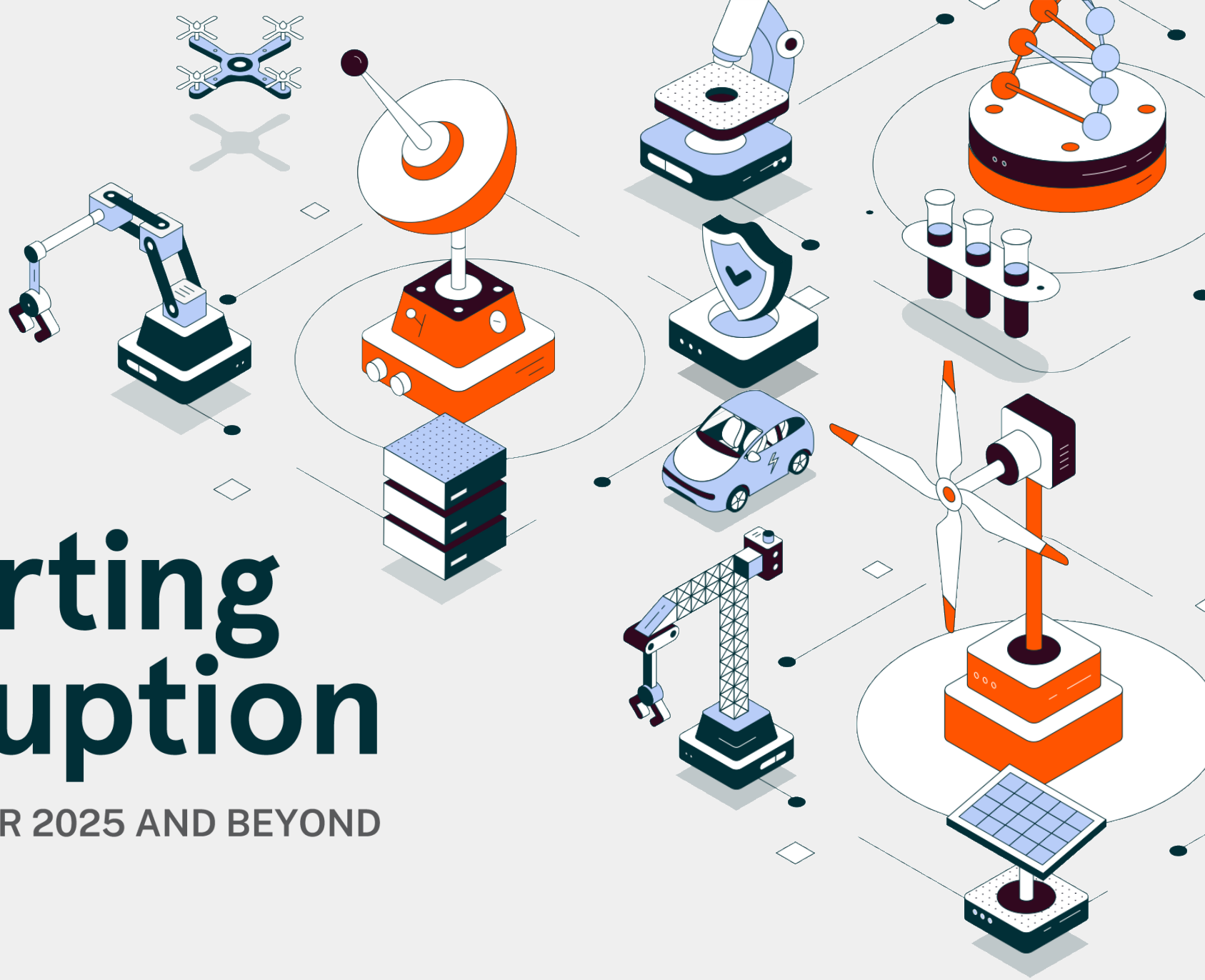


Charting Disruption

GLOBAL X by Mirae Asset

OUTLOOK FOR 2025 AND BEYOND

GLOBAL X
by Mirae Asset

Beyond Ordinary ETFs®

Since 2008, our mission has remained unchanged:
Empowering investors with unexplored and intelligent solutions.

$92 bn in AUM across more than 300 ETF strategies[1]

Primary Listings by Office

Headquartered in New York, with Global X ETFs listed throughout the Americas, Europe, Asia, and Australia.

United States
97 ETF Listings

Europe
42 UCITS ETF & ETP Listings

Hong Kong
36 ETF Listings

Japan
47 ETF Listings

Canada
122 ETF Listings

Australia
41 ETF Listings

Latin America
32 ETF Listings in Brazil & Colombia[3]

MIRAE ASSET
Building on principles

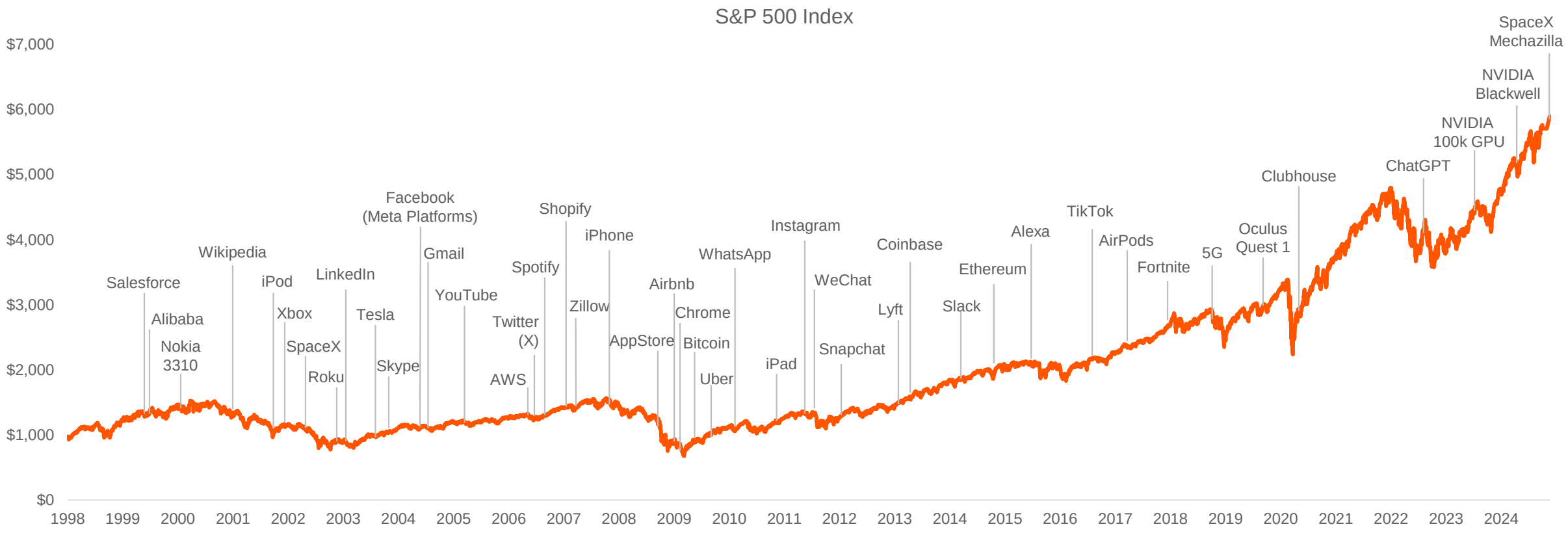
$136 bn	608	13
Total ETF AUM	ETFs	Global Markets[1]

Global X ETFs is a fully-owned subsidiary of Mirae Asset Financial Group, a global industry leader with 58 offices and over 12,000 employees worldwide. Founded in 1997 as one of Asia's pioneering fund management companies, the Group now oversees $606bn in client assets across a portfolio that includes real estate, insurance, private equity, and venture capital.[2]

[1]As of October 31, 2024 [2]As of September 30, 2024 [3]Includes Brazilian Depository Receipt listings of U.S. ETFs

Innovation Advances Despite Near-Term Market Dynamics

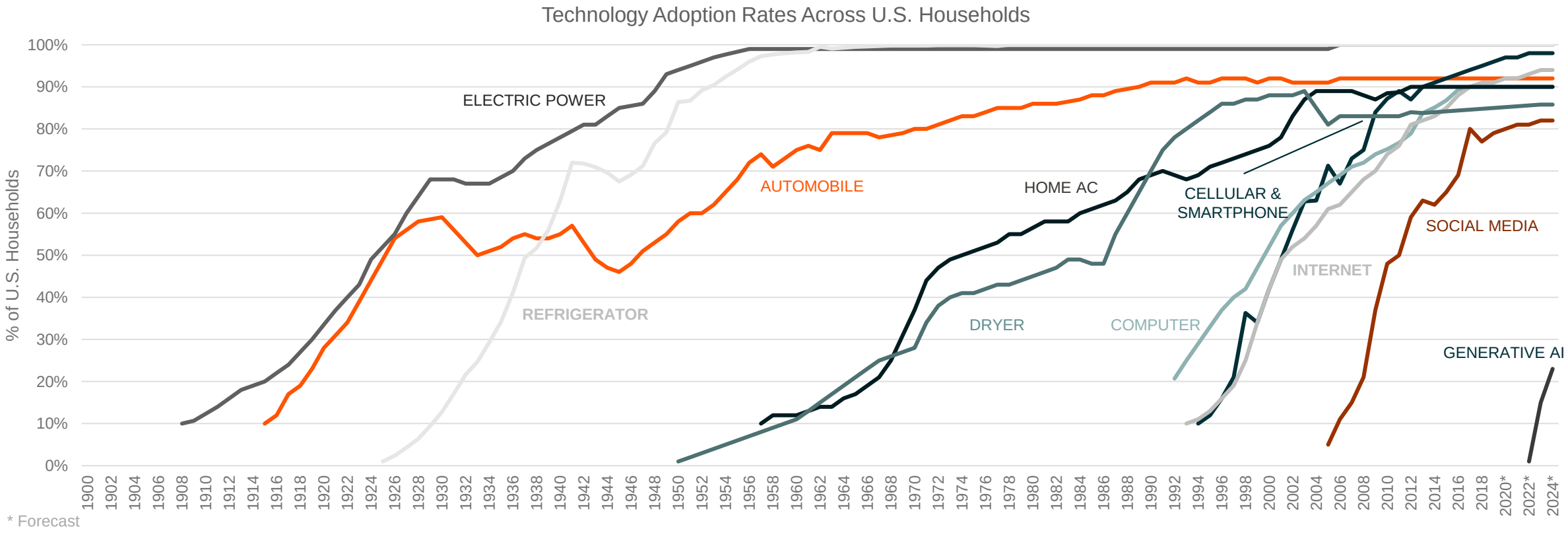
Market cycles come and go, but innovation persists – transforming once-unimaginable concepts into everyday realities.



Source: Bloomberg, L.P. (n.d.). S&P 500 Index. Data as of November 19, 2024.

Modern Technologies Are Breaking Historical Adoption Patterns

Technology adoption cycles reveal a striking pattern: each successive wave of innovation reaches mass adoption faster than the last. Growth that took decades for early 20th century technologies now takes mere years to achieve.

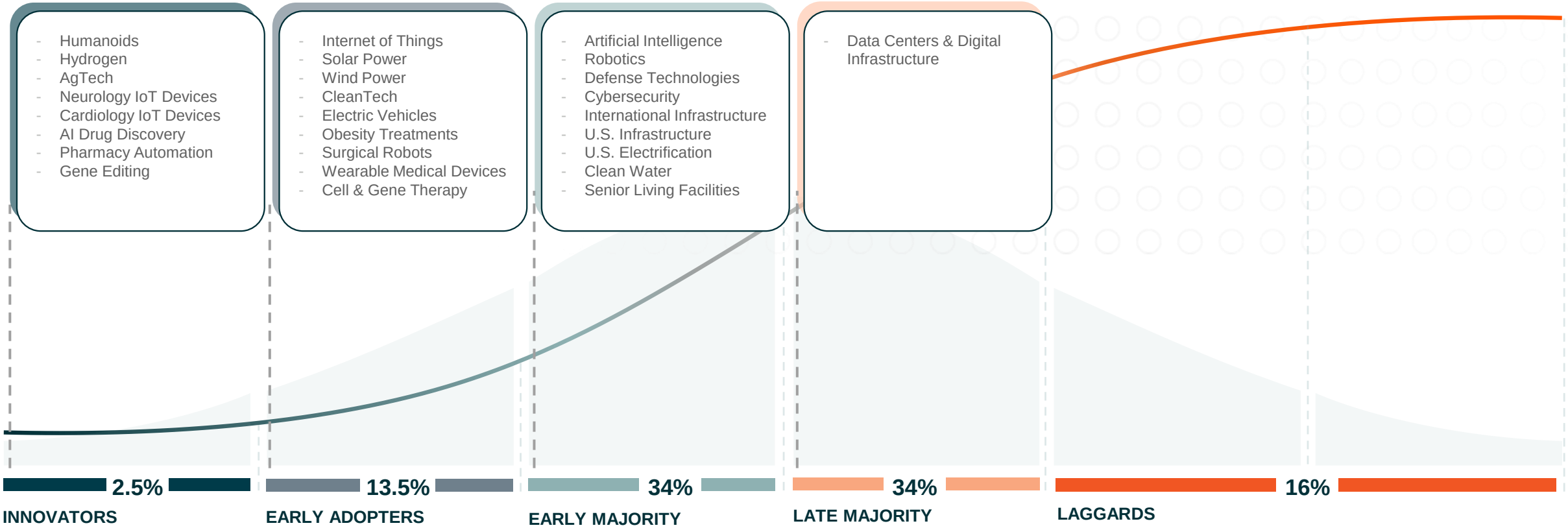


* Forecast

Sources: Generative AI: Backlinko. (2024, June 4). ChatGPT / OpenAI Statistics: How Many People Use ChatGPT?; Other Technologies: Global X ETFs forecast with information derived from: Our World in Data. (2019, July 27). Share of United States Households Using Specific Technologies.

Extraordinary Today, Potentially Ordinary Tomorrow

The next wave of transformative technologies is following familiar adoption patterns, suggesting rapid mainstream integration of what seems futuristic today.



PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

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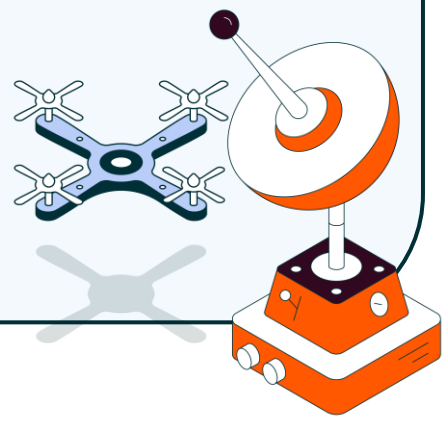
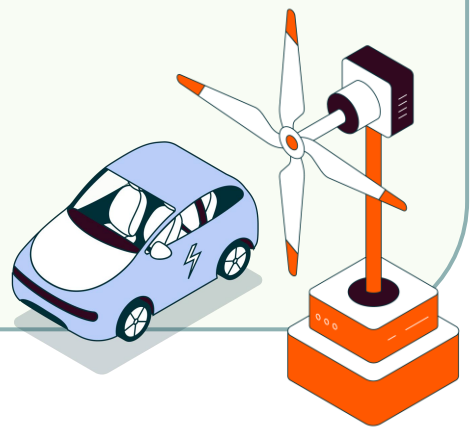
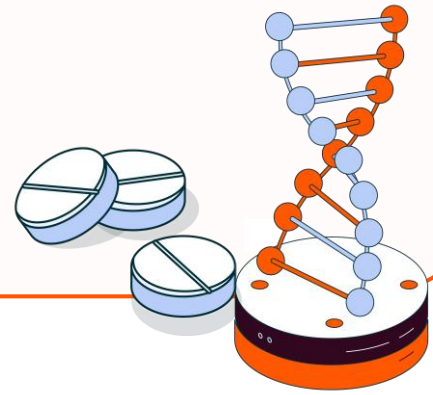
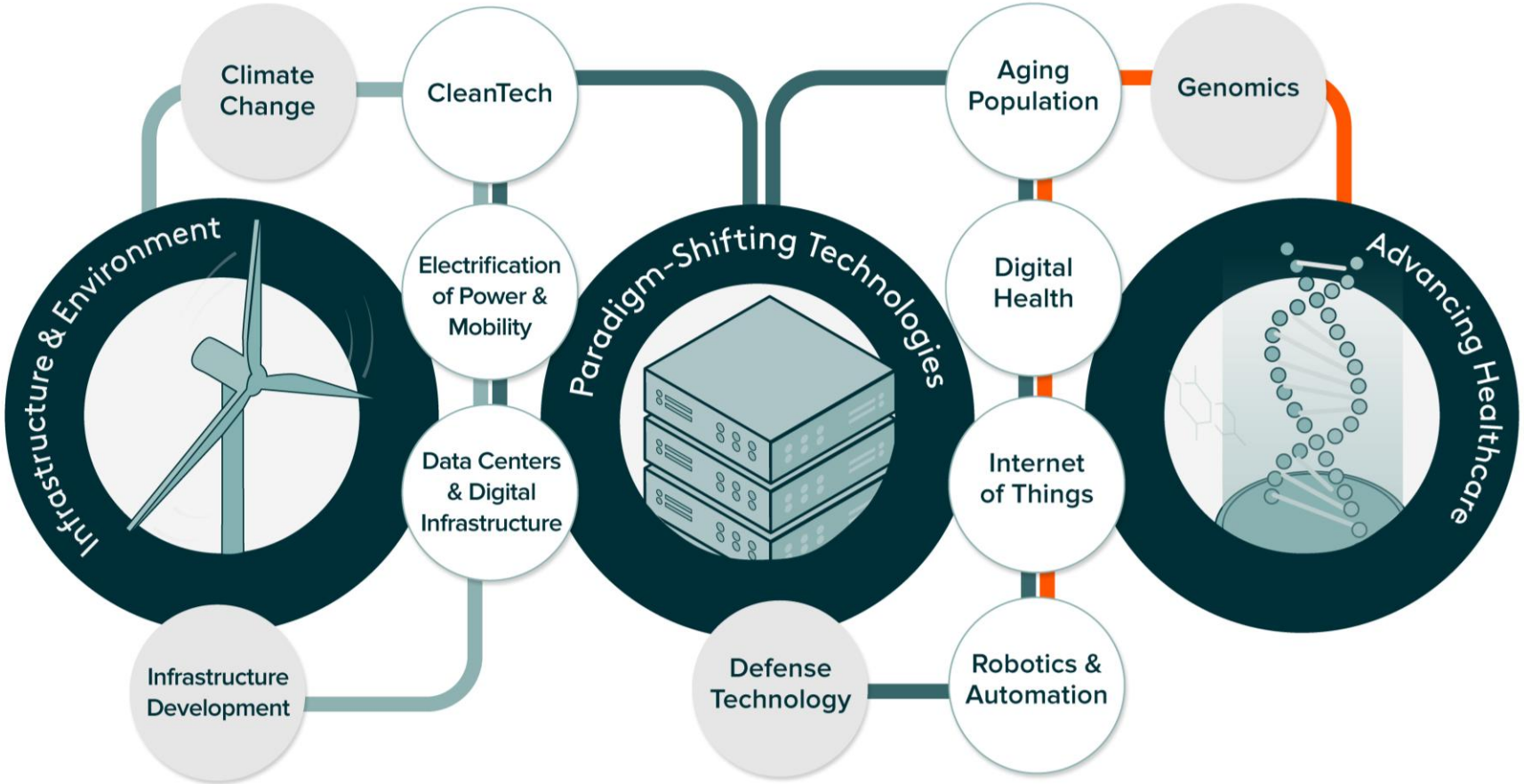






Connecting the Dots: Themes Increasingly Converge

Modern technological advances are dissolving traditional industry boundaries, creating an interconnected ecosystem where innovations in one theme inevitably ripple through others.



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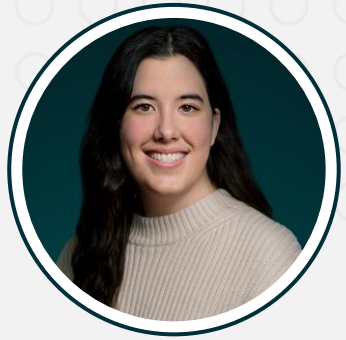

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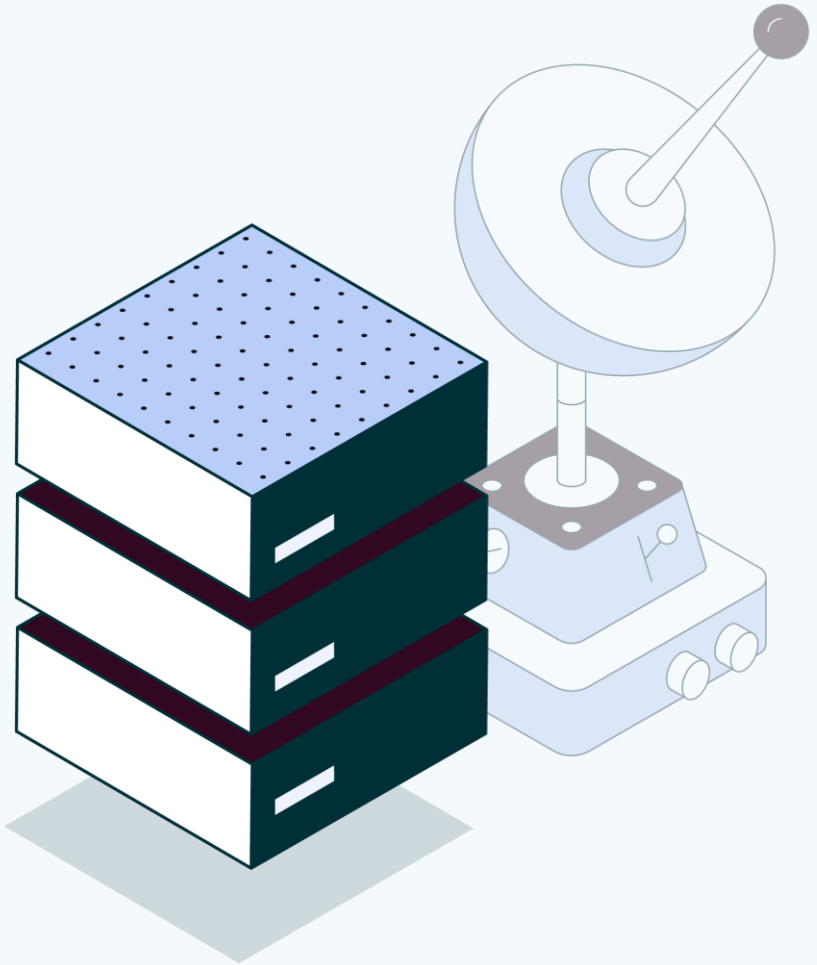
SECTION 1

Paradigm-Shifting Technologies

CHAPTER 1.1

AI Infrastructure:
Laying the Groundwork

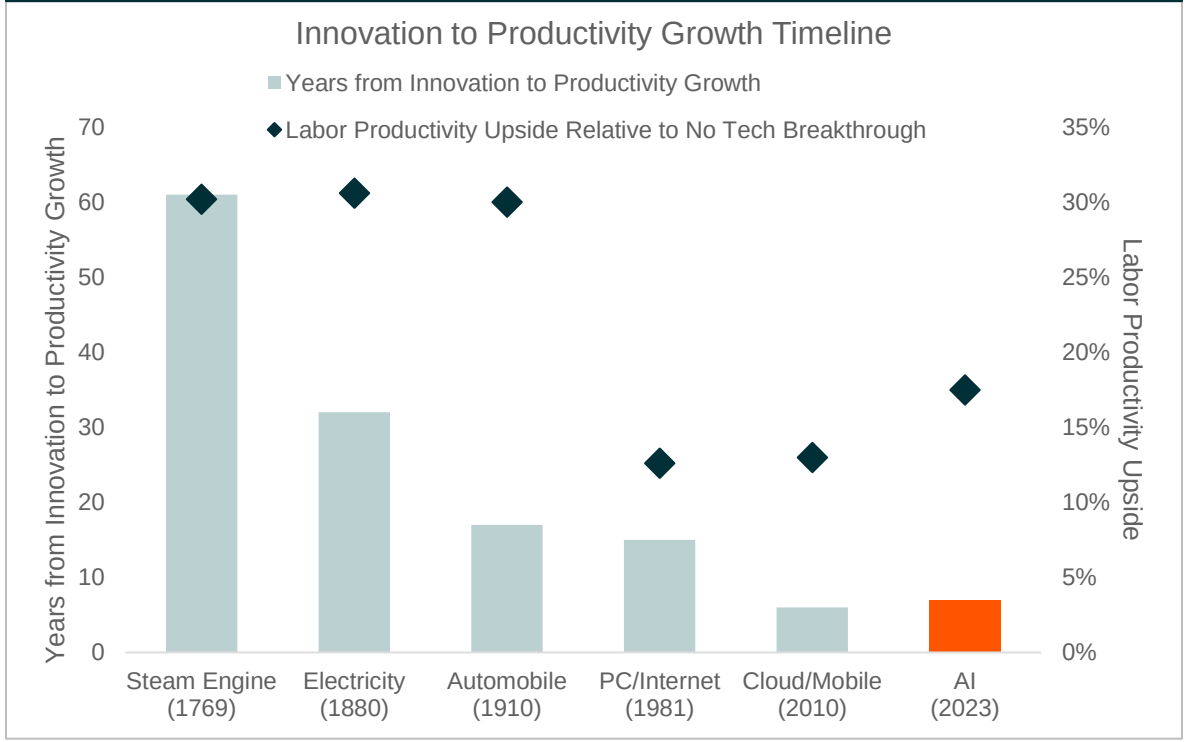


Major advancements in artificial intelligence (AI)-optimized hardware, such as next-generation graphics processing units (GPUs), computer processing units (CPUs), and accelerators, are enabling more powerful and efficient large language models. This is driving a rapid evolution in the data center industry, where providers are investing in capacity expansions, infrastructure upgrades, as well as increased power and energy demands to manage growing AI workloads. Modernized AI infrastructure is critical to fostering the widespread adoption of generative AI applications across industries. The benefits extend beyond data centers, with AI integration also enhancing cell towers, cellular infrastructure, Internet of Things (IoT) devices, and consumer electronics.

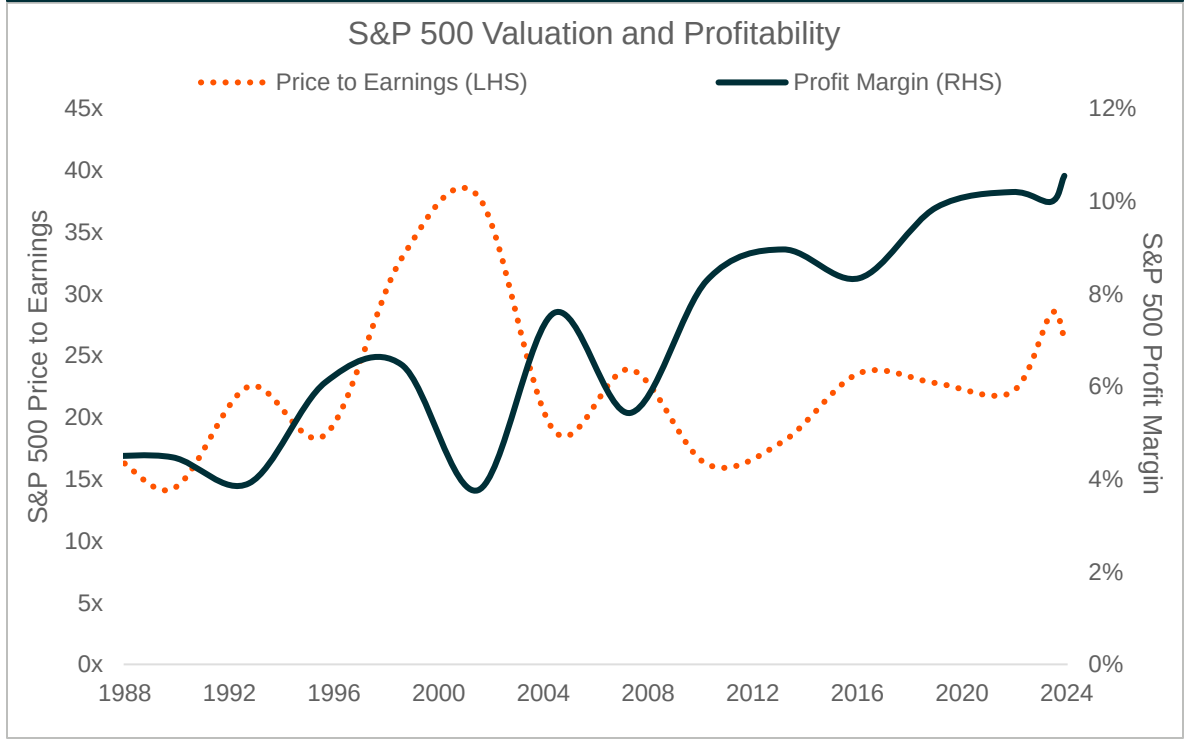
AI Poised to Increase Productivity at a Greater Rate Than the Internet Since Inception

Previous tech shifts boosted productivity, but AI appears on track to surpass even the advent of the internet. Growing AI integration could further elevate corporate profitability.

