health Expenditure Database

High income countries spend disproportionately more on healthcare relative to their share of global population, with 80% of total health spending in high income countries.

Global spending on health



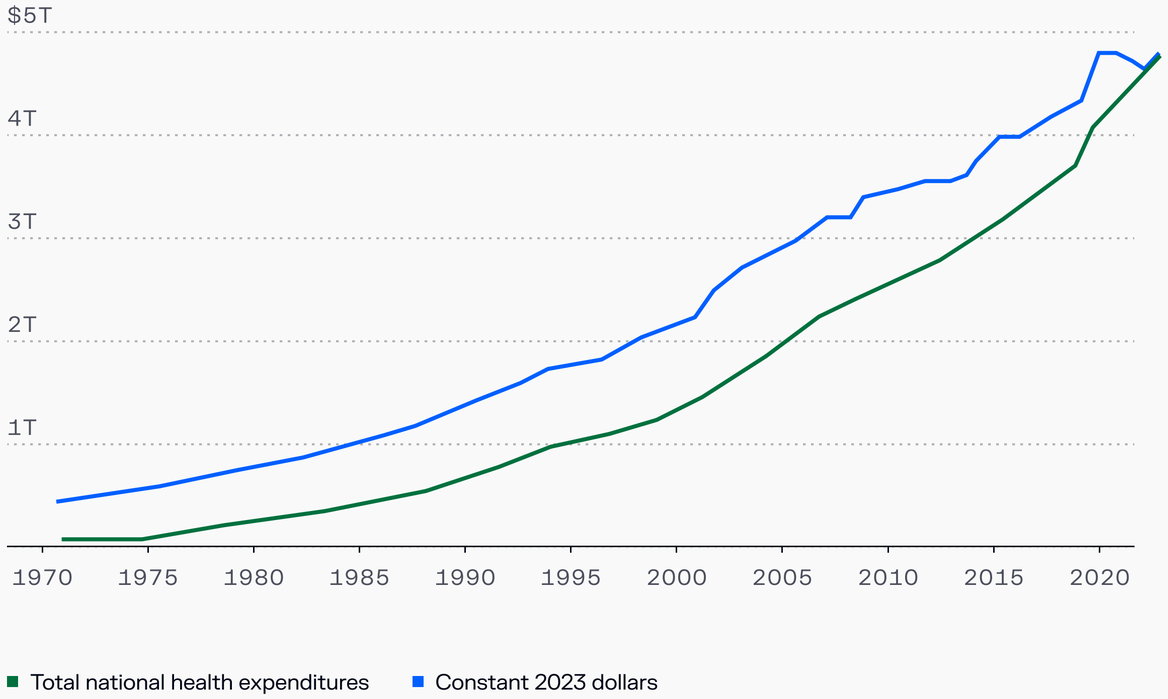
Global population



Source: WHO Global Health Expenditure Database

Adjusted for inflation, total US healthcare spending has increased by nearly 400% since 1970.

Total National Health Expenditures, US dollars, 1970-2023

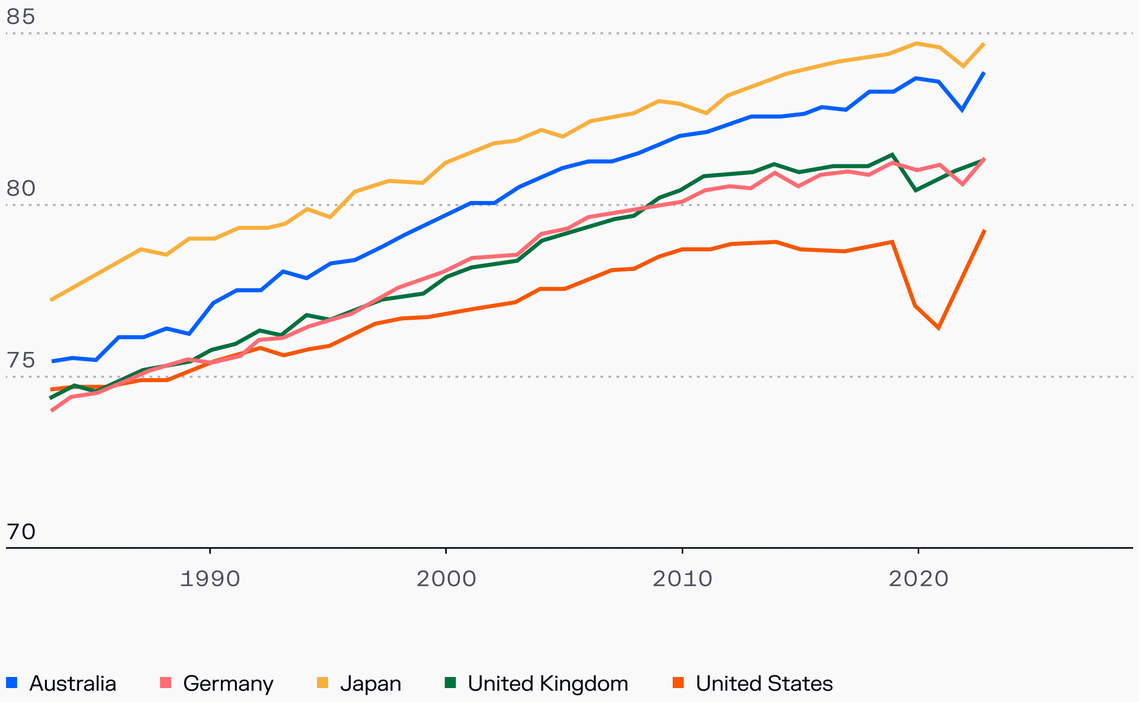


Source: KFF analysis of National Health Expenditure (NHE) data

Despite increased spending on healthcare, US life expectancy still falls below other high-income developed countries.

Life expectancy

PERIOD LIFE EXPECTANCY IS THE NUMBER OF YEARS THE AVERAGE PERSON BORD IN A CERTAIN YEAR WOULD LIVE IF THEY EXPERIENCED THE SAME CHANCES OF DYING AT EACH AGE AS PEOPLE DID THAT YEAR

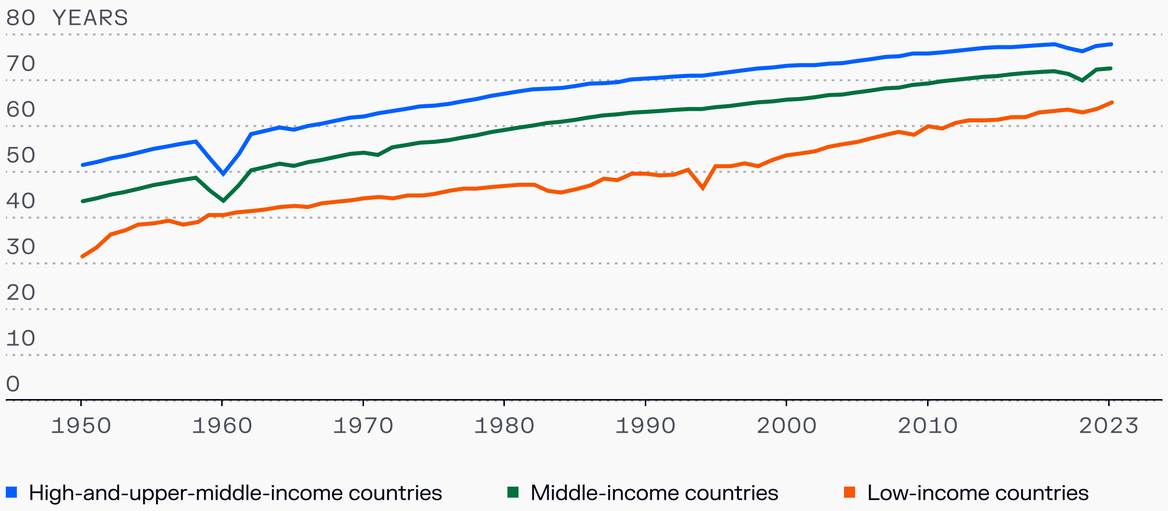


Source: Riley (2005); Zijdeman et al. (2015); HMD (2025); UN WPP (2024)

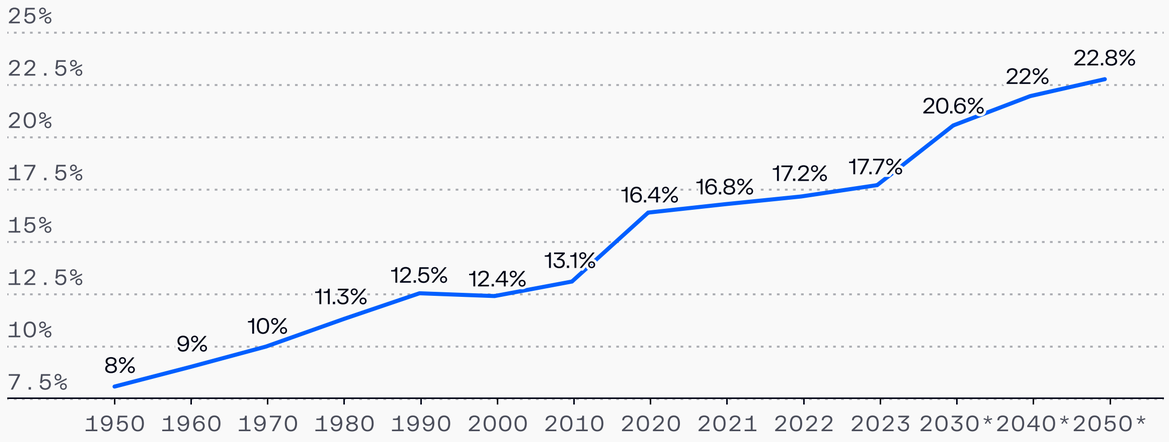
As global life expectancy increases on average, the share of the population above retirement age (65) has increased to nearly 20%, and is projected to reach nearly 25% by 2050.

Life expectancy

PERIOD LIFE EXPECTANCY IS THE NUMBER OF YEARS THE AVERAGE PERSON BORN IN A CERTAIN YEAR WOULD LIVE IF THEY EXPERIENCED THE SAME CHANCES OF DYING AT EACH AGE AS PEOPLE DID THAT YEAR.



% United States population aged 65+

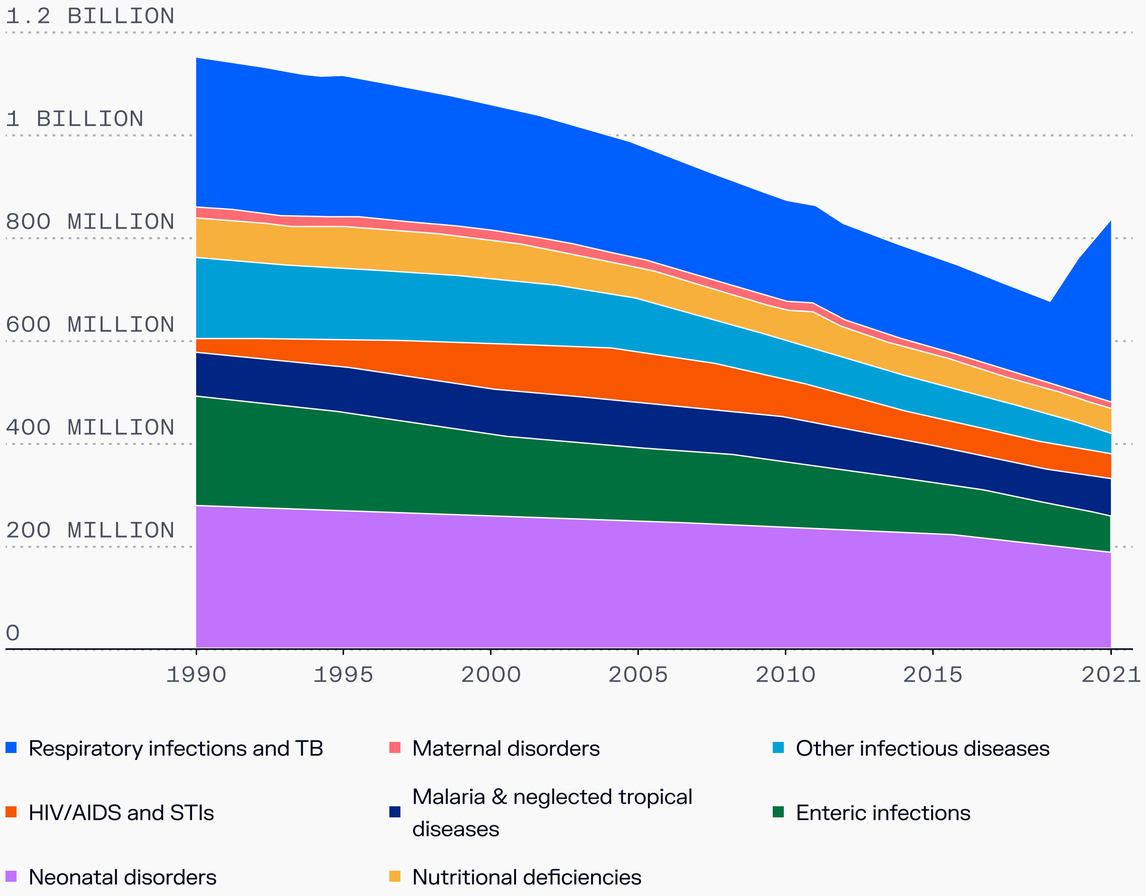


*Source: ChildStats.gov, US Census Bureau, Riley (2005); Zijdeman et al. (2015); HMD (2025); UN WPP (2024); *estimate*

One factor driving increased life expectancies is the decline of communicable disease, infections, nutritional deficiencies, and maternal/neonatal disorders.

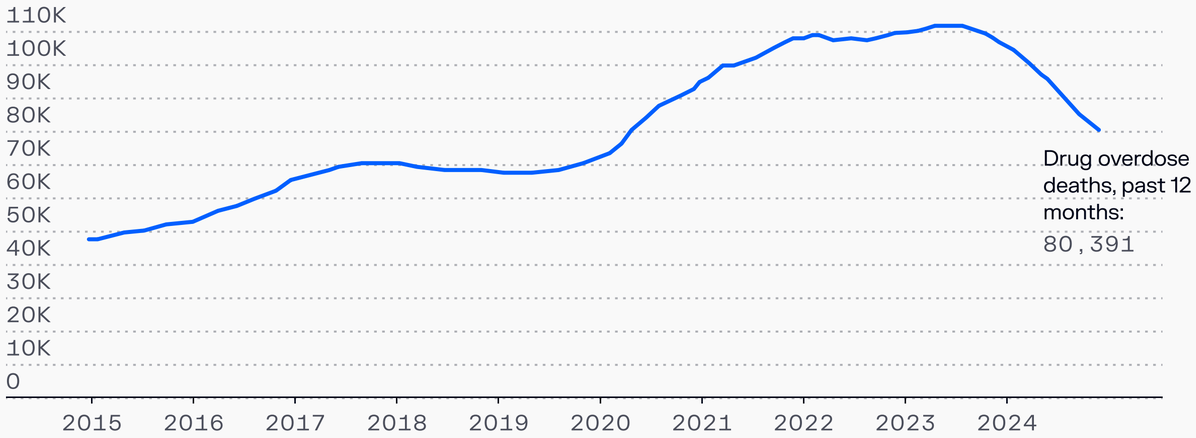
Disease burden from communicable, maternal, neonatal and nutritional diseases, World

ESTIMATED DISEASE BURDEN FROM COMMUNICABLE, MATERNAL, NEONATAL AND NUTRITIONAL DISEASES, MEASURED IN DALYS (DISABILITY-ADJUSTED LIFE YEARS) PER YEAR. DALYS ARE USED TO MEASURE TOTAL BURDEN OF DISEASE - BOTH FROM YEARS OF LIFE LOST AND YEARS LIVED WITH A DISABILITY. ONE DALY EQUALS ONE LOST YEAR OF HEALTHY LIFE

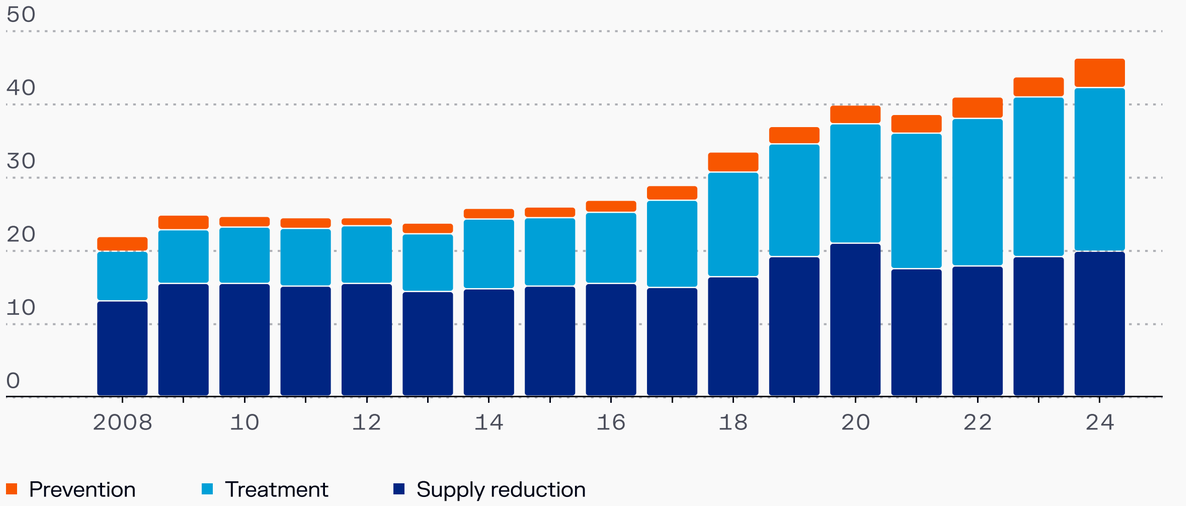


Source: Office of National Drug Control Policy

Similarly, drug overdoses have declined after rising for nearly a decade. Despite this decline, spending on drug control functions has continued to rise.



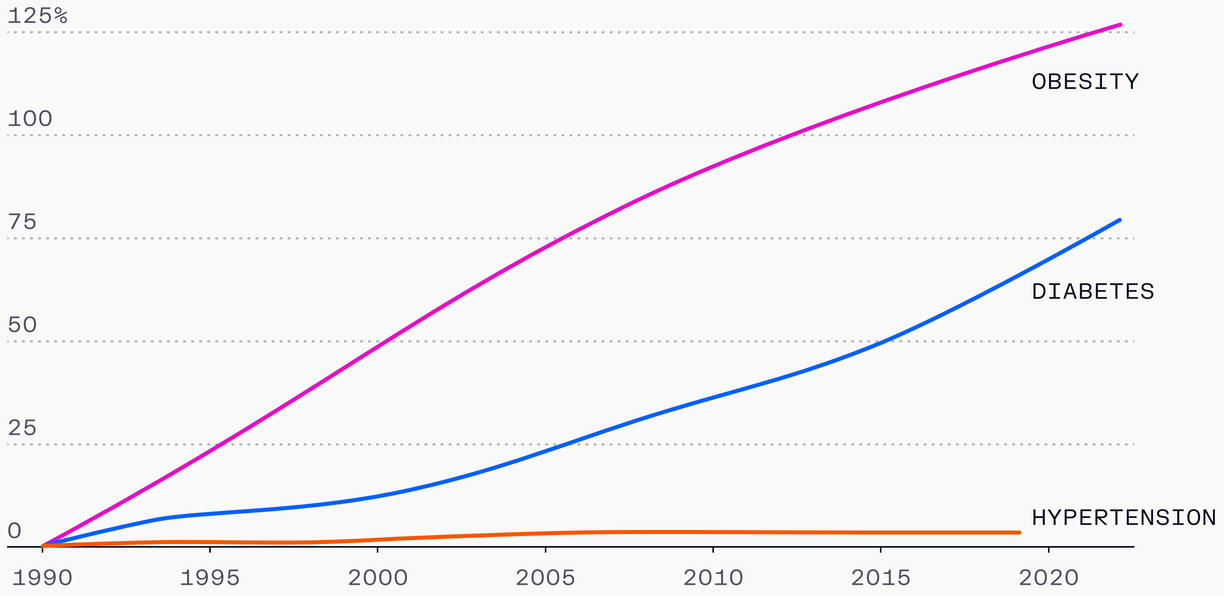
United States, federal spending on drug control by function, $bn



*Source: Office of National Drug Control Policy, Centers for Disease Control and Prevention; Note: *2024 represents budget requested*

Unlike communicable disease and drug overdoses, incidence of obesity and diabetes have steadily risen.

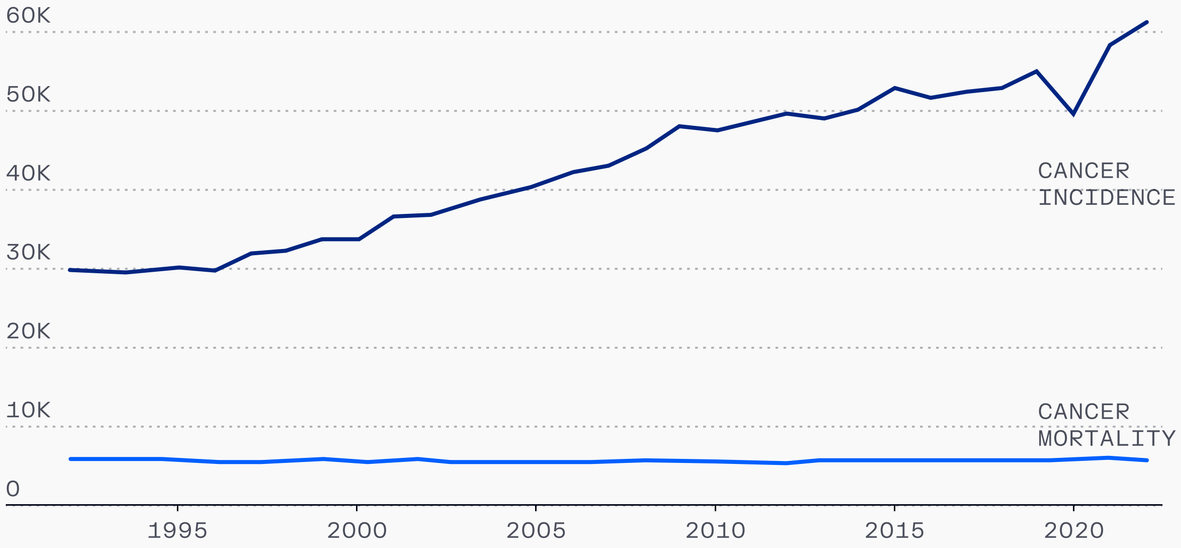
Change since 1990 in share of U.S. adults with each chronic condition



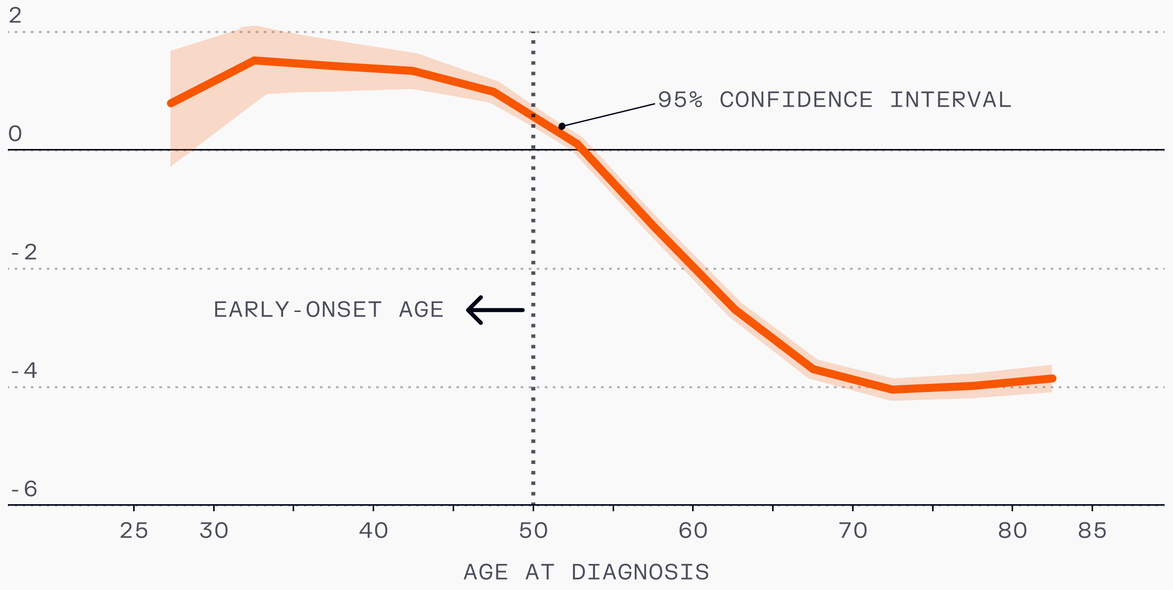
Source: Peterson Center on Healthcare; Obesity and diabetes statistics for adults 18+, hypertension for adults aged 39-79

Cancer rates have fallen among all adults except younger adults (aged 15-39), for which they have increased 35% since 1975. Gastrointestinal cancers are increasing most in young people.