AI: Greater Productivity in Less Time Than the Internet



AI: Likely to Accelerate S&P 500 Profitability to New Highs

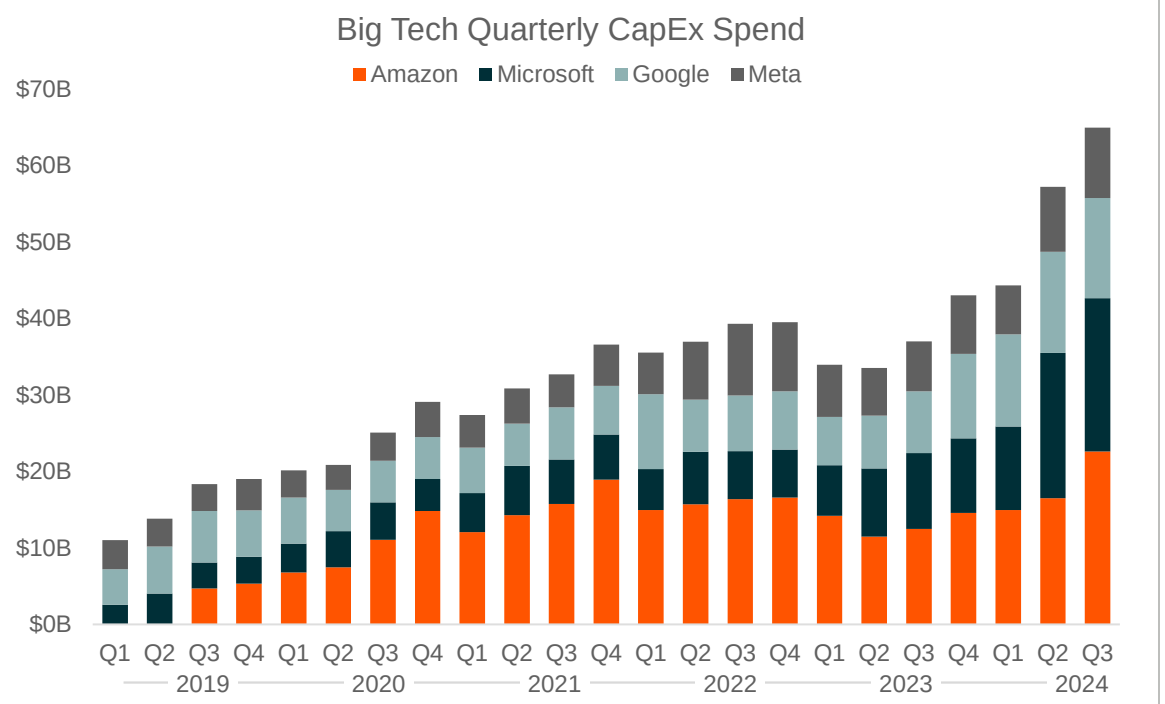


Sources: Charts: LHS: Global X ETFs with information derived from: JP Morgan, Jul 2024; FRED Economic Data, Sep 2024. RHS: Bloomberg, L.P., n.d., accessed on 19 Nov 2024.

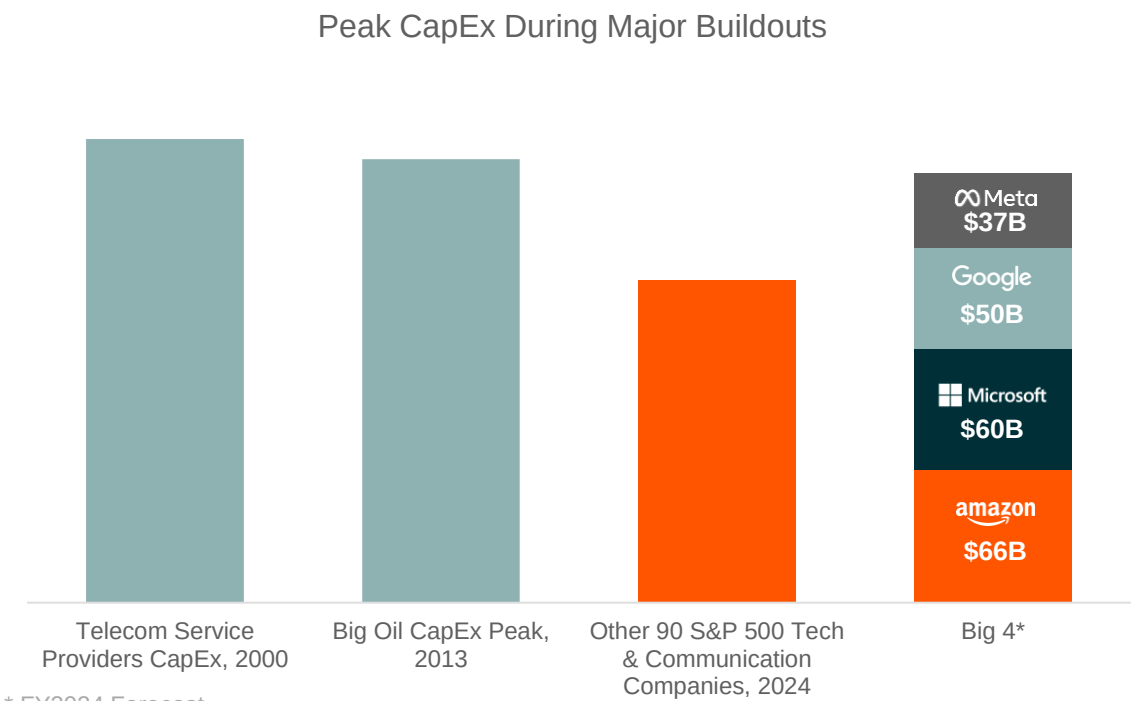
AI Investment: The CapEx Race Is On to Build the Infrastructure that AI Needs, Led by Big Tech

In 2024, Amazon, Google, Microsoft, and Meta are forecast to spend over $213 billion on CapEx, primarily for AI infrastructure.[1] That level is expected to grow even further in 2025.

Big 4 CapEx Spend Already Totaled Over $150B by Q3 2024



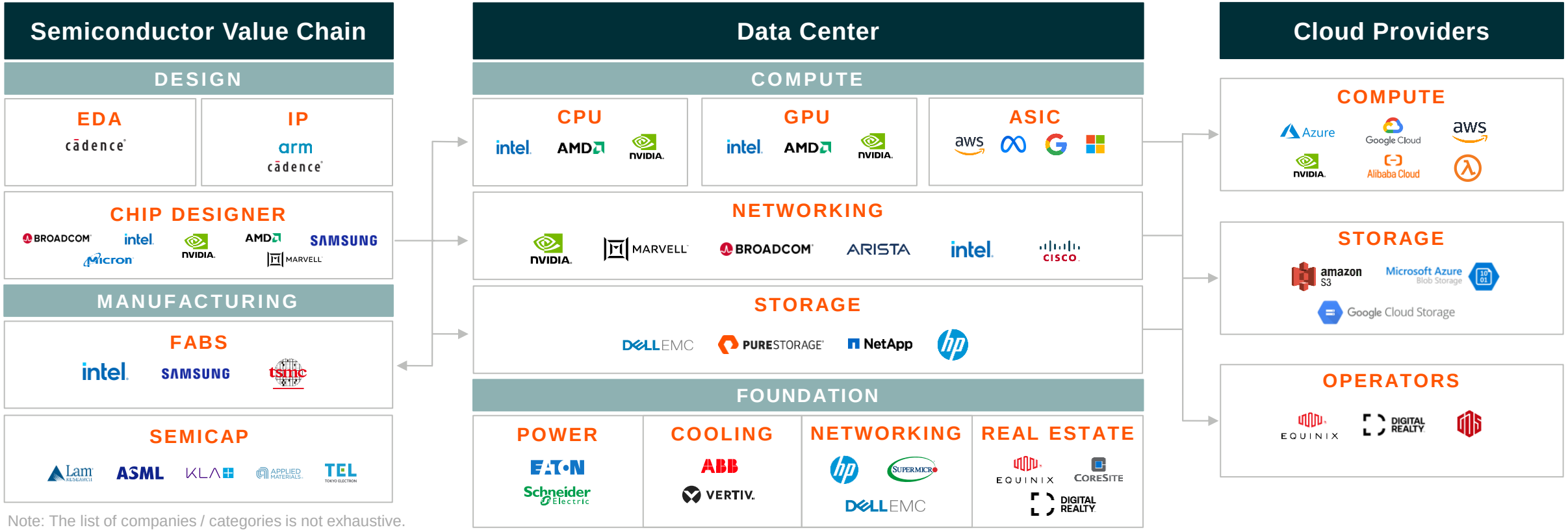
2024 Big 4 CapEx Rivals Telecom and Big Oil at Their Peaks



Note: On the RHS chart, the Telecom and Big Oil figures are adjusted for inflation.
Sources: Text: 1 Forbes, Aug 2024; Charts: LHS: FactSet, n.d., accessed on 1 Nov 2024; RHS: Bloomberg, L.P., n.d., accessed on 1 Nov 2024; FactSet, n.d., accessed on 1 Nov 2024; MarketWatch, Jul 2024.

AI Investment: Infrastructure Spending Set to Benefit a Broad Data Center Ecosystem

Modern data center value chains span three categories – foundational semiconductors, core infrastructure (compute, networking, storage, cooling), and the software layer for technology abstraction.



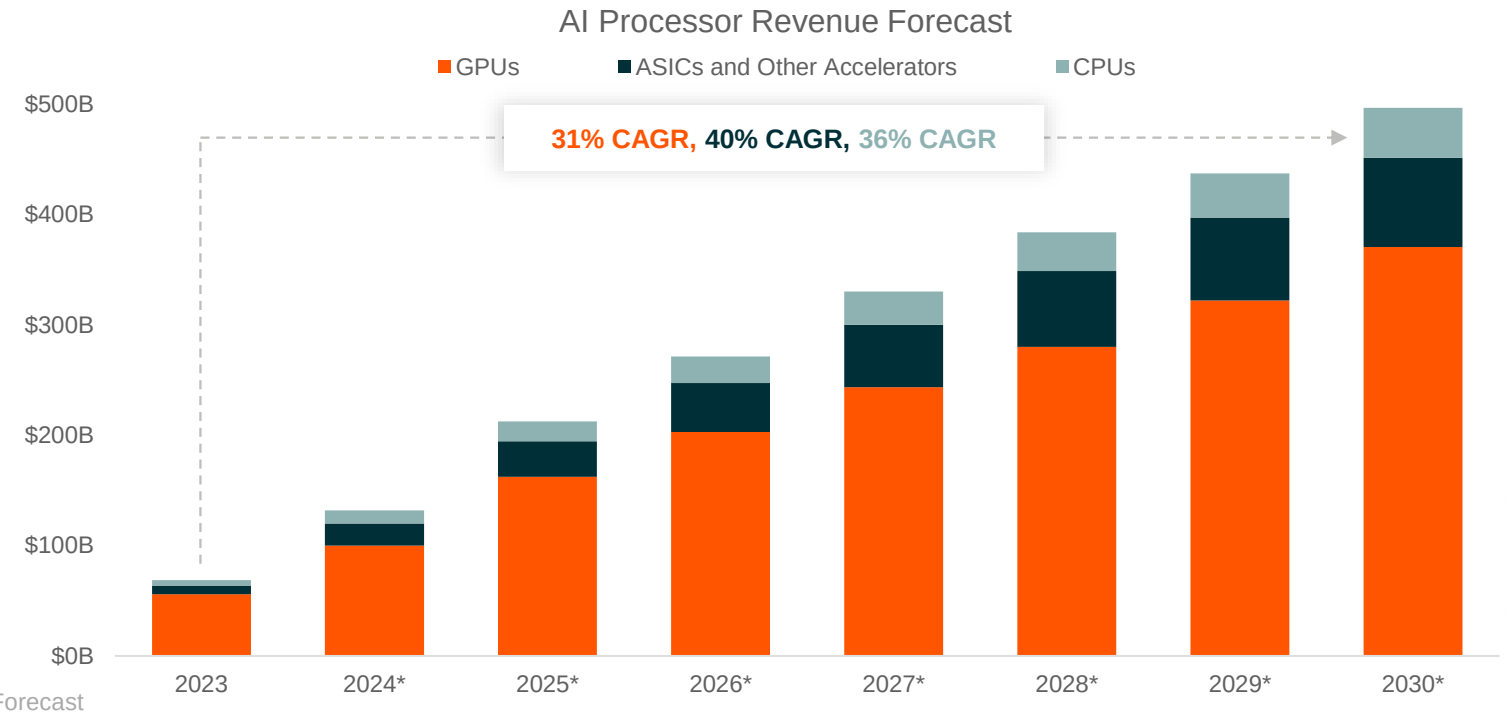
Note: The list of companies / categories is not exhaustive.

Sources: Public Comps, Feb 2024.

Custom ASICs and AI Inferencing Chips Expected to Boost AI Server Market Alongside GPUs

In addition to GPU based AI training chips, application specific integrated circuits (ASICs), such as Google's AI accelerator tensor processing units (TPUs), as well as AI inferencing chips are expected to see growing demand.

GPU Sales Still Expected to Grow at a 30%+ CAGR Through Decade End, but Custom Accelerators Also Gaining Steam



Tensor Processing Units (TPUs)

Produced by **Broadcom** and manufactured by **Taiwan Semiconductor (TSMC)**

Estimates suggest **Broadcom** could earn over **$8 billion** and **$10 billion** from Google's TPU program in 2024 and 2025, respectively.[1]

Training and Inference Accelerator (MTIA)

Was designed in 2020 on **TSMC's** 7 nanometer (nm) process.

Trainium

Made available starting 2021 is also manufactured by **TSMC.**

Supported by: tsmc BROADCOM

Sources: Text: 1. Investing.com, Jun 2024; Charts: LHS: Global X ETFs forecast with information derived from: IDC, Feb 2024; The Next Platform, Jul 2024.

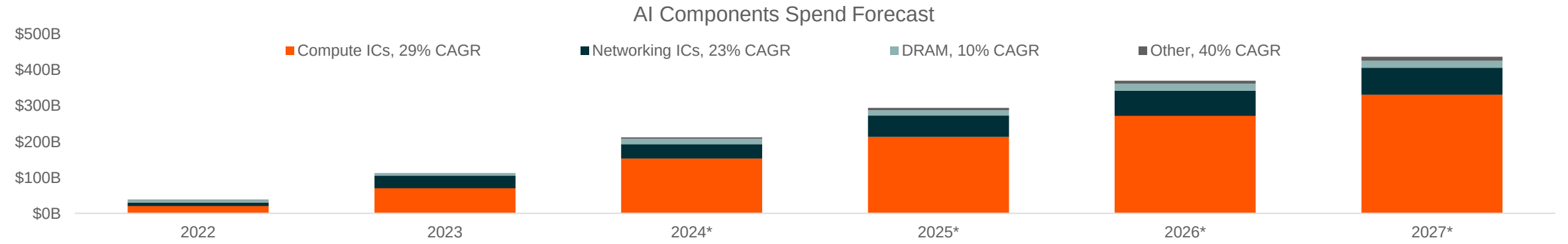
Modern GPU Clusters Require Specialized Networking, Storage, and Power Systems

GPUs have dominated AI CapEx thus far, but as data centers scale out AI servers, networking infrastructure and storage are poised to claim an increasing share of AI spending.

Key Hardware Components of a GPU Cluster

1. GPUs
2. CPU
3. RAM
4. HDDs/ SSDs
5. Networking Hardware
6. PSUs
7. Cooling Systems

Among GPU Components, Networking Set to Capture Growing Portion of the AI CapEx Wave



* Forecast; Note: Other includes Solid State Drives and Hard Disk Drives

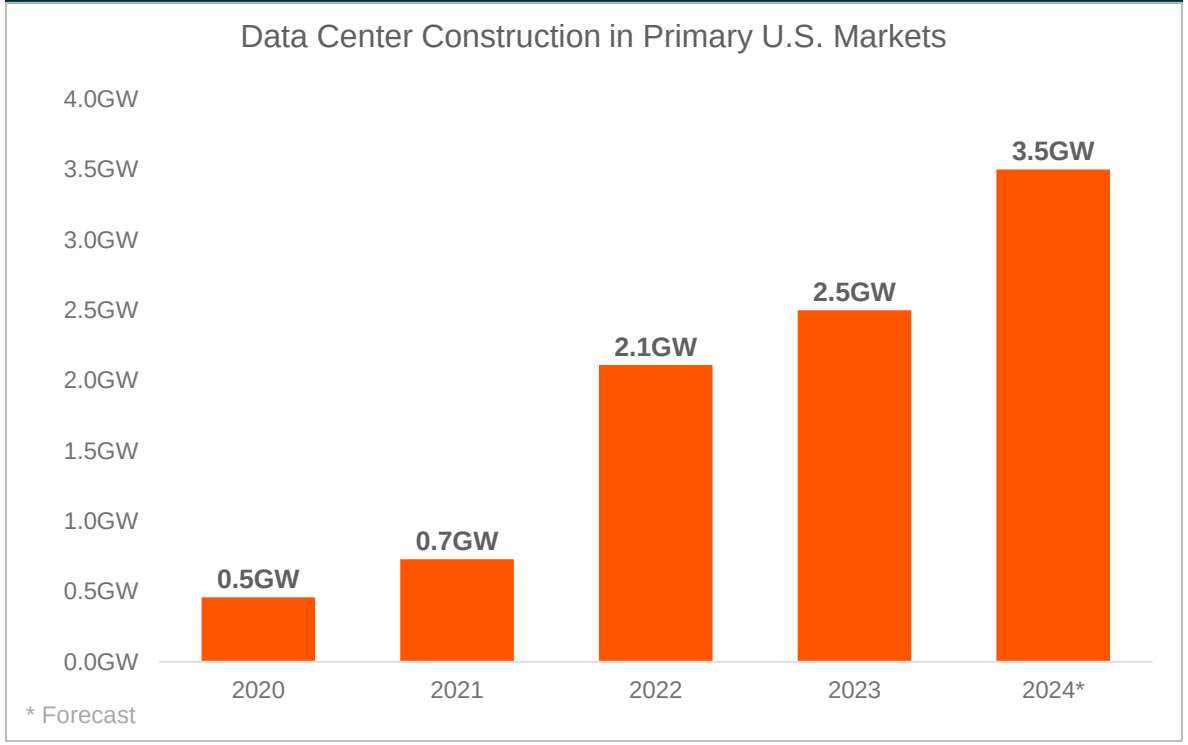
Note: RAM = Random Access Memory; HDDs = Hard Disk Drives; SSDs = Solid-State Drives; PSUs = Power Supply Units

Sources: Charts: Top: AI Multiple Research, Mar 2024; Bottom: Global X ETFs forecast with information derived from: Bloomberg, Mar 2024.

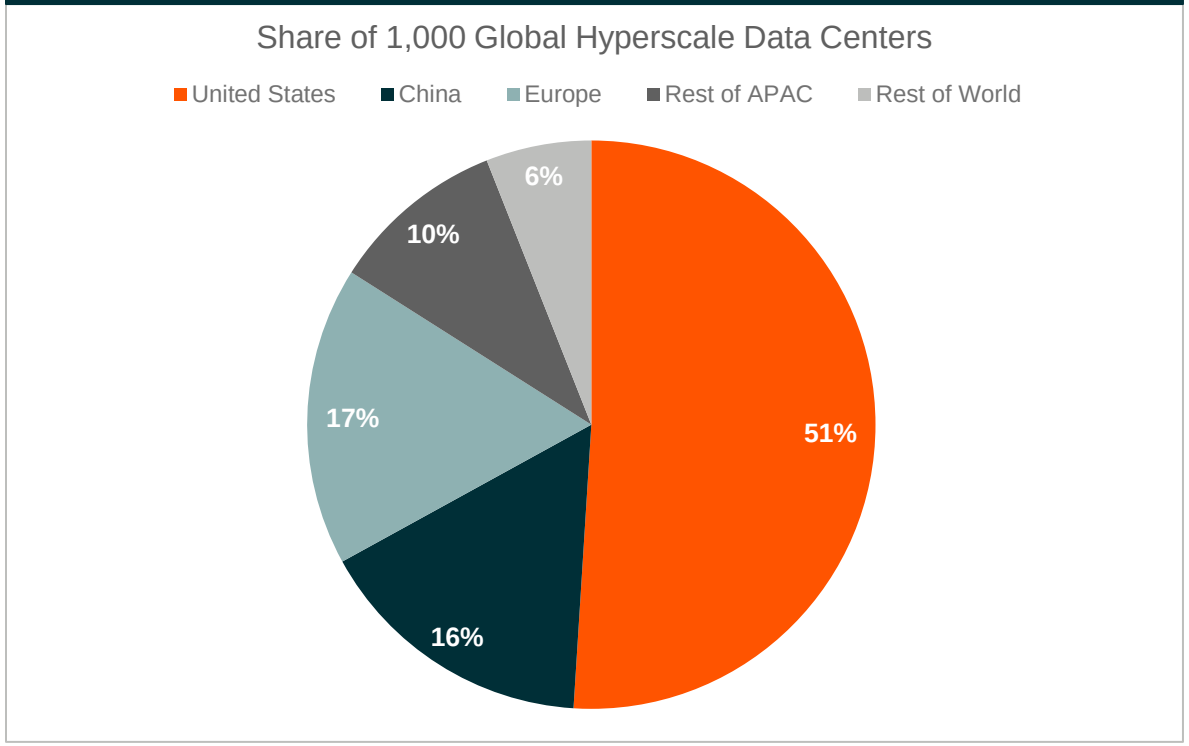
AI Investment: Record U.S. Data Center Construction Activity Already Spurred by AI Demand

Global hyperscale data centers hit 1,000 in 2024, with hyperscale capacity now doubling every four years as cloud giants intensify their AI efforts.[1] North American data center inventory grew by 24.4% YoY in Q1 2024.[2]

2024 U.S. Data Center Activity Expected to Hit New Highs



Over 50% of Hyperscale Data Centers in the United States



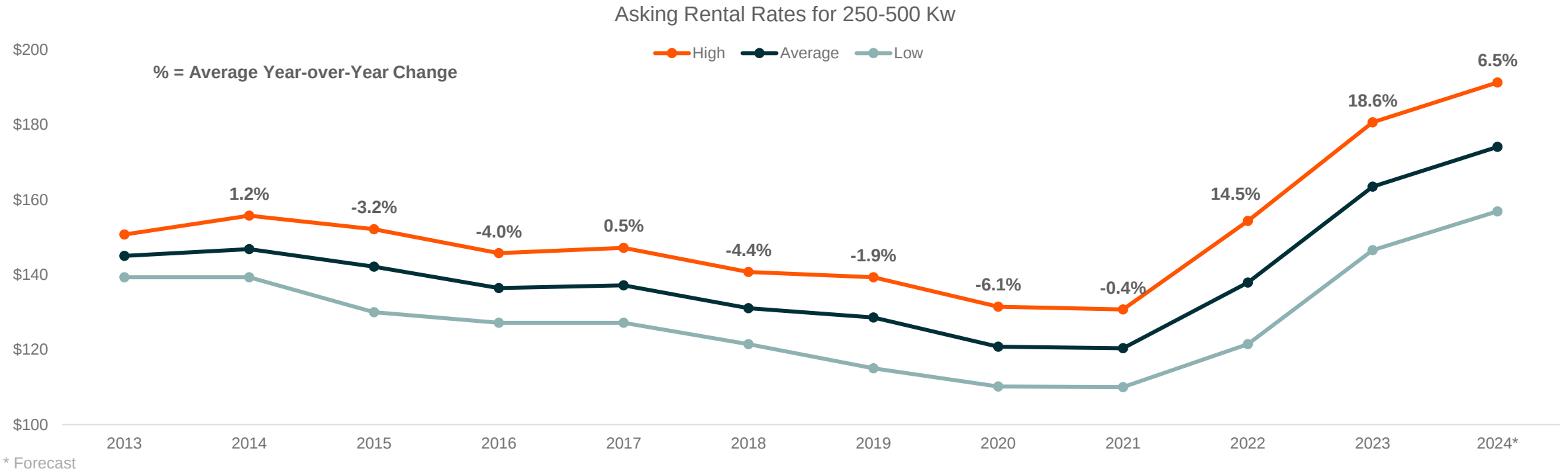
Note: GW = Gigawatts

Sources: Text: 1. Synergy Research Group, Apr 2024; 2. Ibid.; Charts: LHS: CBRE Group, Inc., Mar 2024; RHS: Synergy Research Group, Apr 2024.

AI Investment: Rising Demand and Capacity Crunch Have Existing Data Centers Priced at Premiums

Vacancy rates are declining globally due to strong demand, with existing colocation-based U.S. data centers reaching record lows of 3.7% in 2023.[1] Rental rates for U.S. data centers anticipated to grow by 13% YoY in 2024.[2]

Asking Rental Rates for Data Center Capacity in Primary U.S. Markets Are at 10-Year Highs



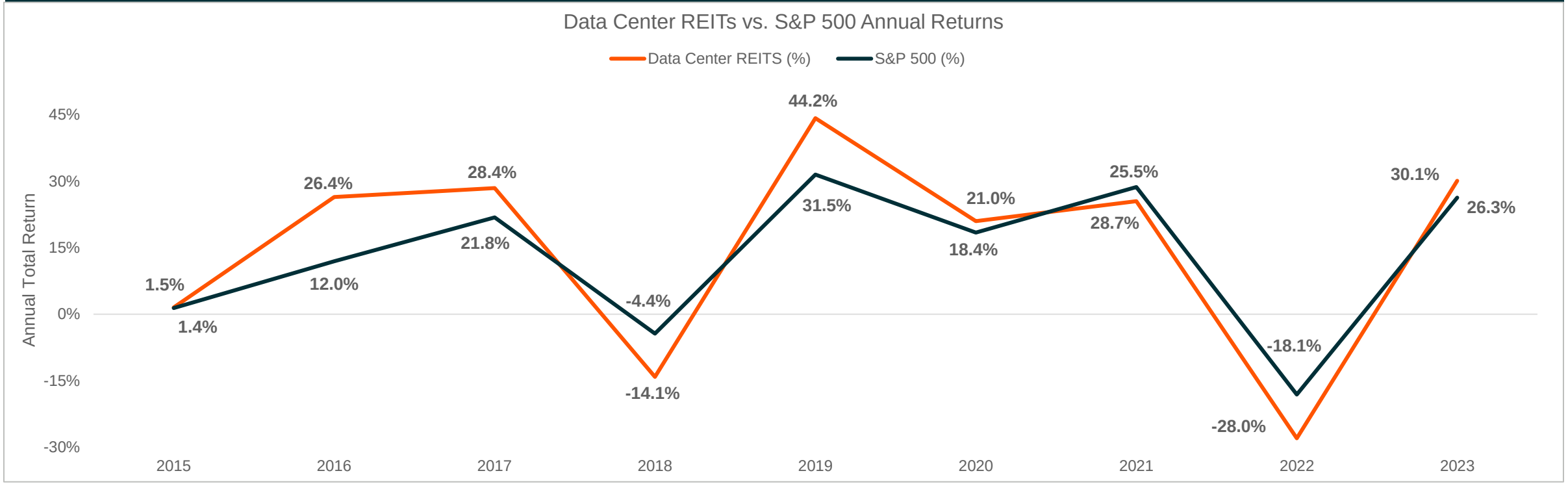
Note: Primary U.S. datacenter markets as defined by CBRE are Northern Virginia, Dallas-Ft. Worth, Silicon Valley, Chicago, New York Tri-State, Phoenix, Atlanta, and Hillsboro.

Sources: Text: 1. Sunbird, Jun 2024; 2. CBRE, Aug 2024; Chart: Global X ETFs forecast with information derived from: CBRE, Aug 2024.

AI Investment: Data Center REITs Leverage Scale Advantages, Deliver Strong Market Performance

Despite being sensitive to the interest rate environment, Data Center REITs can capitalize on cloud computing and AI services to boost growth and earnings, delivering positive market returns.

Data Center REITs Outperformed S&P 500 in Six of the Past Nine Years[1]

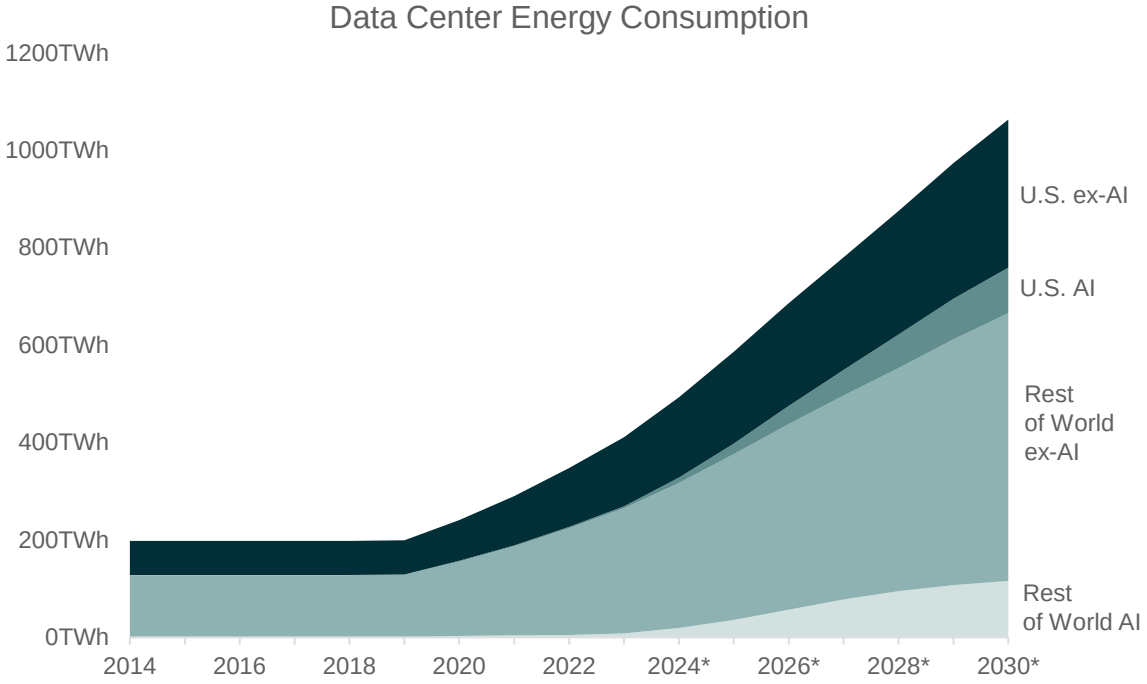


Sources: Text: 1. Nareit, Oct 2024; Slickcharts, 2024; Chart: Nareit, Oct 2024; Slickcharts, Oct 2024.

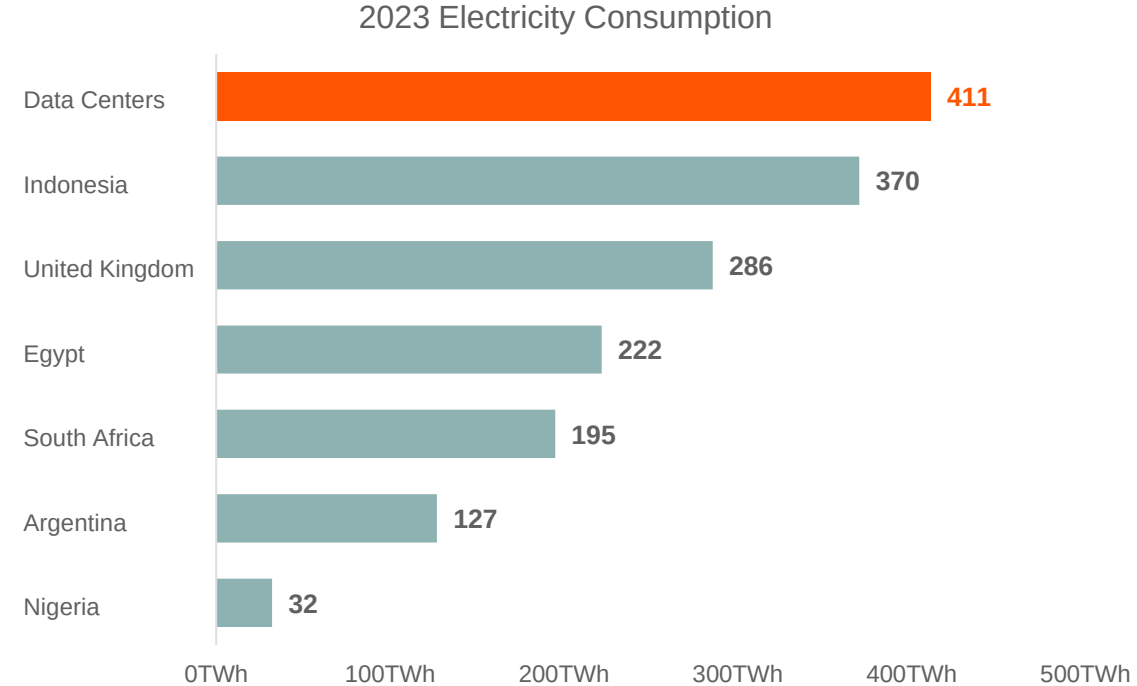
Energy Needs: Growing Data Center Footprint Impacts Global Energy Demand and Supply Dynamic

Global energy consumption from data centers approximated 411 terawatt-hours (TWh) in 2023.[1] By 2030, their consumption could more than double to 1,000TWh, approximately equal to Japan's total electricity use.[2]

Global Data Center Energy Demand Seen Tripling by 2030



Global Data Center Energy Usage Exceeds Entire Countries

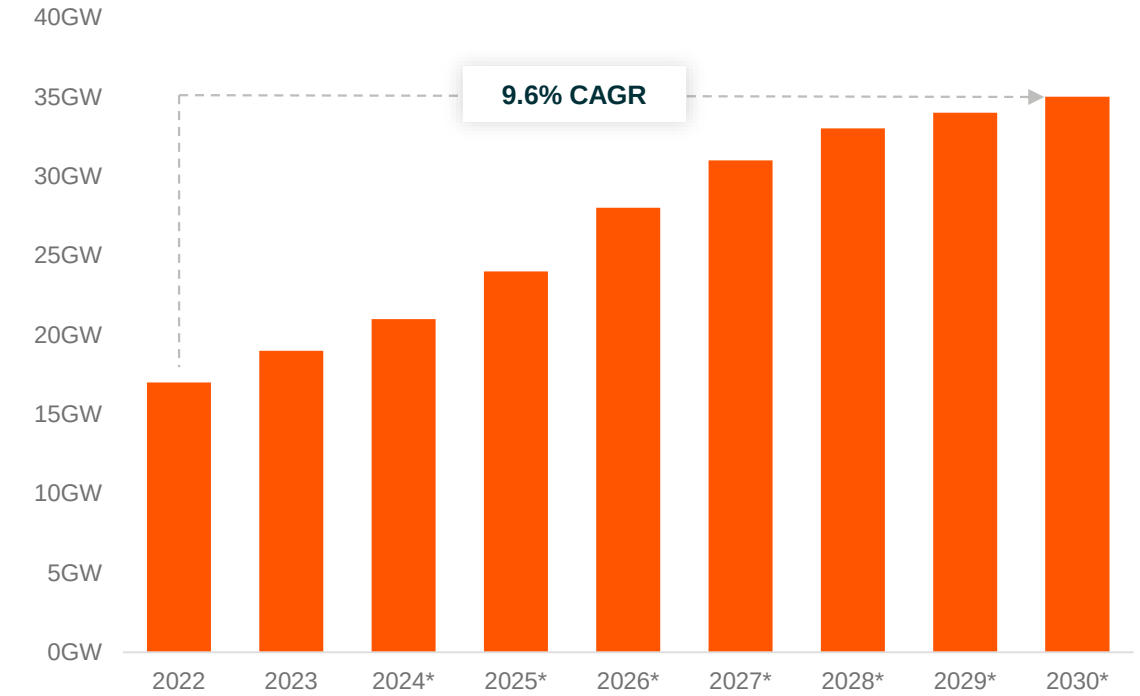


Sources: Text: 1. Goldman Sachs, May 2024; 2. S&P Global, Apr 2024; Charts: LHS: Goldman Sachs, May 2024; RHS: Enerdata, 2024; Energy Central, Jun 2024.

U.S. Data Center Capacity Is Expected to Grow to 35 Gigawatts (GW) by 2030

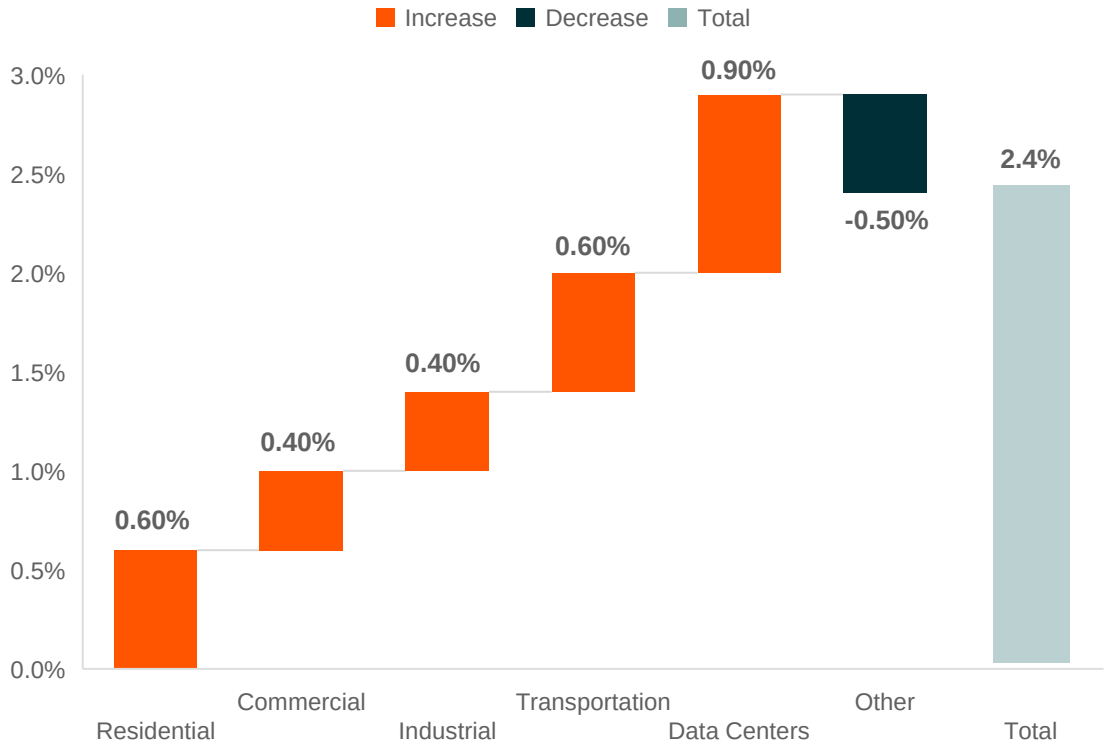
The expanding data center footprint, along with broader AI applications, is projected to significantly increase U.S. power demand. By 2030, U.S. data centers power demand is set to double the 17 GW in 2022.[1]

U.S. Data Center Power Load



* Forecast

U.S. Power Demand CAGR, 2022-2030



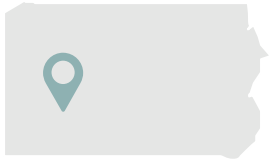
Sources: Text: 1. Data Center Dynamics, Jan 2024; Charts: LHS: Global X ETFs forecast with information derived from: Utility Dive, May 2024; RHS: The Goldman Sachs Group, Inc., Apr 2024.

Tech Giants Tap Nuclear Power for Growing Data Center Power Demands

The growing need for nuclear power is driving big tech companies to form partnerships and commit investments, with a strong focus on small modular reactors.

Amazon Buys a Nuclear-Powered Data Center from Talen

NAME/PROJECT	LOCATION	EXPECTED # OF BUILDINGS
Cumulus Data Assets	Salem Township, Pennsylvania	15



DETAILS

On March 4, 2024, Talen Energy sold Cumulus Data Assets to Amazon Web Services (AWS) for $650 million. The 1,200-acre campus is powered by the nearby 2.5-gigawatt Susquehanna Steam Electric Station, a nuclear plant operational since 1983 and licensed through 2044.[1]

Green Energy Partners and IP3 Form a Phased Joint Venture

NAME/PROJECT	LOCATION	EXPECTED # OF BUILDINGS
Surry Green Energy Center	Surry County, Virginia	15

DETAILS

Approved on February 8, 2024, this data center campus is designed to be powered by the nearby Surry Nuclear Power Plant but the long-term plan includes the development of 4-6 small modular reactors (SMRs) to provide nuclear energy directly to the data centers.[3]

Microsoft Signs 24/7 Nuclear Power Deal with Constellation

NAME/PROJECT	LOCATION	CURRENT # OF BUILDINGS
Boydton Campus	Boydton, Virginia	11

DETAILS

On June 20, 2023, Microsoft signed a deal with Constellation Energy to supply nuclear power to its Boydton, Virginia data center, targeting near 100% carbon-free operation. Constellation will provide up to 35% of the center's power through its carbon-free energy matching platform.[2]

Amazon Data Center Campus to Abut Nuclear Power Station

NAME/PROJECT	LOCATION	EXPECTED # OF BUILDINGS
Lake Anna Tech Campus	Louisa County, Virginia	7

DETAILS

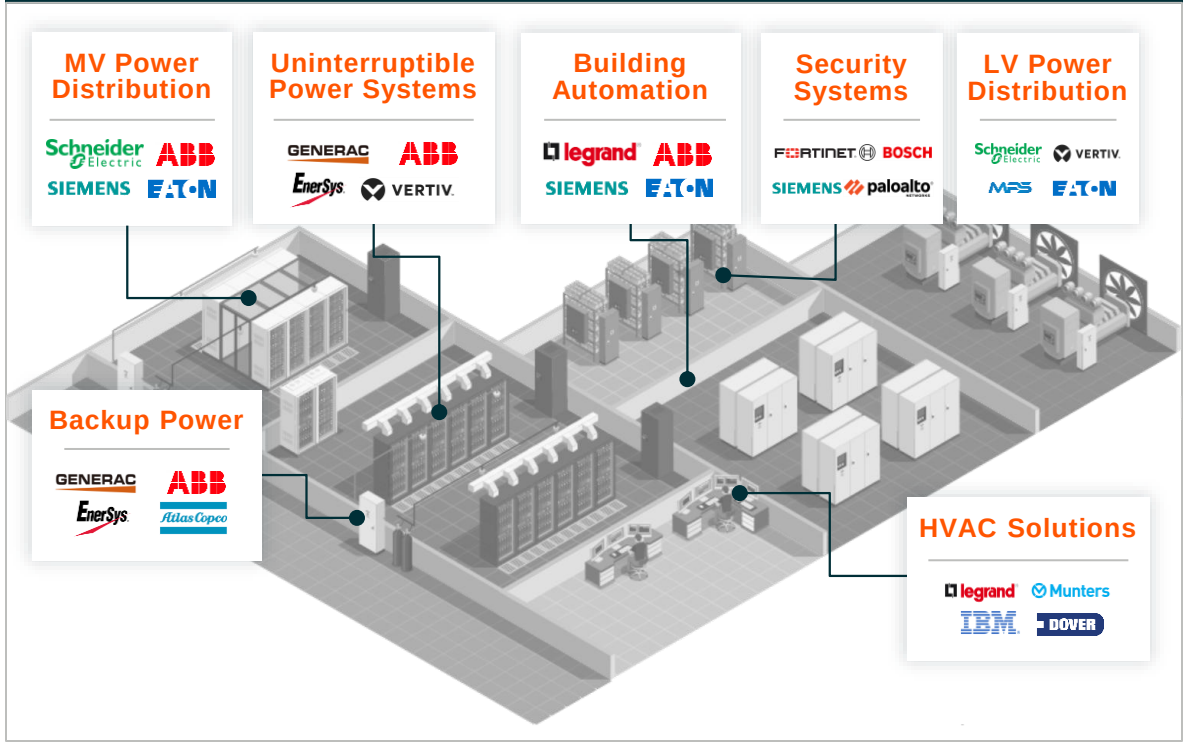
Filed on September 26, 2023, this is one of two data center campuses Amazon plans to build as part of an $11 billion investment in the state. The first campus is expected to house 7 data center buildings and be located near the Lake Anna Nuclear Power Station.[4]

Sources: Text: 1. Nuclear News, Mar 2024; 2. Data Centre Dynamics, Jun 2023; 3. Data Centre Dynamics, Aug 2023; 4. Lake Anna Life, Jun 2024.

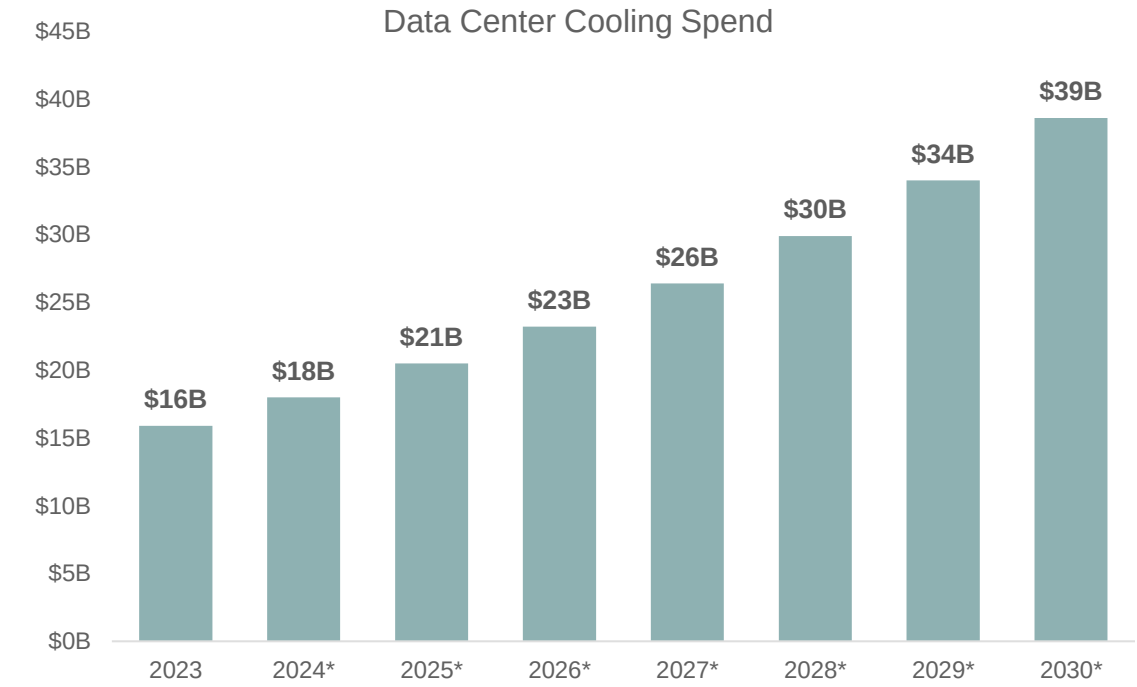
Energy Needs: Liquid Cooling and Power Management Essential to Handle Accelerated Computing

Data center cooling weighs heavily on overall IT budgets as roughly 40% of a data center's costs comes from cooling, power, and security.[1] Data center cooling includes chillers, computer room AC air handlers, and HVAC units.

Data Centers Need Specialized Power and Cooling Systems



Data Center Cooling Market to Approach $39B by 2030[2]



Sources: Text: 1. Public Comps, Feb 2024; 2. Robeco, Jun 2024; Charts: LHS: Global Market Insights, Apr 2024; RHS: Global X ETFs forecast with information derived from: Robeco, Jun 2024.

Beyond Data Centers: Demand for Accelerated Computing Likely to Extend Beyond Generative AI

Accelerator chips are critical for generative AI and a wide array of critical computation-heavy end use cases across industries, expanding both the market potential for chips and energy demands.

Applications of Accelerated Computing

Scientific Simulations
Physics, chemistry, and climate modeling benefit from accelerated computing.

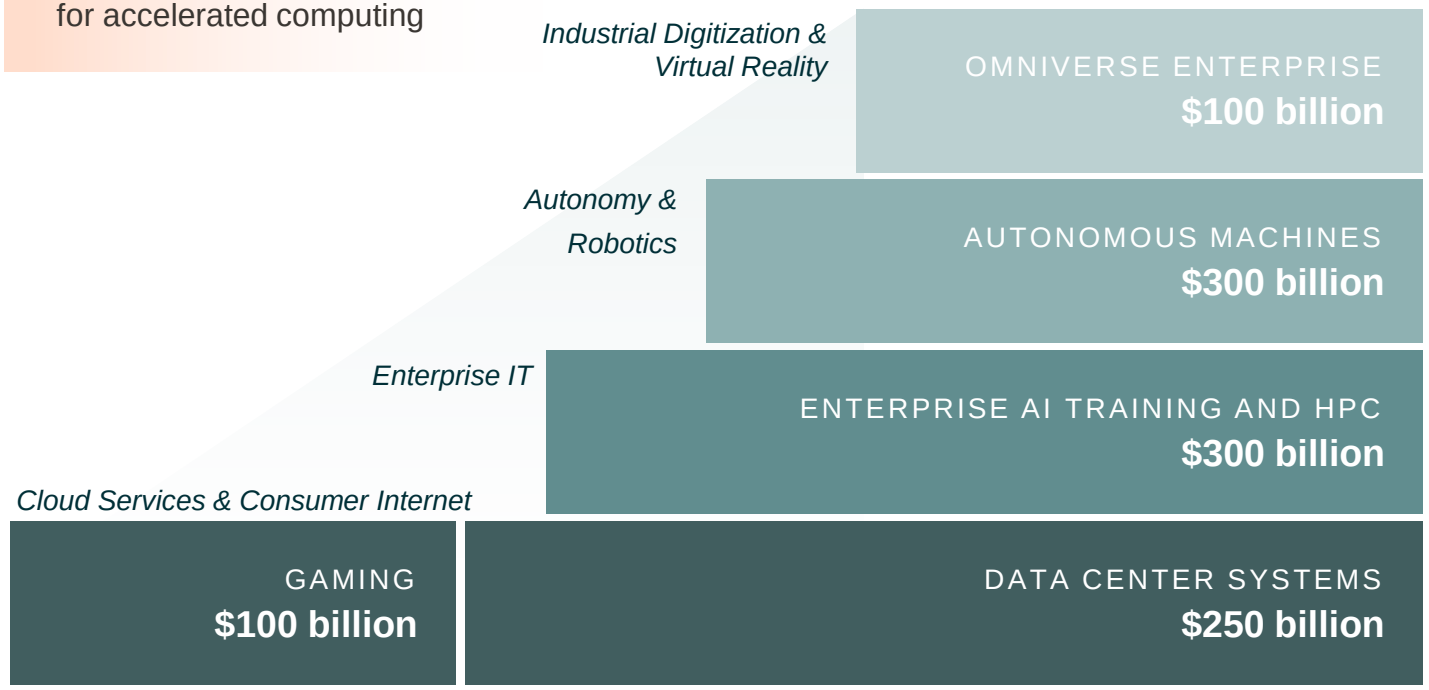
Autonomy
Self-driving vehicles, robotics, and drone navigation rely heavily on accelerated computing for real-time decision making, sensor fusion, and path planning.

Medical Research
Drug discovery and genomics utilize accelerated computing for complex calculations.

Computer Vision
Object detection and image processing in various industries rely on accelerated computing.

Cryptography
Blockchain and cybersecurity applications use accelerated computing for enhanced performance.

+ $1 trillion
addressable opportunity
for accelerated computing



Sources: Charts: RHS: The Next Platform, Oct 2023.

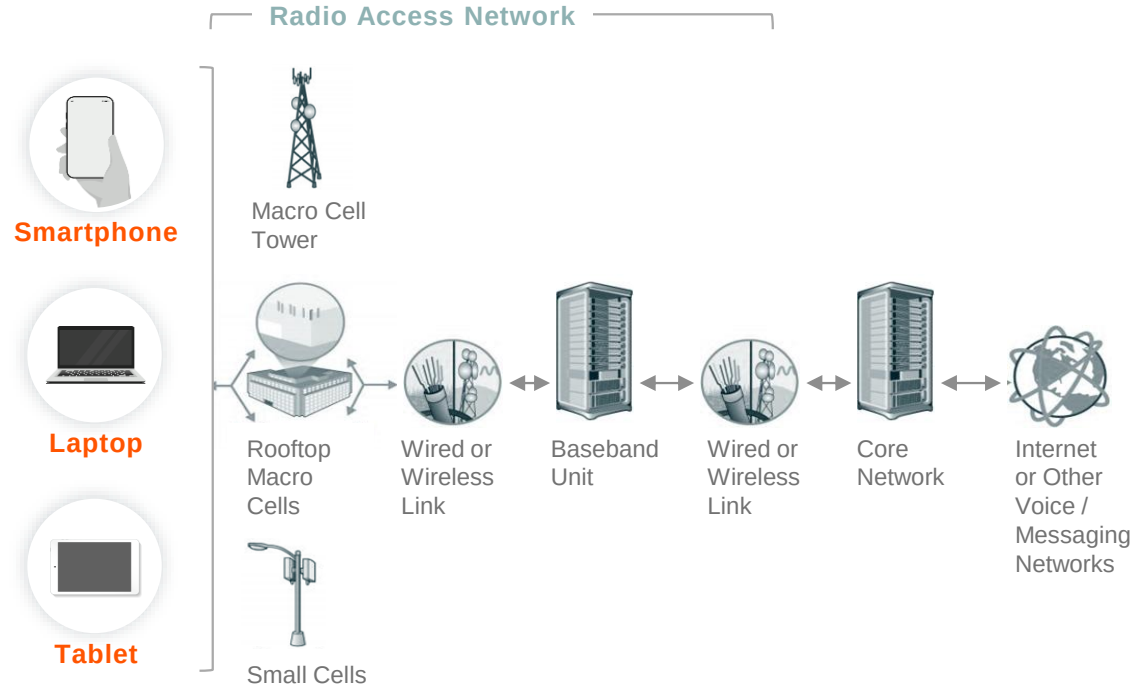
Beyond Data Centers: Infrastructure Between Data Centers and End Users Critical for Adoption of AI

AI's benefits depend on low-latency, high-bandwidth, and secure communications between end users and the data centers running the models, which require quality cellular and communications infrastructure.

Generative AI Use Cases Could Drive Cellular Upgrades

Data Traffic Explosion	Smartphones, video streaming, and social media is driving global mobile data traffic exponentially, straining networks and spurring infrastructure investments.
Low Latency Needs	Gen AI needs faster, more responsive networks. Critical applications relying on cloud-based AI will further drive demand for faster connections.
File Density Needs	Higher resolution media, complex data formats, AI-generated content, and other similar features necessitate investments in content transmission capabilities.
Heightened Data Security	Networks must fortify their defenses to meet heightened data security demands, especially as a wider range of critical systems adapt AI-based automated decision-making.

Cellular Infrastructure Upgrades Span Network and Devices

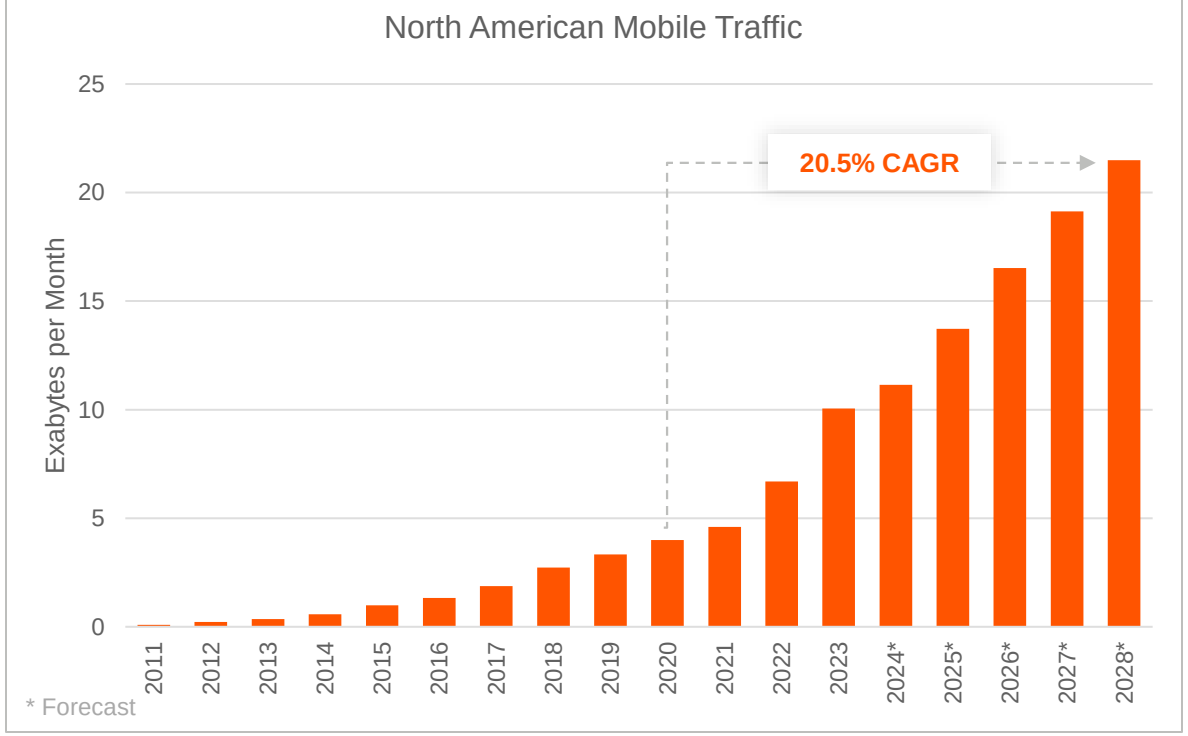


Sources: Charts: RHS: Moniem Tech, Jun 2021.

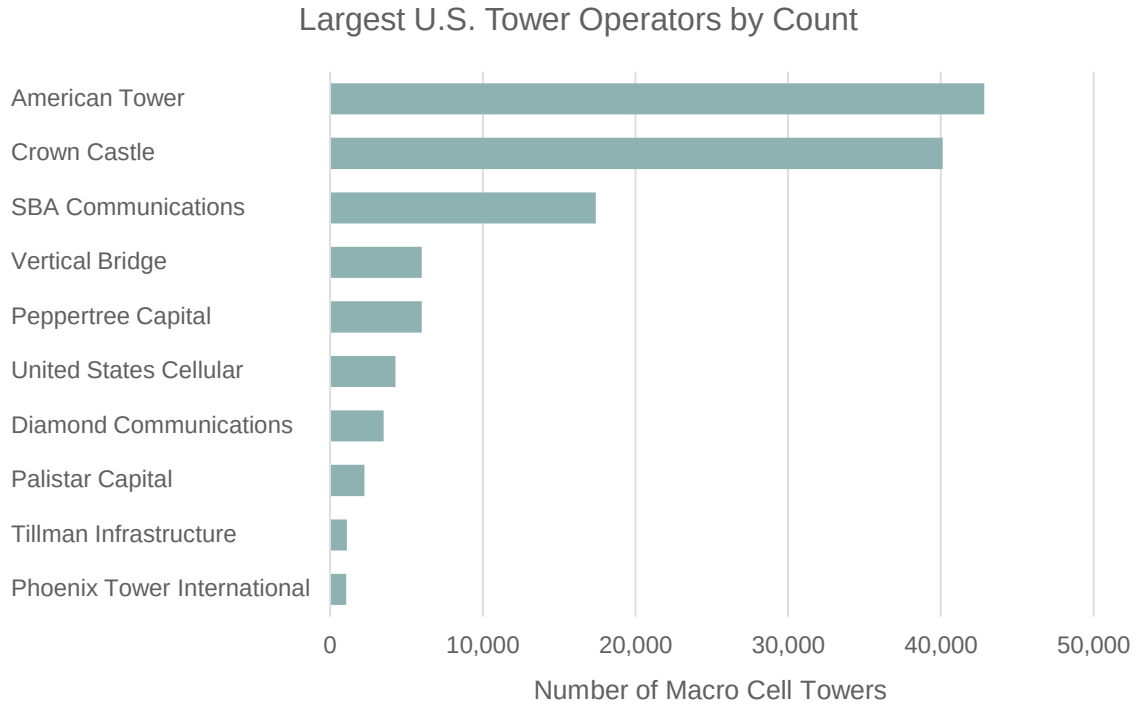
Deployment of Macro and Small Cell Towers Likely to Accelerate Due to AI-Driven Traffic

Mobile and cloud-based AI processing is expected to strain existing cellular networks as users increasingly adopt AI applications, which may require widespread upgrades to devices and cellular infrastructure.