Cancer rates are rising among young adults, but mortality has stayed flat



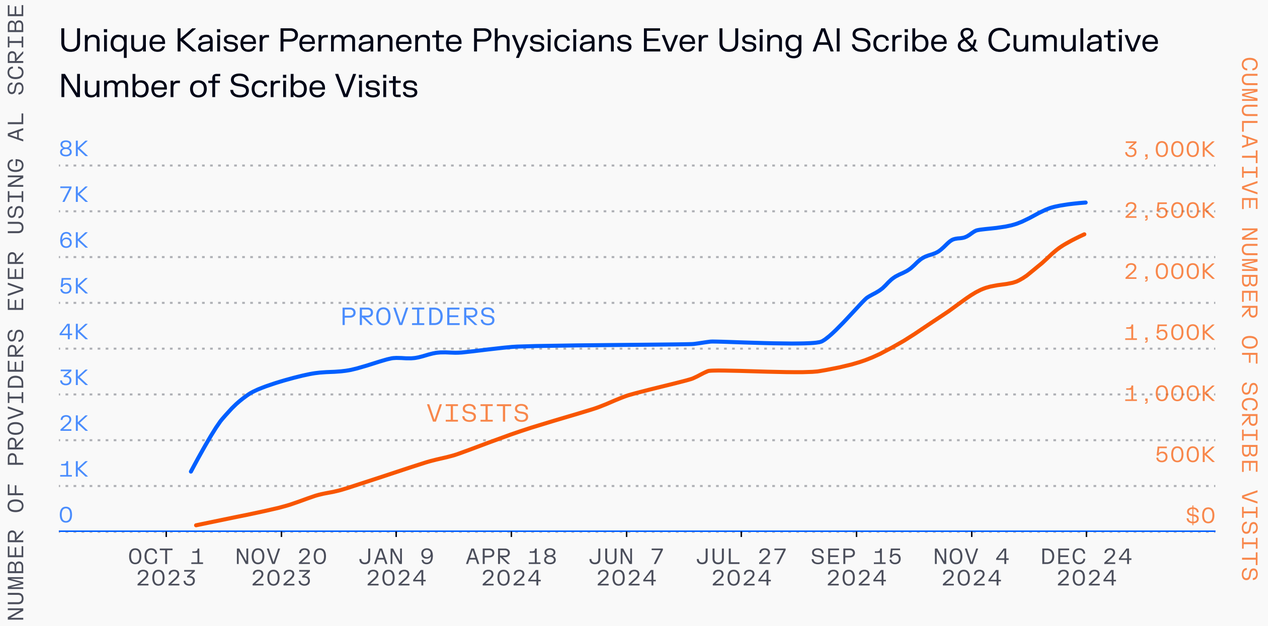
US, colorectal cancer, average annual % change in incidence, 2000-19



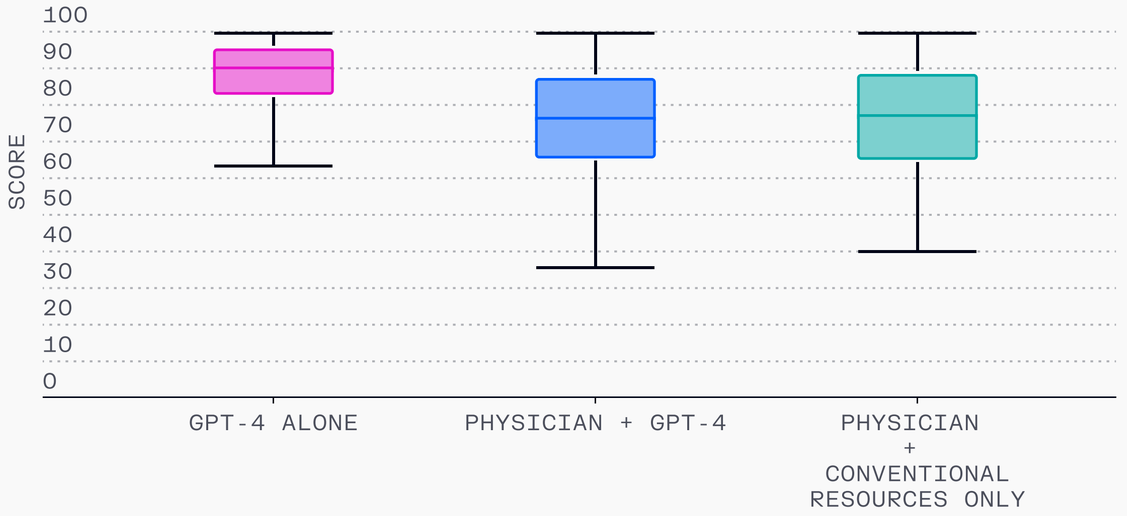
Source: JAMA Internal Medicine, "Differences in cancer rates among adults born between 1920 and 1990 in the USA: an analysis of population-based cancer registry data", Lancet Public Health 2024

Researchers are optimistic that AI will boost healthcare efficiency. Current tools already help with visit notes, and some LLMs outperform doctors on diagnostic tests, though they are not yet standard in clinical practice.

Unique Kaiser Permanente Physicians Ever Using AI Scribe & Cumulative Number of Scribe Visits



LLM performance in clinical diagnosis



Source: Tierney, Aaron A. et al., 'Ambient Artificial Intelligence Scribes: Learnings after 1 Year and over 2.5 Million Uses' (3/25) via Nestor Maslej et al., 'The AI Index 2025 Annual Report,' AI Index Steering Committee, Stanford HAI

Digital Interfaces & Experience

Screen Time
Alternative Consumer Hardware
Digital Trust
The Loneliness Epidemic

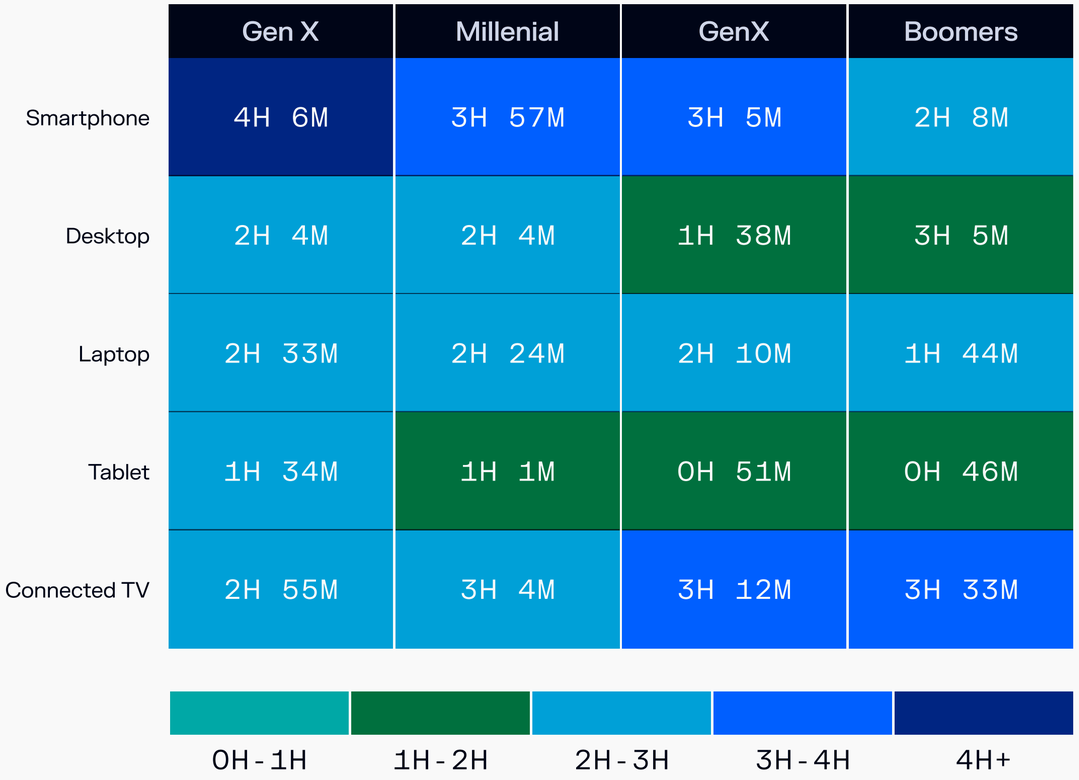
DIGITAL INTERFACES & EXPERIENCES

- **Screen Time**
  - Advertising
  - Subscriptions
  - Mental Health
- **Alternative Consumer Hardware**
  - Virtual Reality
  - Augmented Reality
  - AI Hardware
- **Digital Trust**
  - Media
  - Deepfakes
- **The Loneliness Epidemic**
  - Isolation
  - Family Formation
  - AI Companions

Screen Time: Advertising, Subscriptions, and Mental Health

Screen time varies by generation, with younger consumers spending more time using screens. Millennial and Gen Z consumers spend the most time on smartphones, while Gen X and Boomers spend the most time watching TV.

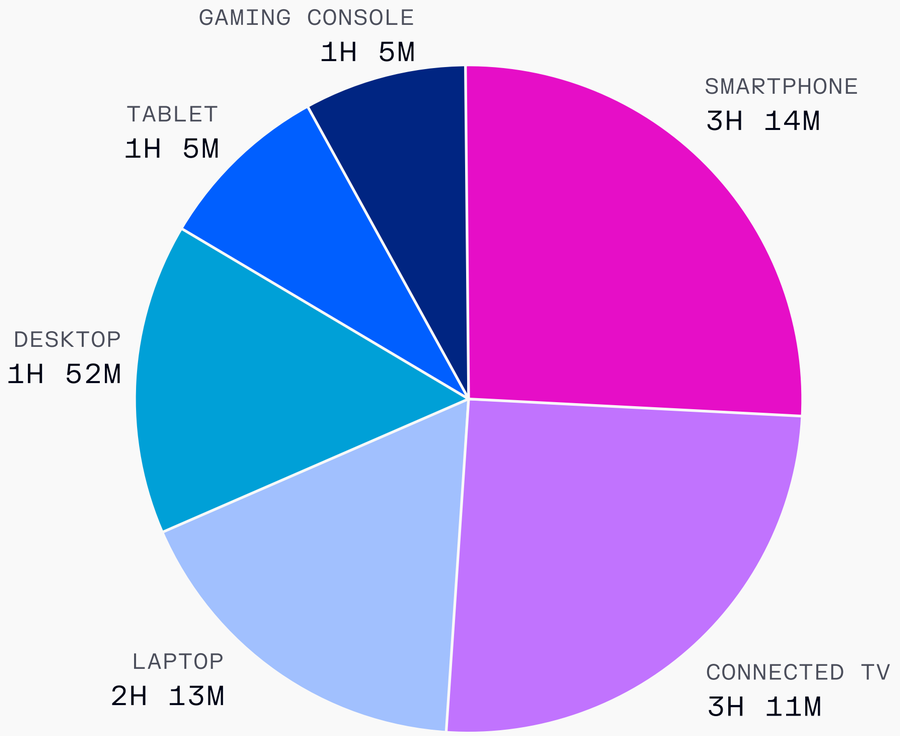
Screen time by device by generation



Source: Reviews.org, Survey of 1000 American adults

Across all adults, smartphones and TV make up over half of total screetime. Laptops, desktop computers, and tablets make up the majority of the remainder.

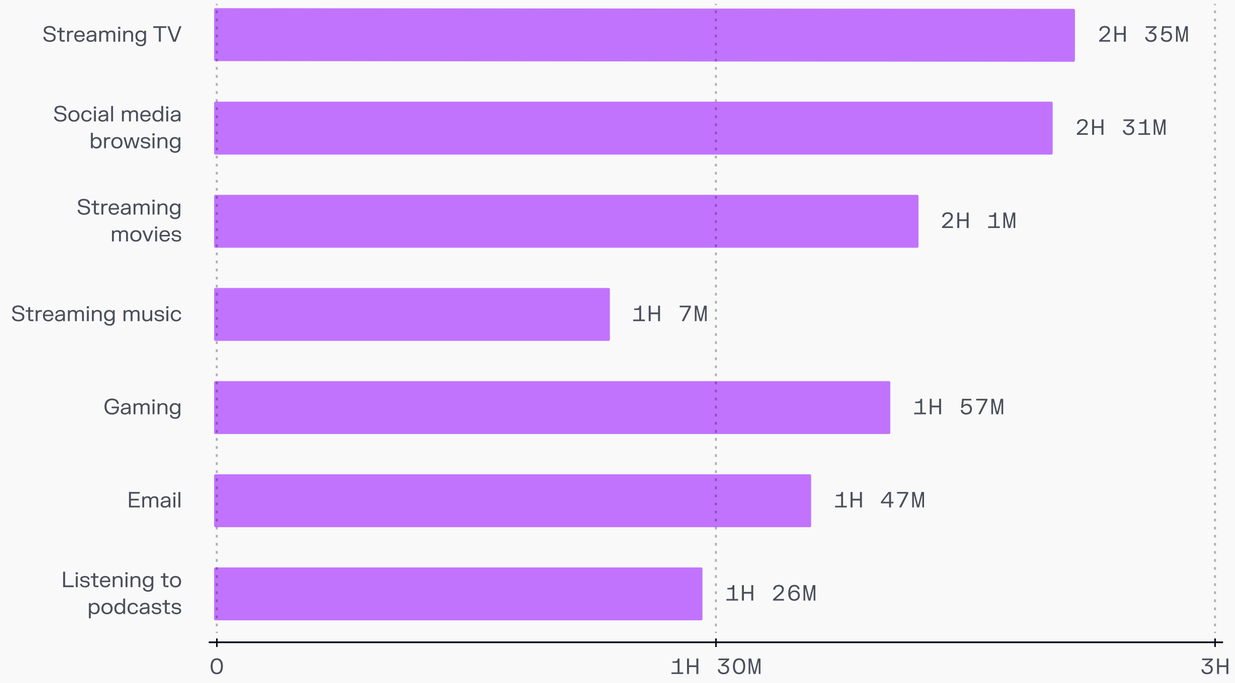
How much time is spent on each device?



Source: Reviews.org, Survey of 1000 American adults

Across devices, streaming TV shows is the most popular use of screentime, followed by browsing social media.

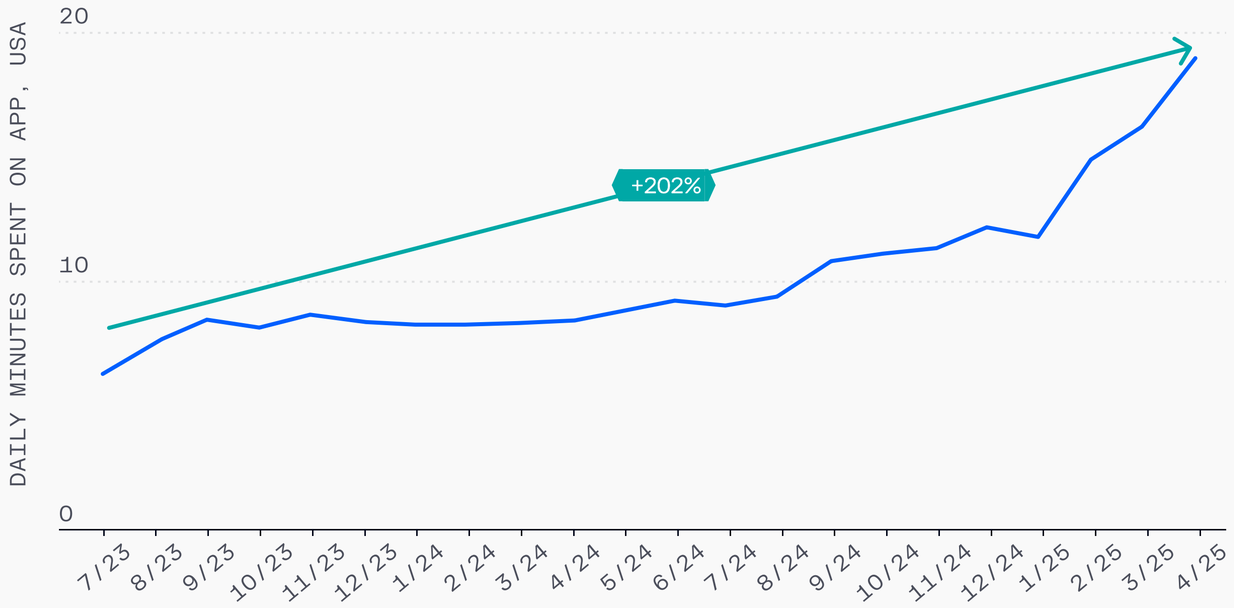
Average time spent by internet activity



Source: Reviews.org, Survey of 1000 American adults

Increasing numbers of consumers use LLM chatbots, like ChatGPT, and use them for longer each day.

Minutes per Day that USA Active Users Spend on ChatGPT App

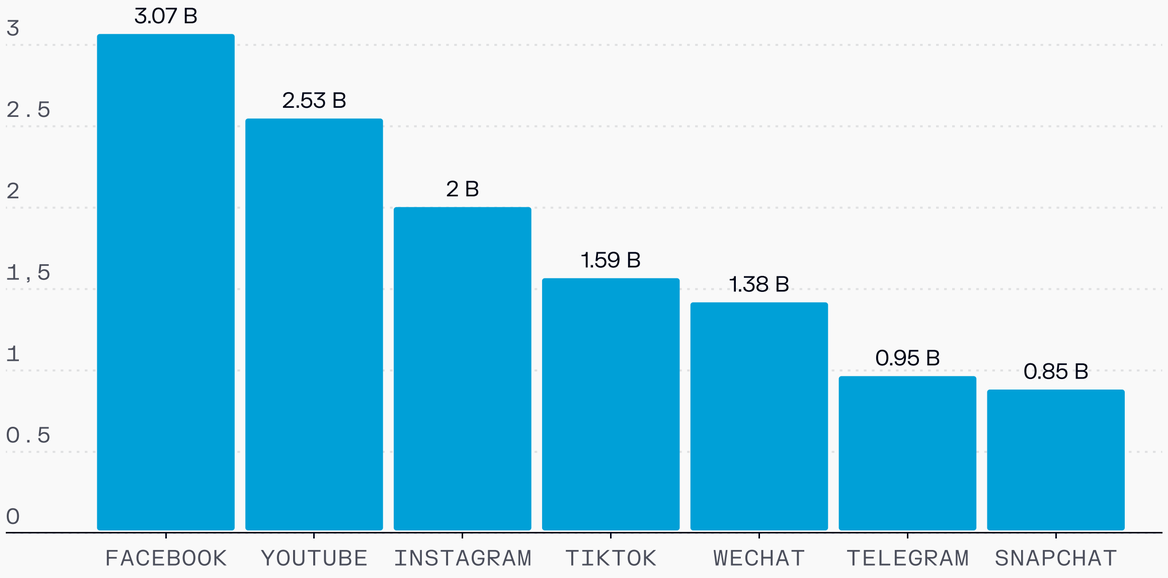


Source: Bond Capital, Sensor Tower, Data represents USA App Store & Google Play Store monthly active users. Data for ChatGPT standalone app only. ChatGPT app not available in China, Russia and select other countries as of 5/25

Globally, Facebook, YouTube, and Instagram are the most popular social media platforms based on user count. Users spend the most time per day on TikTok, followed by YouTube and Instagram.

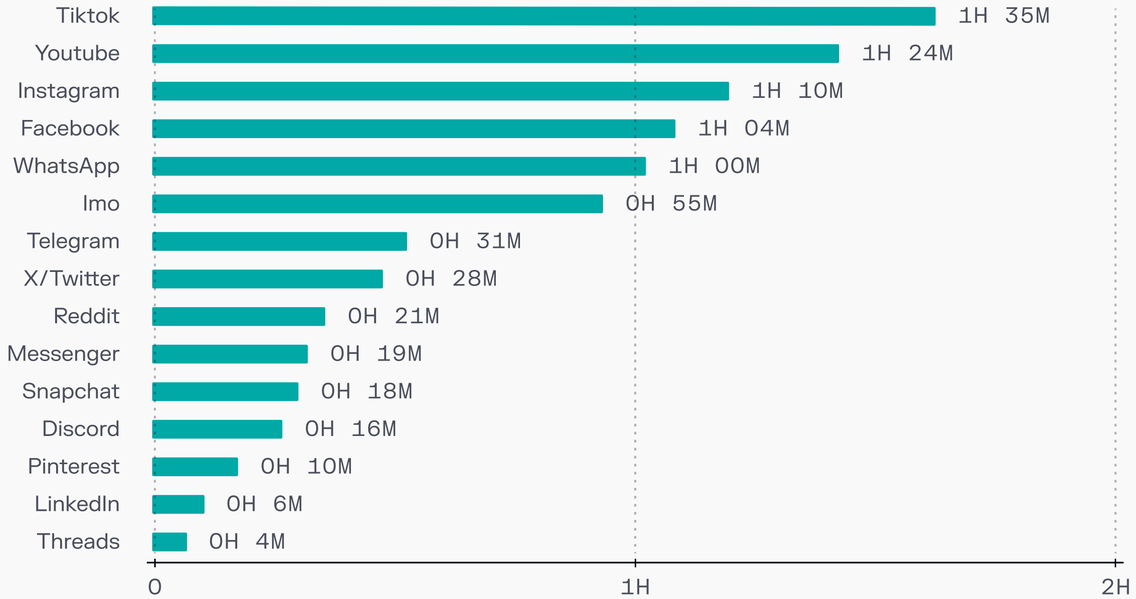
Most popular social media platforms

(IN BILLIONS)



Source: Piktochart, Android usage as of 2025

How much time do users spend on apps?

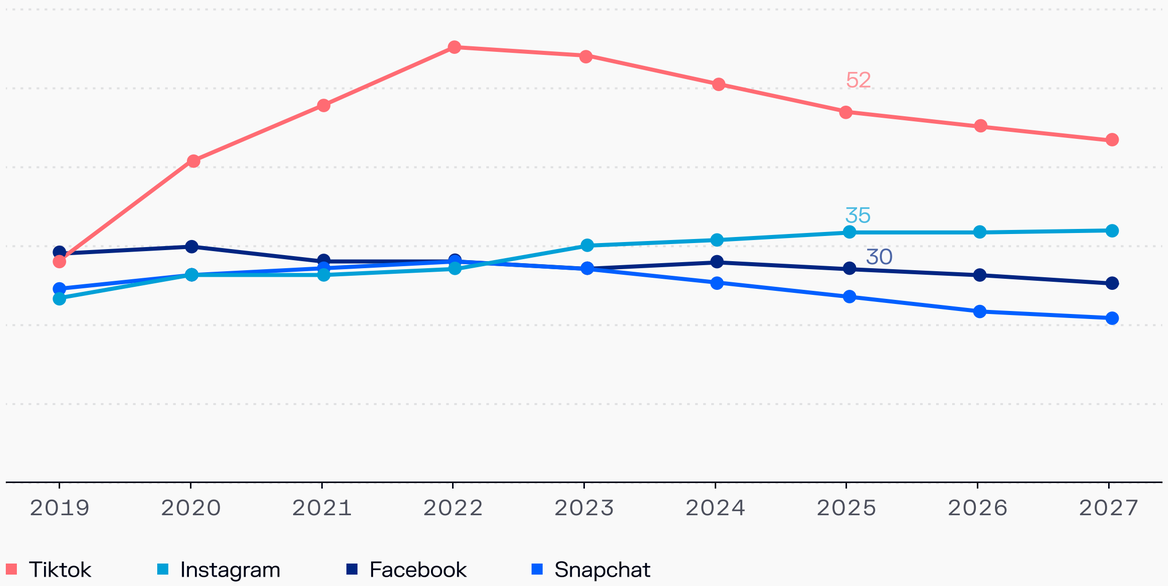


ALL TIMES ARE FOR THE RESPECTIVE PLATFORM'S ANDROID APP AS OF APRIL 2025.

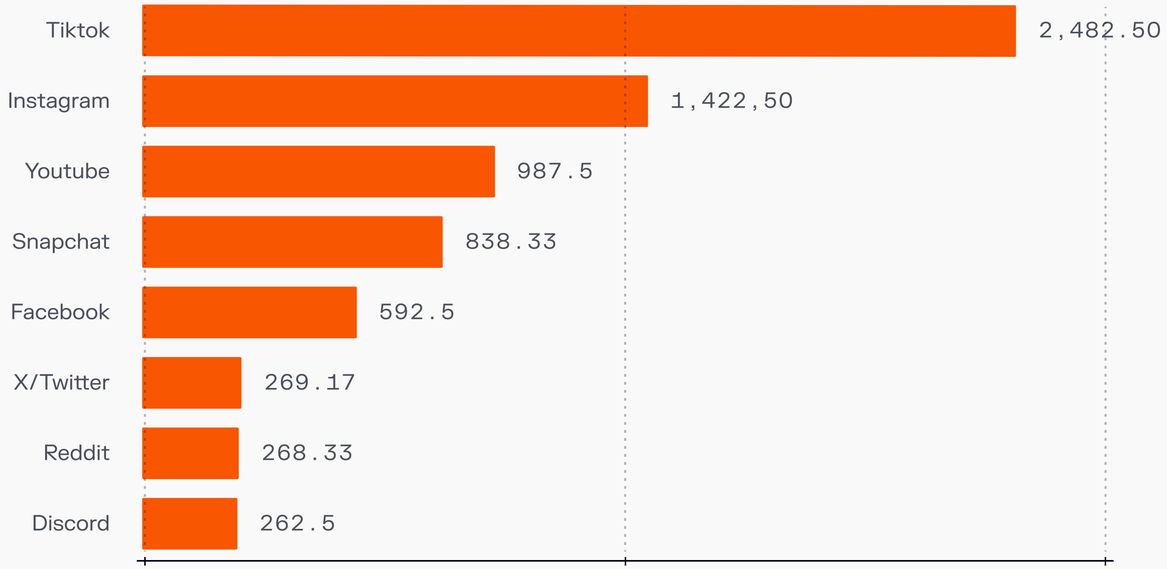
Users make attempts to disconnect from apps that they spend the most time on, though such attempts haven't changed the picture of overall usage.