AI Expected to Further Accelerate Mobile Traffic Growth



Tower Densification Could Grow to Support Traffic Growth

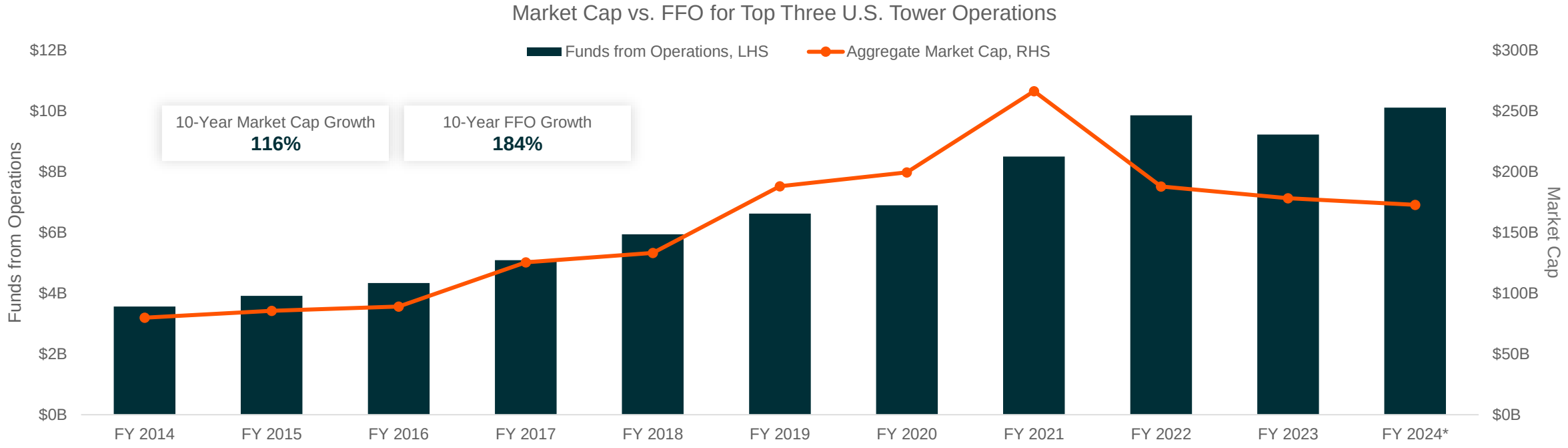


Sources: Charts: LHS: Global X ETFs forecast with information derived from: DemandSage, Jan 2024; RHS: Statista, Jul 2024; Wireless Estimator, Oct 2024.

Beyond Data Centers: Dominant U.S. Cell Tower Operators Display Attractive Financials

Cell tower profitability and income continue to grow despite higher interest rates denting market capitalization. This underscores the resilience of the business model and highlights a potentially undervalued opportunity.

Tower Operators Have Significantly Increased Operating Income, Outpacing the Market's Recognition in Equity Appreciation



*FY 2024 Market Cap is as of Oct 31, 2024. FFO is LTM.

Note: Top 3 U.S. Tower Companies includes American Tower, Crown Castle, and SBA Communications
Sources: Wireless Estimator, Oct 2024; Bloomberg L.P., n.d., accessed on 30 Oct 2024.

Beyond Data Centers: AI Could Spur Personal Device Upgrade Cycle and Boost Smartphone Sales

The integration of generative AI apps in smartphones, such as Apple Intelligence, could drive a global upgrade cycle contributing to projected revenues of over $630 billion by 2030.[1]

Smartphones to Be Redesigned for AI from the Ground Up[2]

Legacy Smartphones

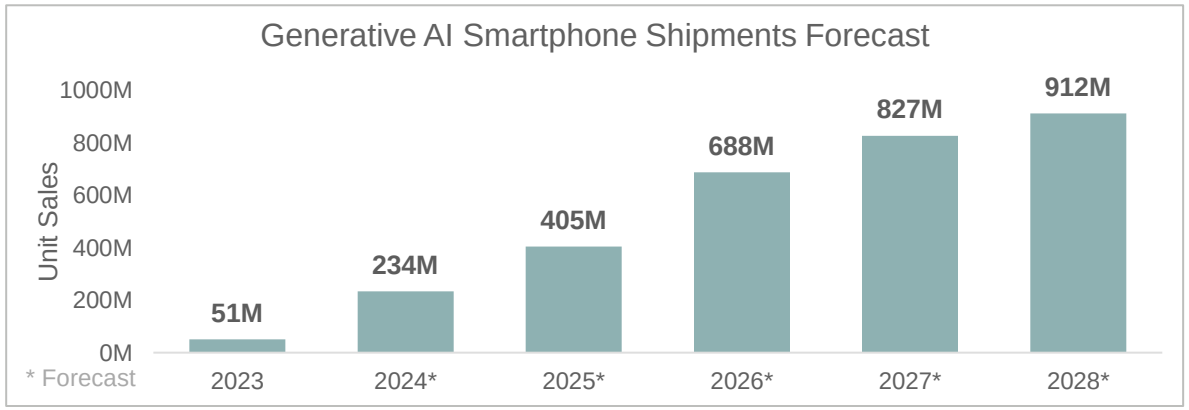
Legacy smartphones use accelerators alongside main processors for efficient on-device AI.

New models feature dedicated NPU cores delivering up to 30 TOPS, enabling NLP and computational photography.

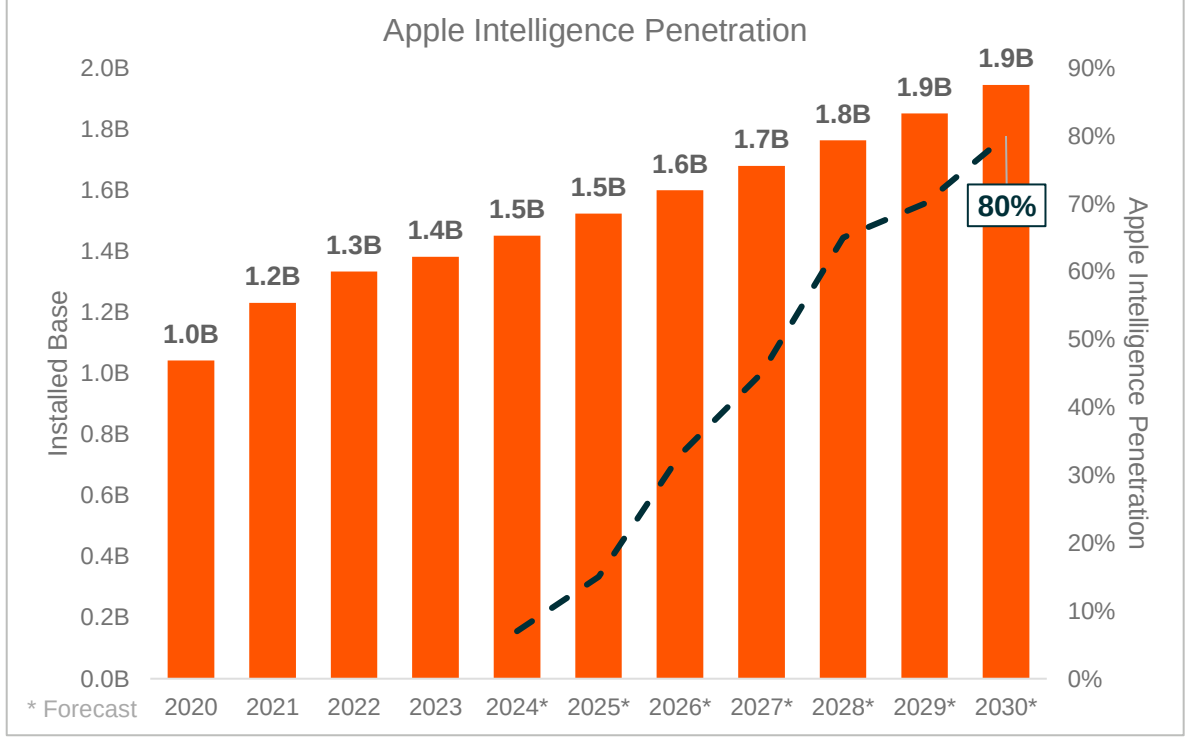
Next-Gen AI Smartphones

SoCs in these smartphones run on-device generative AI models efficiently, with NPUs exceeding 30 TOPS (int-8).

They support Stable Diffusion and LLMs, with wide data access. This category emerged in late 2023.



80% of iPhones Could Run Apple Intelligence by 2030

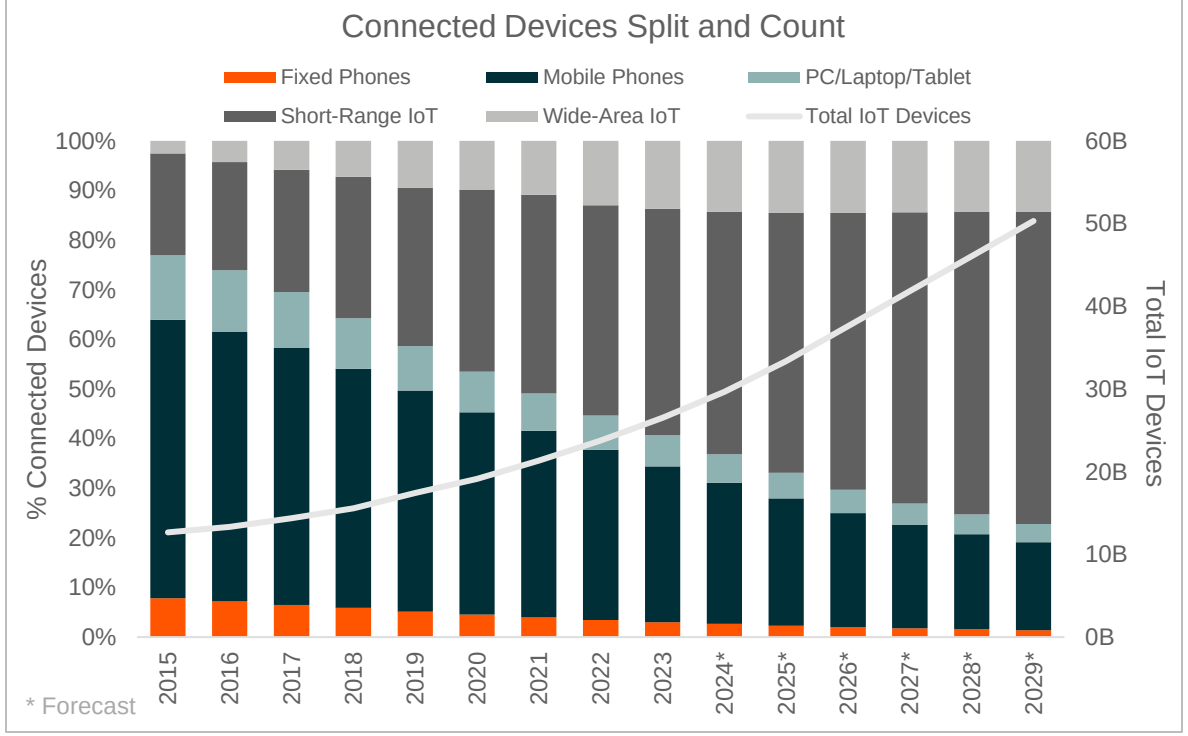


Sources: Text: 1. IDC, Feb 2024; 2. Ibid.; Charts: LHS: IDC, Feb 2024; RHS: Global X ETFs forecast with information derived from: Statista, May 2024.

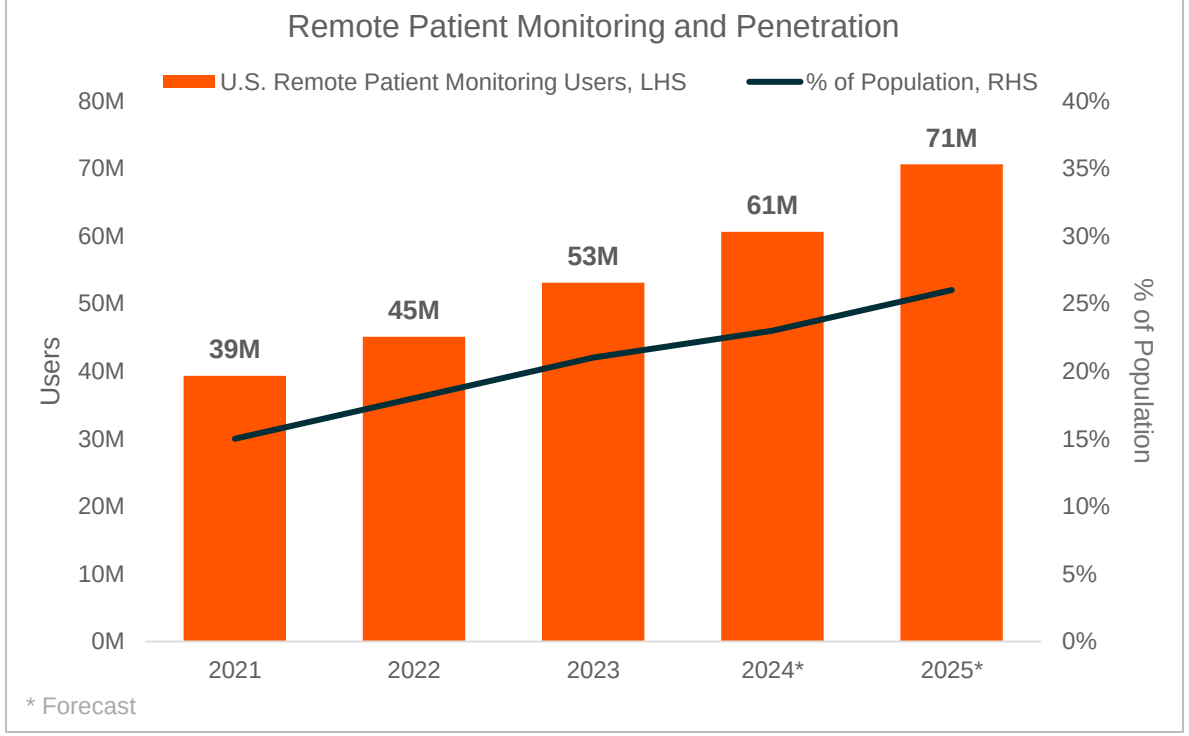
Beyond Data Centers: Edge AI Extends to IoT and the Broader Installed Base of Connected Devices

AI-powered smartphones will prompt consumers to upgrade more devices for AI compatibility. Corporate investments aim to drive upgrades in industrial sensing systems and data capture.

Global IoT Devices Expected to Top 50B by 2030



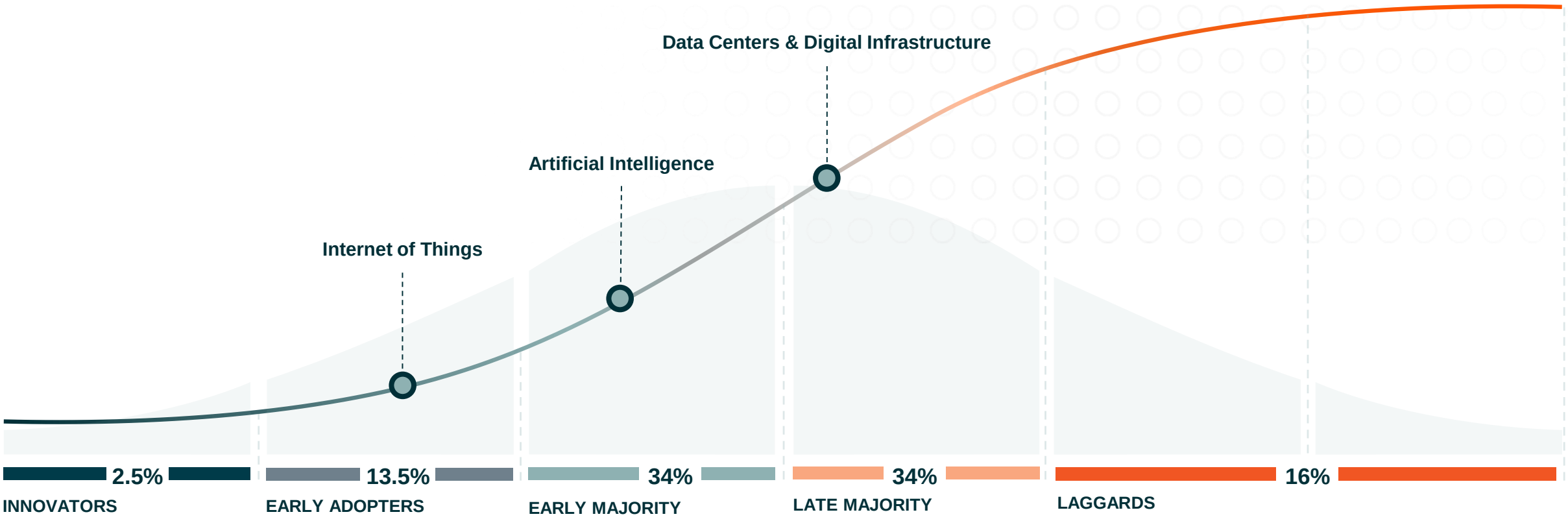
On-Device AI Could Improve Remote Patient Monitoring



Note: Connected devices classified within IoT include items such as wearables, machines, sensors, connected cars, etc. and further categorized as Short-Range IoT and Wide-Area IoT based on connectivity range.
Sources: Charts: LHS: Global X ETFs forecast with information derived from: Ericsson, n.d., accessed on 1 Jul 2024; RHS: Global X ETFs forecast with information derived from: Prevounce, Jan 2024.

S-Shaped Curve of Adoption – AI Infrastructure

Projections anticipate nearly $1.3 trillion in revenues from generative AI by 2032, a result of sales boosts in the tech industry's hardware, software, services, ads, and gaming segments.[1]



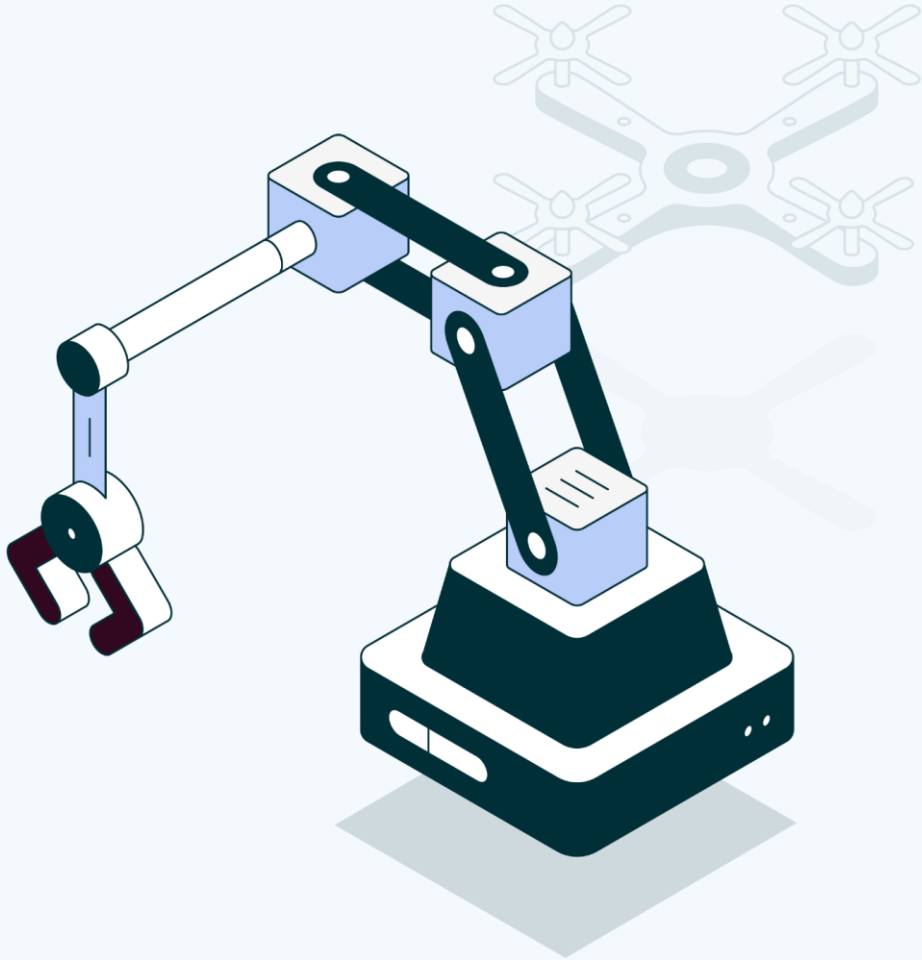
PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: Bloomberg Intelligence, Mar 2024.

CHAPTER 1.2

Robotics:
Breakthroughs in Automation



Promises of efficiency and automation gains amid reshoring and rising labor costs have manufacturers ramping up investments for industrial robotics, accelerating this technology's adoption trajectory. Services such as retail and healthcare is another sector that can benefit from advanced robots' low error rates and high reliability. Humanoid robots are on the horizon as well, poised to revolutionize consumer lives by integrating into homes, potentially creating a trillion-dollar industry within 15 years.[1]

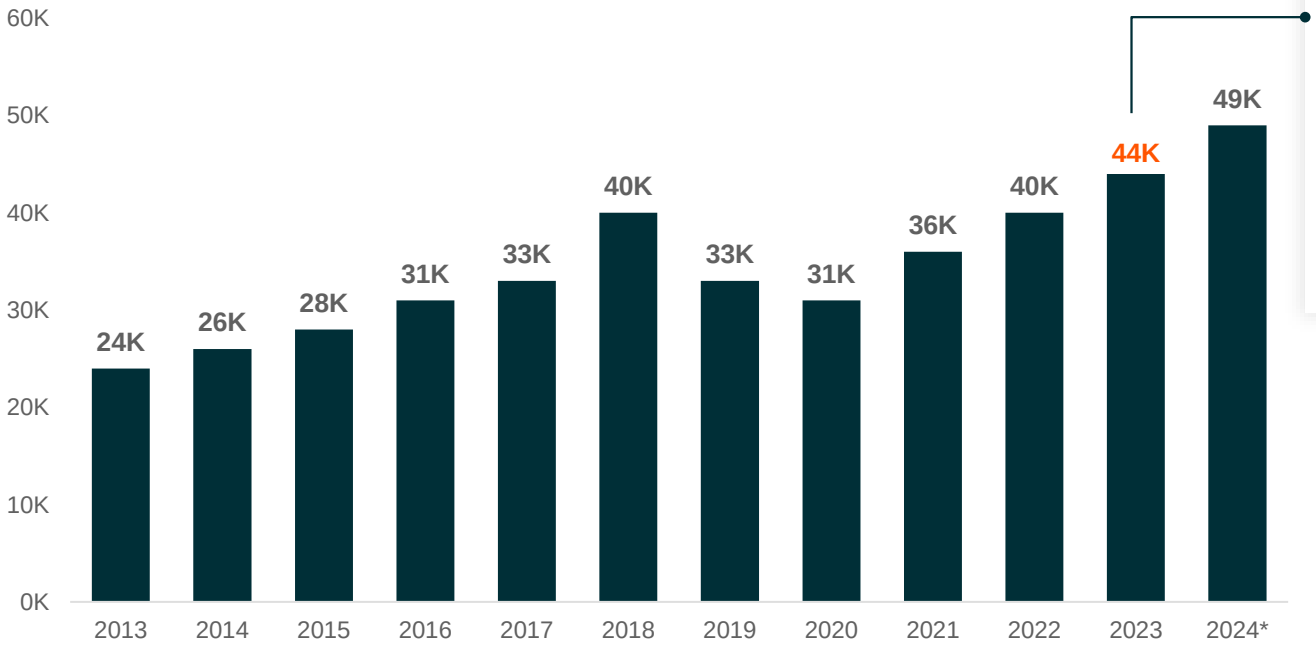
Sources: 1. Global X ETFs forecast with information derived from: Goldman Sachs, 2022; Science Robotics, 2017; Macquarie, Feb 2023; The Economic Times, 2024.

Robotic Adoption: North American Industrial Robot Sales Jump as Manufacturing Enters a New Era

Aggressive investing in automation by U.S. manufacturers aims to support reshoring agendas and respond to a tight labor market. The transition to EVs and clean energy also contributes to the uptick in industrial robot adoption.

Automotive and Electronic Sectors Led Adoption of Industrial Robots in 2023

Annual Installation of Industrial Robots in the United States



* Forecast

UNITED STATES

U.S. manufacturing companies installed **44,303** industrial robot units in 2023, a **12% YoY increase**.

Reshoring in the West

CANADA

Robotic installations in Canada reached **4,616** units, up **43% YoY**. Canada's automotive industry accounted for **55%** of all installations, with sales growing **99% YoY**.

MEXICO

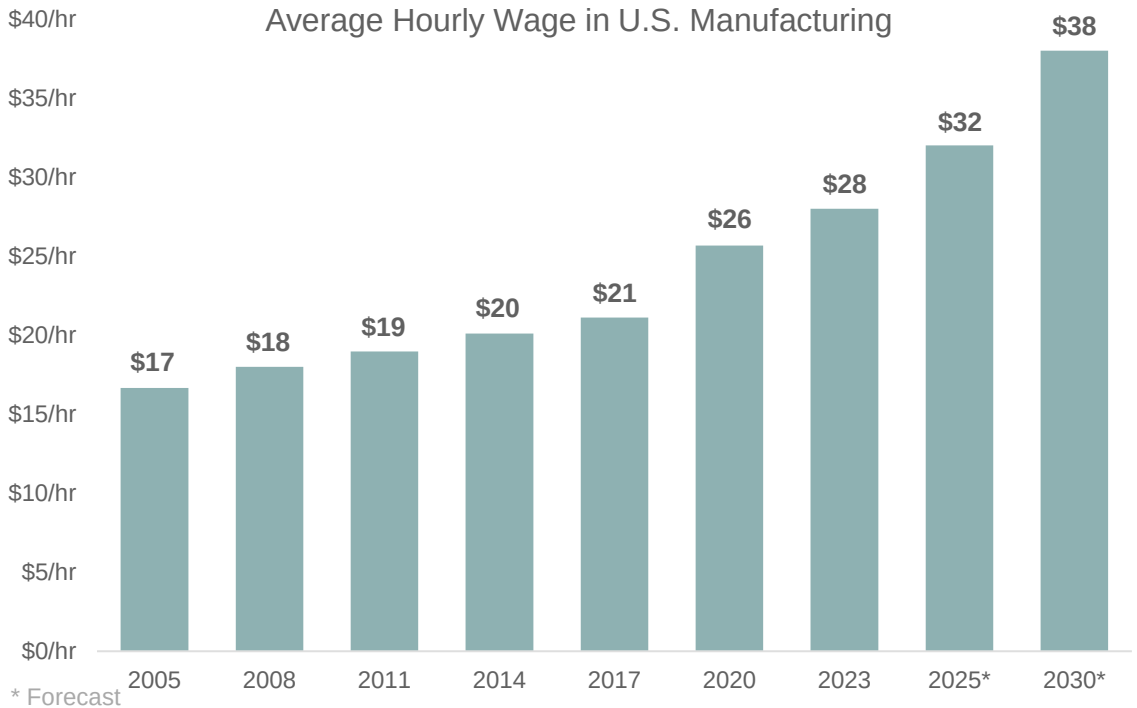
Robotic installations in 2023 remained unchanged at roughly **5,800** after a record year of growth for the country in 2022.

Sources: IFR, Apr 2024.

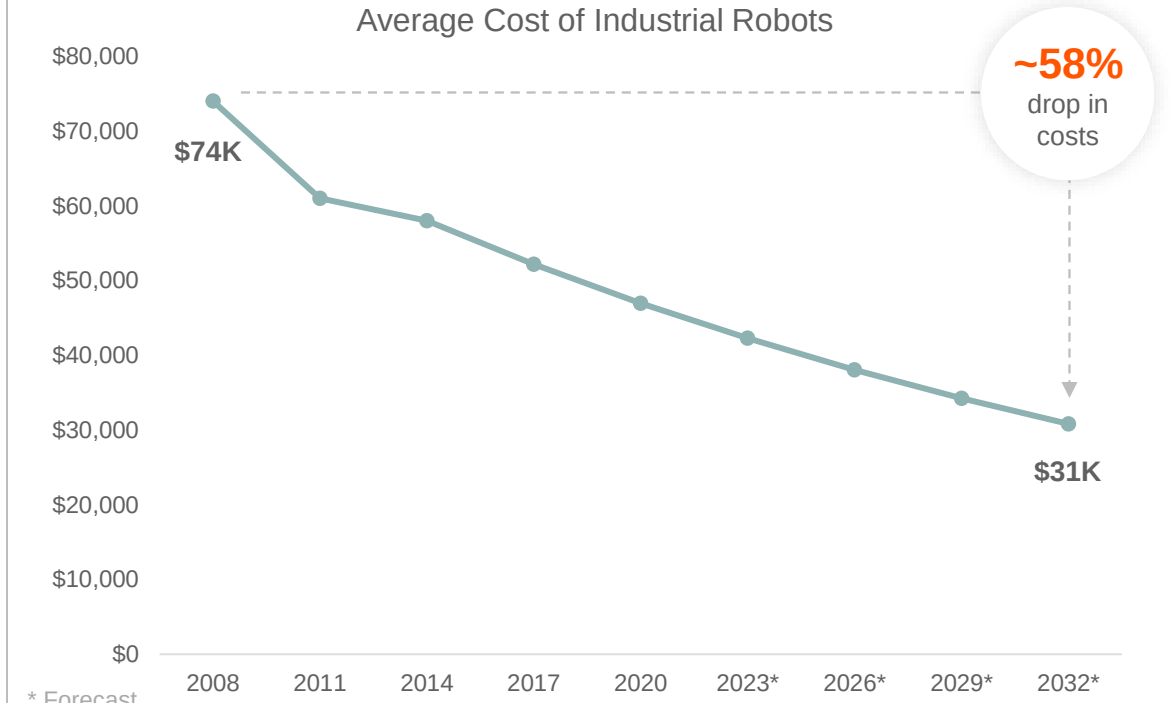
Robotic Automation Is Key to Staying Competitive

Three key factors to accelerating robotic adoption in manufacturing include: 1) A rising cost of labor; 2) An increasing demand for precision goods; and 3) A decreasing cost for robotic setups.

Manufacturing Wages Continue to Grow



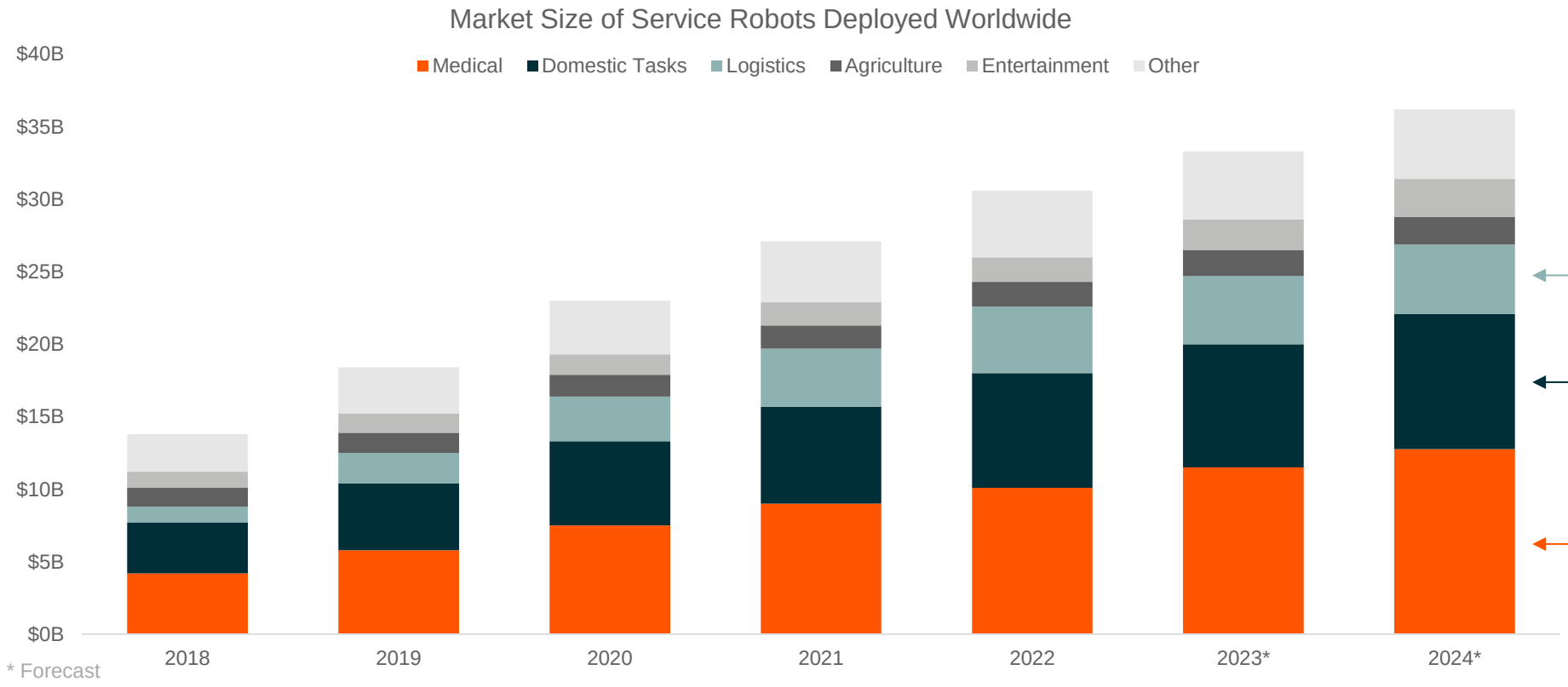
Industrial Robotic Setups Expected to Get Cheaper



Sources: Charts: LHS: Global X ETFs forecast with information derived from: Trading Economics, Apr 2024; RHS: Global X ETFs forecast with information derived from: Goethe University, Nov 2021.

Robotic Adoption: AI Enhancements Boost Momentum for Robotics in the Service Industry

In 2024, the United States is projected to lead the world in service robot revenue.[1] Advancements in generative AI could serve as a catalyst to making service robots more personalized and ready for human engagement.



Recent Developments

amazon AGILITY ROBOTICS

Digit, a bipedal humanoid robot developed by Agility Robotics for transporting and recycling eCommerce totes, is already in use at Amazon warehouses.[2]

Apple is exploring a push into personal home robots. While the full scope of this initiative is unclear, robotics could enable Apple to gain a greater foothold in consumers' homes for domestic tasks.[3]

INTUITIVE SURGICAL

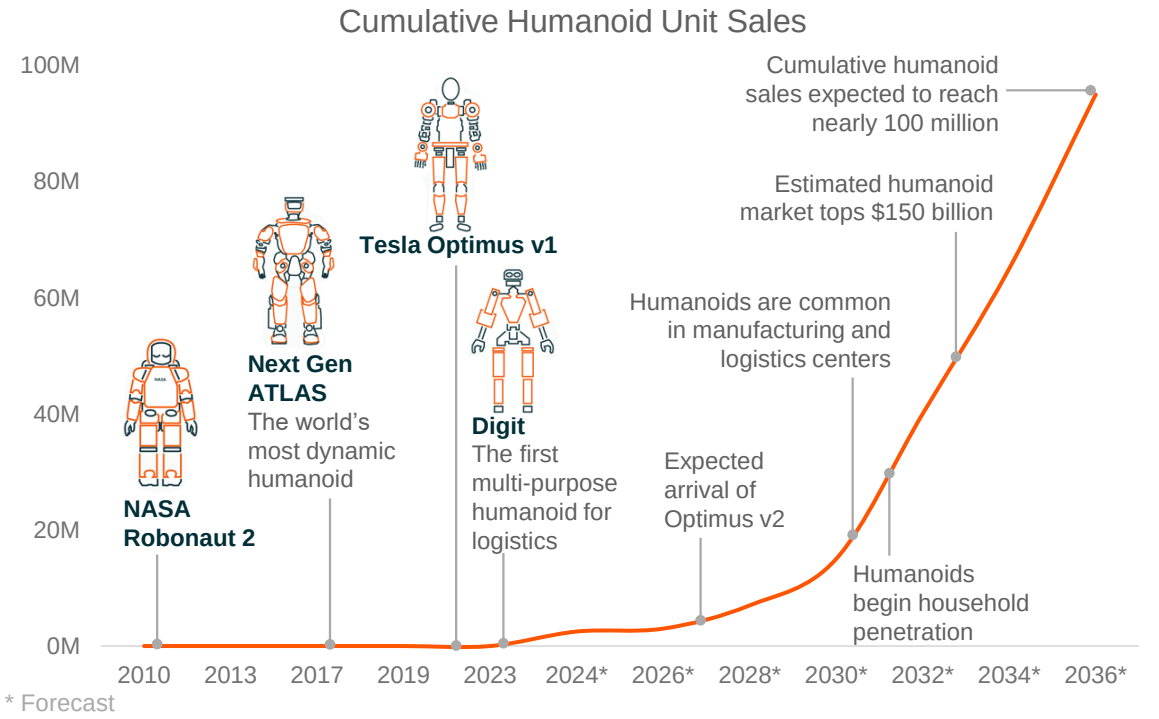
Intuitive Surgical received FDA clearance for a labeling revision for its da Vinci X/XI, used in radical prostatectomy, a procedure to remove the prostate gland after a cancer diagnosis.[4]

Sources: Text: 1. Statista, Mar 2024; 2. Retail Insights Network, Oct 2023; 3. Bloomberg, Apr 2024; 4. The Robot Report, Jun 2024; Chart: Global X ETFs forecast with information derived from: Statista, Mar 2024.; IFR Pressroom, Oct 2022.

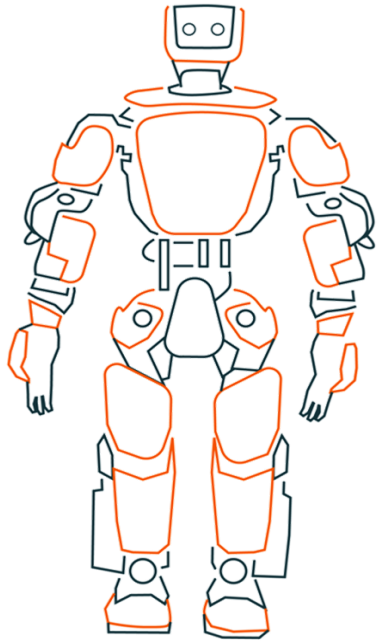
Consumer-Grade Humanoids Expected to Deliver the Next Robotics Breakthrough

Humanoids in both the workplace and at home could soon become a reality, thanks to recent advances in hardware and AI. Also, declining robotics hardware costs now make commercial-scale production and implementation achievable.

Adoption of Humanoids Following Major Innovations



Estimated Production Cost for a Standard Humanoid in 2023



$50,000
estimated total cost for standard humanoid

$10,000
for end-to-end AI software

$5,000
for all other parts including body materials

$10,000
for sensors and chips

$5,000
for inertial measurement units and torque sensors

$10,000
for servomotors and motor drives

$2,000
for battery system

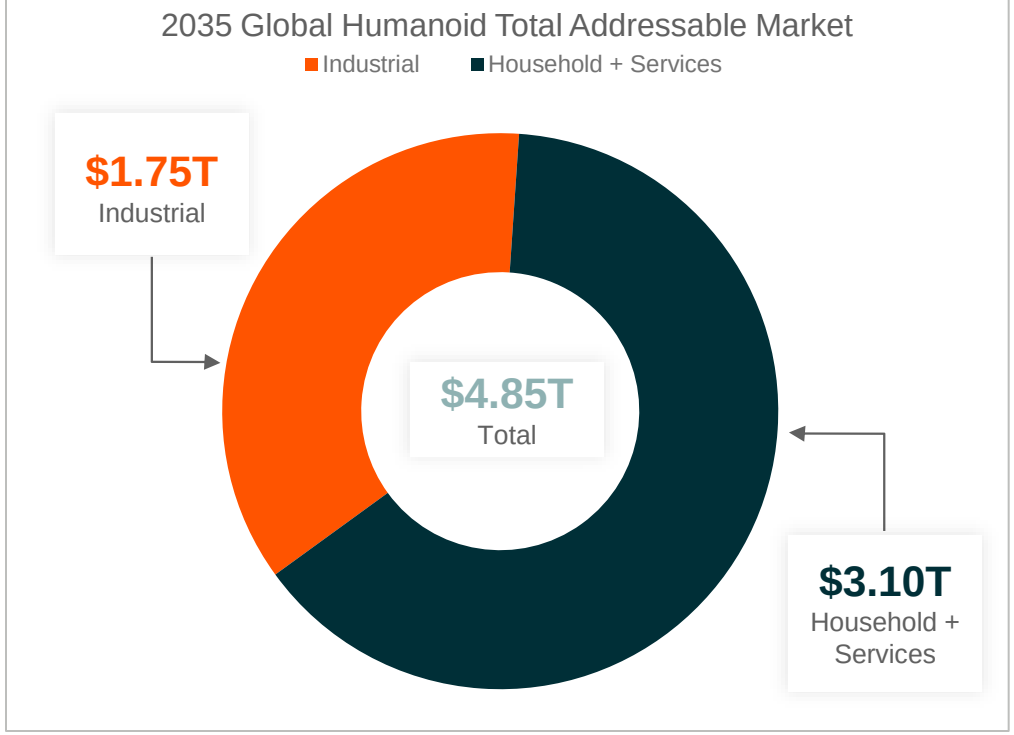
$8,000
for precision reducers

Sources: Charts: LHS: Global X ETFs forecast with information derived from: Goldman Sachs, Nov 2022; Science Robotics, Dec 2017; The Economic Times, Jan 2024; RHS: Macquarie, Feb 2023.

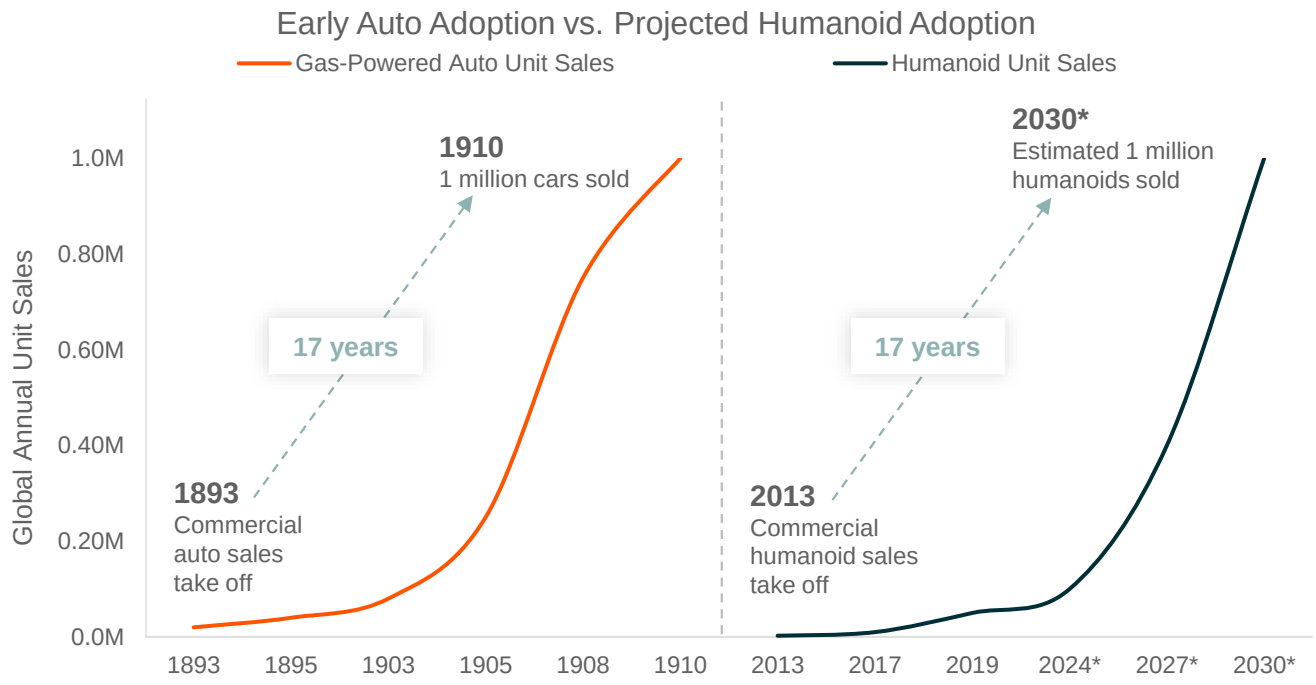
Humanoid Integration Could Mirror Early Automobile Adoption, with Similar Market Potential

Patented in 1886, gas-powered vehicles reached commercial sales by 1893 and soon became a household essential with widespread consumer sales.[1] Humanoids could follow a similar trajectory as AI improves.

Humanoids Present Large Market Opportunity[2]



Early Humanoid Adoption Curve Resembles Early Auto Days

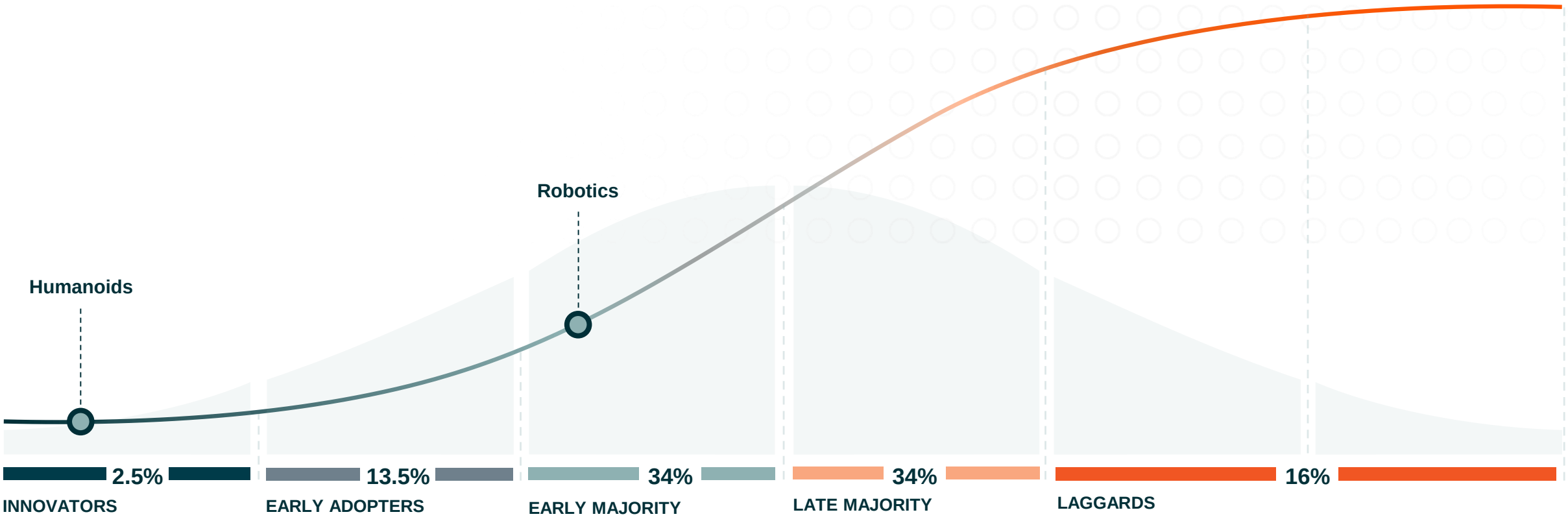


* Forecast; Note: 2013-2019 are estimates by Global X ETFs.

Sources: Text: 1. Whisbi, Feb 2022; 2. Robozaps, Aug 2024; Charts: LHS: Global X ETFs forecast with information derived from: Goldman Sachs, Nov 2022; Journal of Marketing Research, Apr 2019; Science Robotics, Dec 2017; The Economic Times, Jan 2024; RHS: Global X ETFs forecast with information derived from: Strategy + Business, Aug 2023; Whisbi, Feb 2022.

S-Shaped Curve of Adoption – Robotics

Advancements in artificial intelligence are likely to accelerate robotics adoption. The addressable market for humanoids is projected to surpass $4.8 trillion by 2035.[1]



PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: 1. Robozaps, Aug 2024.

CHAPTER 1.3

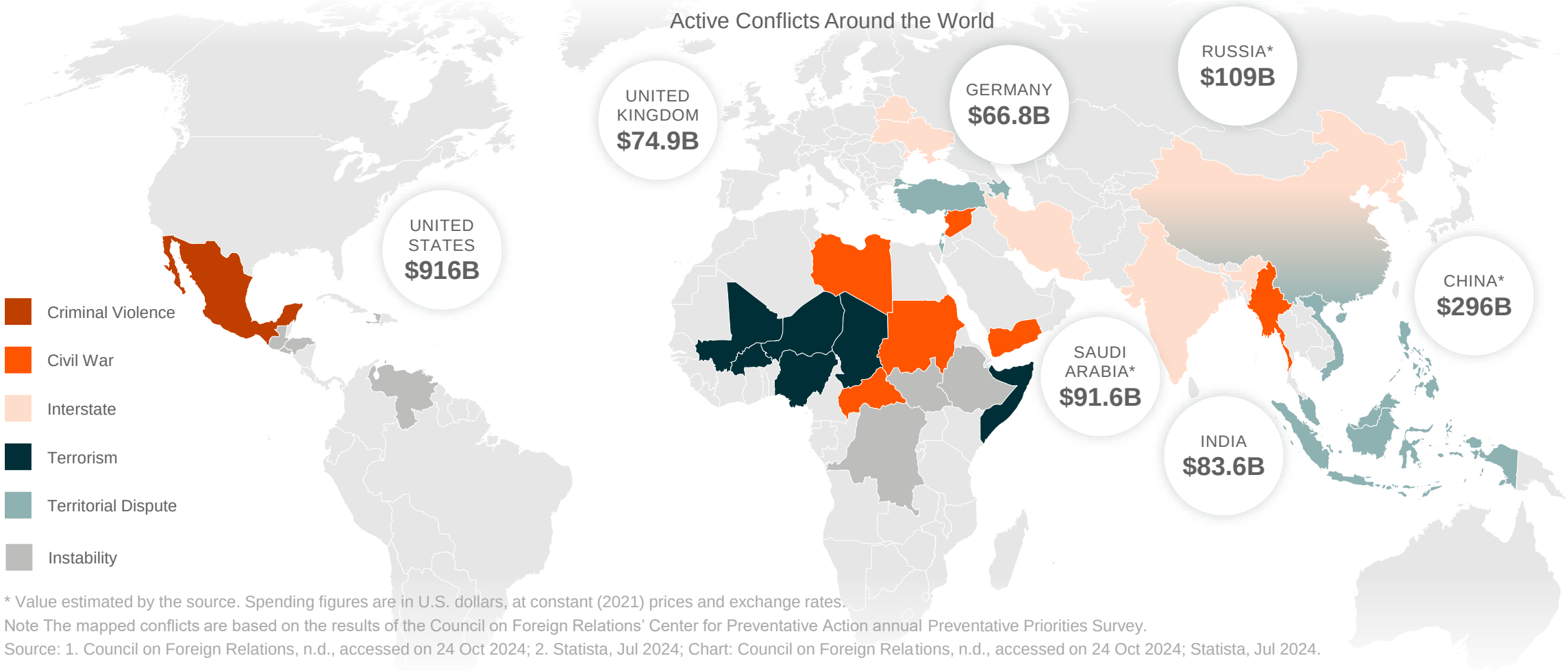
Defense Technology:
Shield of Innovation

Rising geopolitical tensions, accelerating deglobalization, and the increasing integration of technology into defense and national security are driving a significant rise in military and defense spending. By 2030, global defense expenditures are expected to surge nearly 40%, surpassing $3.4 trillion, with a growing portion allocated to artificial intelligence (AI), cybersecurity, and other advanced defense technologies.[1] This trend potentially benefits businesses and solution providers throughout the supply chain, including major military contractors, providers of cutting-edge components and hardware, as well as developers of defense-specific software.

Sources: 1. Global X ETF forecast with information derived from SIPRI, 2024.

Defense Spending: Mapping Global Conflicts and Military Expenditures

The Council on Foreign Relations (CFR) currently lists over 30 ongoing conflicts worldwide, ranging in scope and type.[1] Global military expenditures exceeded $1.6 trillion for the top seven spending nations in 2023.[2]



* Value estimated by the source. Spending figures are in U.S. dollars, at constant (2021) prices and exchange rates.

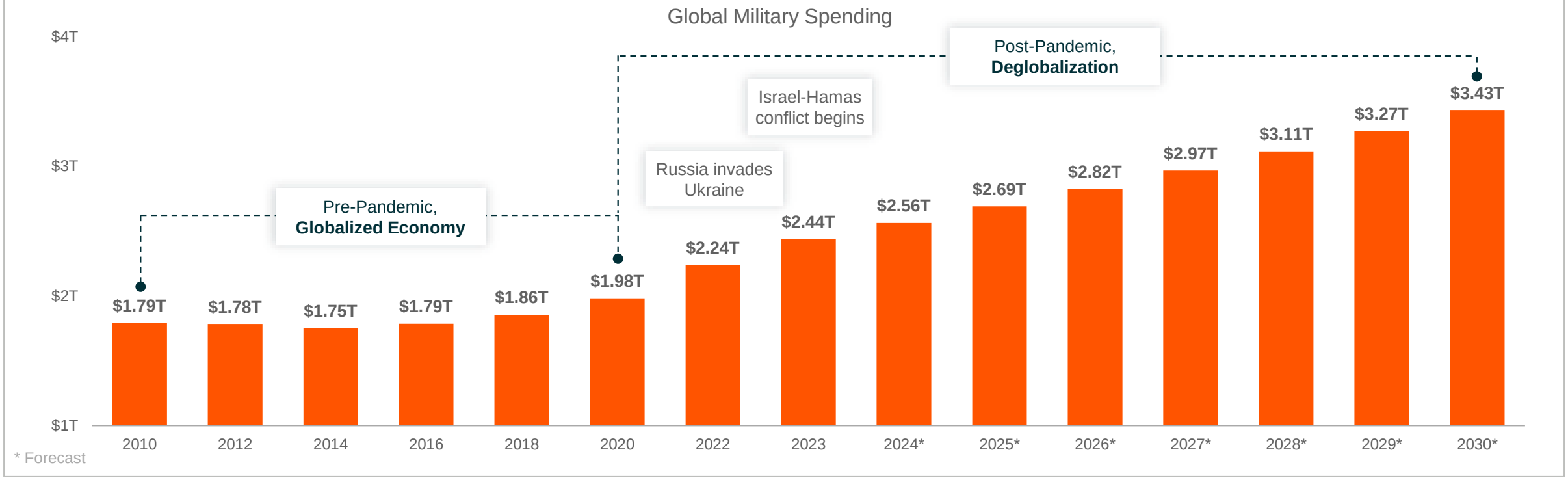
Note The mapped conflicts are based on the results of the Council on Foreign Relations' Center for Preventative Action annual Preventative Priorities Survey.

Source: 1. Council on Foreign Relations, n.d., accessed on 24 Oct 2024; 2. Statista, Jul 2024; Chart: Council on Foreign Relations, n.d., accessed on 24 Oct 2024; Statista, Jul 2024.

Defense Spending Worldwide Adds Up to Trillions of Dollars

World military expenditure hit an all-time high of $2.4 trillion in 2023, fueled by the ongoing war in Ukraine and escalating tensions in the Middle East.[1] Spending is expected to grow at a 5% annualized rate to $3.4 trillion by 2030.[2]

Global Military Spending Rose Consistently over Last Two Decades with Further Growth Anticipated

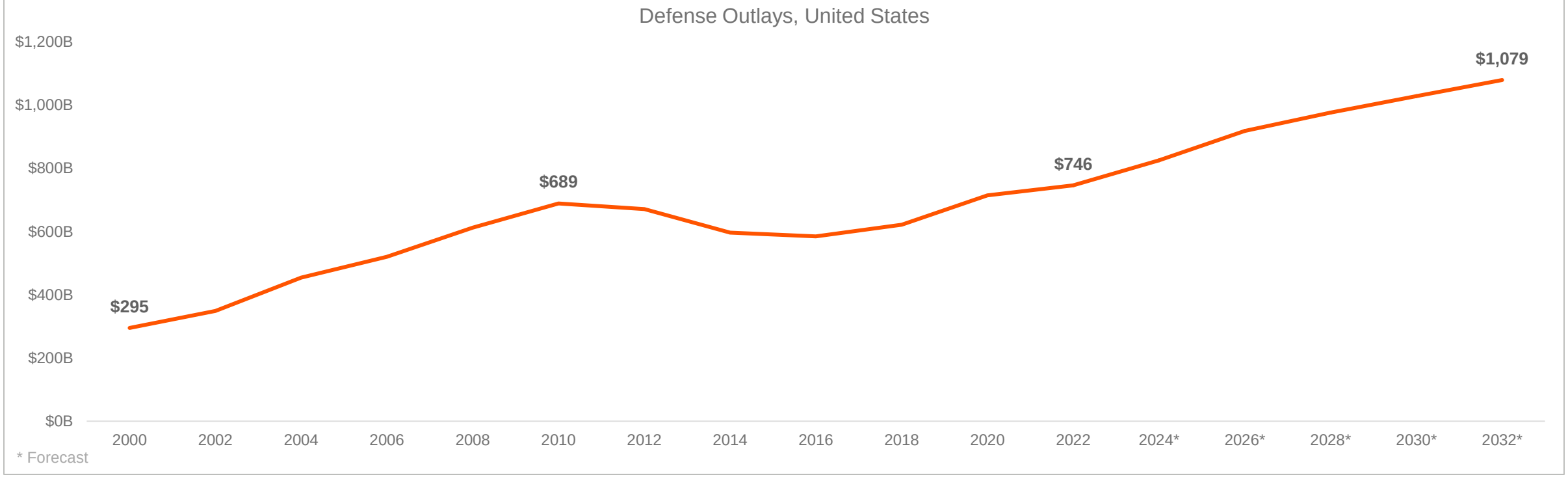


Sources: Text: 1. SIPRI, 2024; 2. Global X ETFs forecast with information derived from: SIPRI, 2024; Chart: Global X ETFs forecast with information derived from: SIPRI, Apr 2024.