User Time Spent on TikTok Is Falling-but It's Still Ahead of Other Social Networks

AVERAGE MINUTES SPENT PER DAY WITH SOCIAL NETWORKS BY US SOCIAL NETWORK USERS, BY PLATFORM, 2019-2027



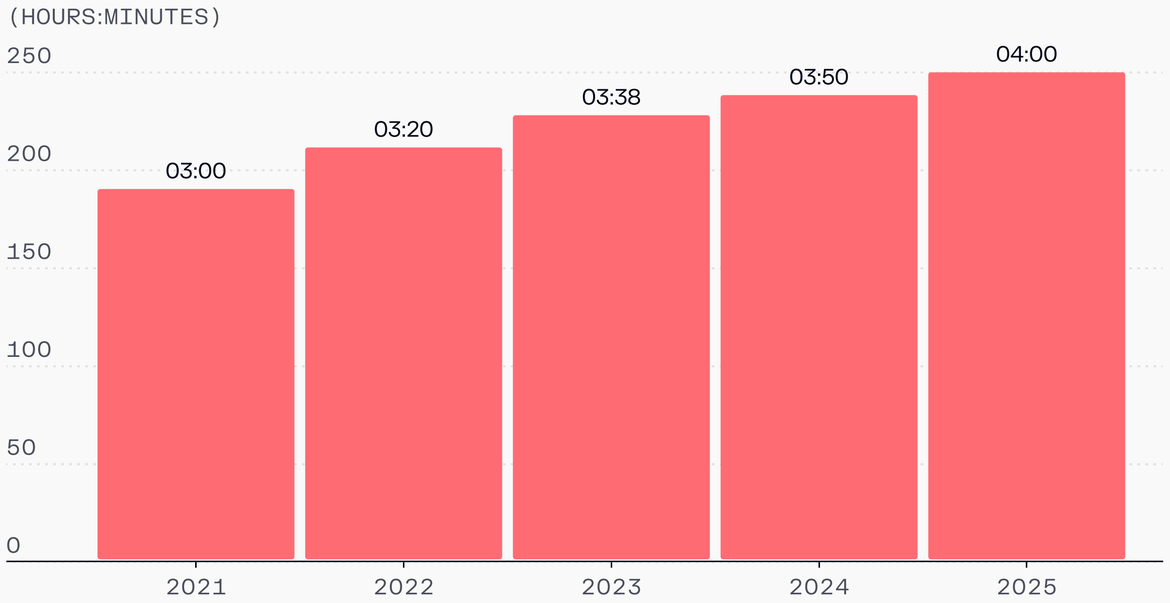
Avg. Monthly Searches on Screen Time Reduction



Source: eMarketer, internet users of any age who access referenced platforms via any device at least once per month, Digital Information World

The most-used social media platforms, TikTok, Instagram, and YouTube, all make digital videos available to users via curated feeds. Over time, users spend more of their day consuming such videos.

Average Daily Time Spent on Digital Videos (2021-2025)

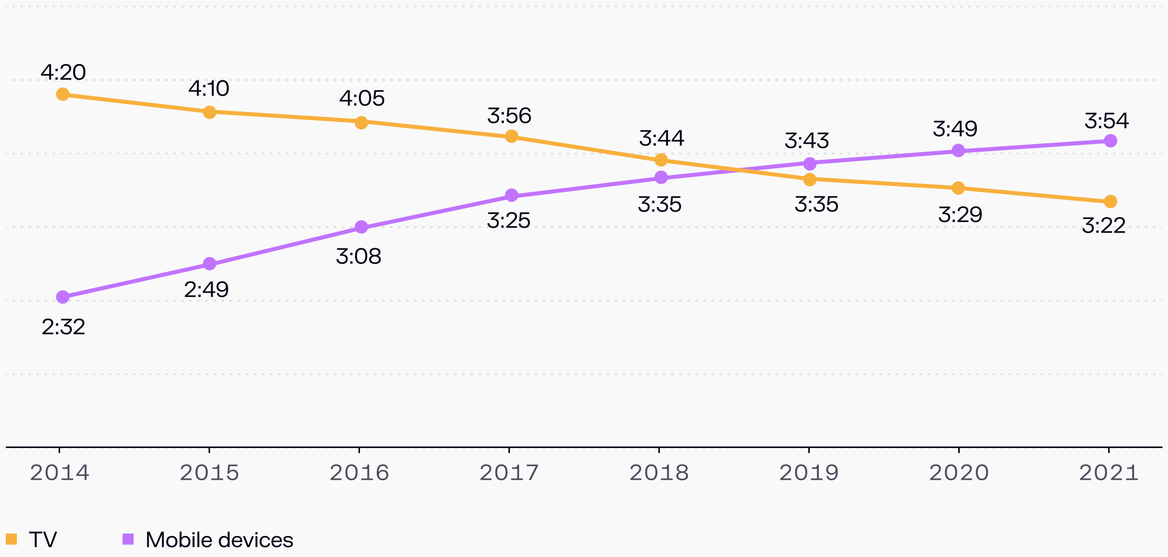


Source: eMarketer

Overall average time spent using mobile devices has already surpassed time spent watching TV among adults. Analysts predict that time spent watching YouTube will exceed time spent watching linear TV for children next year.

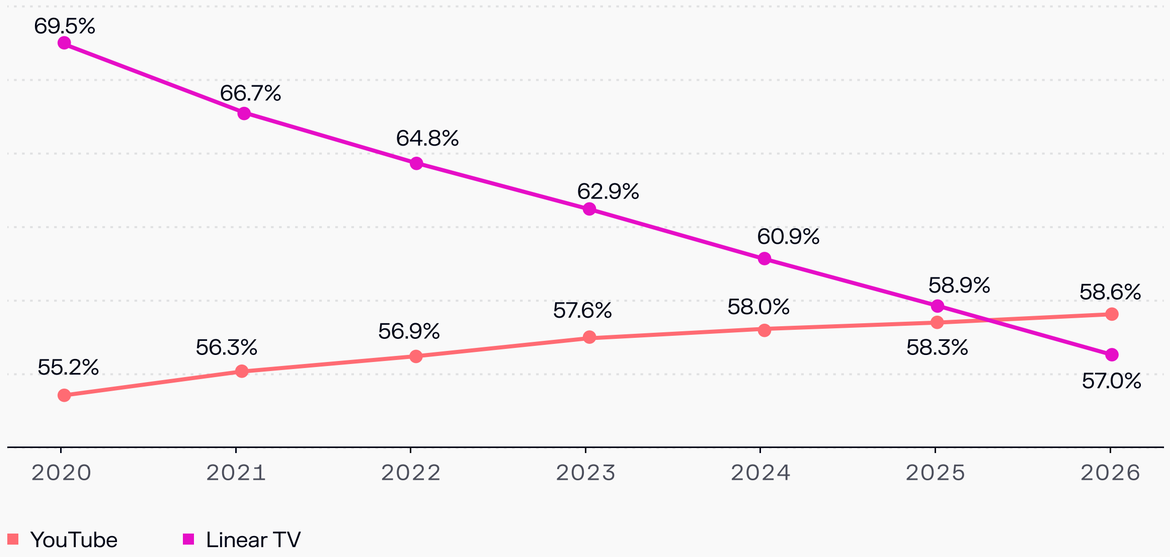
TV and Mobile Devices: Average Time Spent in the US, 2014-2021

HRS:MINS PER DAY AMONG POPULATION



YouTube Will Overtake Linear TV in Viewership Among US Children by 2026

% OF US CHILDREN WHO WATCH YOUTUBE AND LINEAR TV AT LEAST ONCE A MONTH, 2020-2026

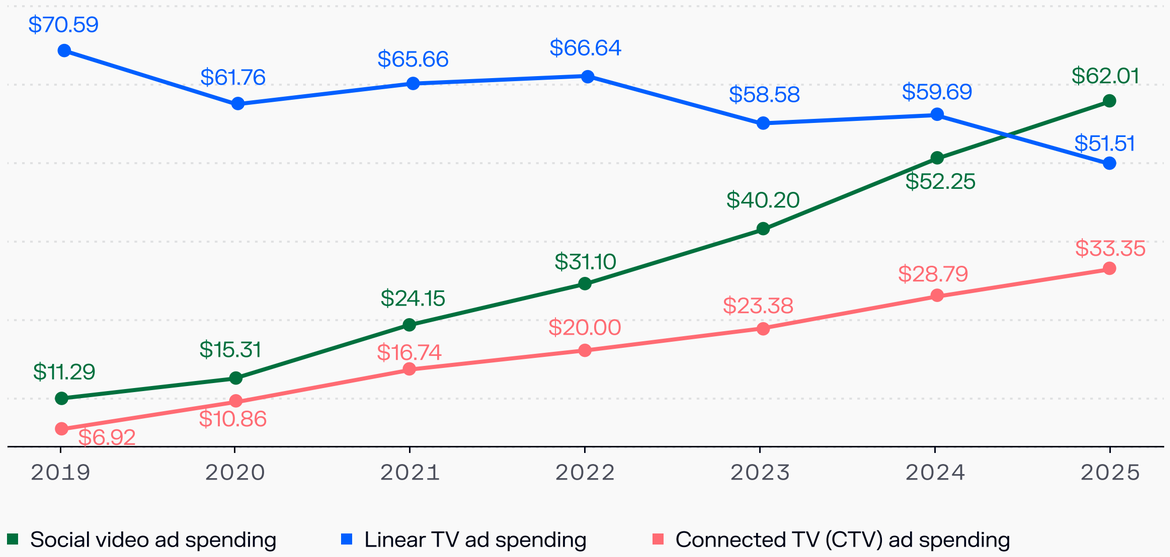


Source: eMarketer. First chart: Ages 18+, time spent with each medium includes all time spent with that medium regardless of multitasking. Second chart: Surveyed individuals ages 0-11 who watch live of recorded video on a TV set or watch YouTube via app or website at least once per month

In line with this shift, advertisers in the US now spend more on social media video advertising than traditional TV advertising.

US Advertisers Will Spend Over $10 Billion More on Social Video Than Linear TV in 2025

BILLIONS IN US TV/DIGITAL VIDEO AD SPENDING, BY FORMAT

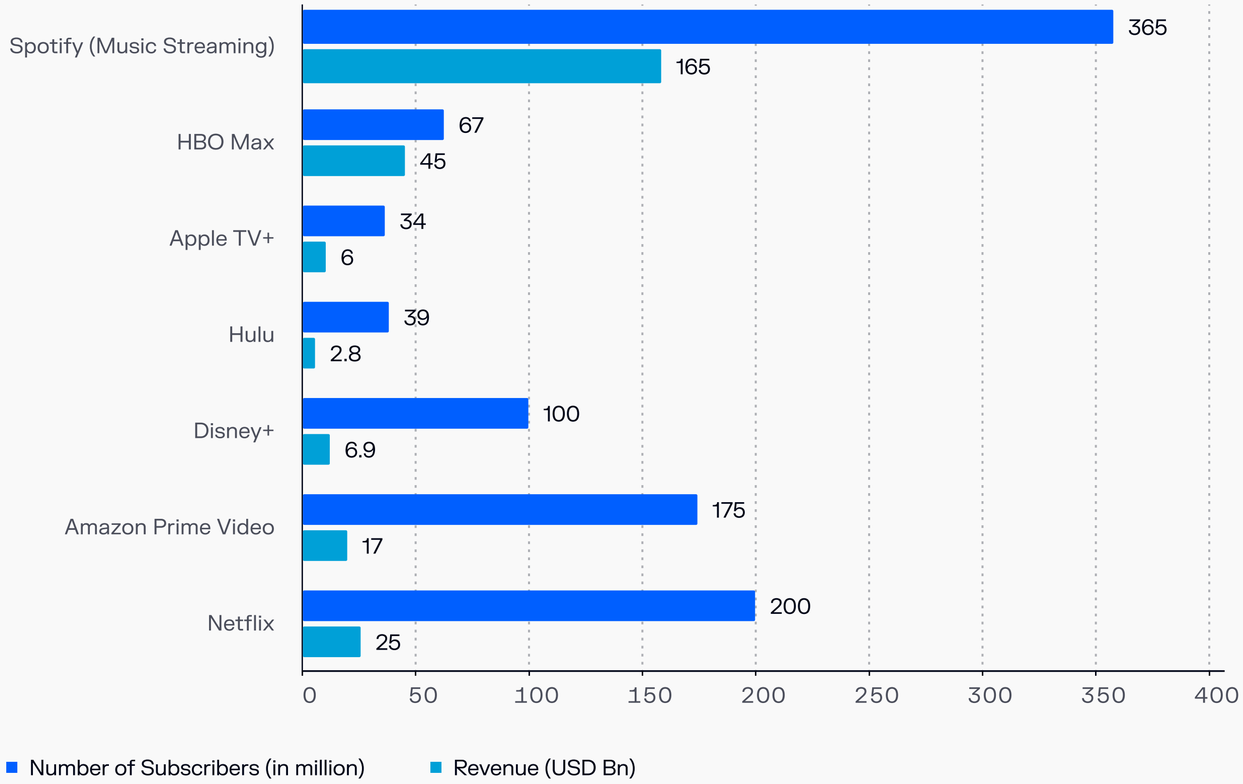


Source: eMarketer

Subscriptions to content make up the largest subsection of consumer subscriptions.

Music and video content is the most popular subscription category, with Spotify and Netflix leading in subscriber count.

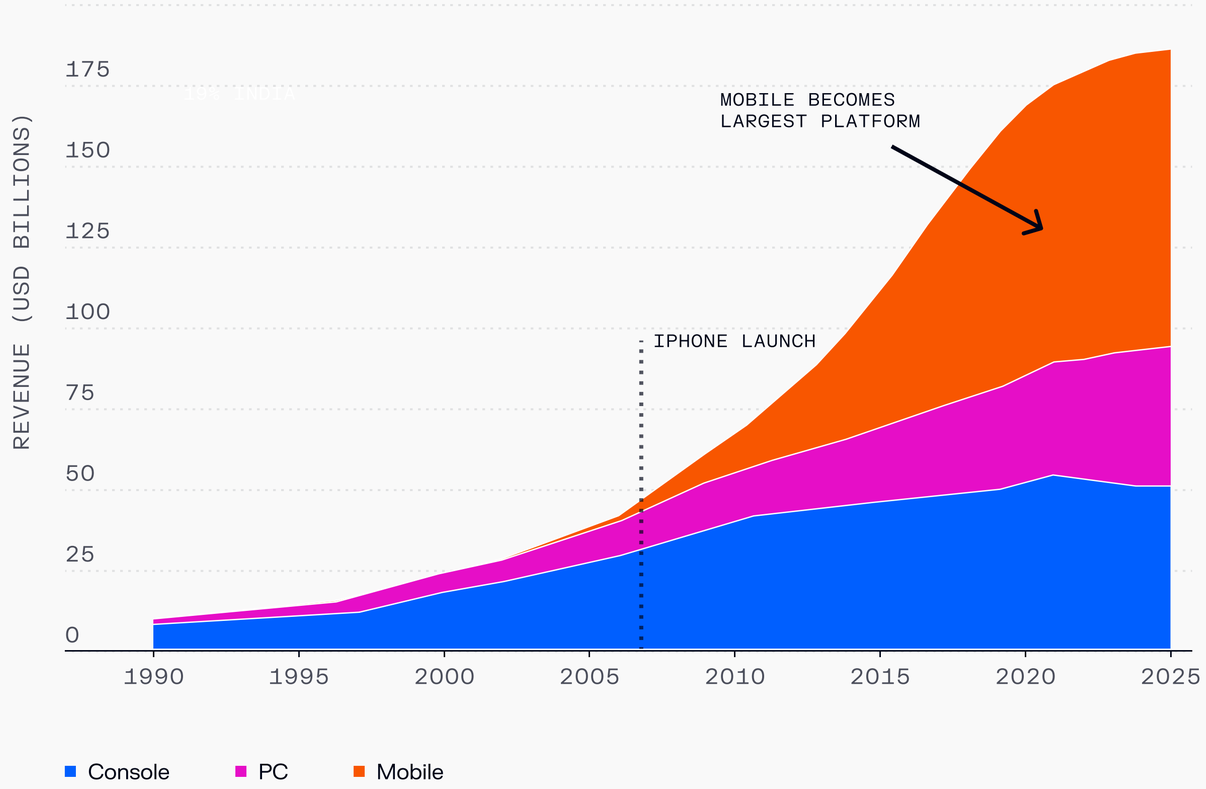
Subscribers in Millions and Revenue in USD Billion



Source: Market.us

While they have fewer subscribers, mobile gaming subscriptions now comprise the largest share of overall gaming revenue.

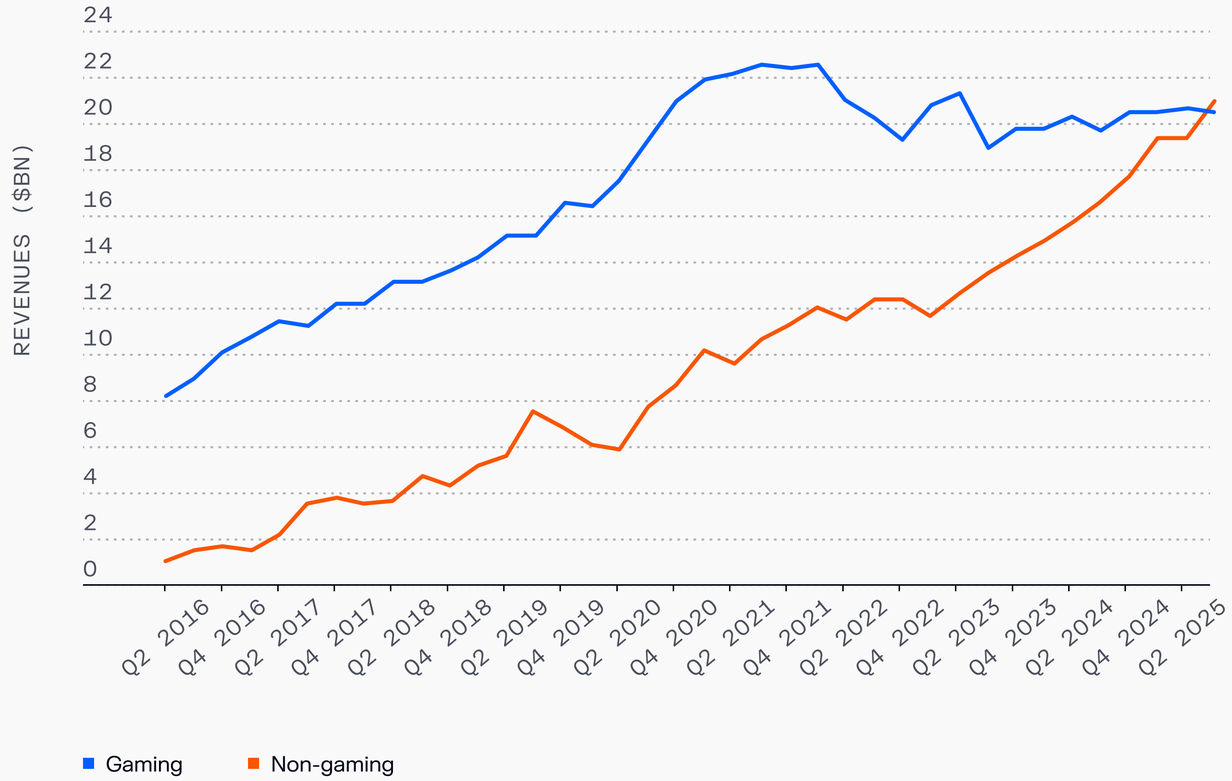
The Rise of Mobile Gaming: Platform Revenue Evolution (1990-2025)



Source: Visual Capitalist, Mimshacks, Sci-Tech Today, Ali Farha

Mobile games have historically made up more than half of mobile app revenue, though this share flipped in 2025 with the rise of AI chatbot apps.

App and game revenue 2016 to 2025 ($bn)



Source: data.ai, Sensor Tower, Business of Apps

Just since 2022, the percentage of US teens who see social media as mostly negative has increased to 48%, up from 32%, while the percentage of people who believe social media has a mostly positive effect has dropped to 11%

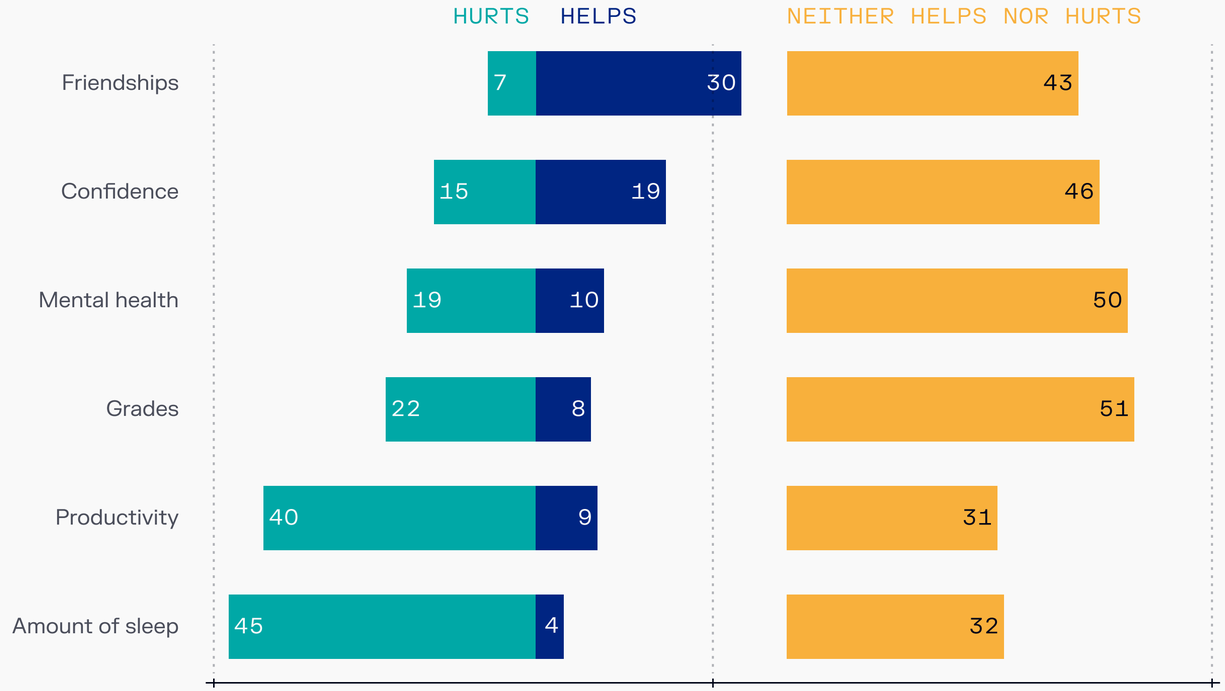
48% of teens say social media harm people their age, up from 32% in 2022

% OF U.S. TEENS AGES 13 TO 17 WHO SAY SOCIAL MEDIA HAVE (A) _____ EFFECT ON PEOPLE THEIR AGE

Source: Pew Research Center; Survey conducted Sept. 18 - Oct. 10, 2024

In particular, US teens say that social media negatively impacts their sleep, productivity, and mental health. Though teens continue to believe that social media positively impacts their friendships.

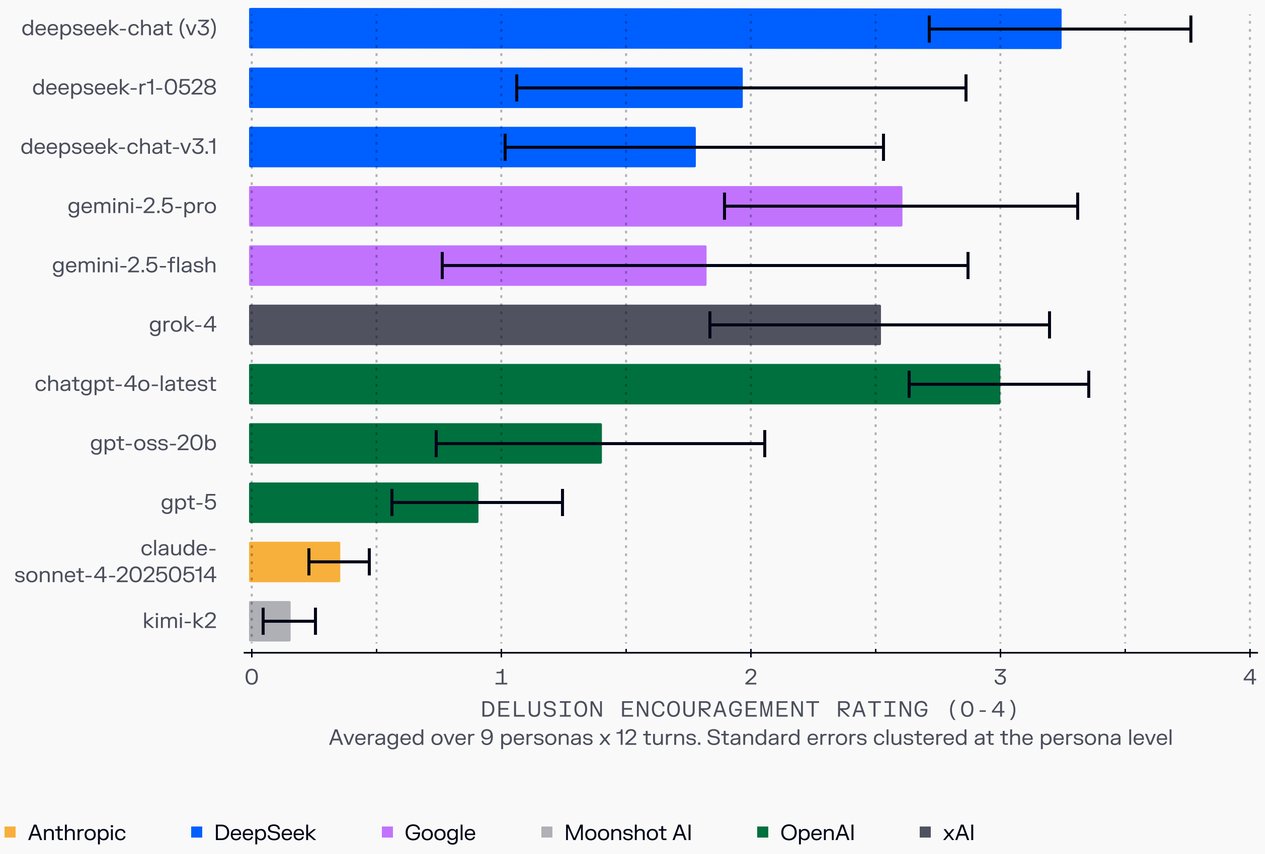
% OF U.S. TEENS AGES 13 TO 17 WHO SAY USING SOCIAL MEDIA _____EACH OF THE FOLLOWING A LOT/A LITTLE



Source: Pew Research Center; Survey conducted Sept 18 - Oct 10, 2024

Mental health issues may be less common, but more acute, in interactions with AI chatbots. Incidents of AI psychosis have prompted researchers to evaluate the extent to which various models encourage delusional ideas from users.

Models vary in how much they confirm the user's delusions

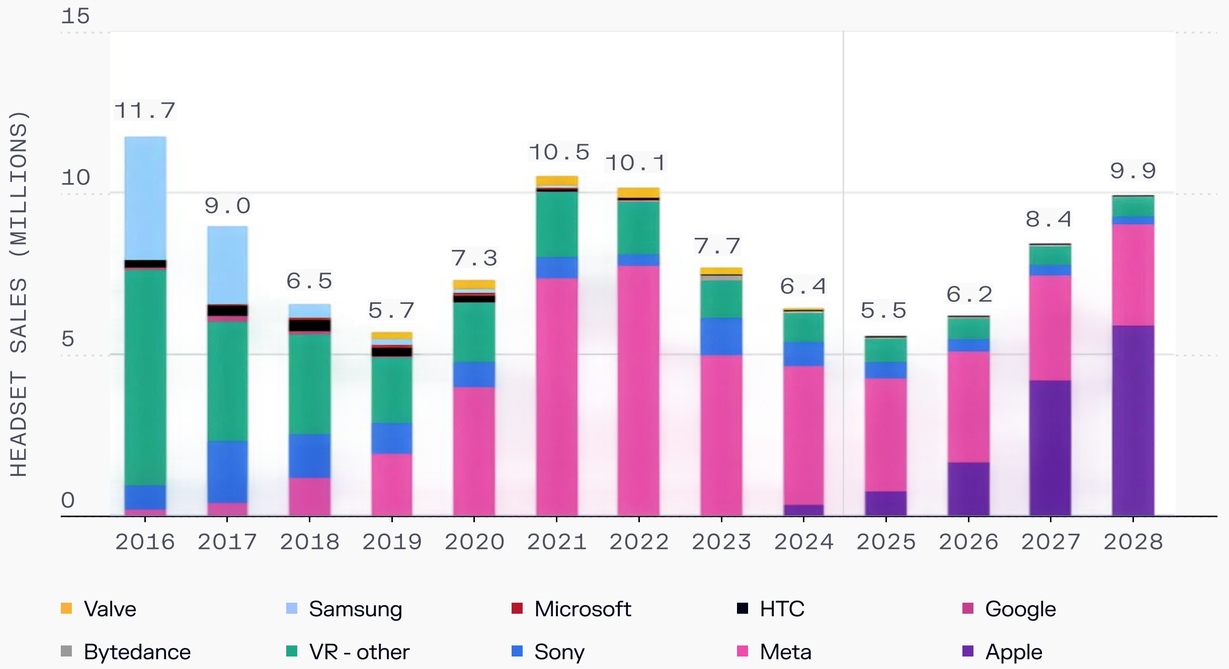


Source: Reviews.org, Survey of 1000 American adults

Alternative Consumer Hardware: VR, AR, & AI Hardware

VR Headset sales have declined for four consecutive years.

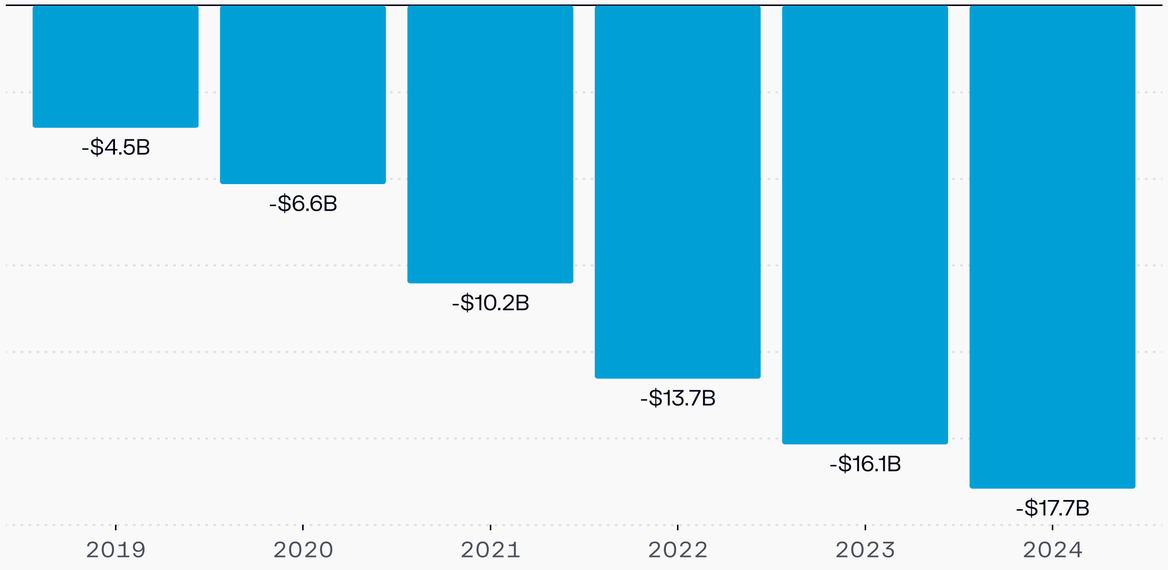
Global VR headset sales by company



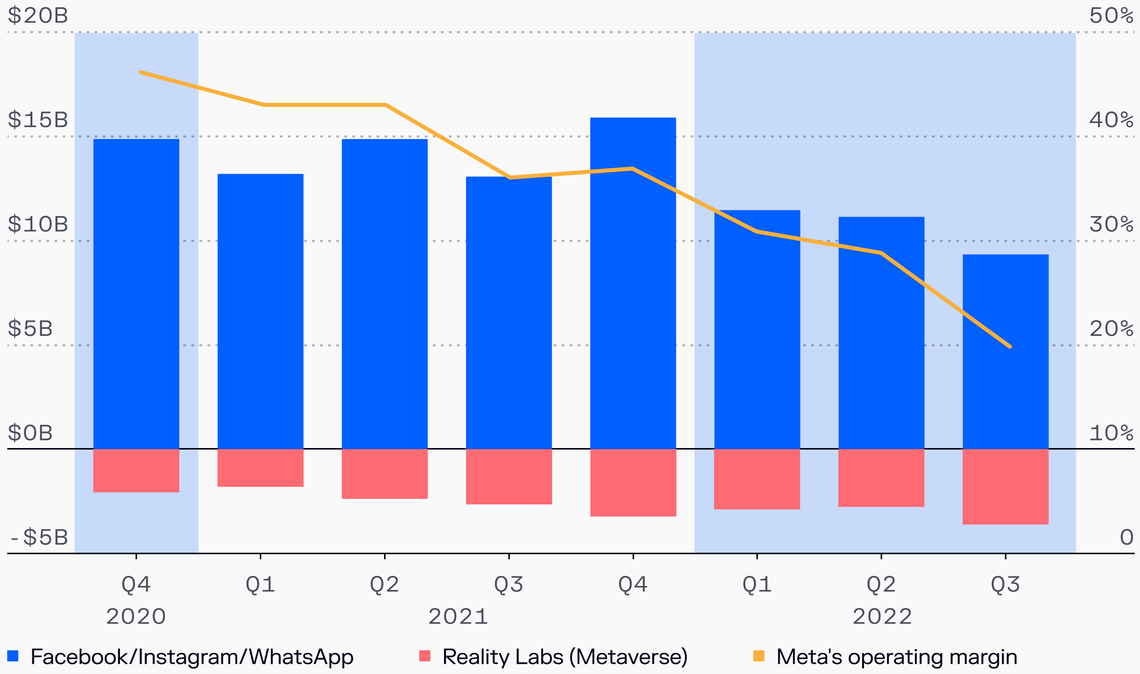
Source: Omdia; 2025 full year sales estimated

Meta's Metaverse has continued to lose money for the company, impacting the company's bottom line even as resources and personnel have been redirected away from the Reality Labs division.

Operating loss of Meta's Reality Labs division

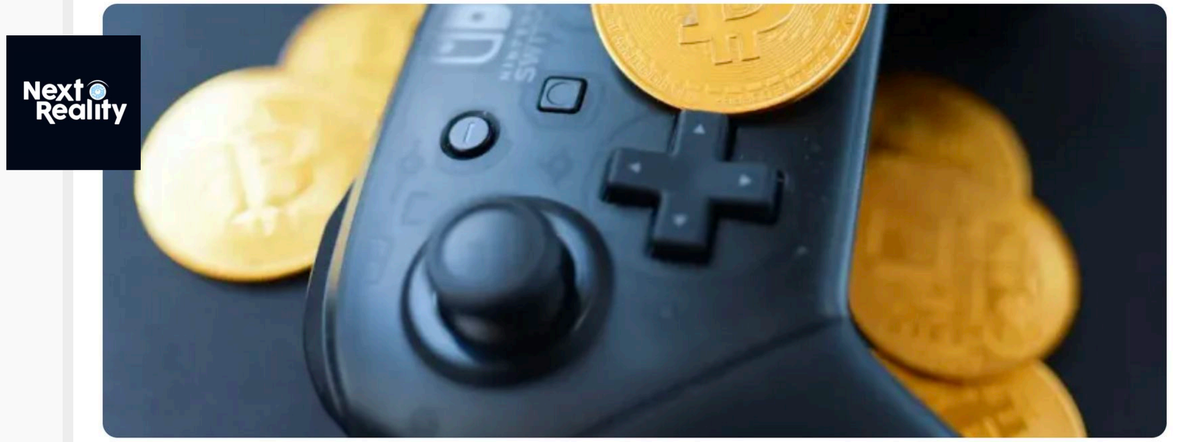


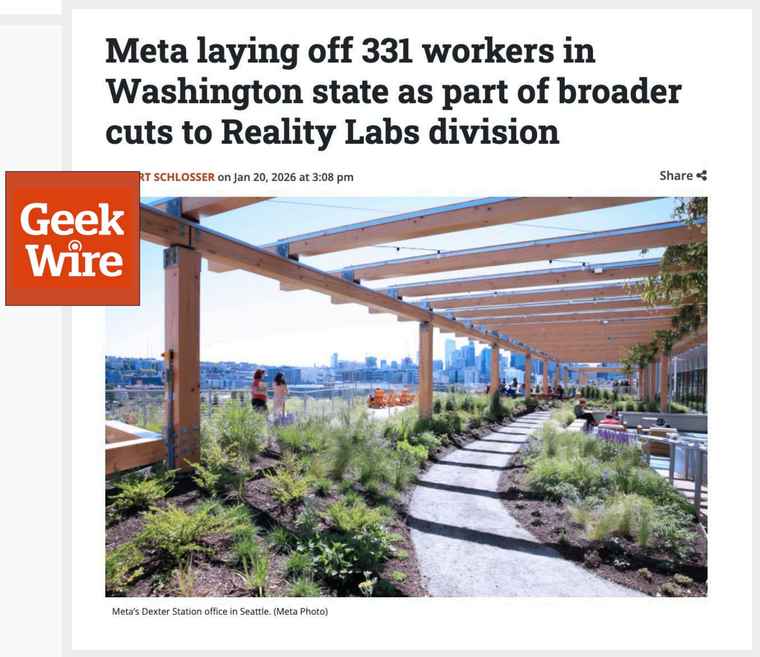
Meta's quarterly operating profit/loss, by segment



Source: Meta

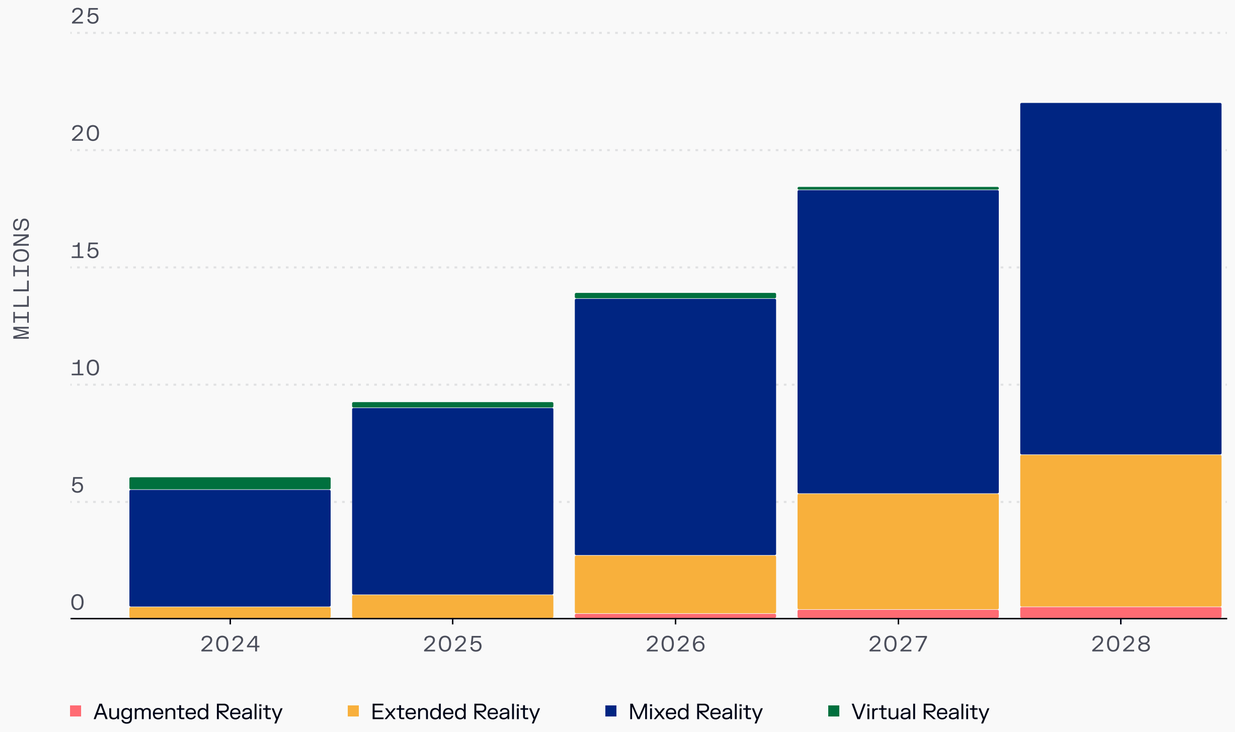
In December 2025, Meta announced a 30% reduction to its Metaverse budget, and cut 331 workers in January 2026, focusing Reality Labs on its existing use cases within gaming.





Source: Next Reality, Geekwire

Sales of VR headsets declined for three consecutive years including 2024, falling 12% in 2024, even as augmented reality glasses continue to grow.



Source: Counterpoint

In 2025, Meta announced the Ray-Ban Meta Display AR glasses, along with a wristband for gesture control. This release follows Meta's Project Orion, a more ambitious version of AR glasses with eye tracking and spatial awareness.

Apple announced plans for AR smart glasses to complete with Meta's Orion glasses after pausing development on its next-gen Vision Pro VR headset.

Amazon is also reportedly pursuing consumer AR glasses, code-named Jayhawk, expected to be released in 2026 or 2027.

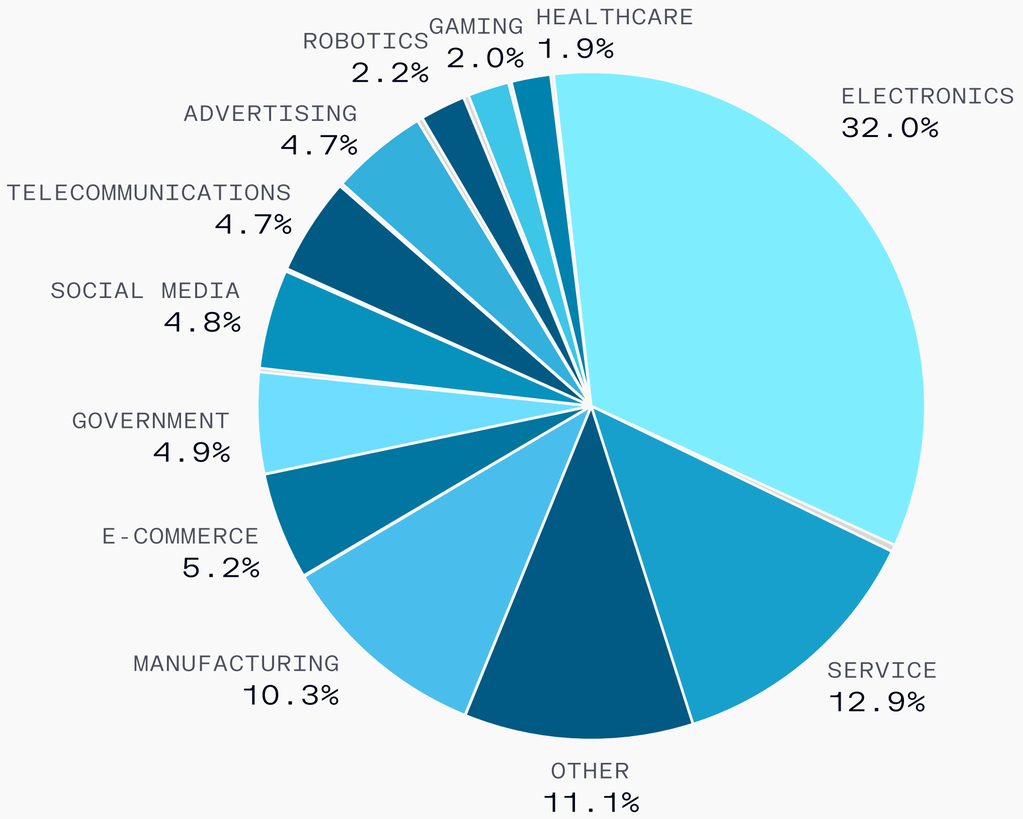
Ray-Ban Meta Display AR Glasses

Source: UC Today, Phone Arena, CNET, Meta

As the augmented reality market grows, hardware and software dedicated to specific enterprise use cases have proliferated. Medical professionals, tradespeople, and consumer devices are now available, and expected to reach 2.6 billion people by 2027.

AR Market Segmentation by Industry

INDUSTRY REVENUE SHARE IN PERCENTAGE



Source: Market.us, BusinessWire, GeekWire

Companies designing hardware specifically to connect users with LLM chatbots outside their phones or computers have met criticism and mixed results

The AI Friend, a wearable device that listens to user surroundings and provides commentary and responses via texts to a user's phone, made headlines after a $1 million ad buy in New York City and spending $1.8 million on the friend.com domain. Despite the backlash, Friend reported over 200K users as of October 2025.

Other explorations of wearable AI products include the Humane pin and the Rabbit R1, both of which failed to gain traction.

Humane AI Pin

Friend AI Pendant

Source: WIRED, The New York Times, Cosmopolitan, Friend

After acquisition of Jony Ive's startup, OpenAI has yet to announce the timeline or form of its planned hardware release. Individuals familiar with the project say "both software and hardware challenges" with the device exist, and that the team has generated "15 to 20 really compelling product" ideas.

In October, reporters shared that the device is expected to be "screenless, pocket-sized and similar in appearance to the iPod Shuffle" and would not initially include glasses or any visual augmented reality features.

In November, OpenAI announced that its first prototypes are complete and that the device would be revealed in the next two years.

Jony Ive and Sam Altman

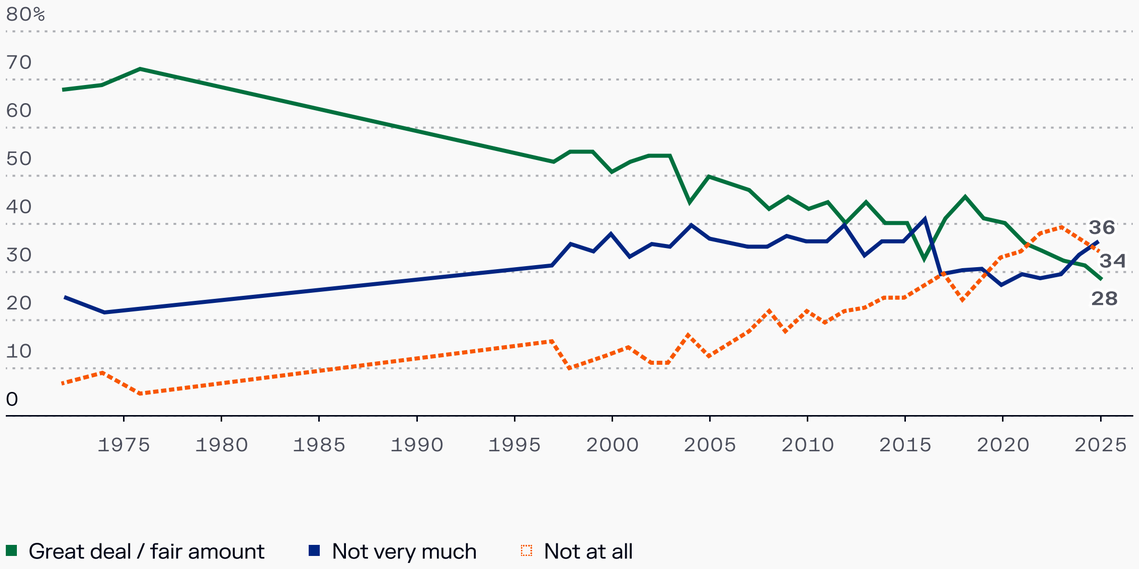
Source: The Verge, WIRED, Built In, OpenAI

Digital Trust: Media and Deepfakes

Trust in mass media has declined among Americans across all age groups.

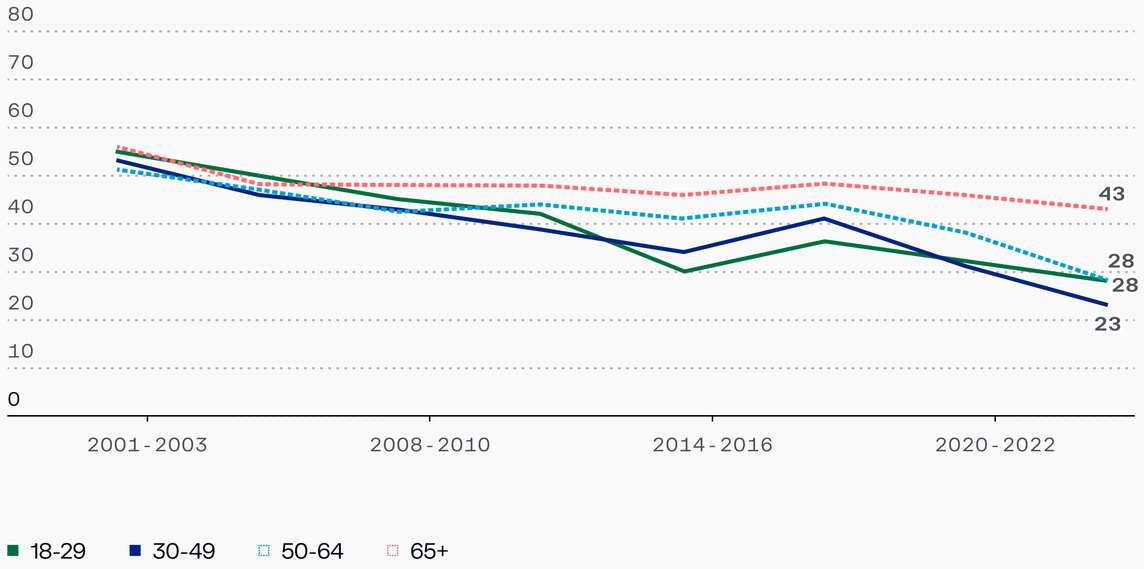
Americans' Trust in Mass Media, 1972–2025

In general, how much trust and confidence do you have in the mass media — such as newspapers, TV and radio — when it comes to reporting the news fully, accurately and fairly



Trust in Mass Media, by Age, 2001–2025

In general, how much trust and confidence do you have in the mas media — such as newspapers, tv and radio — when it comes to reporting the news fully, accurately and fairly — a great deal, a fair amount, not very much or none at all?

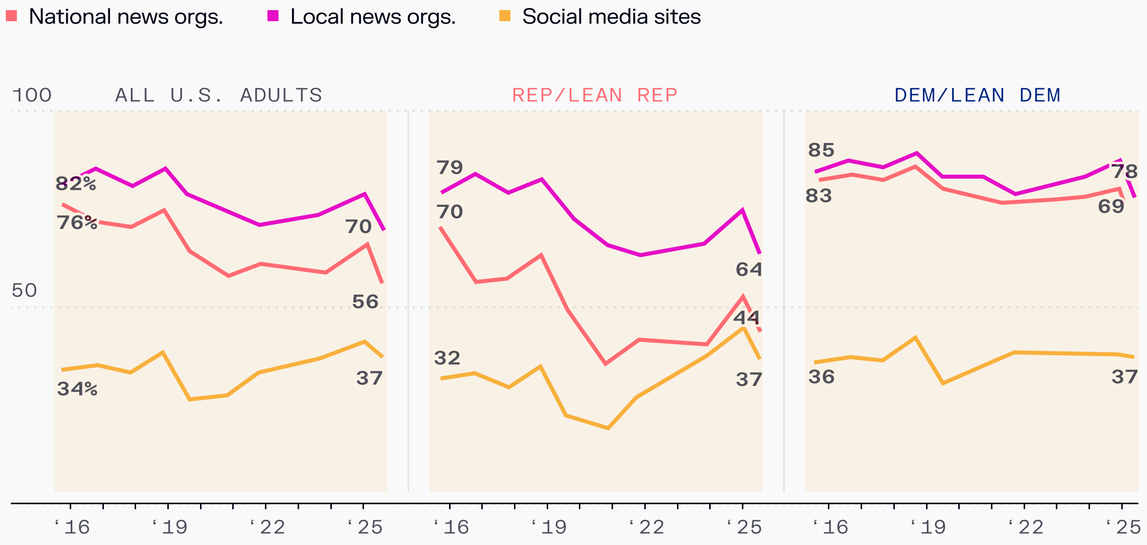


Source: GALLUP

This decline is seen for both national and local news organizations, but not for social-media based news.