Defense Spending: Emerging U.S. Military and Defense Initiatives Spur Increase

The Fiscal Responsibility Act of 2023 adopted a proposed topline of $886 billion for fiscal year 2024 defense spending, a 3.2%YoY increase. Of that, $842 billion was earmarked for the Department of Defense.[1]

U.S. Congressional Budget Office Projects Defense Spending to Top $1 Trillion by Decade End[2]

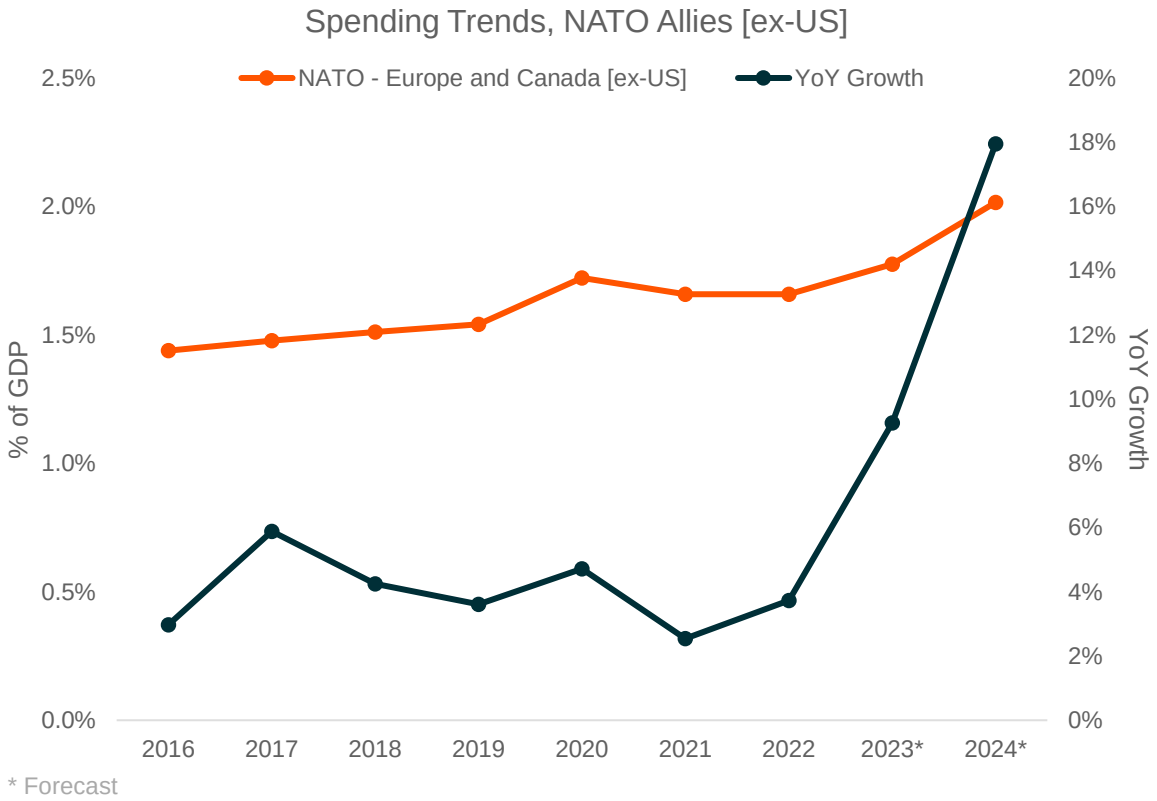


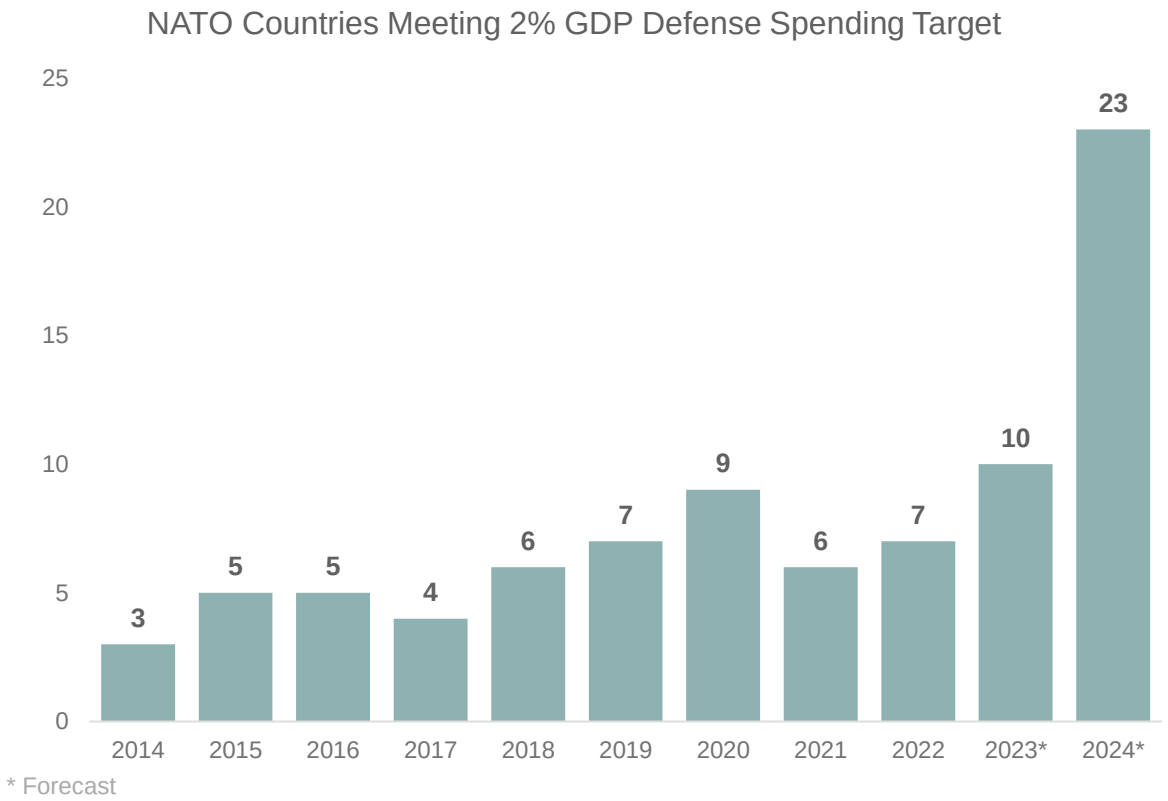
Note: Actual spending each year could exceed outlays.

Sources: Text: 1. The Fiscal Times, May 2023; 2 Congressional Budget Office, May 2022; Chart: Congressional Budget Office, May 2022.

Defense Spending: North Atlantic Treaty Organization (NATO) Allies Pledge to Invest 2% of GDP

In 2024, 72% of the NATO Allies are on track to meet or exceed their target investment of at least 2% GDP on defense, up from only 11% in 2014.[1] Estimated spending for 2024 is expected to surpass $400 billion.[2]

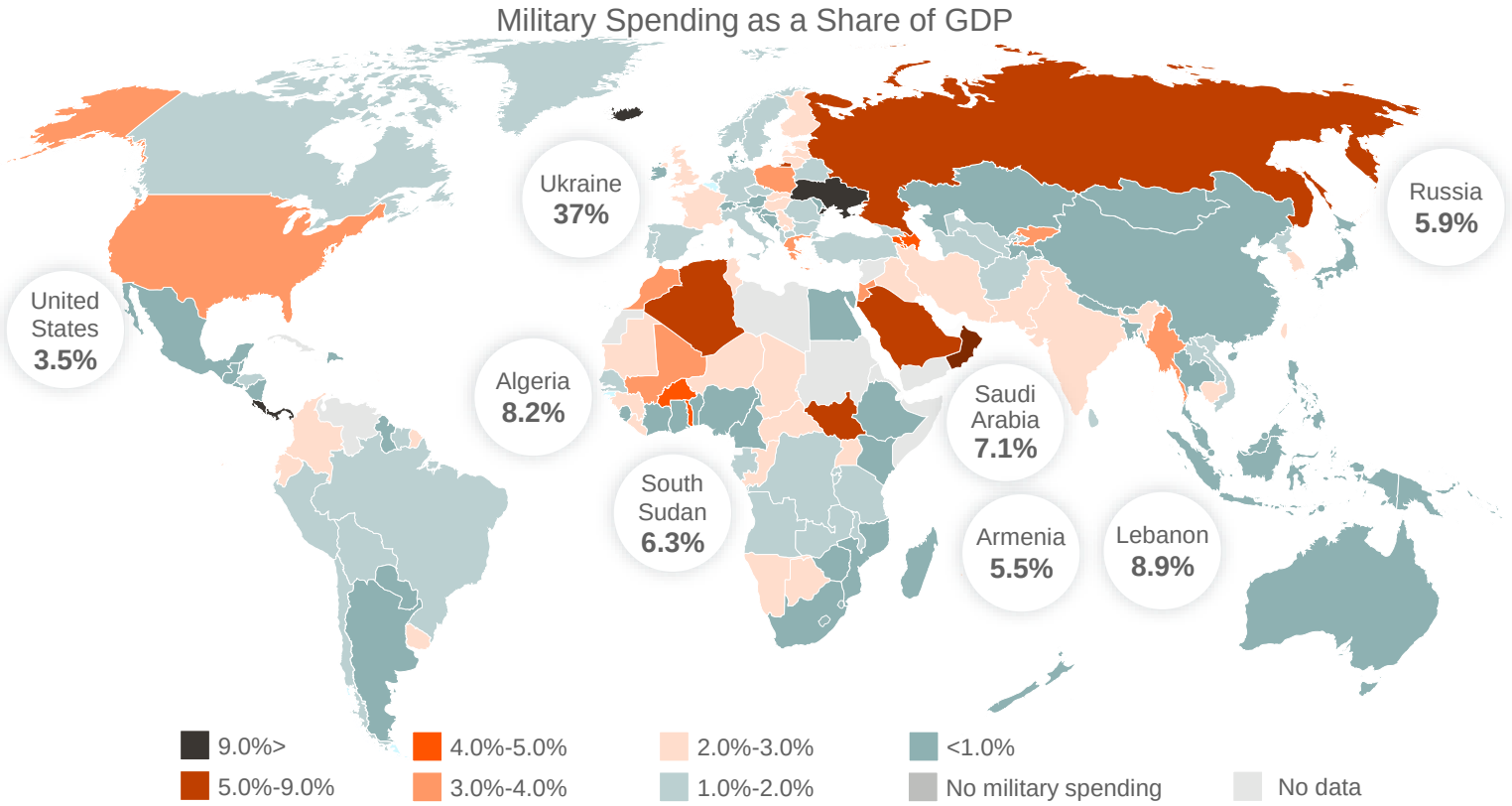




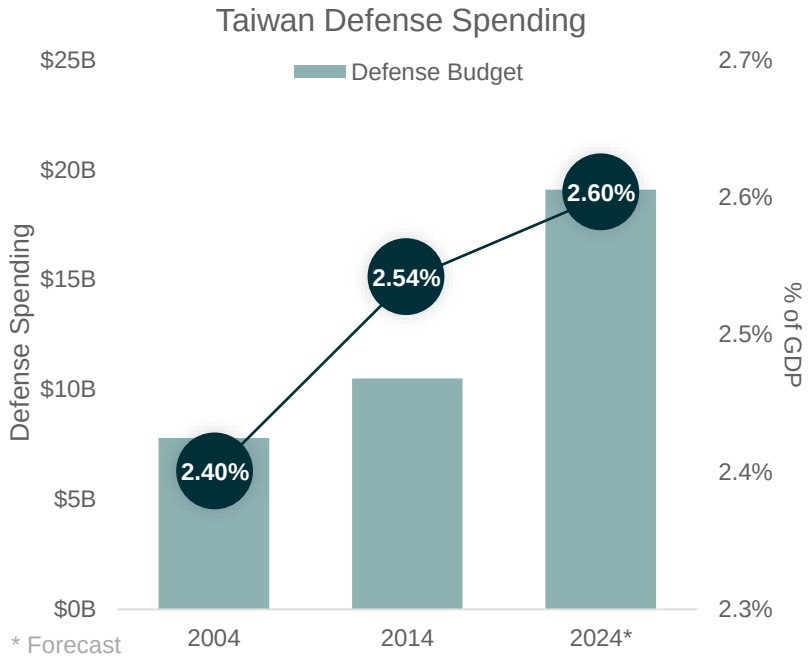
Sources: Text: 1 NATO, Jul 2024; 2. Ibid.; Chart: NATO, Jun 2024.

Intensifying Defense Investments and Commitments Is a Global Phenomenon

Escalating geopolitical crises worldwide are compelling major global economies and conflict-prone regions to bolster their defense spending, with growing support for technology-based solutions.



Military burden – a measure of the relative economic cost of the military for the country – rose to a global average of 2.3% in 2023, up from 2.2% in 2022.[1]

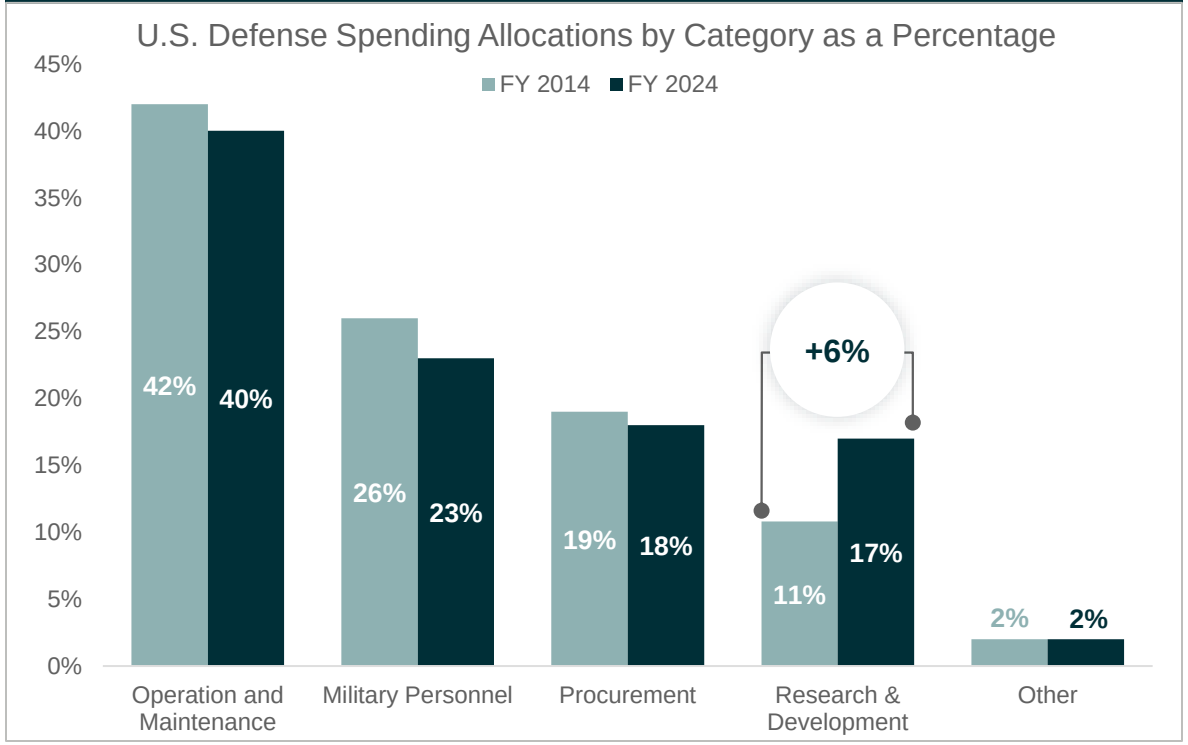


Sources: Text: 1. SIPRI, Apr 2024; 2. Global Taiwan Institute, Sep 2023; Charts: LHS: SIPRI, Apr 2024; RHS: Global Taiwan Institute, Sep 2023.

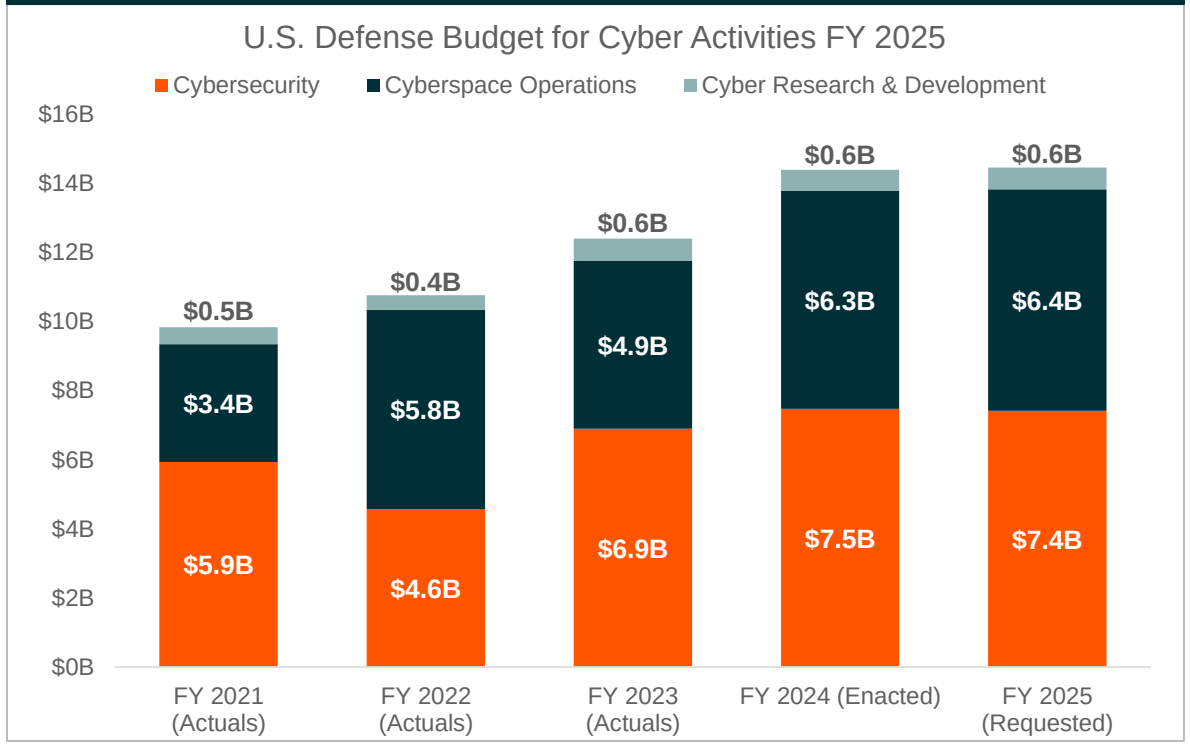
Defense Spending: Growth Expected to Help Digital Solutions and Cybersecurity Investments

In the past, military spending primarily revolved around acquiring conventional hardware and ensuring uninterrupted ammunition supplies. Now, budgets reflect the shift toward digitization.

Budget Designation Redistribution Primarily Benefits R&D



DoD Budget for Cybersecurity Increased 15% from FY 2023

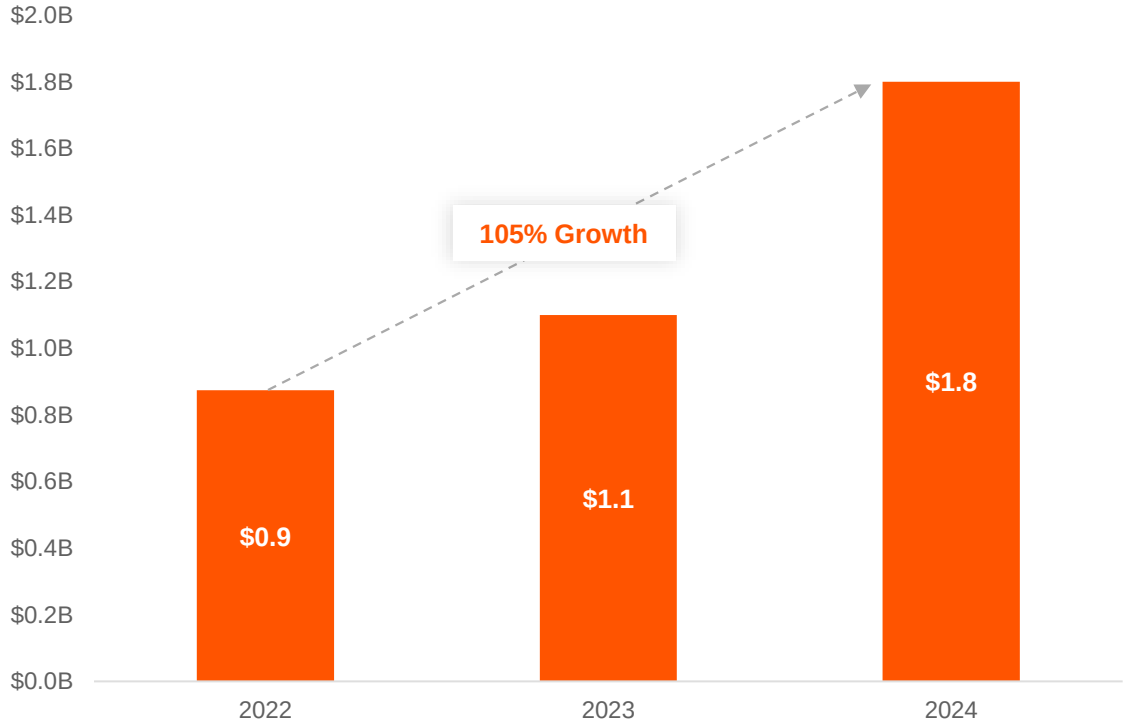


Sources: Charts: LHS: Congressional Budget Office, Jun 2024; RHS: U.S. Department of Defense, May 2023.; GovWin IQ, May 2024.

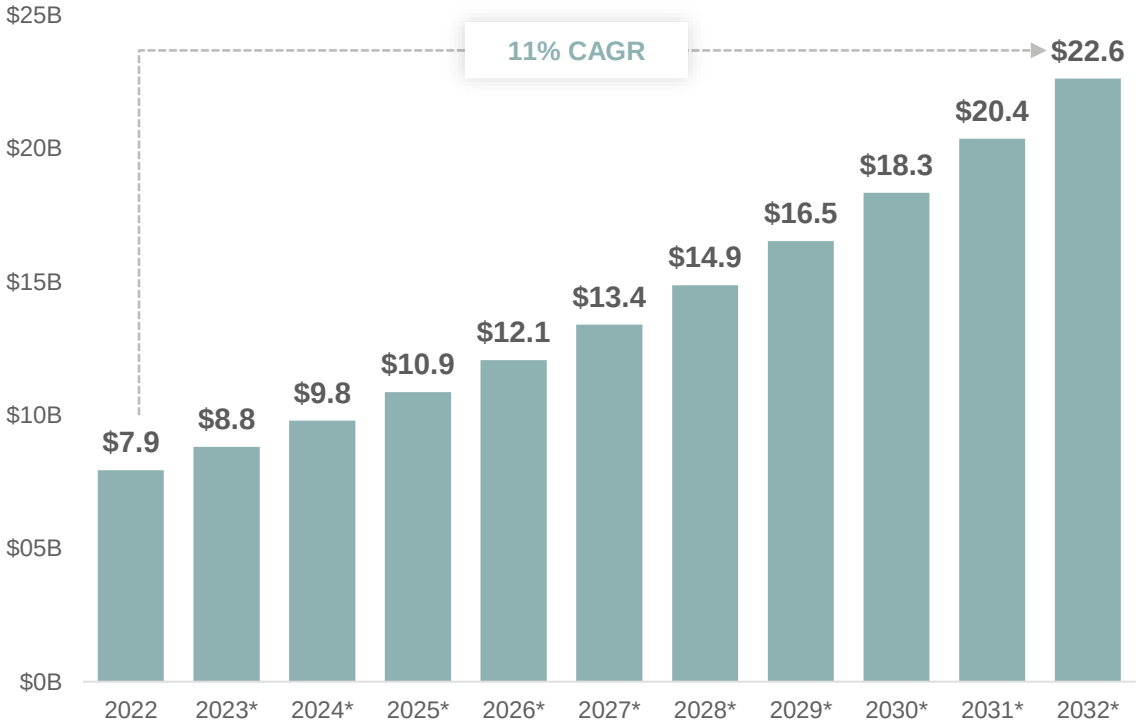
AI Also Poised to Emerge as Beneficiary of Growing Defense Tech Spend

Innovations in technology are reshaping modern warfare by introducing new capabilities and altering traditional strategies. AI, robotics, and cybersecurity increasingly play pivotal roles in revolutionizing the nature of conflict.

Pentagon's Budgetary Request for AI Funds



AI in Global Military Spending Forecast



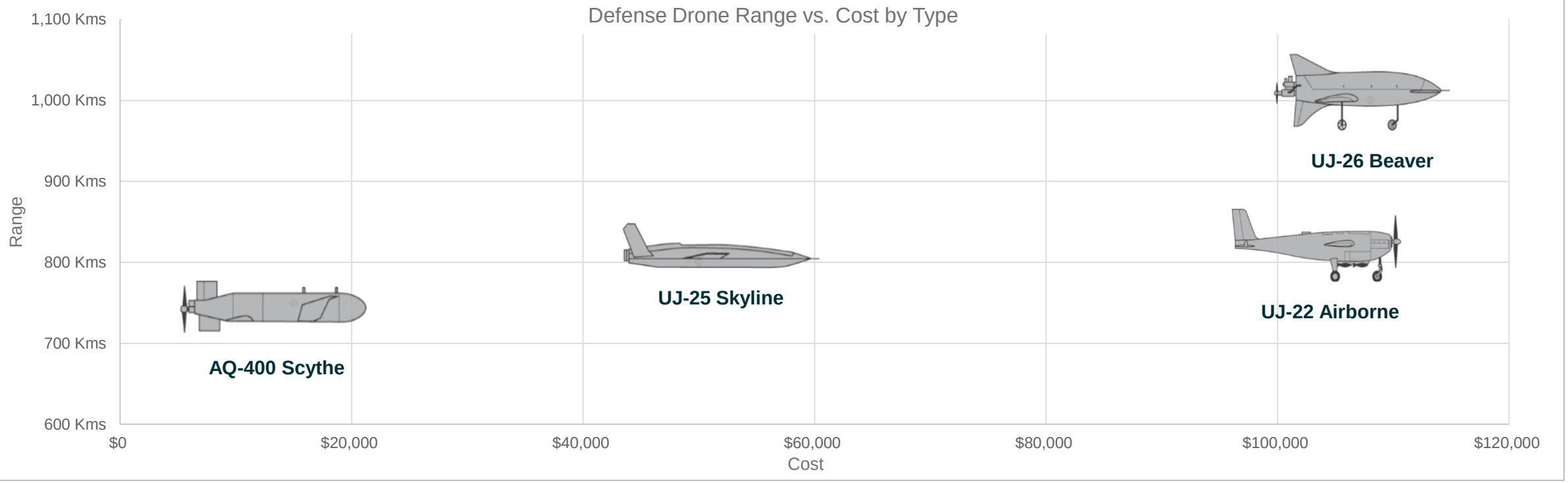
* Forecast

Sources: Charts: LHS: Roll Call, Mar 2024; RHS: Precedence Research, Jul 2023.

Unmanned Aerial Systems and Drones Potentially Change the Economics of War

Drones have shifted the balance of warfare in favor of less financially resourced armies. Their flexibility and affordability contribute to their growing importance on the battlefield.

With Tech Advances and Increased Affordability, New Drones Now Rival Much More Expensive Defense Systems Like Tanks

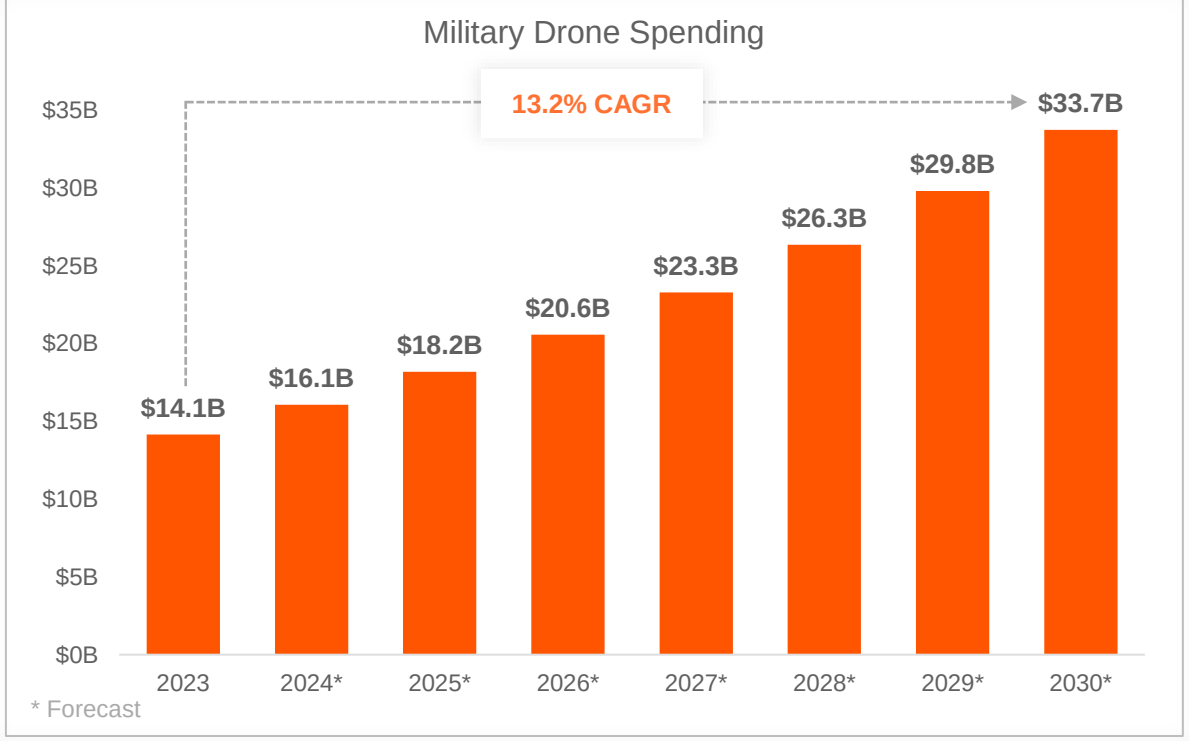


Sources: Chart: The Globe and Mail, Feb 2024; Reuters, Mar 2024.