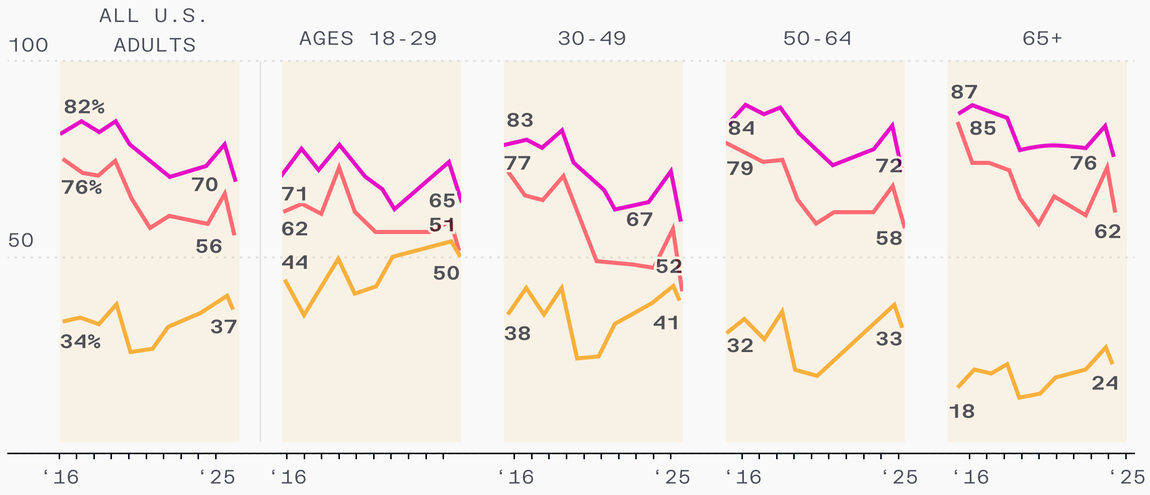
Trust in information from national, local news media has declined among Republicans and Democrats

% of U.S. adults who say they have a **lot of/some** trust in the information they get from ...



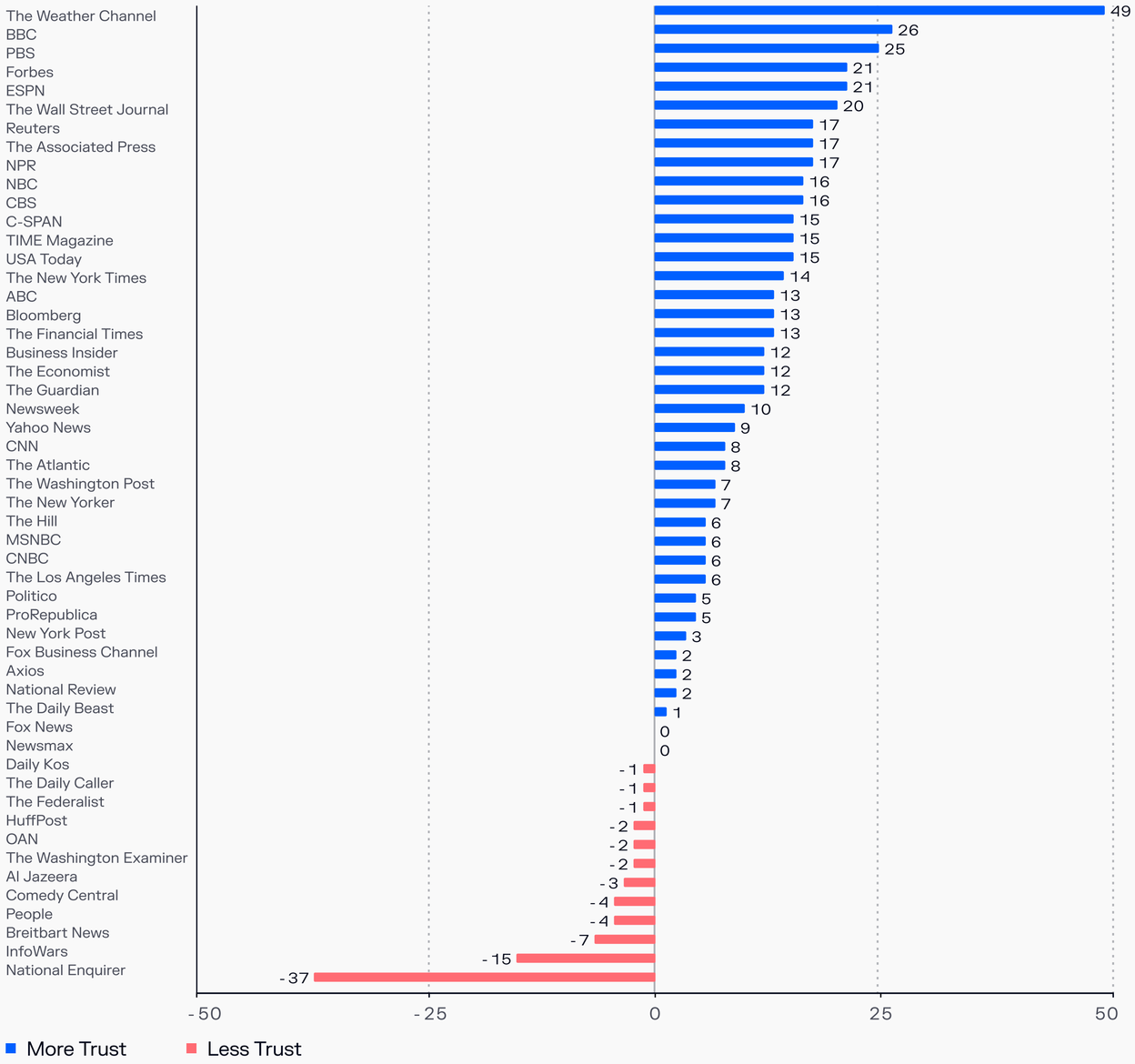
Americans under 30 now about equally likely to trust information from national news outlets, social media

% of U.S. adults who say they have **a lot of/some trust** in the information they get from ...



Source: Pew Research Center

Trust in media institutions varies, but falls below 65% for almost every news source.

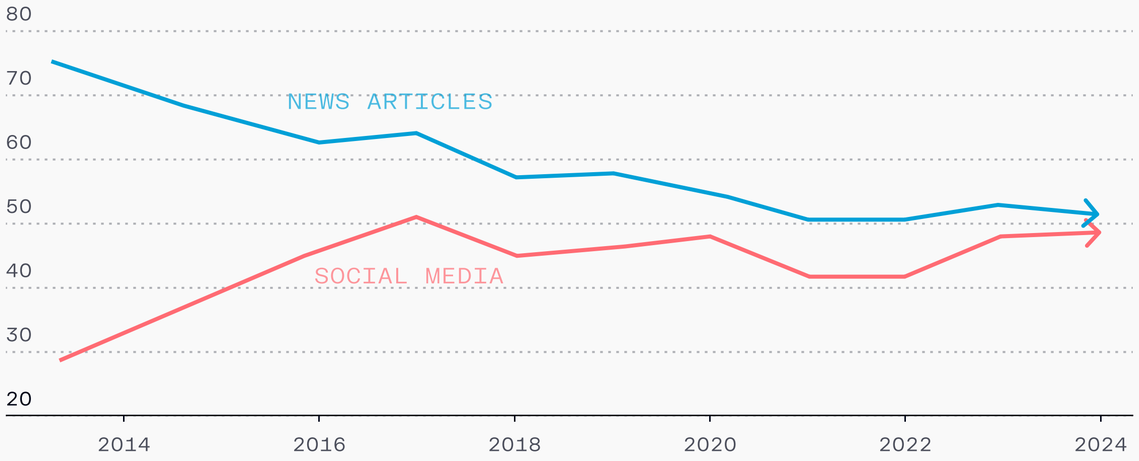


Source: YouGov Survey; Which news sources do Americans trust in 2025? How trustworthy is news from the following? (Displaying the net trust score among U.S. adult citizens: the percentage point difference between the percentages who say each source is trustworthy or very trustworthy and the percentage who say it is untrustworthy or very untrustworthy)

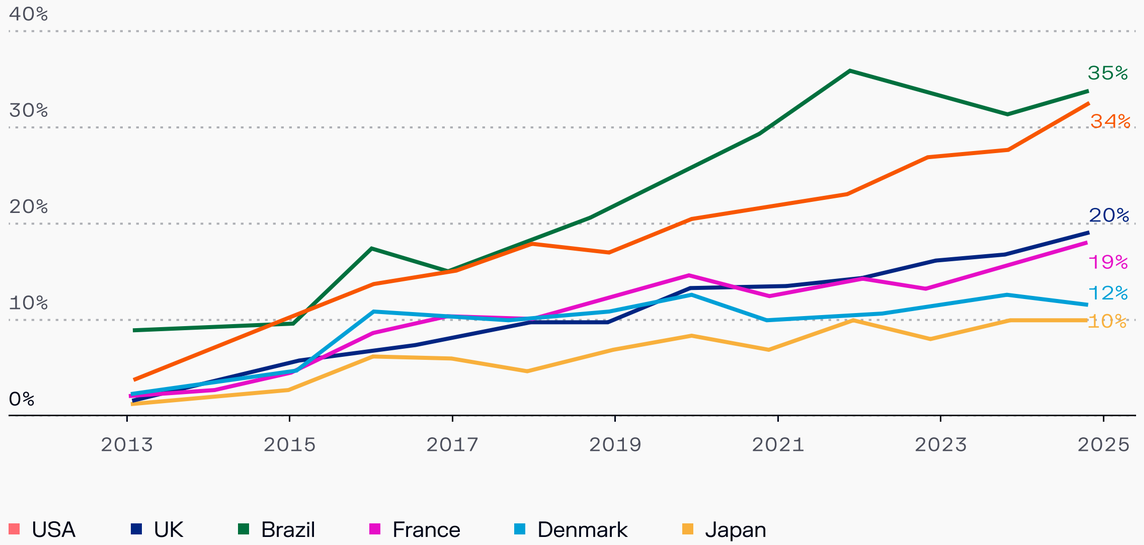
In line with this shift, traditional articles have declined as a source of news while social media posts have become more popular.

People are now as likely to get their news directly from social media as from reading a news article

% OF US ADULTS WHO GET NEWS FROM DIFFERENT SOURCES



Proportion that say social media is their main source of news (2013-2015)

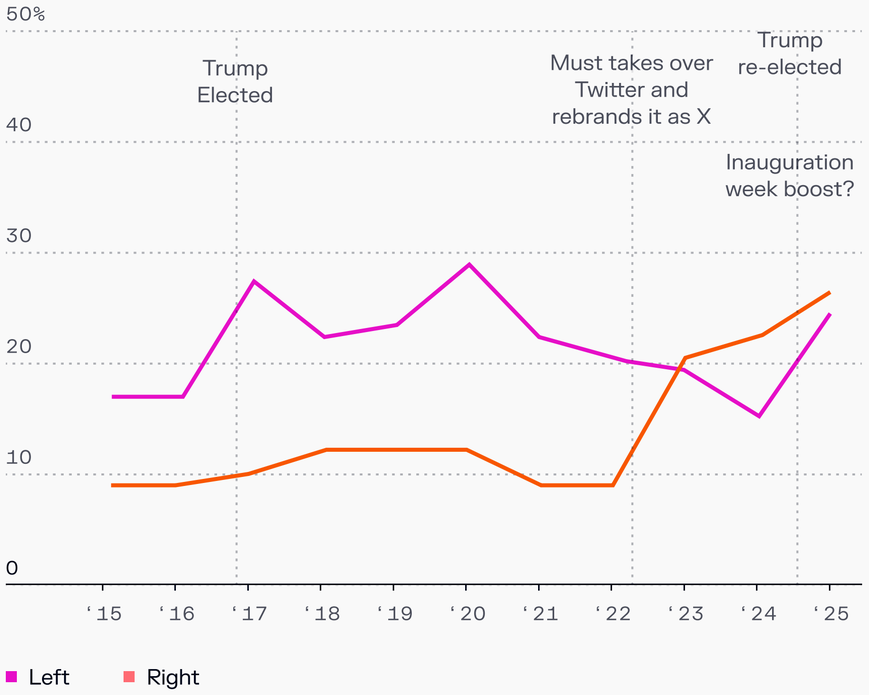


Source: Reuters Digital News Report, Cooperative Election Study, Reuters Institute, University of Oxford

This shift is most pronounced among users who are politically right-leaning and younger.

Proportion that used Twitter/X for news in the last week

BY POLITICAL LEANING 2015-2016 – UNITED STATES

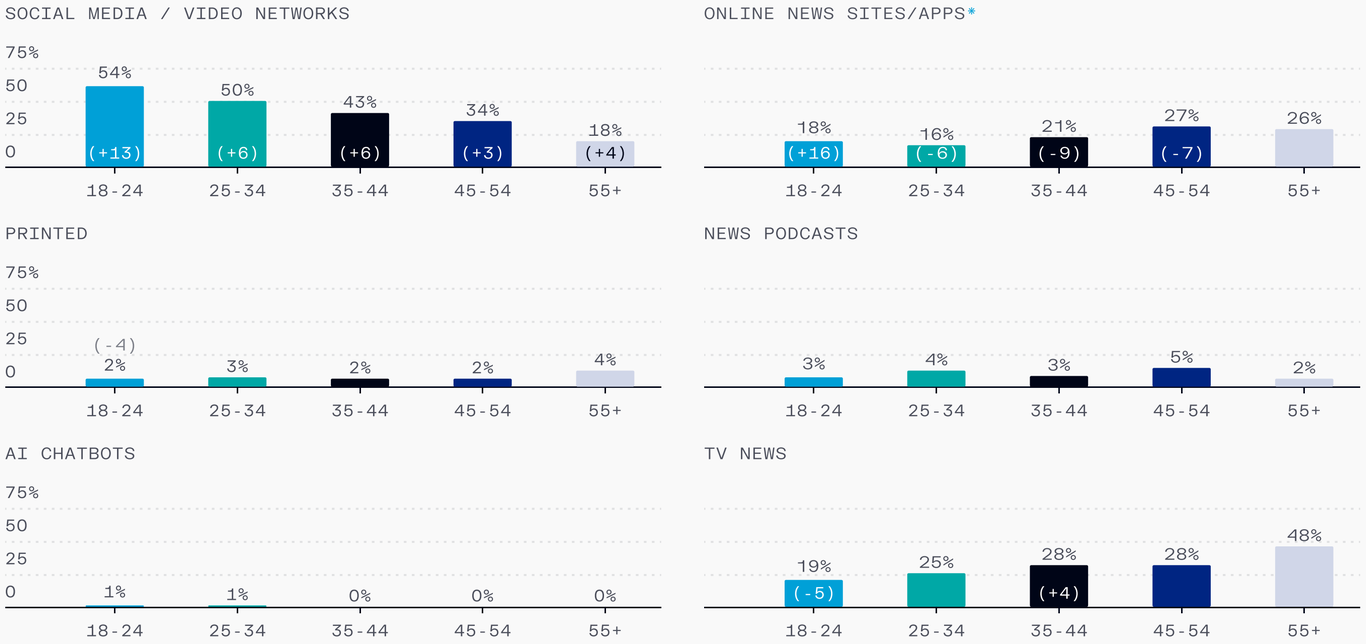


Source: Reuters Institute, University of Oxford, World Economic Forum

Proportion that say each is their main source of news

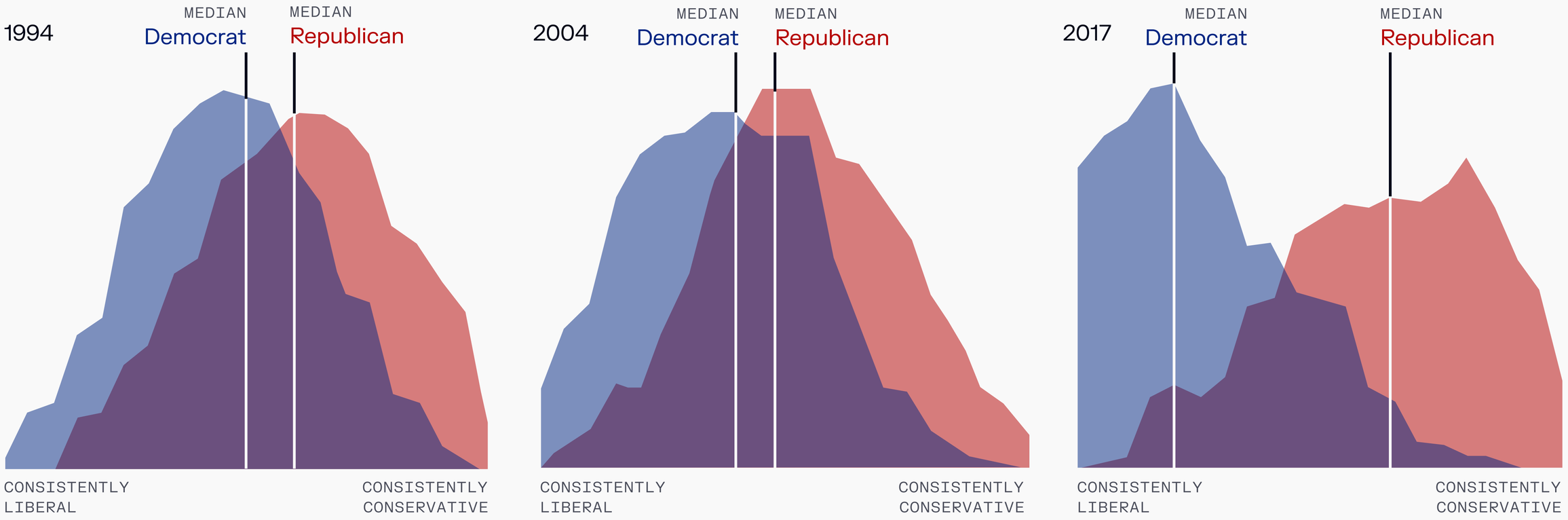
BY AGE - UNITED STATES

Figures in parentheses indicate change from previous year in percentage points (pp).
Ordered from younger to older age group preferences.
*Younger groups less likely to access **news websites/apps**.



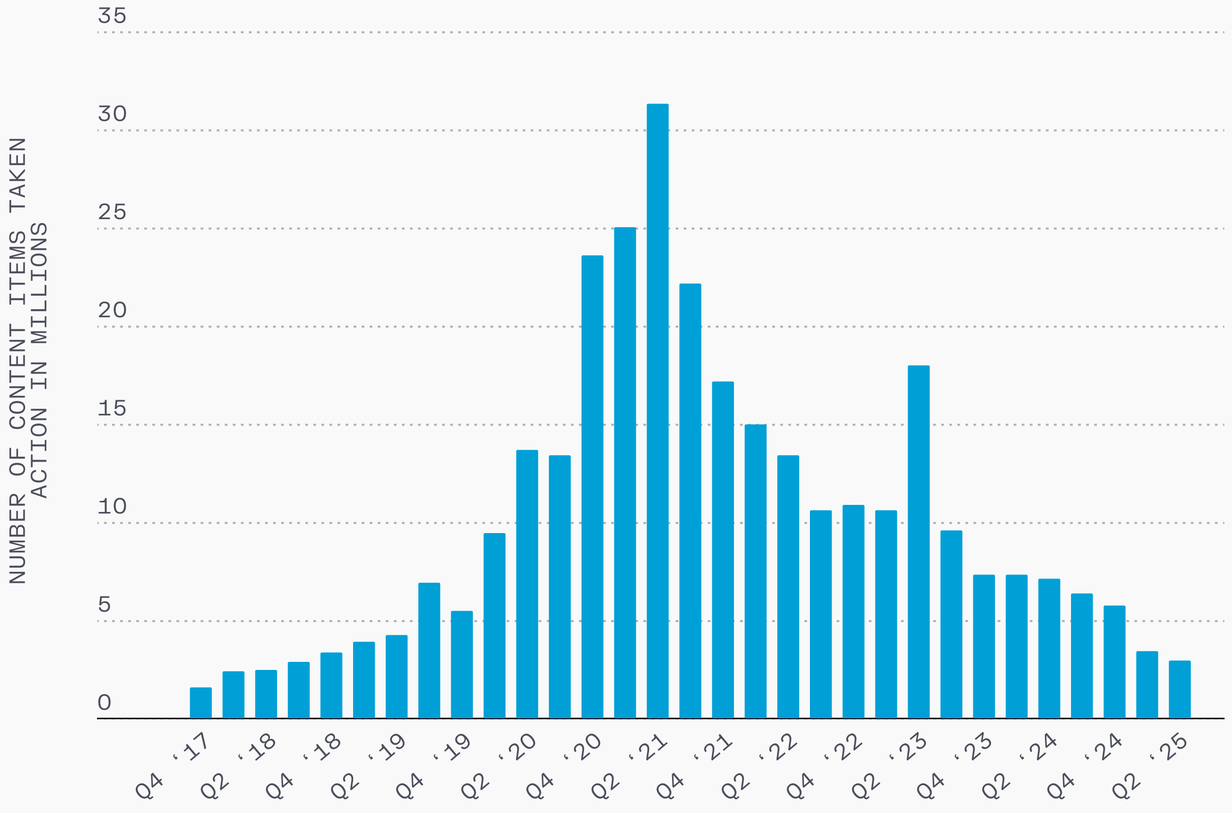
Q4. You say you've used these sources of news in the last week, which would you say is your MAIN source of news? Base: All that used a source of news in the last week aged 18–24 = 213, 25–34 = 328, 35–44 = 296, 45–54 = 227, 55+ = 788.

Studies of social and traditional news media coverage suggest that users today may have more polarized or one-sided views as a result of algorithmic echo chambers.



Source: Brookings Institute

In January 2025, Meta announced plans to sunset some content moderation policies by loosening rules and enabling “free expression.” The company reported that this shift, coincident with the new administration taking office, resulted in fewer accidental post removals.

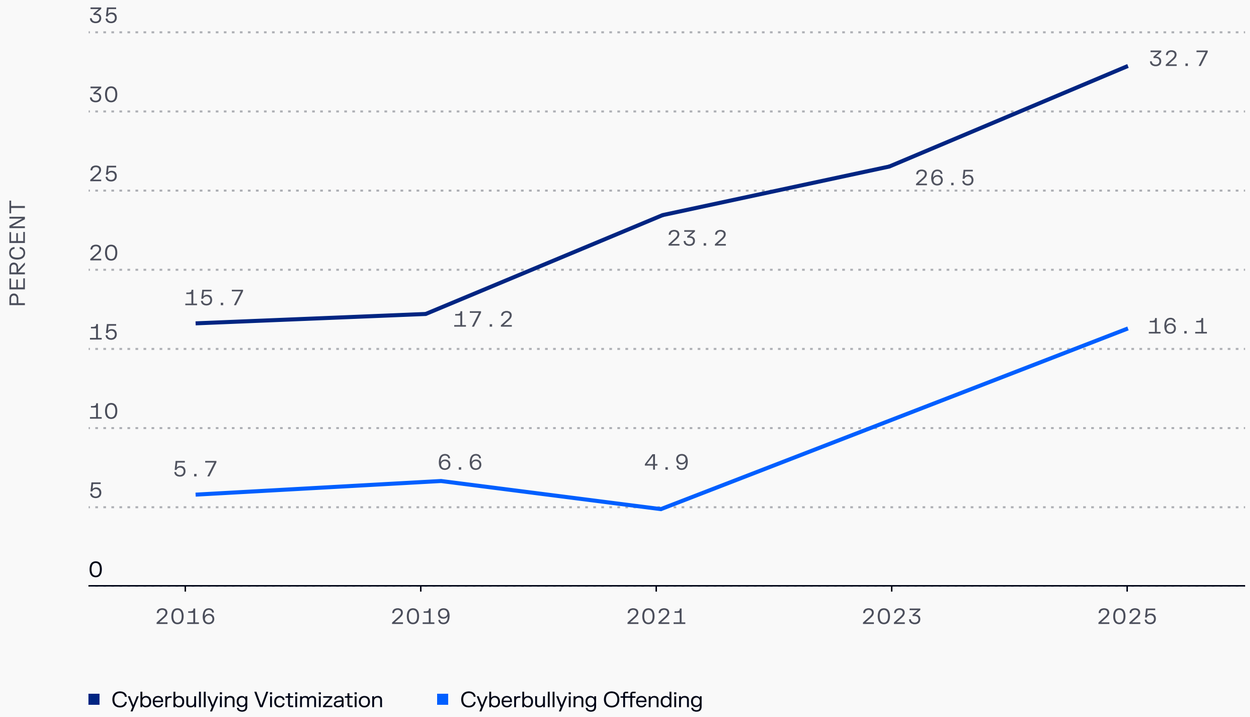


Source: WIRED, Meta

This change is taking place despite continually rising reports of online harassment, hate speech, and cyberbullying.

Recent Cyberbulling Over Time

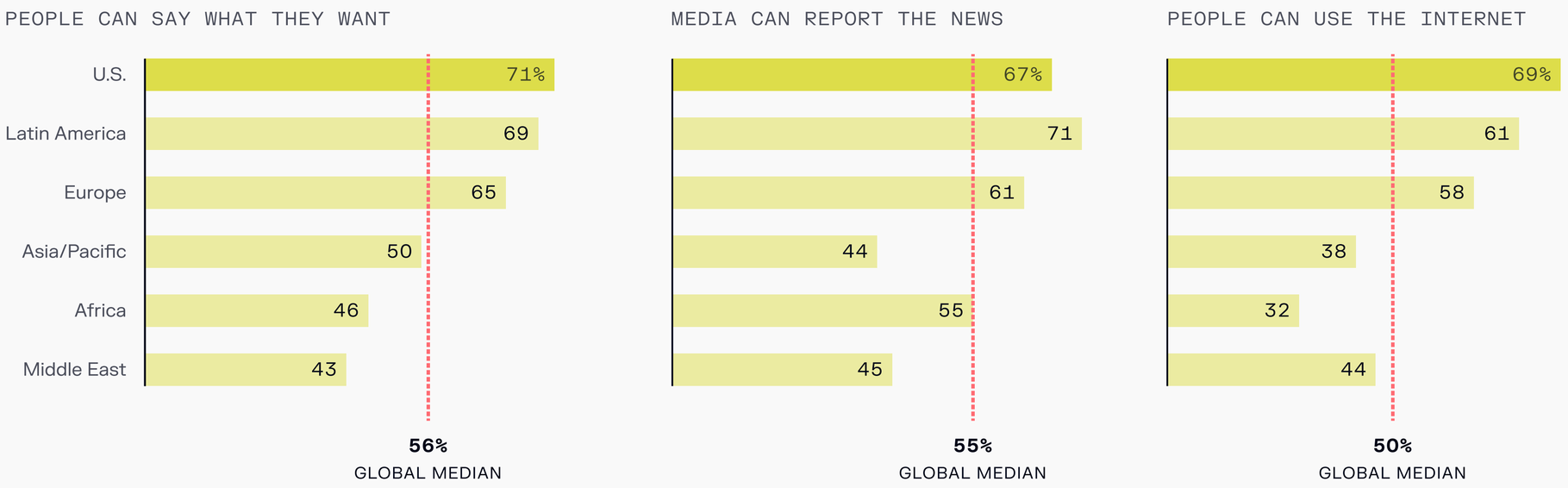
NATIONALLY REPRESENTATIVE SAMPLES OF U.S. 13 TO 17-YEAR-OLDS



Source: WIRED, Meta

The shift away from content moderation, however, aligns with the relative preferences of Americans for free speech, freedom of the press, and freedom on the internet.

Regional median saying it is very important that ___ without state/govt censorship in our country

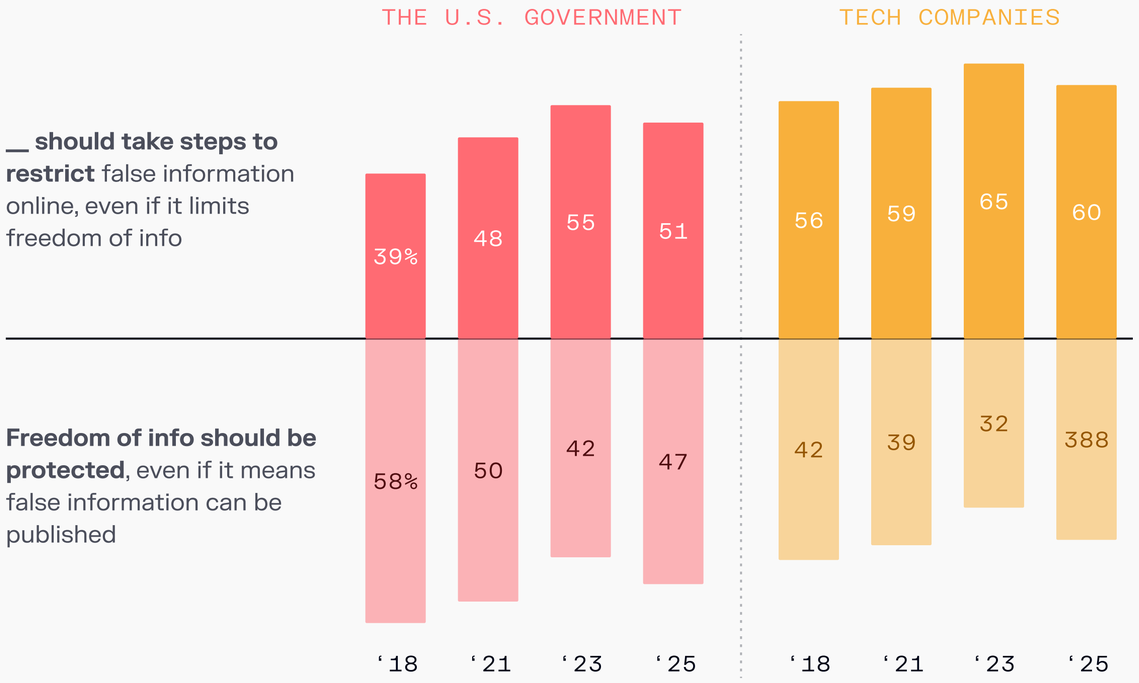


Source: Pew Research Center

In the last two years, Americans have become even less likely to support restrictions on misinformation.

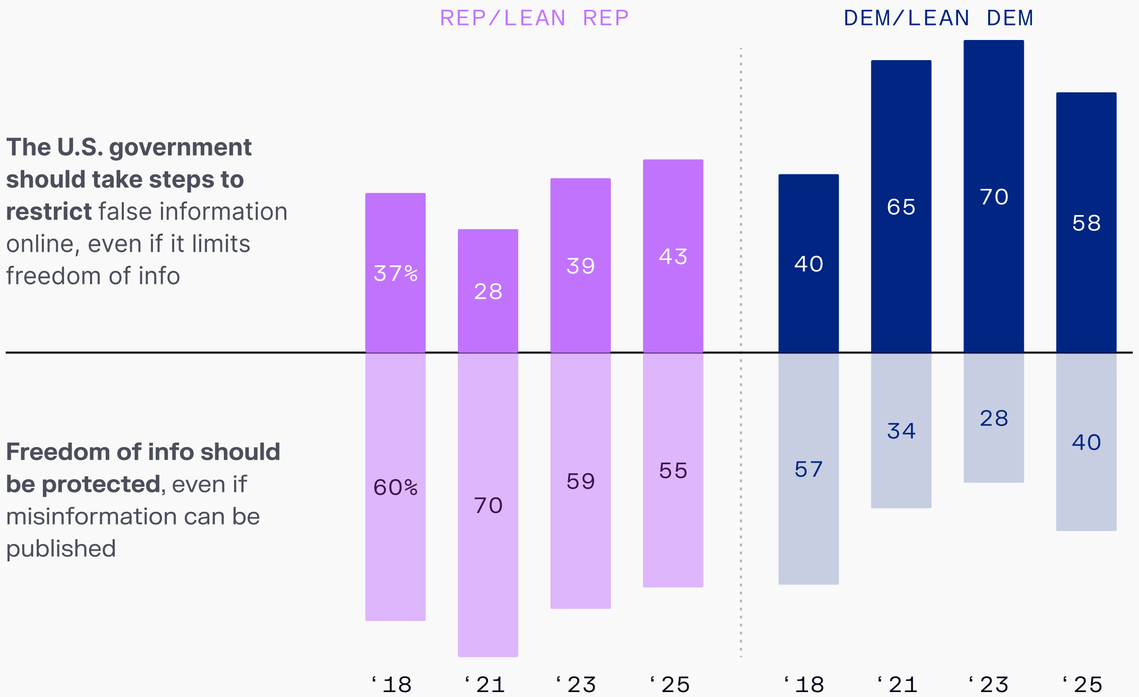
Since 2023, Americans have become slightly less likely to favor restrictions on false information online

% OF U.S. ADULTS WHO SAY …



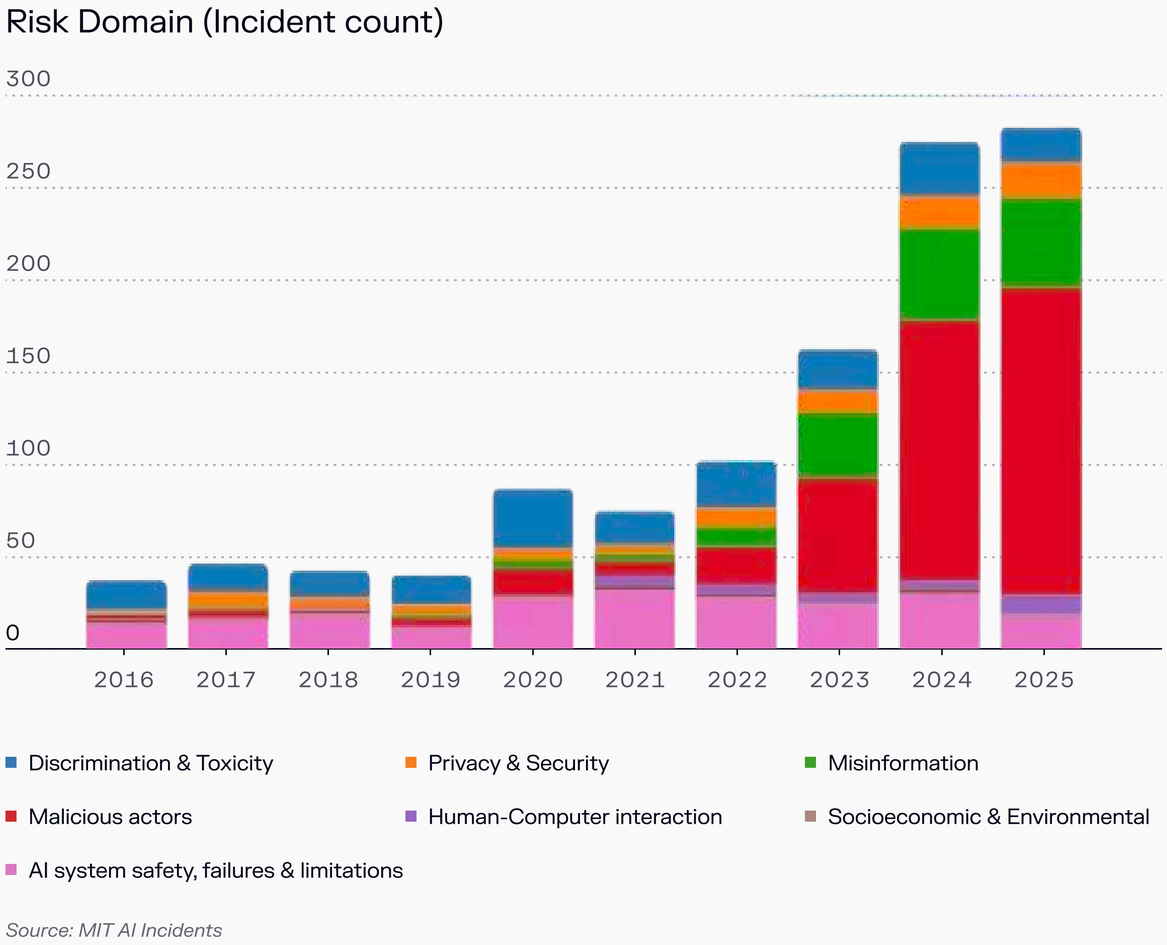
Democrats' support for government restrictions on false info online has fallen since 2023

% OF U.S. ADULTS WHO SAY …



Source: Pew Research Center, Spring 2024 Global Attitudes Survey of US adults Feb. 24 - March 2, 2025

Concerns around content moderation and misinformation have grown in light of increasing volumes of deepfakes and scams perpetrated by AI users. Such incidents have increased by multiples in the last three years and have become the majority of AI-related incidents.

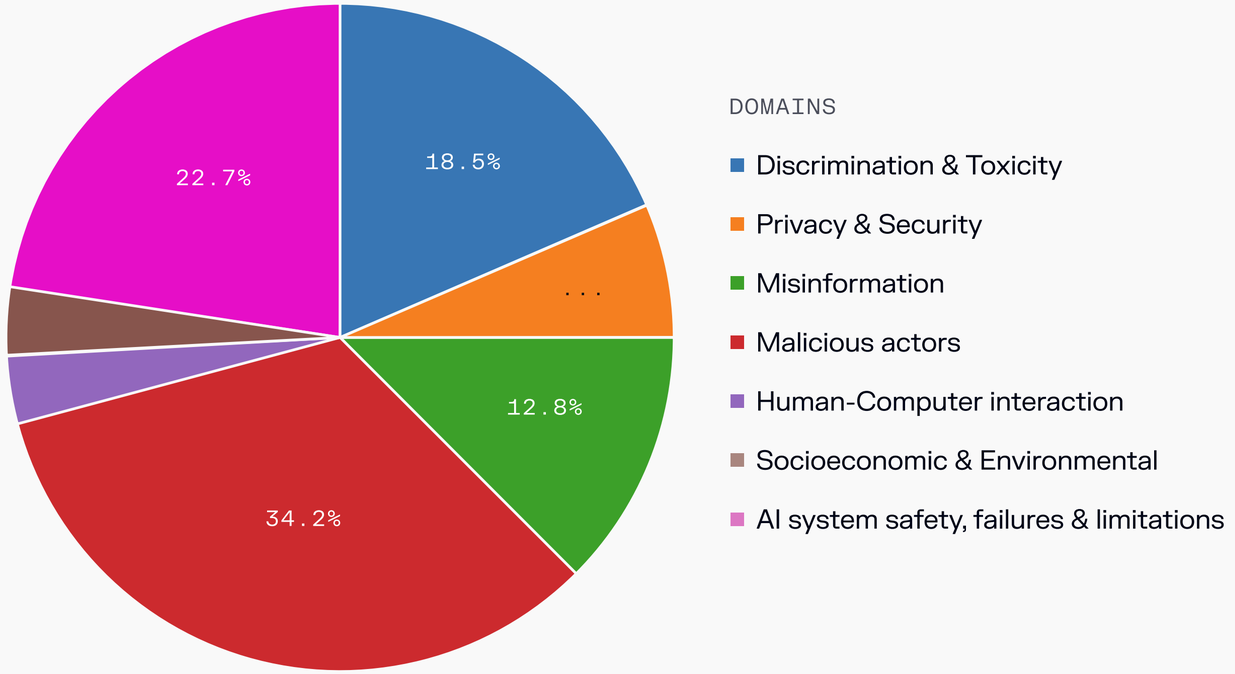


Source: MIT AI Incidents

The largest category of recorded AI incidents is driven by malicious actors.

Risk Domain (All Incidents)

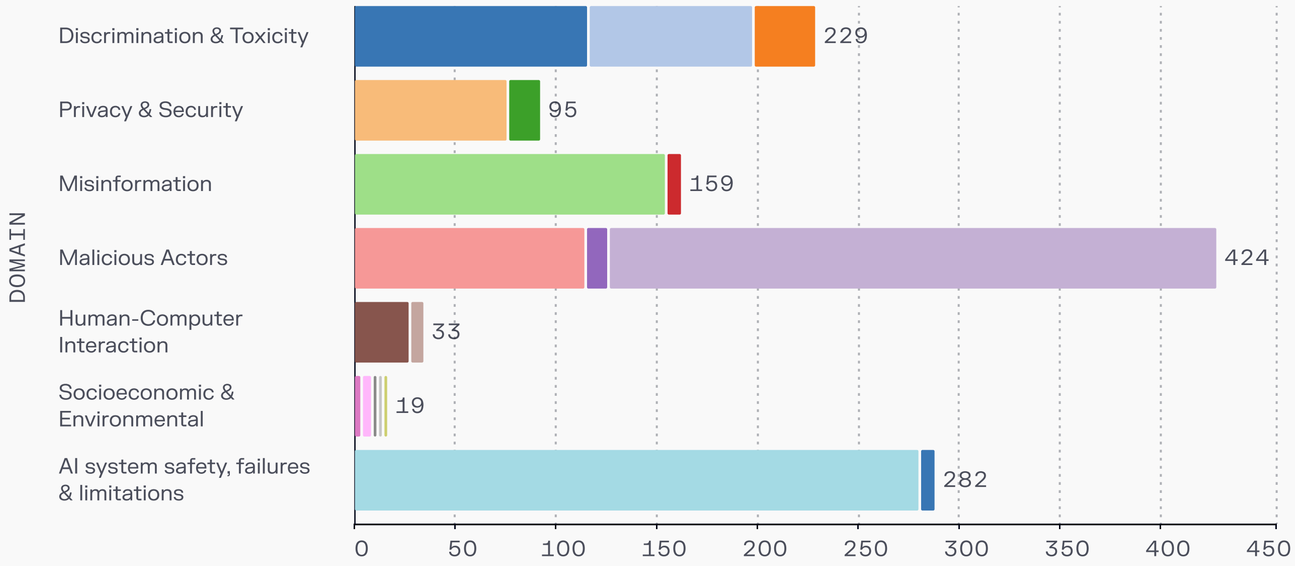
PROPORTION OF ALL REPORTED INCIDENTS



Source: MIT AI Risk Tracker

Of these the majority are scams, fraud, and targeted manipulation.

Incident count by Domain/Submodmain



SUBDOMAINS

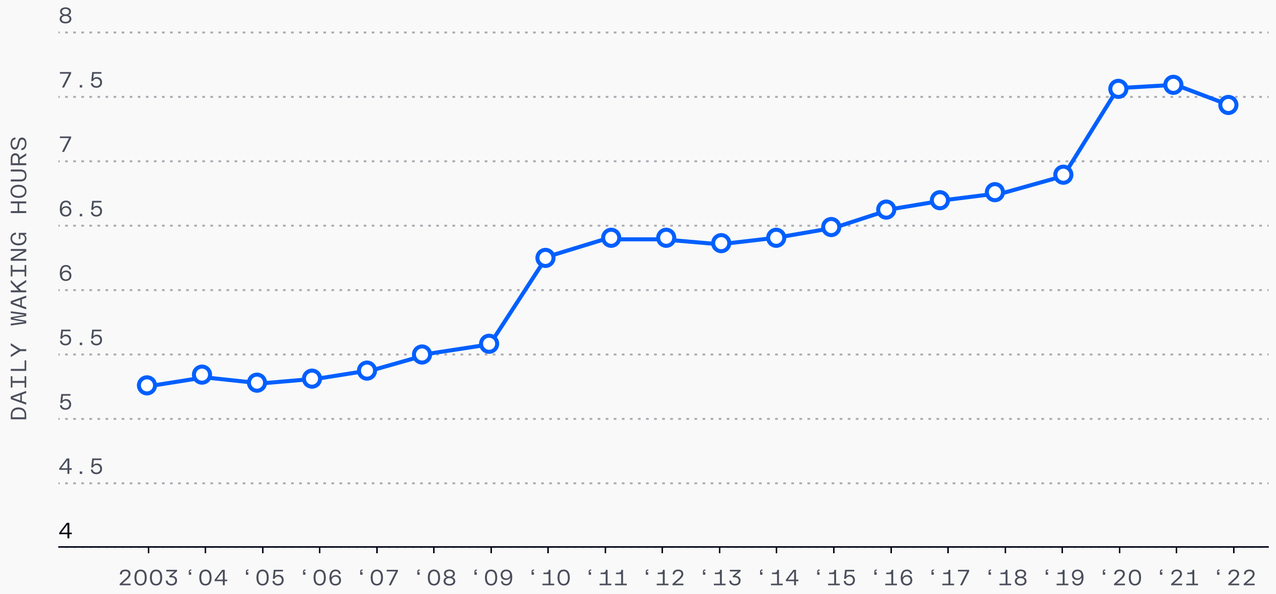
- Unfair discrimination and misrepresentation
- Exposure to toxic content
- Unequal performance across groups
- Compromise of privacy and confidentiality
- AI system security vulnerabilities
- False or misleading information
- Pollution of information environments
- Disinformation, surveillance, and control
- Cyberattacks, weapons development
- Fraud, scams, and targeted harms
- Overreliance and unsafe automation
- Loss of human agency and deskilling
- Power centralization and dependency
- Increased inequality and disparities
- Economic and cultural disruption
- Competitive dynamics
- Governance failure
- Environmental harm
- AI pursuing its own goals
- Lack of capability or robustness
- Lack of transparency or interpretability

Source: MIT AI Risk Tracker

The Loneliness Epidemic: Isolation, Family Formation, and AI Companions

Over time, isolation (daily time spent alone) has increased among Americans. Time alone peaked during COVID but still remains above the pre-COVID trend.

Time Spent In Isolation

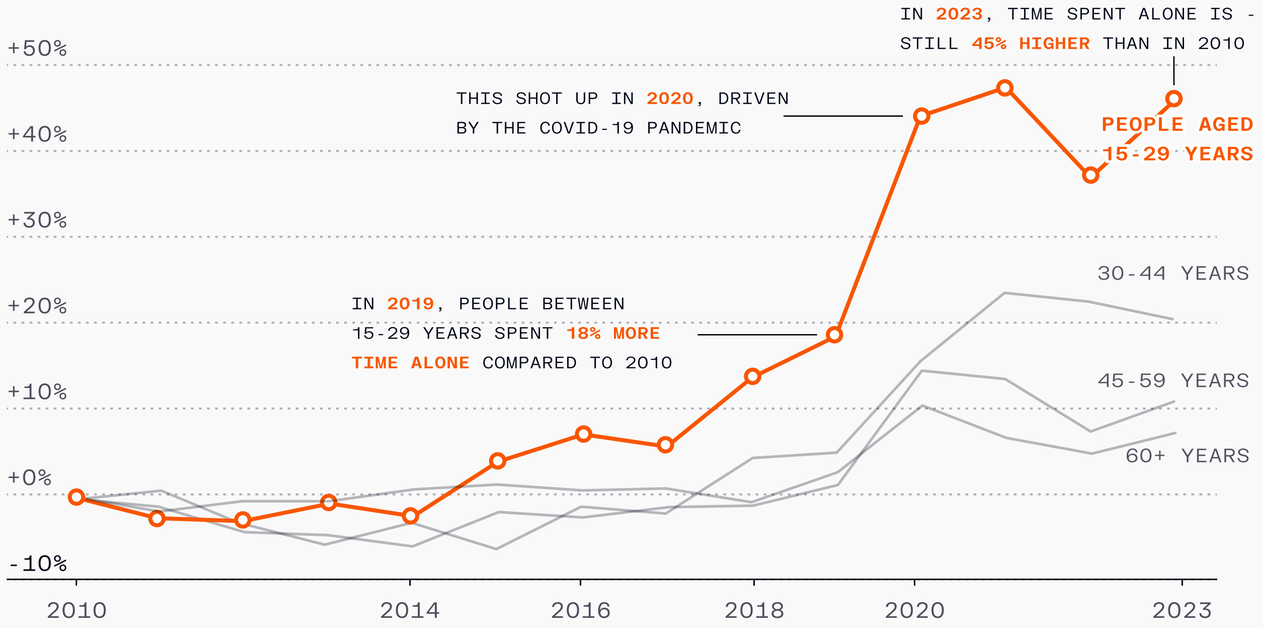


Source: Financial Times, American Time Use Survey, ARK Institute

This uptick in time alone is most pronounced among younger people, though it is present in all age groups.

Young Americans are spending much more time alone

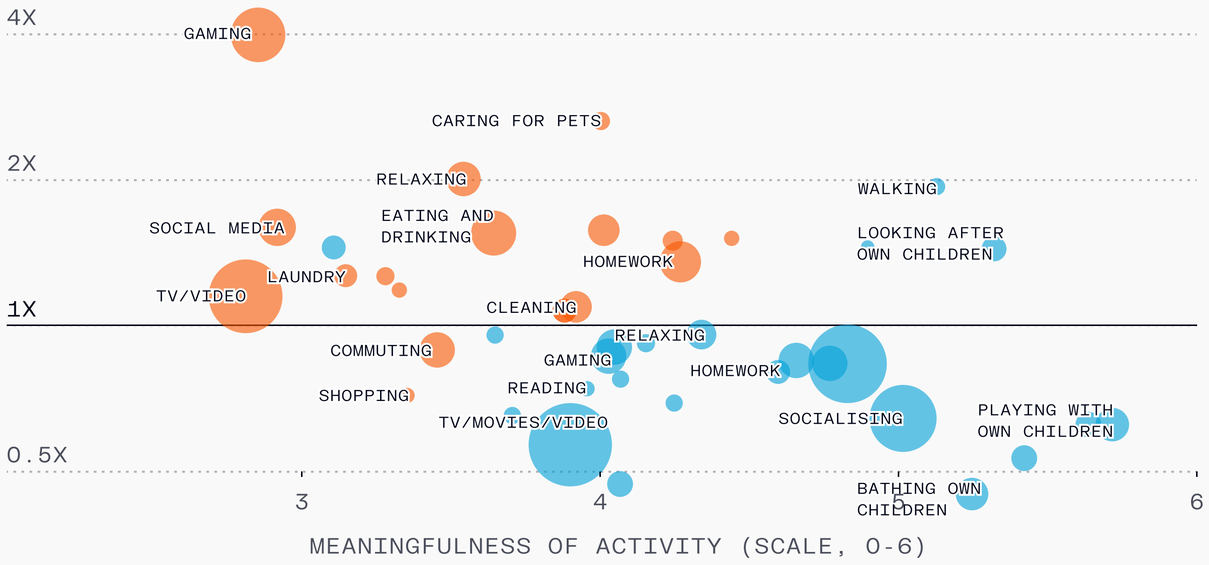
RELATIVE CHANGE IN AVERAGE SURVEY RESPONSES COMPARED TO 2010.
TIME SPENT ALONE MEANS NO ONE ELSE WAS PHYSICALLY PRESENT AND CAN STILL INCLUDE PHONE OR VIDEO CALLS.



Source: Financial Times, American Time Use Survey, ARK Institute, US Bureau of Labor Statistics

Activities that involve time alone have increased among young Americans, while social activities have declined.