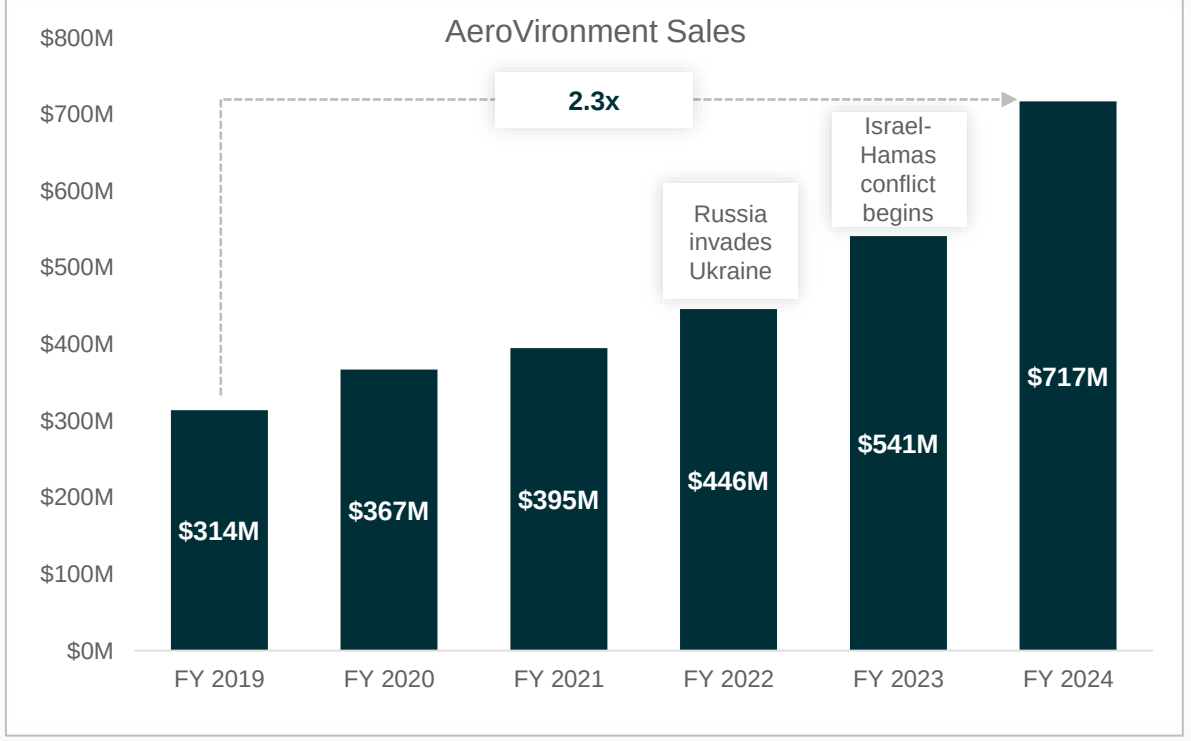
Spending on Drones and Autonomous Aerial Vehicles Expected to Grow at a 13% CAGR

Secular growth of the drone market looks to help the category grow to over $30 billion in spending by 2030.[1] AeroVironment, one of the largest pureplay drone vendors, reported $717 million for fiscal year 2024.[2]

Anticipated Increases in Military Drone Spending Worldwide



AeroVironment Sales Rapidly Increased in Last 5 Years



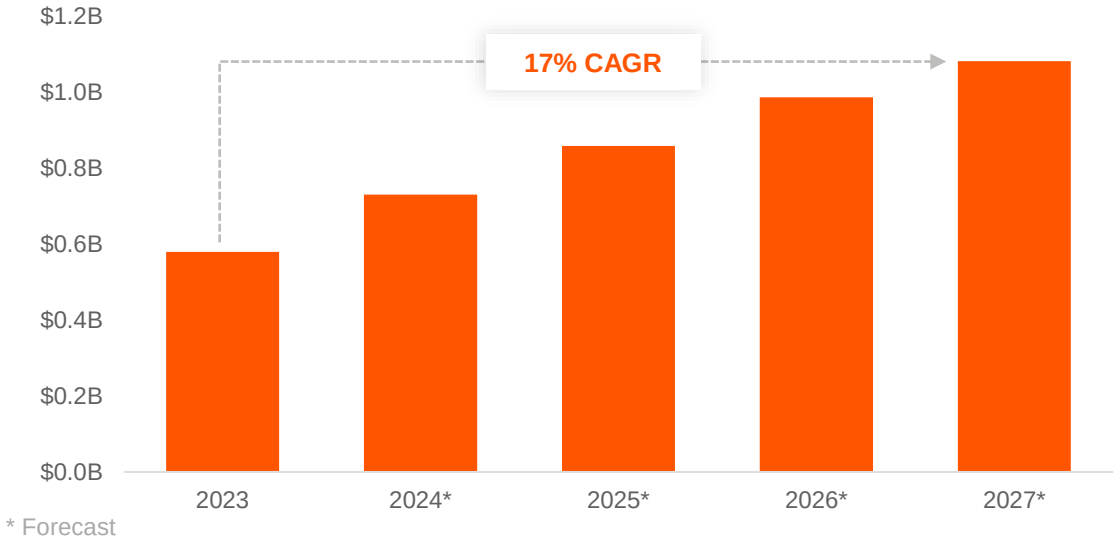
Sources: Text: 1. Global X ETFs forecast with information derived from: Fortune Business Insights, Oct 2024; 2. AeroVironment, Jun 2024; Charts: LHS: Global X ETFs forecast with information derived from: Fortune Business Insights, Oct 2024; RHS: AeroVironment, Jun 2024.

Autonomous Robotic Combat Vehicles Set to Revolutionize Ground Operations

Recently, development programs for Unmanned Ground Vehicles (UGVs), especially Robotic Combat Vehicles (RCVs), have surged, covering everything from scouts equipped with disposable anti-tank missiles to armored unmanned tanks.

Global militaries are increasingly shifting mounted and dismounted capabilities to un-crewed systems to reduce casualties and improve operational effectiveness in urban environments. Military projects now focus on advancing technologies like lidar, radar, vision sensors, ultrasonic range, GPS, Inter-Vehicle communication, and AI. Armies from the United States, China, and Europe lead this transformation.

Global Robotics UGV Market



* Forecast

Major Global Programs

United States Army

The United States is developing the RCV under the Next Generation Combat Vehicle program, with prototypes from McQ, Textron, General Dynamics, and Oshkosh Defense. One will be selected for production starting in 2028. The United States plans to spend $868.5 million on RCV development from 2023 to 2028, including a $92.5 million request for 2025.[1,2]

British Army

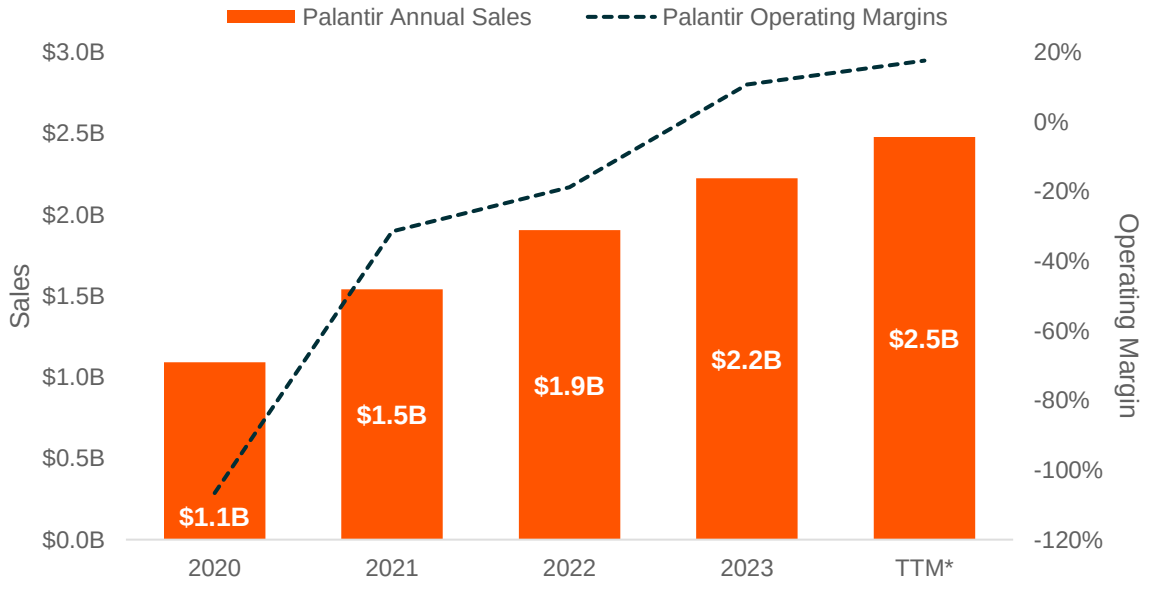
In April 2023, the Defense Equipment and Support unit conducted its first heavy UGV trials, testing Elbit's ROBUST UGV, Milrem's Type X, and Rheinmetall's Wiesel. This initiative aims to shape the United Kingdom's long-term UGV strategy and is part of the broader Human Machine Teaming Project, which targets a RAS-enhanced Brigade Combat Team by 2025.[3]

Sources: Text: 1. Defense IQ, Jan 2024; 2. Congressional Research Service, Jul 2024; 3. Defense IQ, Jan 2024; Chart: Defense IQ, Jan 2024.

Defense Provides a Target Market for Software Companies as Capabilities Expand

Government spending on technological solutions necessitates investments in modern, nimble, foundational software infrastructure, benefitting a wide range of platforms and specialized defense IT providers.

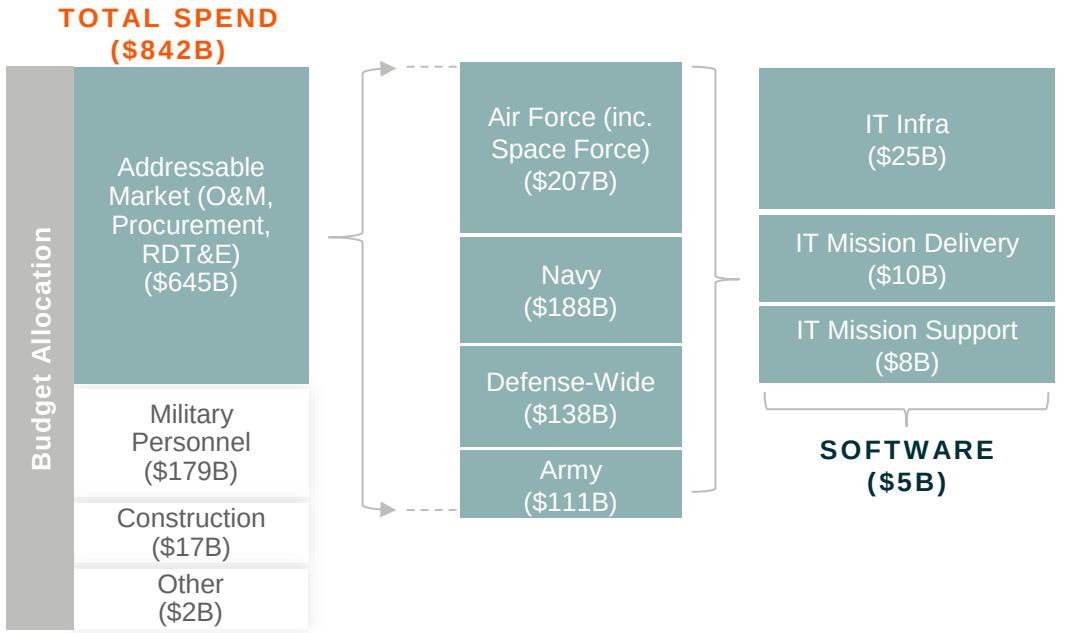
Palantir Annual Sales and Operating Margins



* TTM as of August 2024

Palantir's revenues display robust growth fueled by major government contracts, with several aimed at enhancing the U.S. defense combat capabilities with AI.[1] These contracts are typically serviced through recurring contracts.

U.S. Defense Spend Breakdown



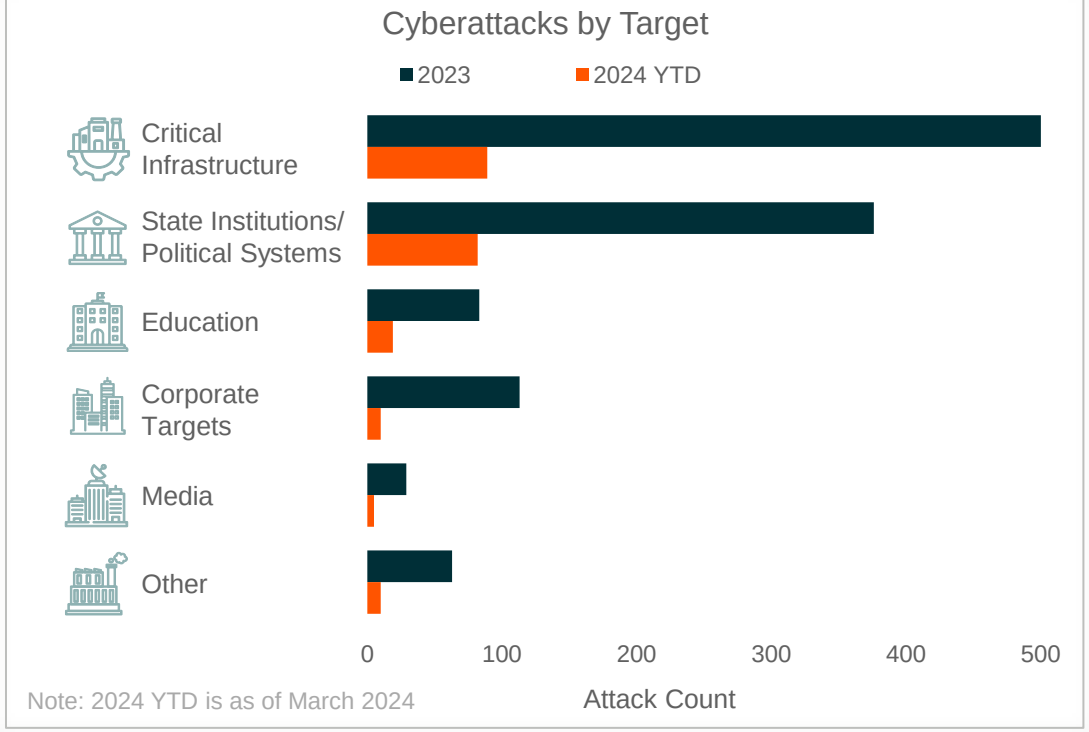
Software currently accounts for less than 1% of U.S. DoD spending.[2] However, as defense increasingly relies on AI and data analytics, the military will likely need boost its software investment meaningfully.

Sources: 1: Palantir, Feb 2024; 2. U.S. Department of Defense, May 2023; Charts: LHS: Companies Market Cap; Aug 2024; Palantir, Feb 2024; RHS: U.S. Department of Defense, May 2023.

Government Cybersecurity Investments Prioritize Safeguarding Critical State Infrastructure

Driven by increasing threats and regulatory requirements, government sector cybersecurity spending is expected to grow meaningfully through this decade. This reflects widespread updates to policy frameworks.

Critical Infrastructure Key Target for Cyber Attacks



Note: 2024 YTD is as of March 2024

U.S. Government Cybersecurity Spend Continuing to Grow

The signing of the IIJA in 2021 provided **$1.9 billion** for cybersecurity grants to states and local governments, as well as updates to the electrical grid, and DHS research.[1]

The DoD launched a **multi-billion-dollar** zero trust architecture plan in 2022.[2]

The U.S. federal budget proposal for cybersecurity spending in fiscal year 2024 included:

$13 billion for civilian cybersecurity spending across the federal government.[3]

$3 billion for the Cybersecurity and Infrastructure Security Agency (CISA), an increase of $103 million.[4]

~$12 billion requested by the Biden administration to roll out zero trust security.[5]

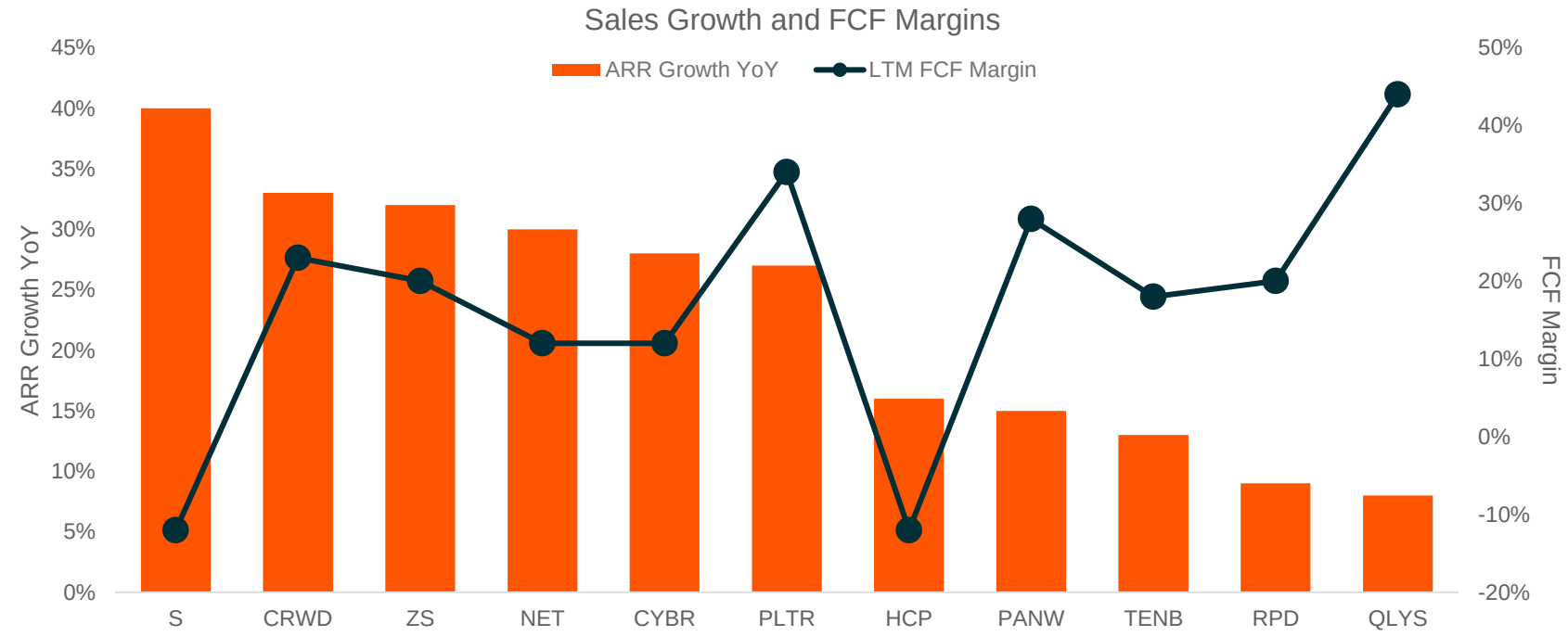
Future spending is not anticipated to slow, as the Pentagon sought **$14.5 billion** for their FY 2025 cybersecurity budget.[6]

Sources: Text: 1. CISA, 2024; 2. U.S. Department of Defense, Nov 2022; 3. MeriTalk, Mar 2024; 4. MeriTalk, Mar 2024; 5. Federal News Network, Sep 2023; 6. C4ISRNET, Mar 2024; Charts: LHS: Statista, Mar 2024; RHS: GovCon Wire, Apr 2024; CSO, Sep 2022.

Cybersecurity Leaders Offer Stickier Growth and Better Operating Profile Than Broader Cloud

The pressing need for cybersecurity software has resulted in robust recurring revenue growth for cybersecurity companies, often surpassing the broader cloud software industry standards.

Average Sales Growth and Net Retention for Cybersecurity Companies Is Higher Than the Broader Cloud Cohort



23% Cyber ARR Growth Average **vs.** **18%** For Broader Cloud

17% Cyber LTM FCF Margin **vs.** **13%** For Broader Cloud

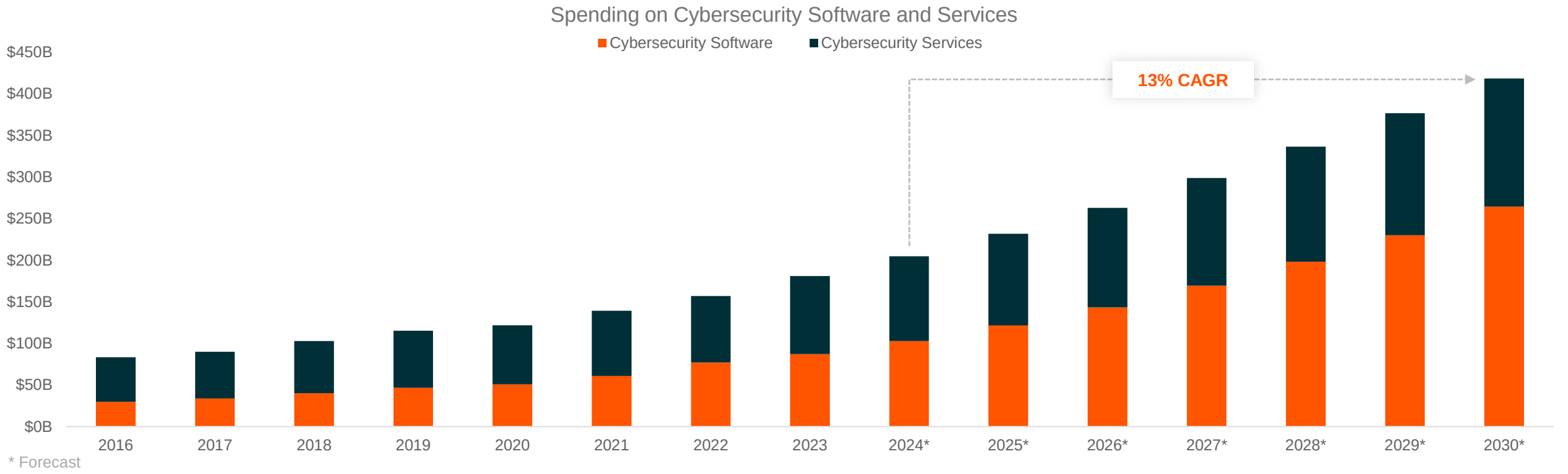
Note: ARR = Annual Recurring Revenue; LTM FCF = Last Twelve Months Free Cash Flow.

Note: S = Sentinel One, CRWD = CrowdStrike, ZS = Zscaler, NET = Cloudflare, CYBR = CyberArk, PLTR = Palantir, HCP = HashiCorp, PANW = Palo Alto Networks, TENB = Tenable Holdings, RPD = Rapid7, QLYS = Qualys.
Source: Meritech Capital, Aug 2024.

Software Growth Likely to Increase Cybersecurity Spending by Over 2x to $418 Billion by 2030[1]

Cybersecurity spending is projected to grow as cloud-native and AI-native security solutions come to market. Government cybersecurity spending could further help with growth.

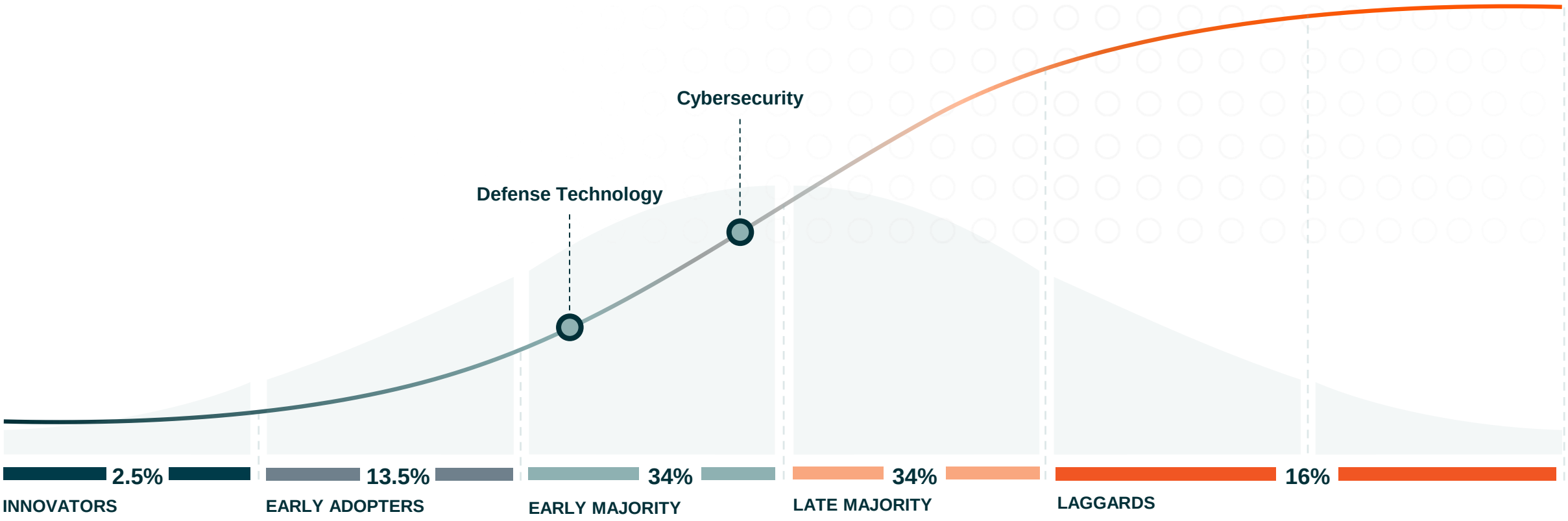
Adoption of Cloud Technology Is Accelerating Shift of Spending from Services to Cybersecurity Software



Source: 1: Global X ETFs forecast with information derived from: Gartner, Aug 2024.

S-Shaped Curve of Adoption – Defense Technology

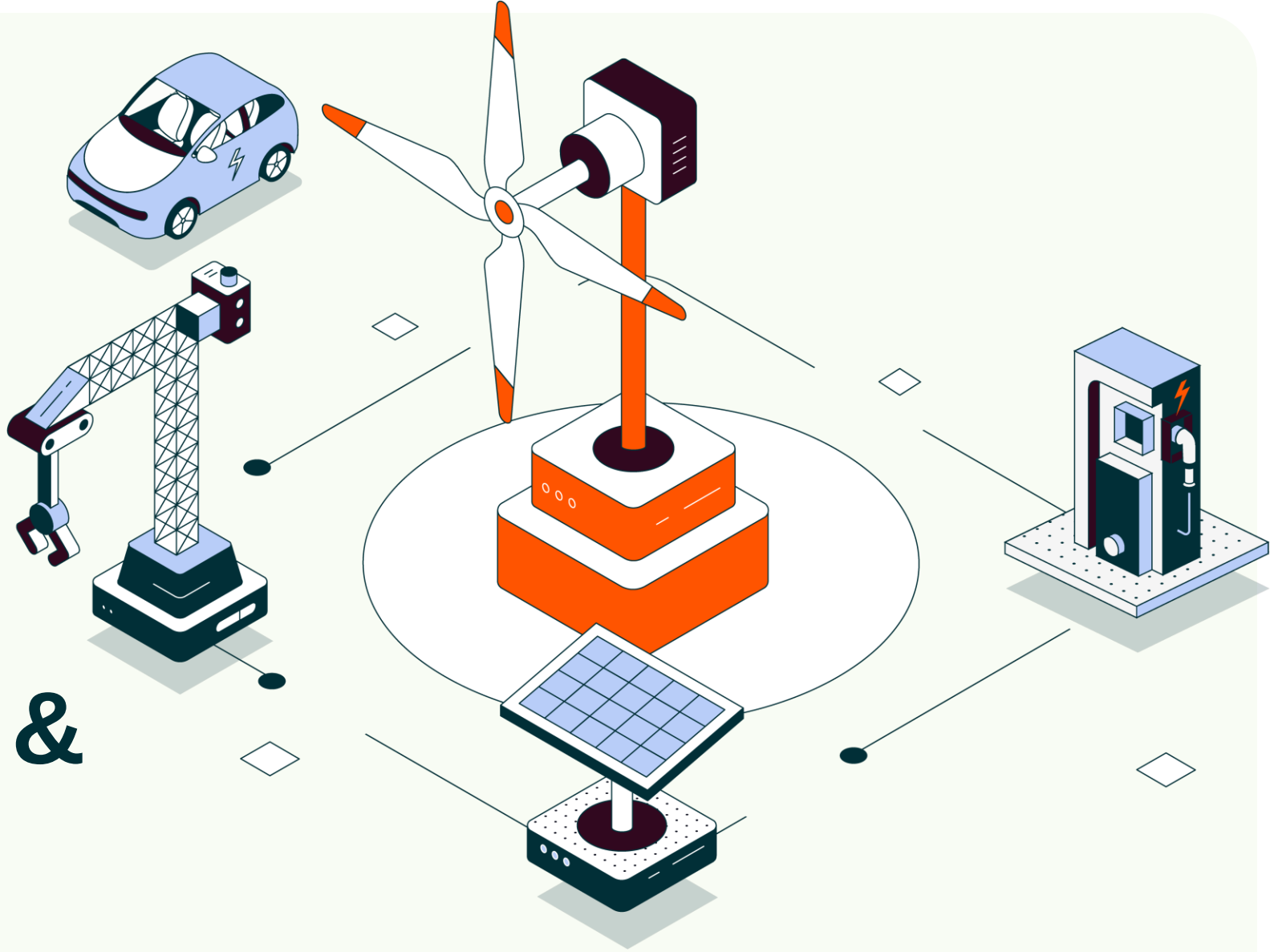
Global military expenditures could grow to $3.4 trillion by 2030, as countries ramp up spending on conventional ammunition and defense technology solutions.[1]



PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: 1. SIPRI, Apr 2024.

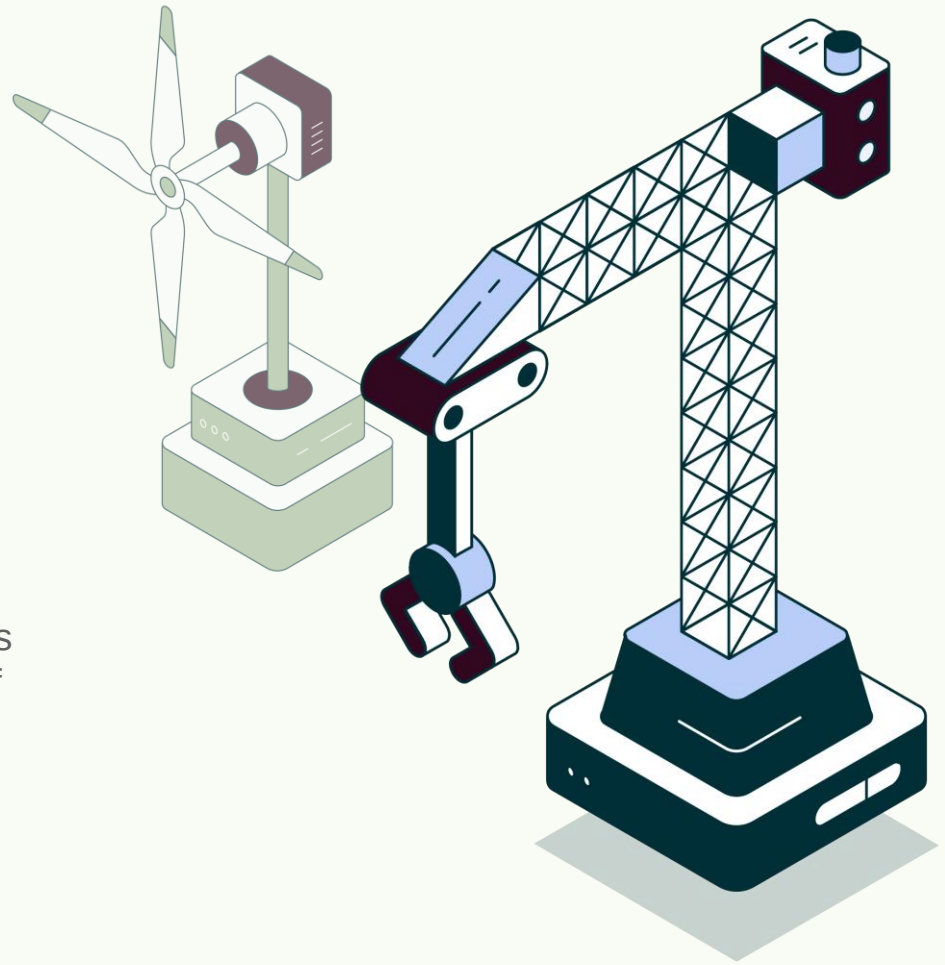


SECTION 2

Infrastructure & Environment

CHAPTER 2.1

Infrastructure:
Paving the Way Forward



The United States, similar to many other countries, likely sits poised at the beginning of an infrastructure renaissance, reflecting the demands of several powerful converging global trends, including climate change, electrification, technology advancements, and aging assets. In addition, government policies could lead to trillions in public and private investments for the development of infrastructure assets around the world. As the world struggles to reduce its carbon footprint, vast swaths of the built environment are being remade to become more energy efficient and resilient.