Change in time spent on different activities between 2010 and 2023, by meaningfulness of activity



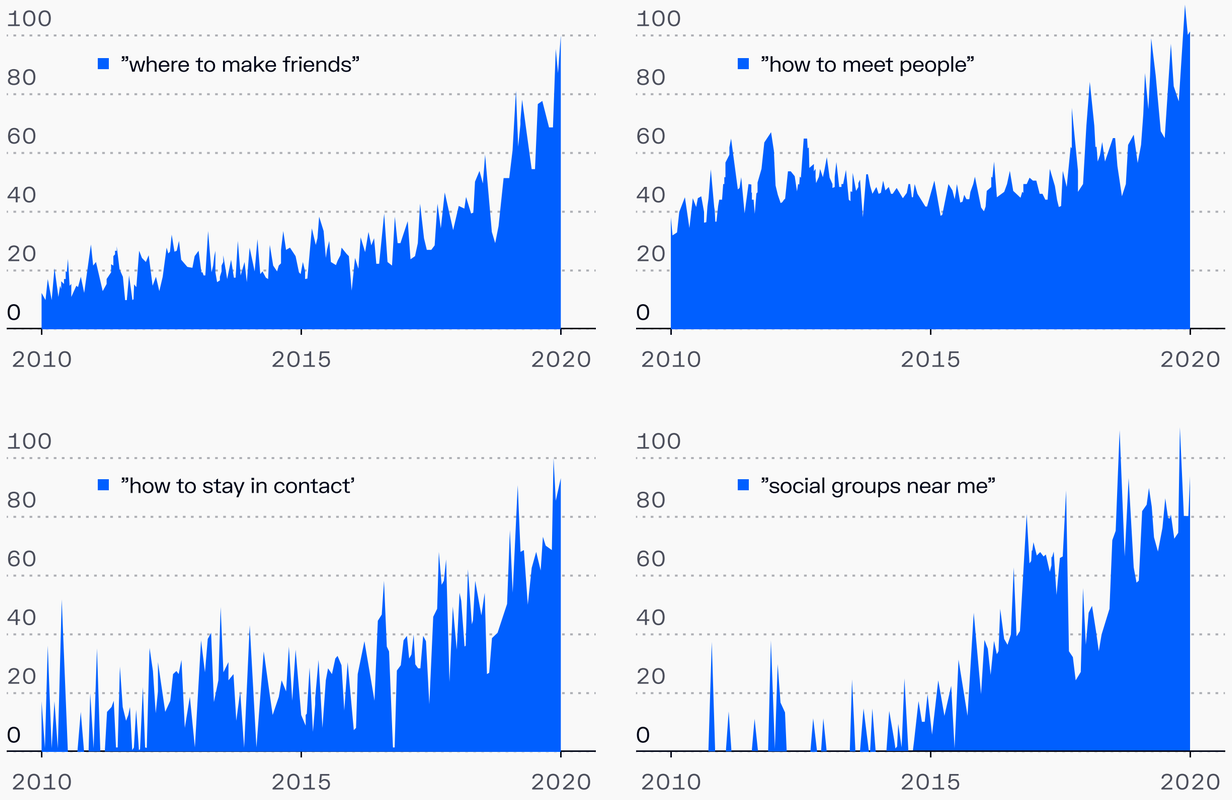
Who activity was done with: Alone With others

Source: Financial Times, American Time Use Survey, ARK Institute, US Bureau of Labor Statistics

This trend is exhibited in Google search trends, which show an increase over time in queries like ”where to meet people” and ”how to stay in contract.”

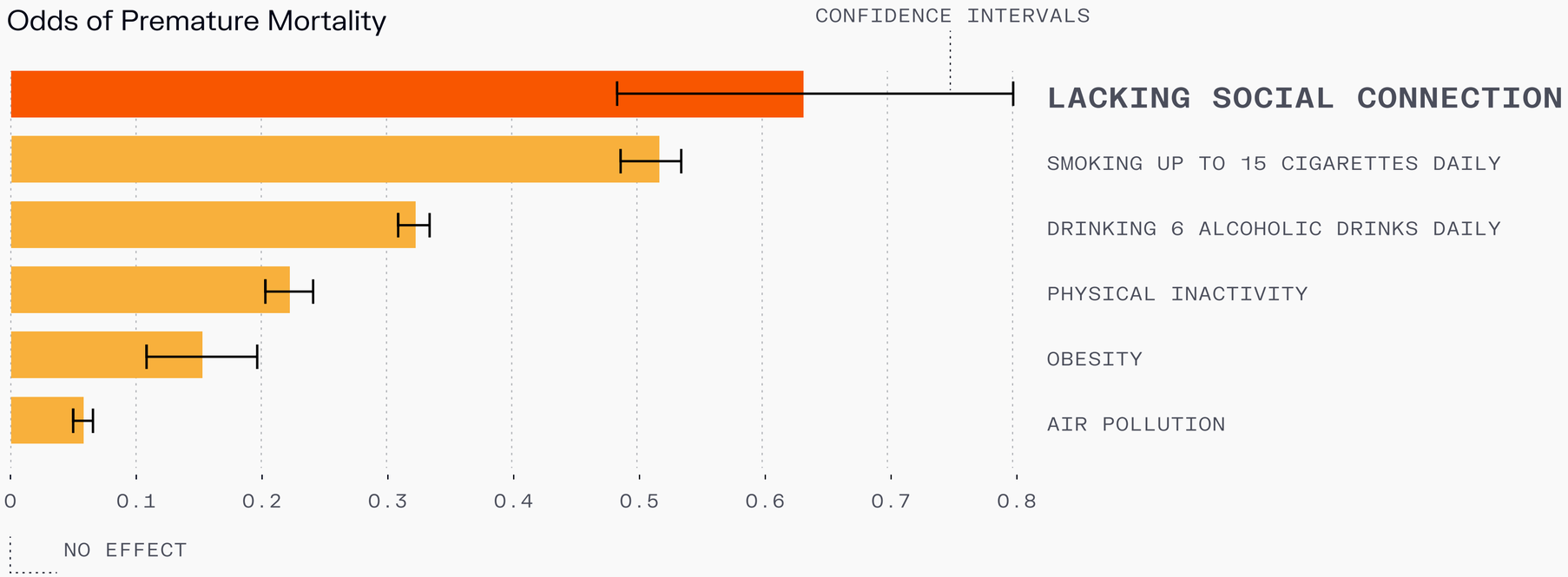
Google Search Trends For ___

US, INDEXED SUCH THAT 100 = MAX



Source: Bloomberg, Google Trends

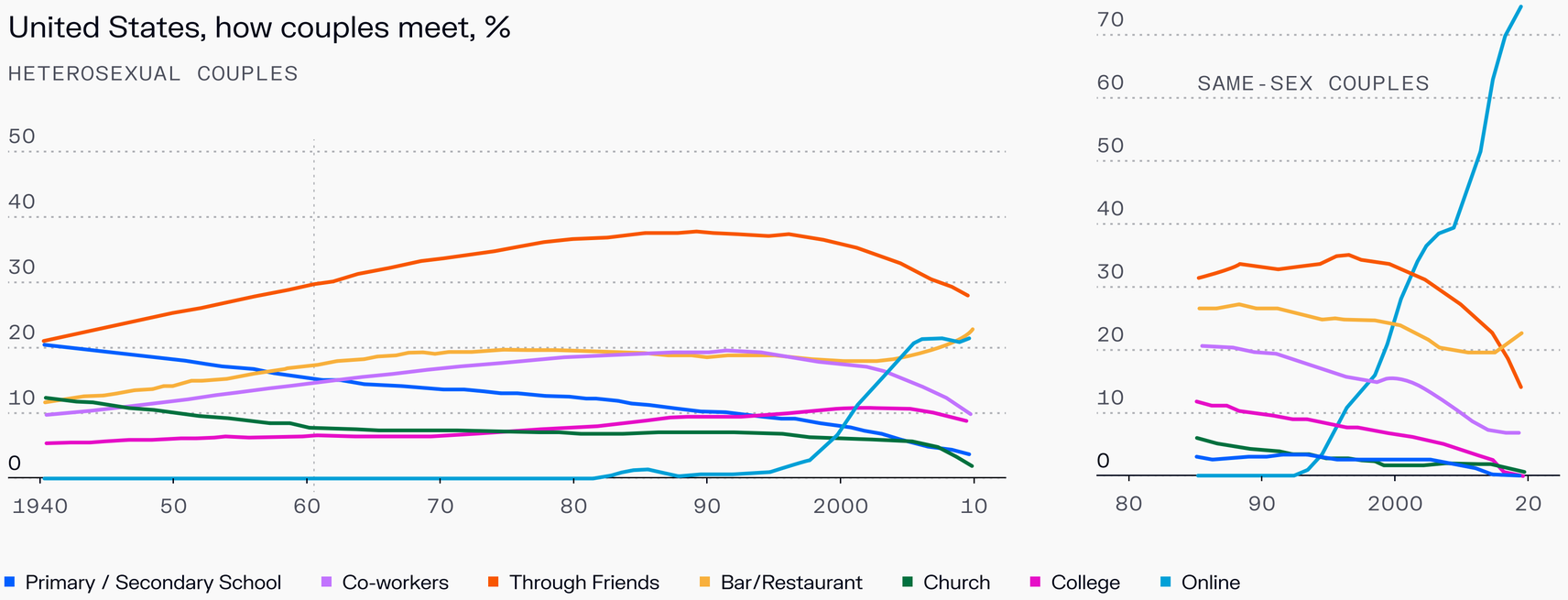
Studies have shown that time spent alone can be more dangerous as smoking, drinking, and lacking physical activity when considered in relation to premature death.



Source: Office of the US Surgeon General, Advancing Social Connection as a Public Health Priority in the United States

As time spent with others declines, fewer romantic relationships form through social connections. Online dating as the connector between couples has increased rapidly in the last two decades.

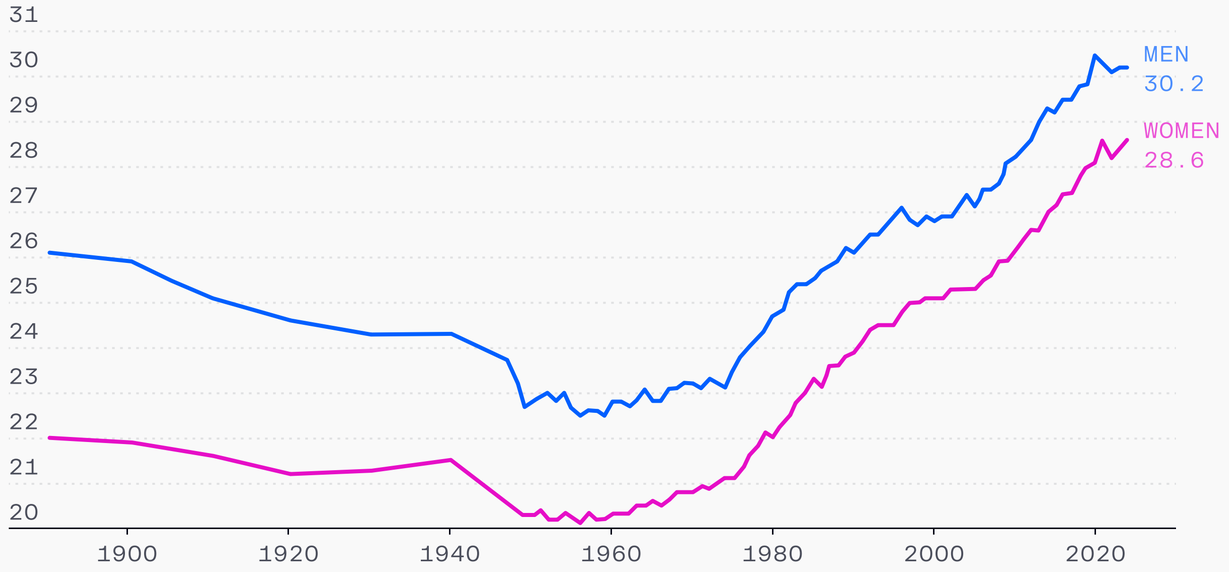
United States, how couples meet, %



Source: Searching for a Mate: The Rise of the Internet as a Social Intermediary

In line with the decrease in time spent forming social connections, the age of first marriages has become later since the 1950s.

Median age of first marriage by sex, 1890-2024

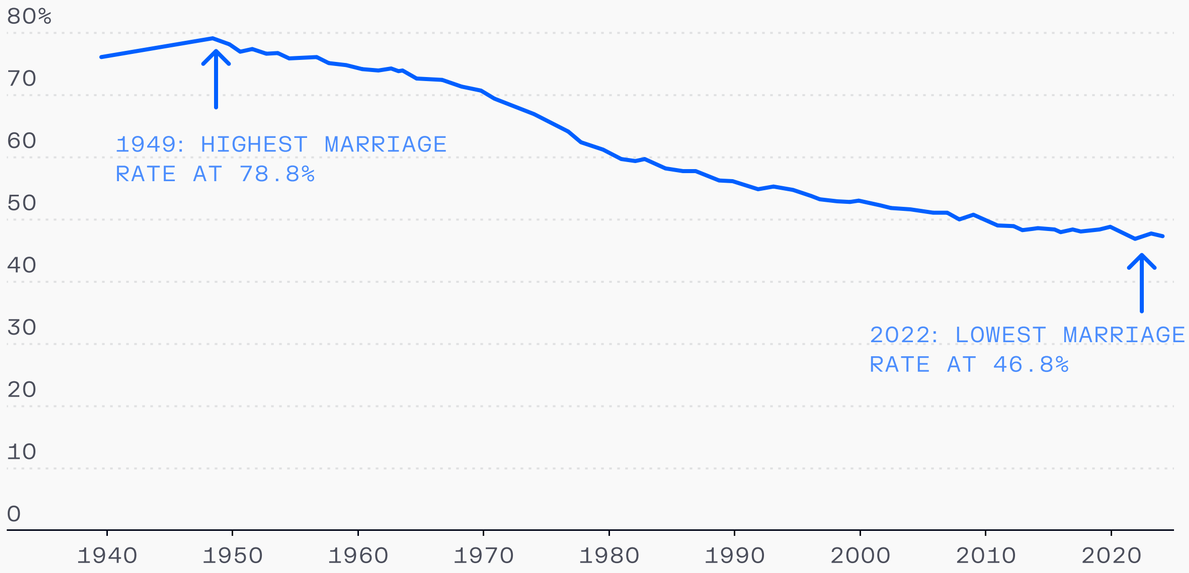


Source: US Census Bureau

Fewer US households are headed by married couples than at any other point in history.

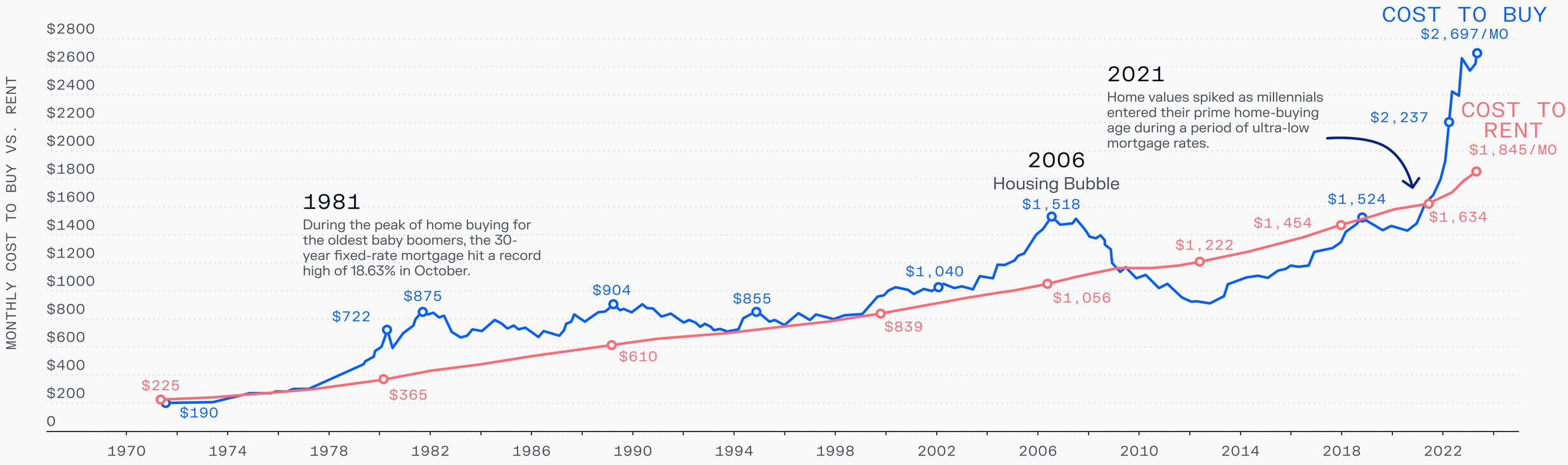
Households headed by married couples in the 2020s are the lowest ever recorded in the US.

SHARE OF HOUSEHOLDS HEADED BY MARRIED COUPLES, 1940-2024



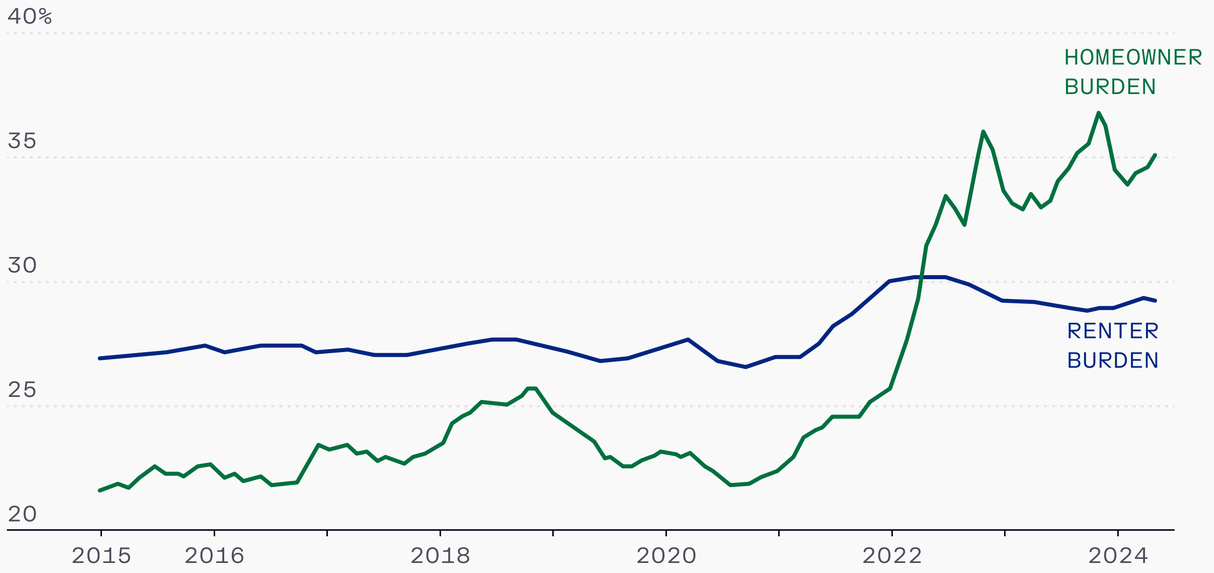
Source: US Census Bureau

One driver of this shift may be the increased cost of home ownership. The cost of a single family residence adjusted for inflation has continued to rise precipitously. The cost of buying a home versus renting is higher even than during the housing bubble.



Source: Visual Capitalist, Reventure Consulting, Zillow, Case Shiller, BLS, S&P CoreLogic Case-Shiller Home Price Index, Zillow Group Inc

The % of income spent on housing costs across renting and buying has remained relatively flat for renting, but home ownership has increased from 30% to ~35% since 2022.

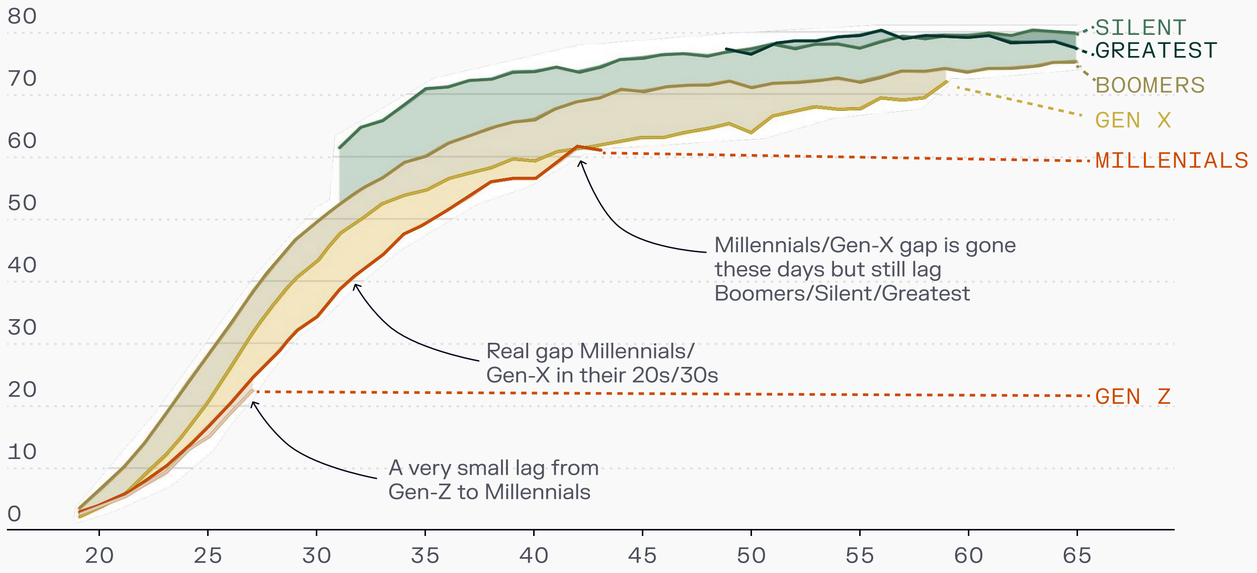


Source: Visual Capitalist, Reventure Consulting, Zillow, Case Shiller, BLS, S&P CoreLogic Case-Shiller Home Price Index, Zillow Group Inc

Millennials are less likely to own homes than Gen Xers did at the same age, and both have lower homeownership rates than the Boomer, Silent, and Greatest generations.

Homeownership rate across the generations

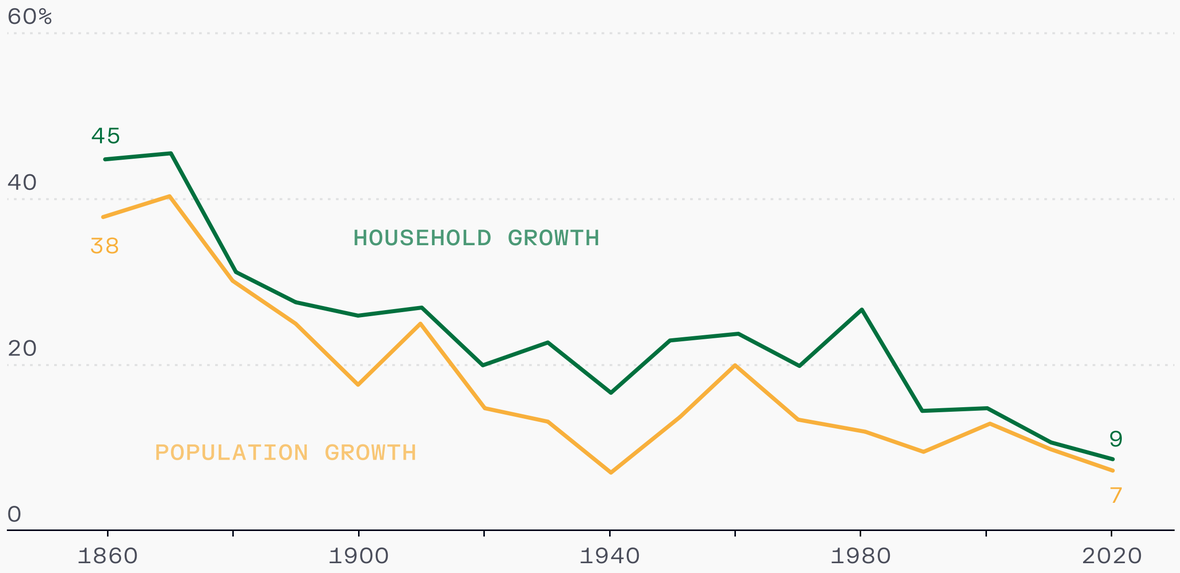
1976 TO 2024



Source: Economic Innovation Group, Ben Glasner,IPUMS: CPS ASEC; In this analysis, individuals are classified as homeowners only if they are aged 19 or older, are identified as the householder or a spouse (RELATE codes 101, 201, 202, 203), and live in a household where the dwelling is owned or being bought (OWNERSHP = 10). All others, including children, extended family, non-relatives, and individuals in renter-occupied or no-cash-rent units, are not classified as homeowners.

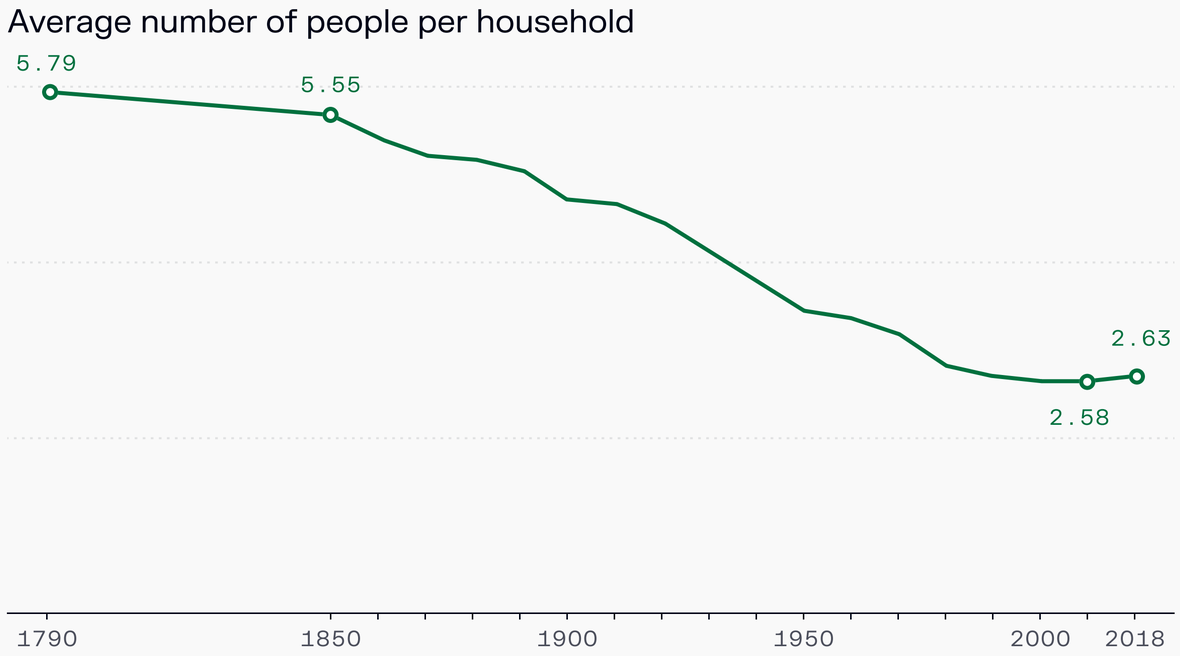
The growth in the number of US households has continued to decline dramatically.

% growth in number of U.S. households and population per decade



Source: Pew Research Center Analysis of census historical statistics and 2018 American Community Survey; Note: Population growth refers to growth in the population residing in households since the previous decennial census.

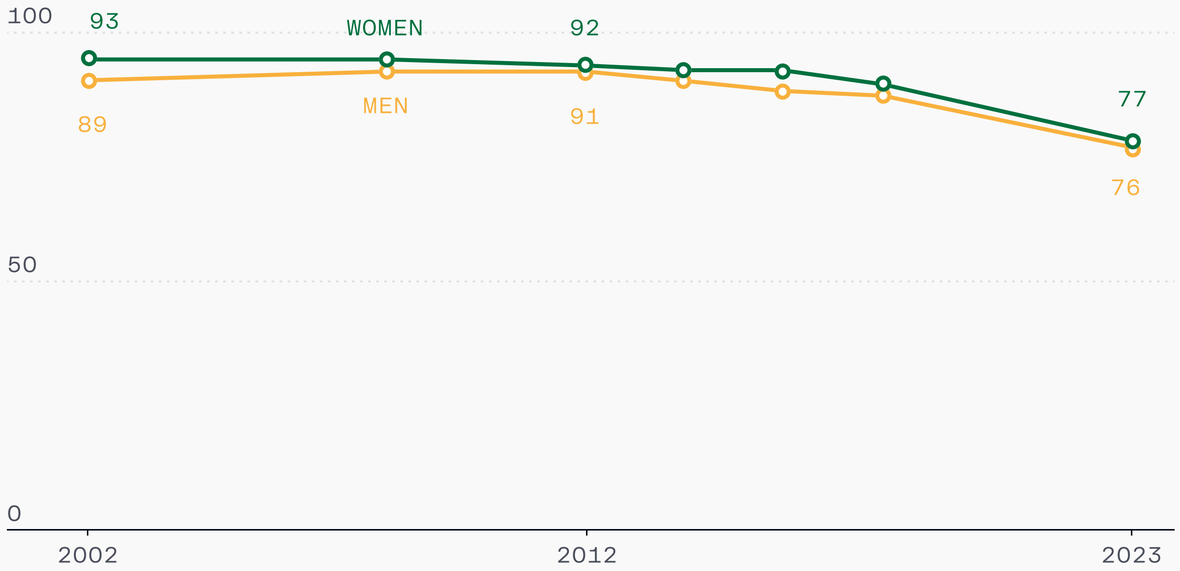
Elevated home prices make moving out harder, contributing to an increase in the number of people per American household for the first time in 160 years.



Source: Pew Research Center Analysis of census historical statistics and 2018 American Community Survey; Note: Data labels are for 1790, 1850, 2010 and 2018. Average household size is not available for the years between 1790 and 1850.

Though household sizes are growing, new births are declining, particularly amidst adults ages 20 to 39.

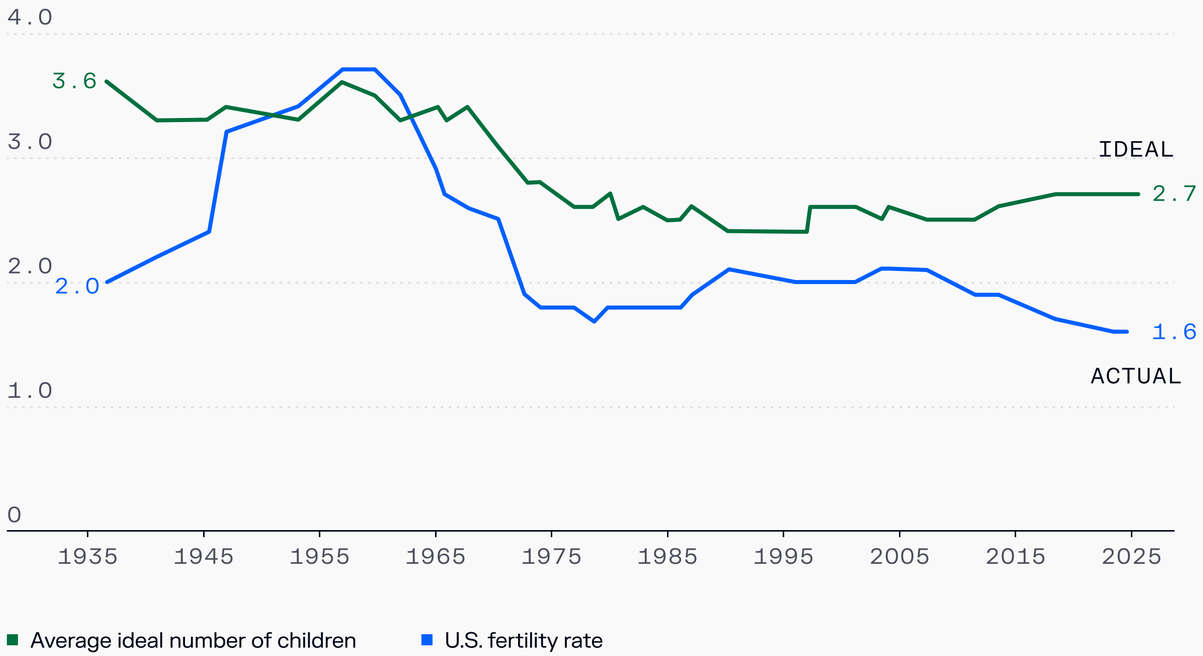
% of U.S. adults ages 20 to 39 who already have, or plan to have, at least one child



Source: US National Center for Health Statistics Data, GALLUP, Pew Research Center; Note: Based on U.S. women and men ages 20 to 39. Number of planned children is the number of live births (for women) or children ever fathered (for men) plus the number of additional children intended. Values are labeled for 2002, 2012 and 2023.

Americans are having fewer children than they say they would like to.

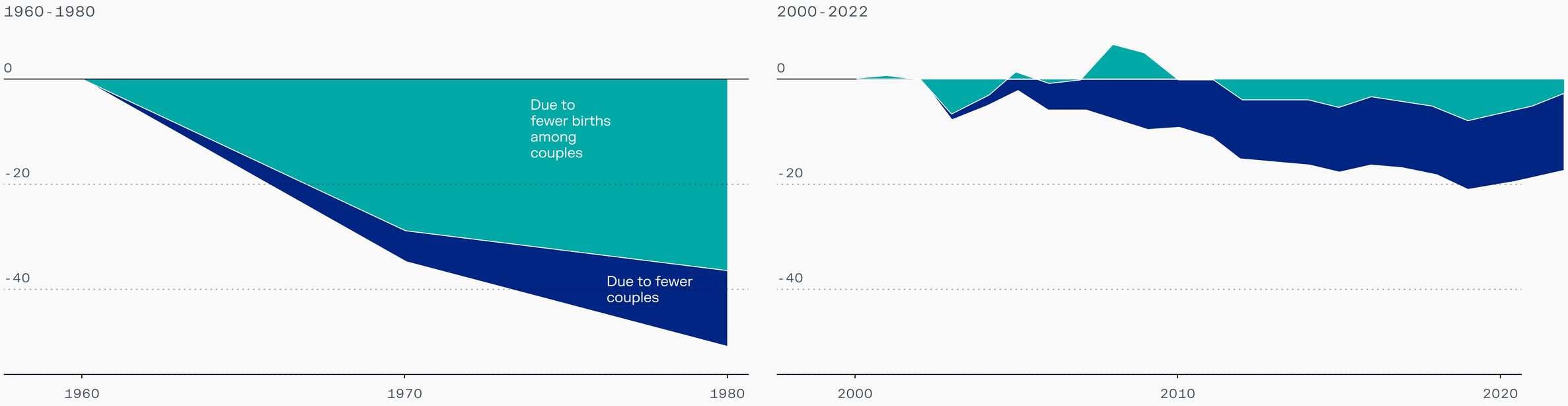
What do you think is the ideal number of children for a family to have?



Source: US National Center for Health Statistics Data, GALLUP, Pew Research Center; Ideal number of children averages for 1936–1996 are estimated. Fertility rate figures are based on U.S. National Center for Health Statistics data, compiled by Human Fertility Database.

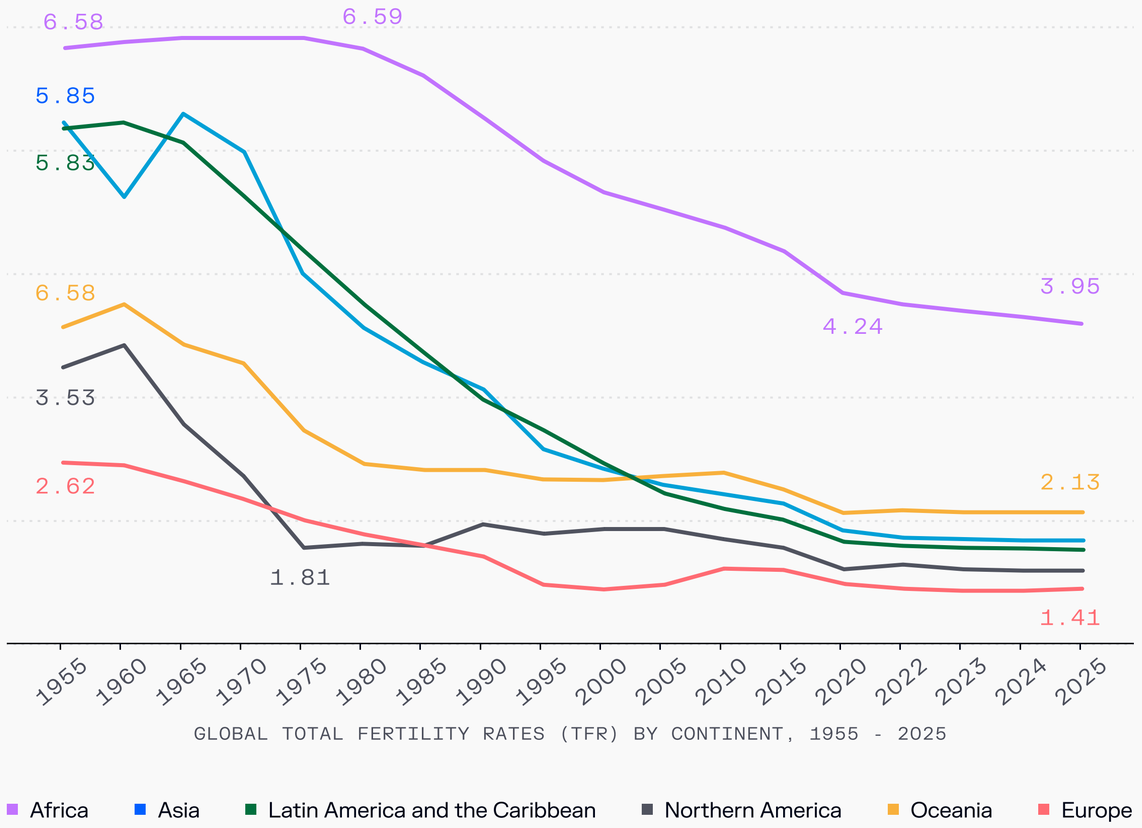
Historically, declining birth rates were due to couples having fewer children. Today, the decline is due mainly to fewer couples being formed.

Percentage change in US total fertility rate, by contributing factor



Source: Financial Times, American Community Survey and Lyman Stone

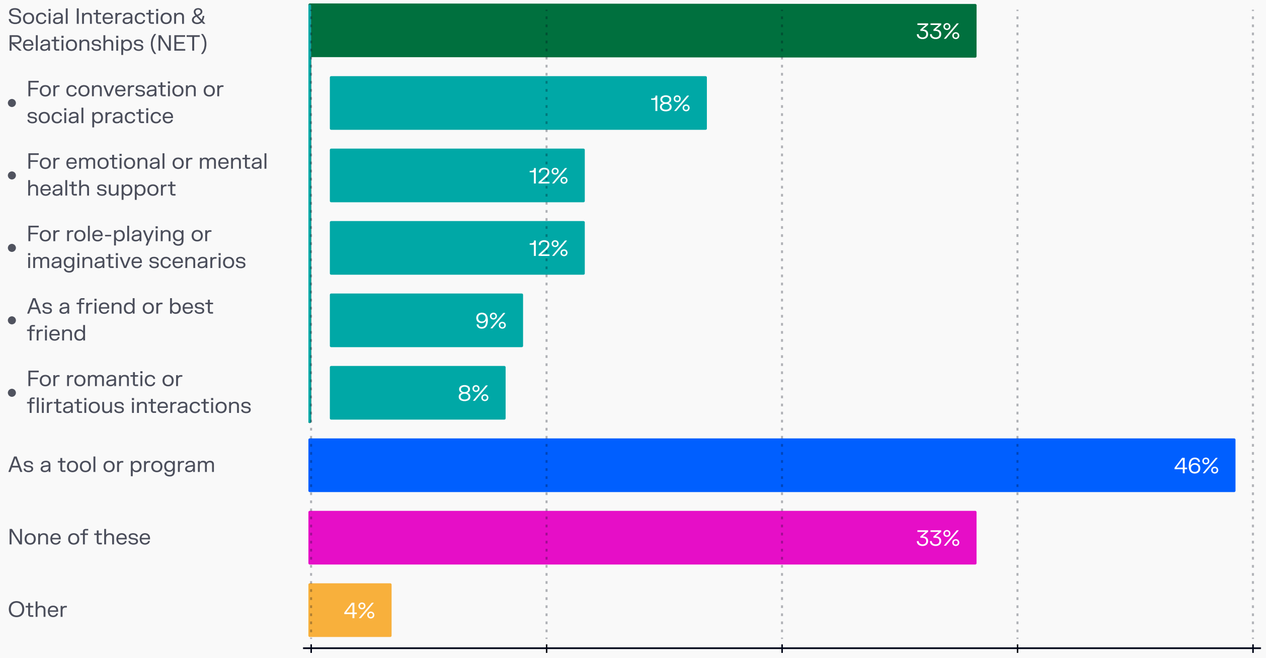
This phenomenon exists across continents; only Africa has a fertility rate above the 2.1 replacement rate



Source: Worldometer; TFR is expressed as the average number of children per woman

In light of less time spent physically with others, growing numbers of teen ChatGPT users use AI for companionship, with 33% of teens having used AI for social interaction or relationships.

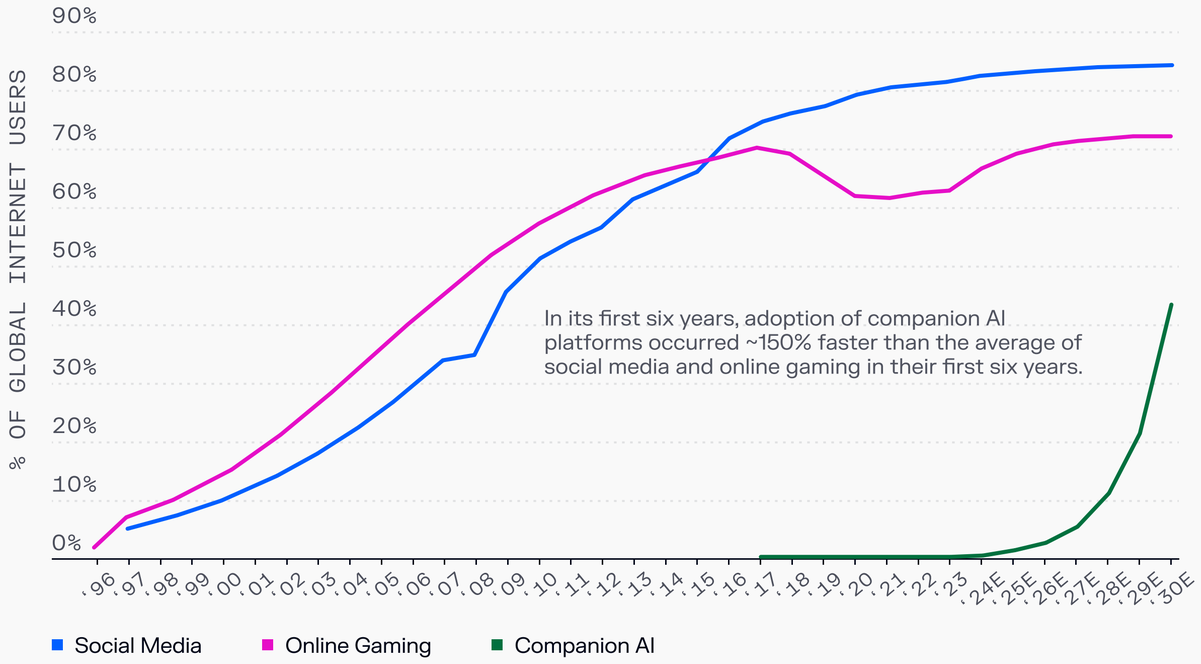
How teens use or view AI companions.



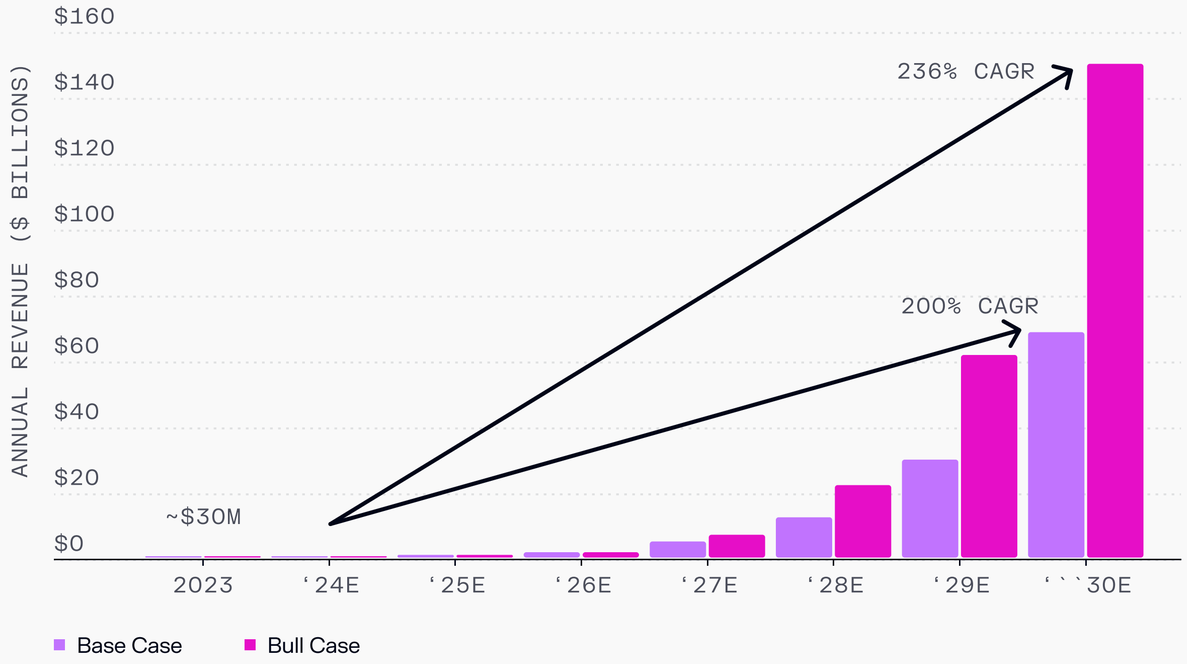
Source: Common Sense Media Report "Talk, Trust, and Trade-Offs: How and Why Teens Use AI Companions";
Note: Q: Which of the following describes how you use or view AI companions?

Companion AI platforms have experienced rapid adoption, and are expected to grow exponentially into 2030.

Global Adoption Of Consumer Applications



Global Companion AI Revenue Forecast

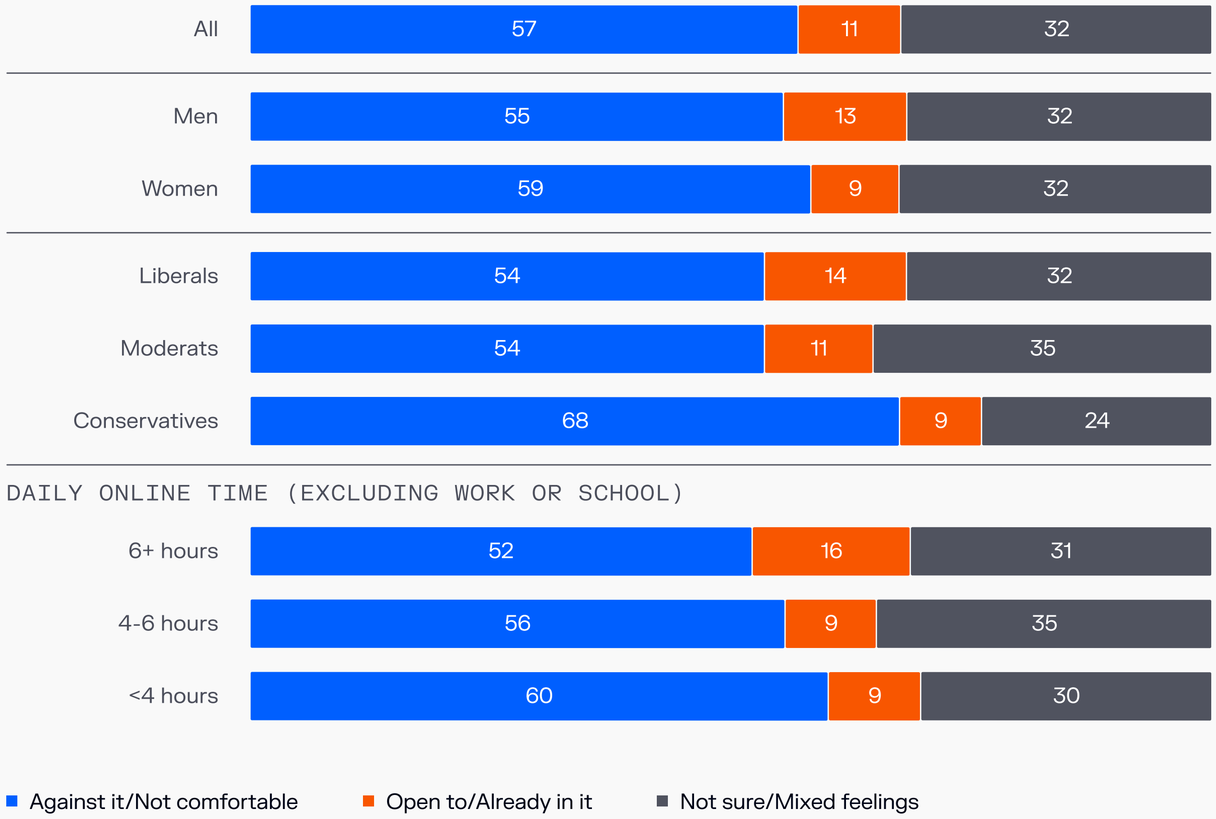


Source: ARK Institute

75% of Gen Z thought that AI partners could fully replace human companionship, according to one survey.

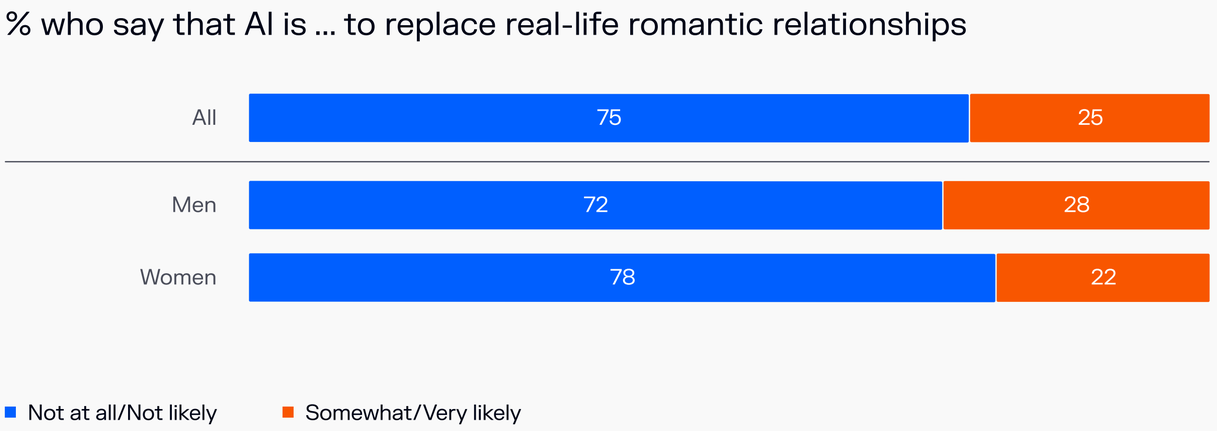
In addition, Google searches for Feelings for AI' and 'Fell in love with AI' have increased 120% and 132%, respectively.

% who say they are ... when it comes to the idea of having an AI friend



Source: IFS Tech and Family Survey of 2,000 adults 18-39, Forbes, Joi AI

25% of adults aged 18-39 believe that AI could replace real-life romantic relationships generally.



Source: IFS Tech and Family Survey of 2,000 adults 18-39, Forbes, Joi AI

In terms of a personal relationship, 10% of adults aged 18 to 29 say they will probably have a romantic relationship with an AI companion, or already have.

Do you think you could ever have a romantic relationship with an AI chatbot companion?

	All	18-29	30-44	45-64	65+
I already have	**1%**	1%	1%	0%	0%
Definitely	**2%**	3%	3%	0%	0%
Probably	**3%**	6%	5%	1%	1%
Probably not	**8%**	11%	10%	8%	6%
Definitely not	**81%**	71%	74%	86%	91%
Not sure	**5%**	8%	7%	4%	3%

Source: YouGov survey of 5,484 US adults

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