Infrastructure Development: At the Center of Several Structural Forces

The convergence of multiple long-term structural trends could potentially unlock trillions of dollars in government funding and private investments for infrastructure development.[1]

Structural Trend	Climate Change	Electrification of Power & Transport	Growth of Disruptive Technologies	Global Fragmentation	Aging Infrastructure Assets	Shifting Demographics
Potential Infrastructure Needs	Renewable Energy	Power Grids	Data Centers	Power Grids	Roads	Roads
	Smart Grids	EV Chargers	EV Chargers	Power Plants	Bridges	Housing
	Clean Water Infrastructure	Energy Storage	Energy Storage	Renewable Energy	Tunnels	Clean Water Infrastructure
	Green Buildings		Power Plants	Production Facilities	Clean Water Infrastructure	Power Grids
	EV Chargers		Renewable Energy		Wastewater Infrastructure	Wastewater Infrastructure
	Sea Walls		Power Grids		Power Grids	Retail

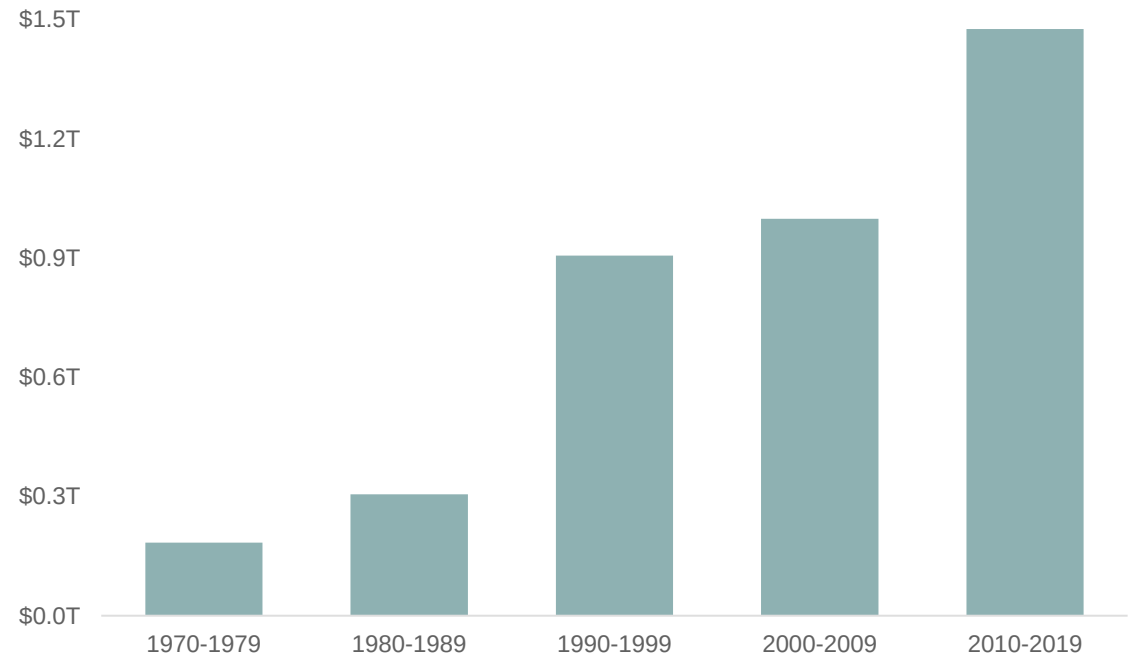
Sources: Text: 1. Brookfield, Jun 2024.

Climate Change: Extreme Weather Events Pose Significant Risks to Global Infrastructure

Accomplishing global climate change and development objectives by 2030 likely requires an investment of $6.9 trillion in sustainable infrastructure each year.[1]

Losses from Climate and Weather Events Are Rising

Global Reported Economic Losses Attributed to Climate and Weather Extremes



Climate Change Is Linked to Recent Extreme Weather

Hurricane Helene's record-breaking rainfall in the Southeast United States in September 2024:

Rainfall was

10% to 50% heavier

across the region due to a warmer climate.[2]

Central Europe's record-breaking floods in September 2024:

Occurrence was

2x more likely

and 7% more intense due to climate change.[3]

West Africa's dangerous heatwave in February 2024:

Occurrence at least

10x more likely

due to climate change.[4]

Canada's record-breaking wildfires from May to July 2023:

Occurrence at least

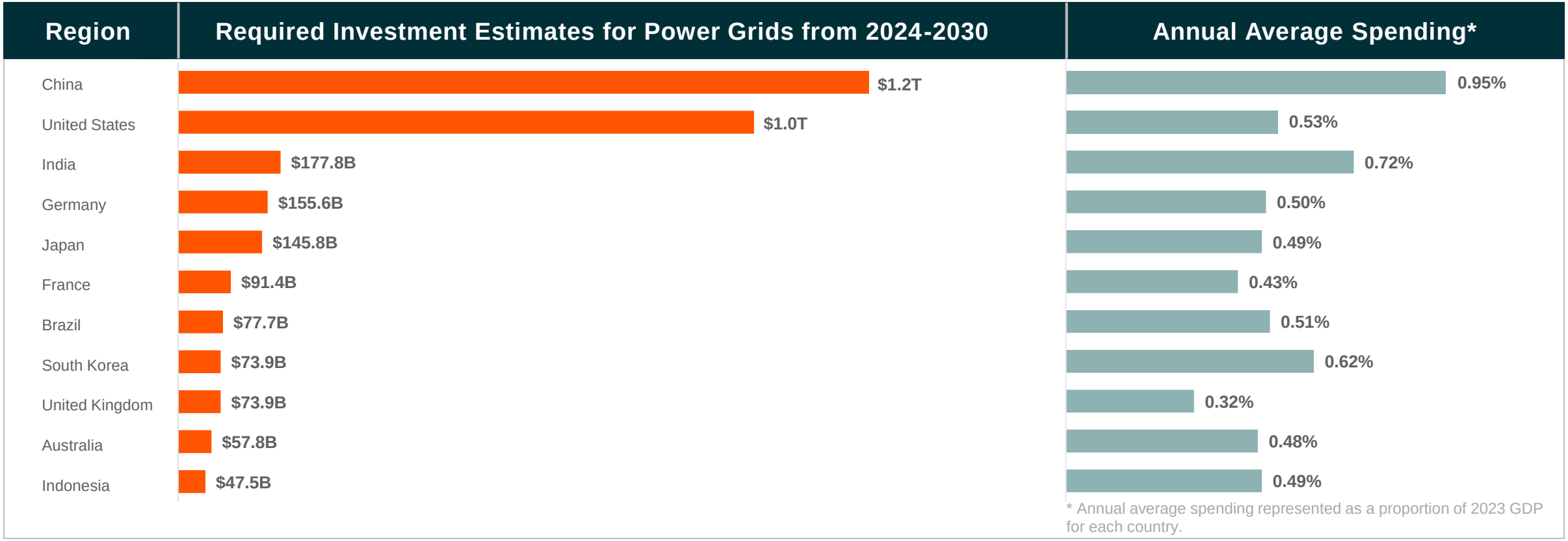
2x more likely

and 20% more intense due to climate change.[5]

Sources: Text: 1. OECD, Apr 2024; 2. Yale Climate Connections, Oct 2024; 3. World Weather Attribution, Sep 2024; 4. Carbon Brief, Mar 2024; 5. Carbon Brief, Aug 2023; Charts: LHS: World Economic Forum, Nov 2023.

Electrification of Power and Transport: Significant Grid Investments Are Required

Renewable energy and electric vehicles are two technologies that can reduce emissions. To support advancements toward net-zero emission targets, governments will need to invest trillions into power grids through 2030.[1]

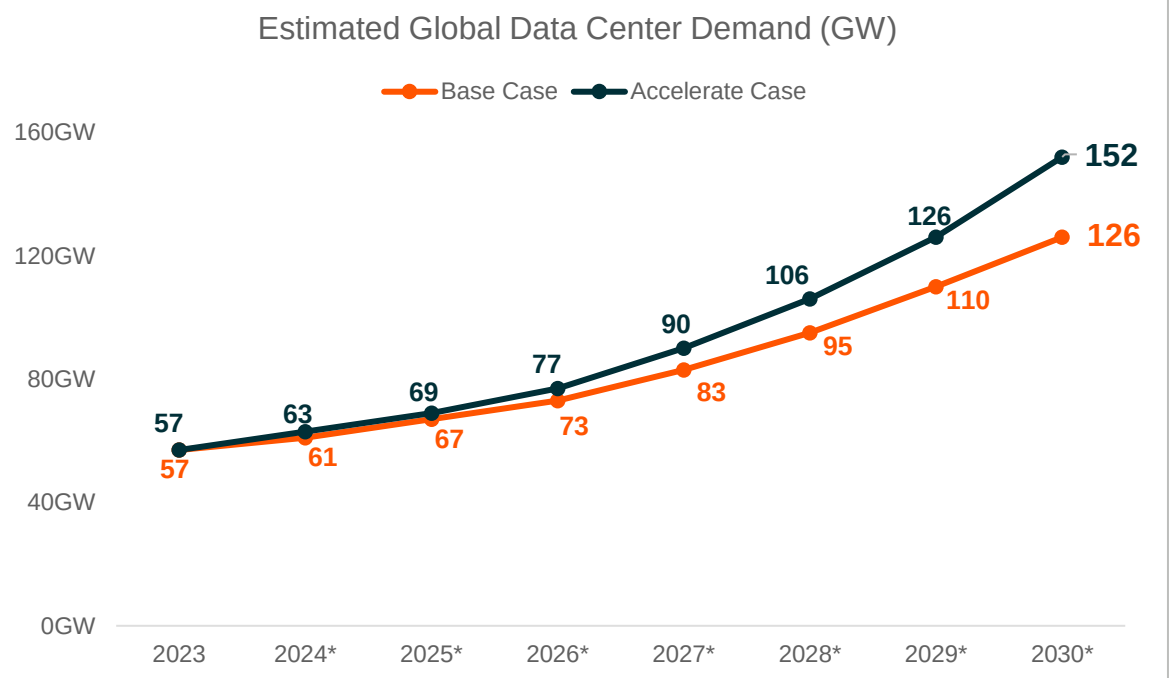


Sources: Text: 1. BloombergNEF, Jul 2024; Charts: BloombergNEF, Jul 2024.

Disruptive Technologies: Infrastructure Investment Needed to Support Expected Growth Rates

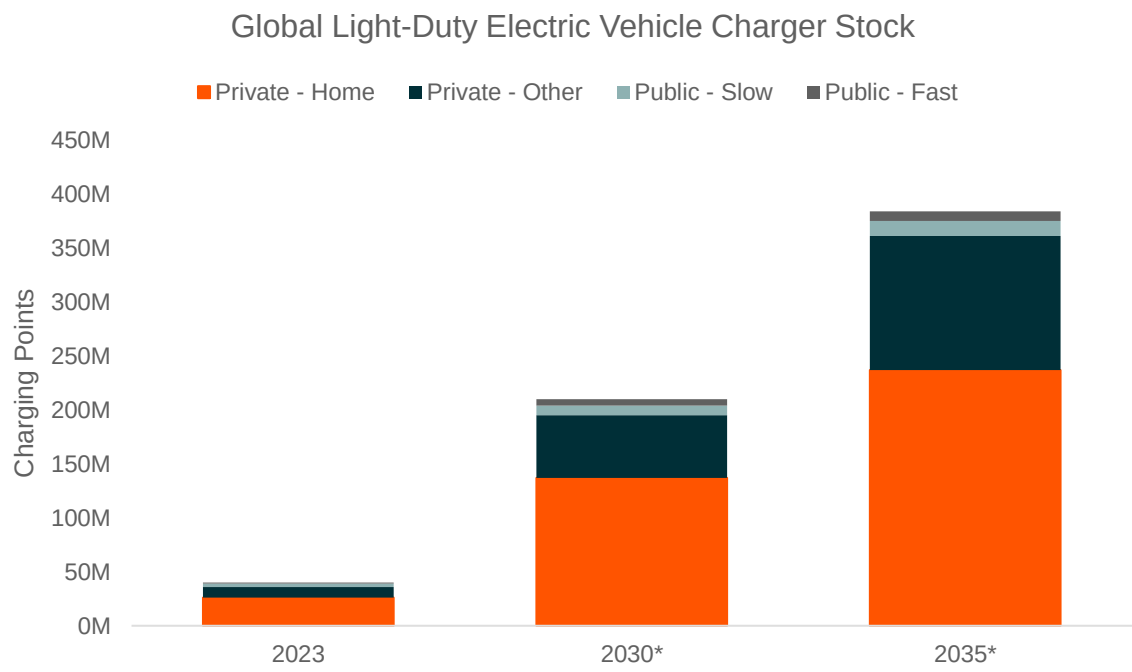
The expected growth rates for transformative technologies, such as generative AI and EVs, necessitate significant investments into infrastructure assets.

Data Center Demand Could Grow as Generative AI Advances



* Forecast; Note: The two lines represent two potential rates of growth.

EV Charging Infrastructure Central to Widespread EV Use



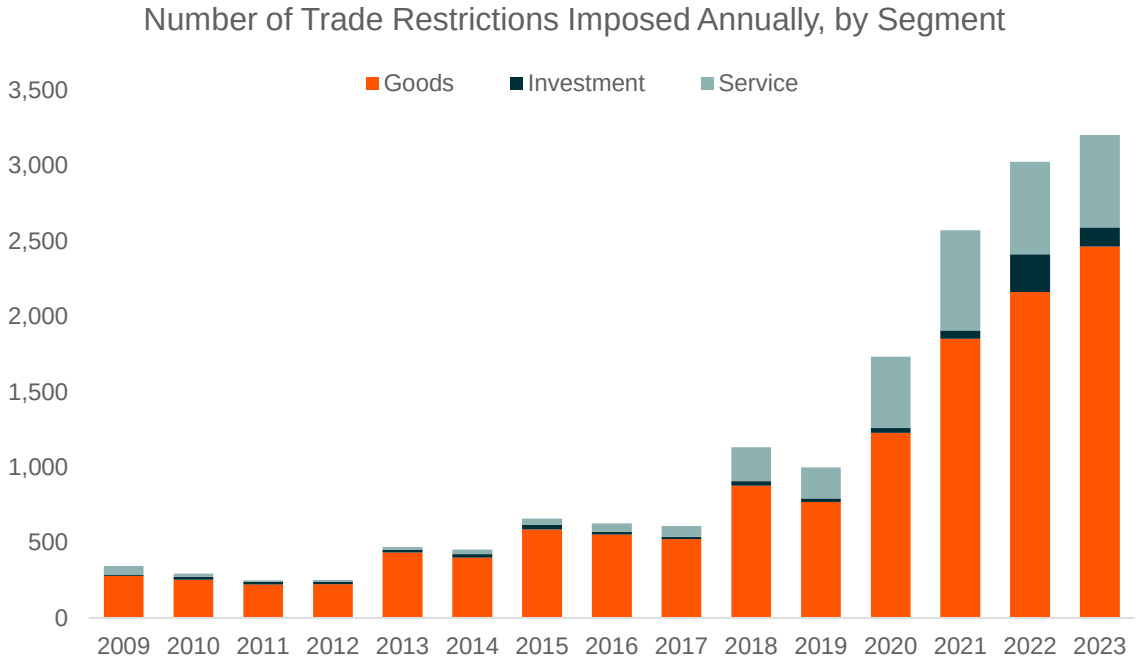
* Forecast

Sources: Charts: LHS: KKR, Feb 2024.; RHS: IEA, Apr 2024.

Global Fragmentation: Manufacturing Investments Likely as Nations Prioritize Self Sufficiency

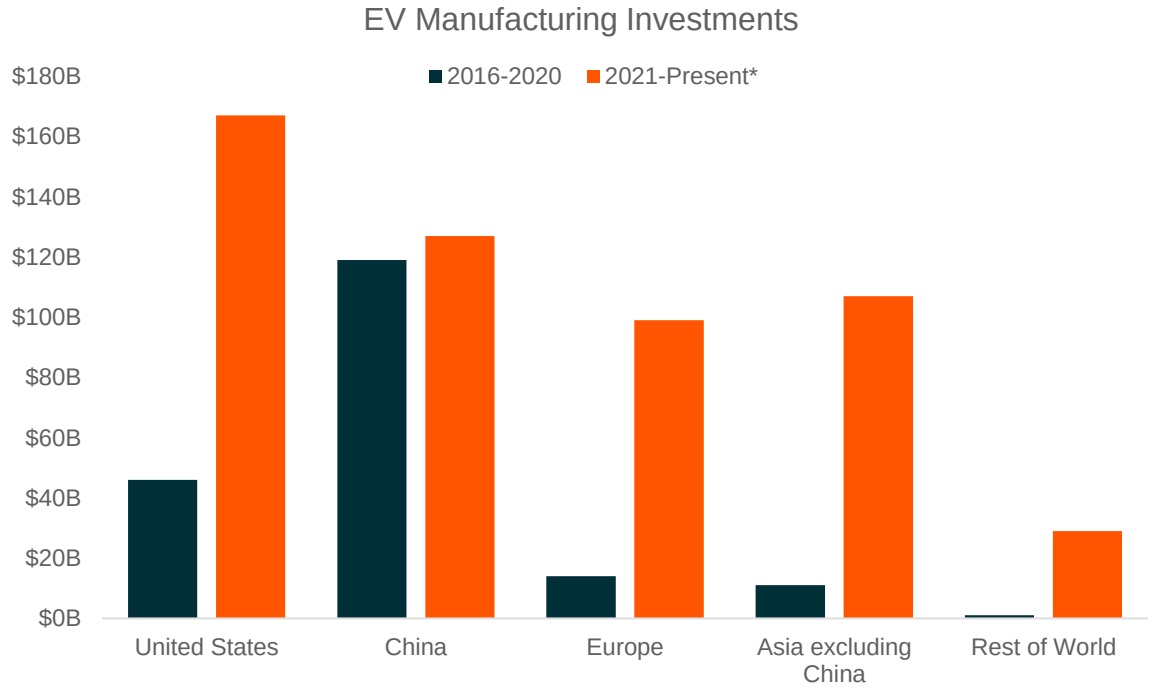
Many governments are implementing policies to grow their domestic manufacturing footprints in order to boost their energy security, supply chain resilience, and global influence among an increasingly divided global landscape.

Trade Restrictions Suggest Growing Fragmentation



Note: Totals across all segments only include trade restrictions that have been categorized as 'harmful'.

More Regions Are Investing in Manufacturing for EVs



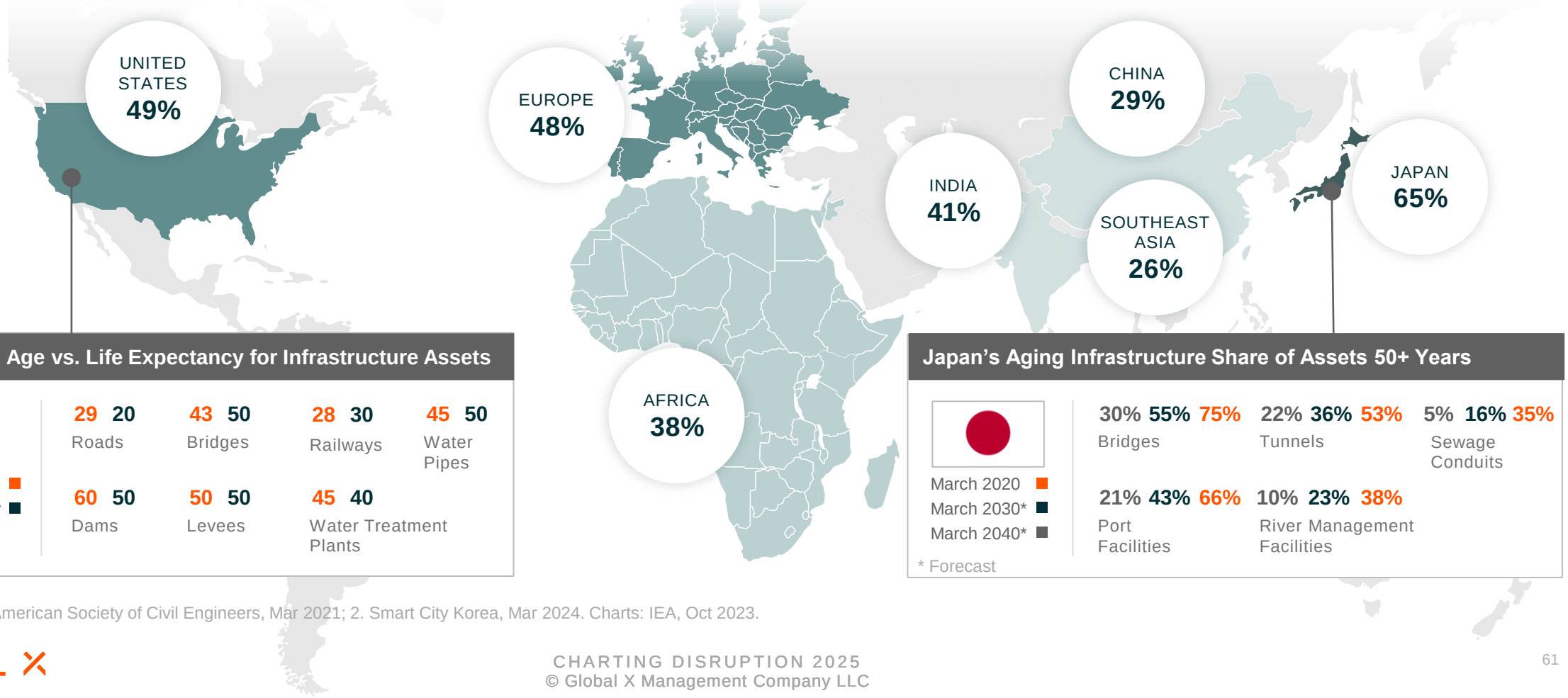
* Data as of March 8, 2024.

Sources: Charts: LHS: Global Trade Alert, n.d., accessed on 14 Aug 2024; RHS: EDF, Mar 2024.

Aging Infrastructure Assets: A Common Concern Across Developed Economies

Aging infrastructure assets, such as decades-old bridges and power grid infrastructure, can amplify the risks associated with climate change, slow the growth of disruptive technologies, and impede shifting demographics.

Share of Power Grid Infrastructure Assets Over 20 Years Old



U.S. Average Age vs. Life Expectancy for Infrastructure Assets

Average Age
Life Expectancy

	Average Age	Life Expectancy
Roads	29	20
Bridges	43	50
Railways	28	30
Water Pipes	45	50
Dams	60	50
Levees	50	50
Water Treatment Plants	45	40

Japan's Aging Infrastructure Share of Assets 50+ Years

March 2020
March 2030*
March 2040*

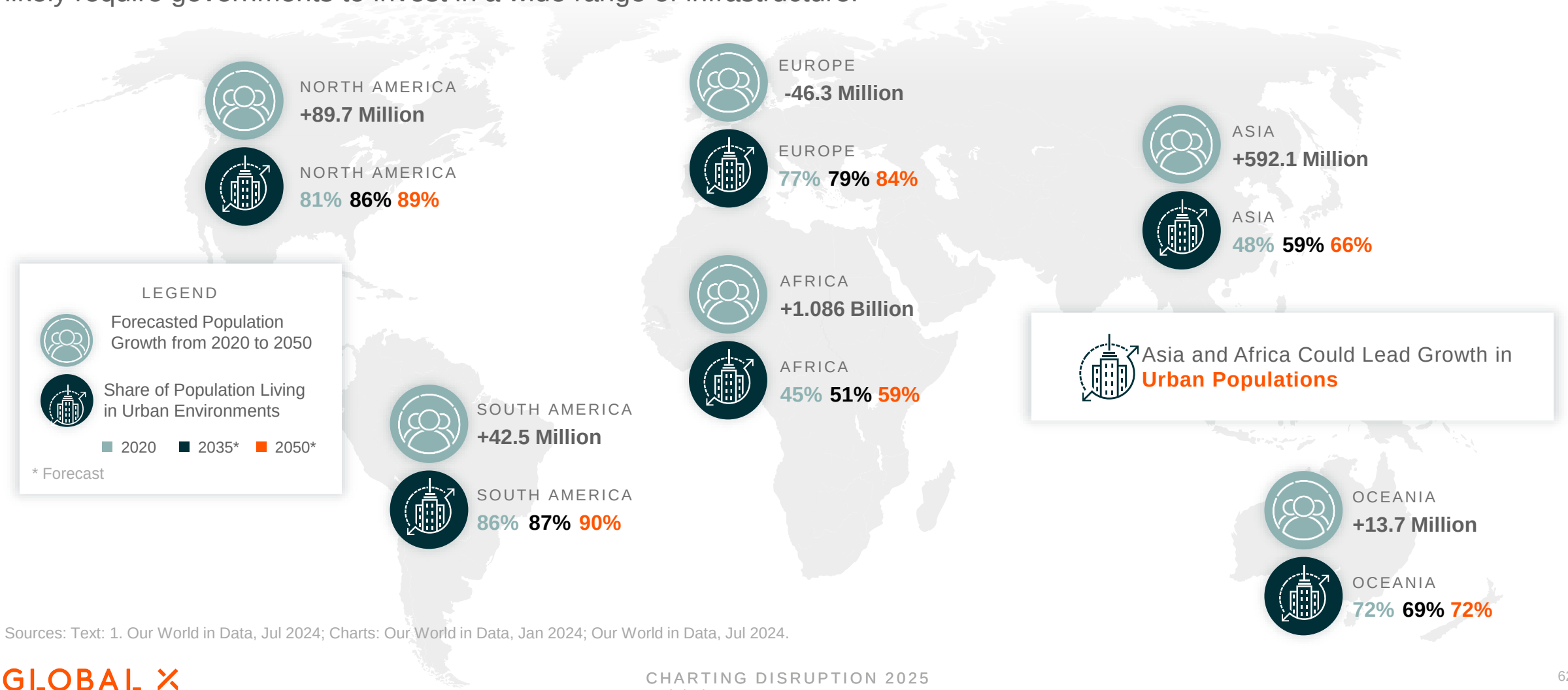
	March 2020	March 2030*	March 2040*
Bridges	30%	55%	75%
Tunnels	22%	36%	53%
Sewage Conduits	5%	16%	35%
Port Facilities	21%	43%	66%
River Management Facilities	10%	23%	38%

* Forecast

Sources: Text: 1. American Society of Civil Engineers, Mar 2021; 2. Smart City Korea, Mar 2024. Charts: IEA, Oct 2023.

Shifting Demographics: Increasing Population, Especially in Urban Areas

In 2050, 70% of the world's nearly 10 billion people could be living in cities. Supporting younger, more urban populations will likely require governments to invest in a wide range of infrastructure.



Sources: Text: 1. Our World in Data, Jul 2024; Charts: Our World in Data, Jan 2024; Our World in Data, Jul 2024.

Infrastructure Development: Governments Planning Trillions in Current and Future Investments

In addition to the tailwinds from structural trends, many governments are allocating significant capital toward infrastructure development to support net-zero emissions goals and shifting demographics.

UNITED STATES

In November 2021, President Biden enacted the Infrastructure Investment and Jobs Act (IIJA), which set aside **$1.2 trillion** of spending across a range of infrastructure segments.[1] The Inflation Reduction Act and CHIPS Act, both enacted in 2022, also outline billions of dollars toward infrastructure development.[2]

JAPAN

In Japan, the government's proposed green transformation could require over **$1.1 trillion** in public-private financing toward sustainable technologies and infrastructure, including renewable energy, carbon capture utilization and storage (CCUS), hydrogen, EVs, green houses, and sustainable industrial operations.[3]

INDIA

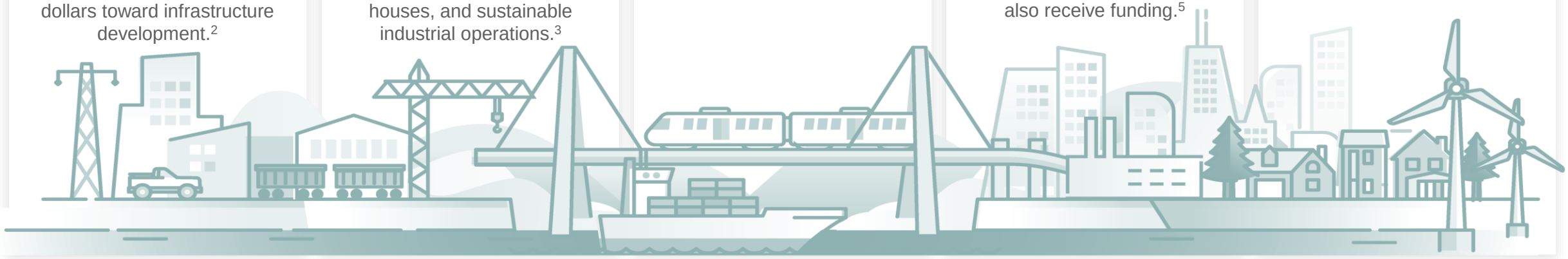
In India, the government plans to spend around **$133 billion** on infrastructure developments in the current fiscal year that runs from April 2024 to April 2025.[4]

EUROPEAN UNION

In July 2024, the European Commission selected 134 transport projects to receive over **€7 billion** in grants from the EU's Connecting Europe Facility program. Railway projects will receive 80% of the announced funding. Waterways and maritime route projects will also receive funding.[5]

CANADA

In April 2024, the Canadian government launched a **$6 billion** housing infrastructure fund to accelerate housing construction.[6]

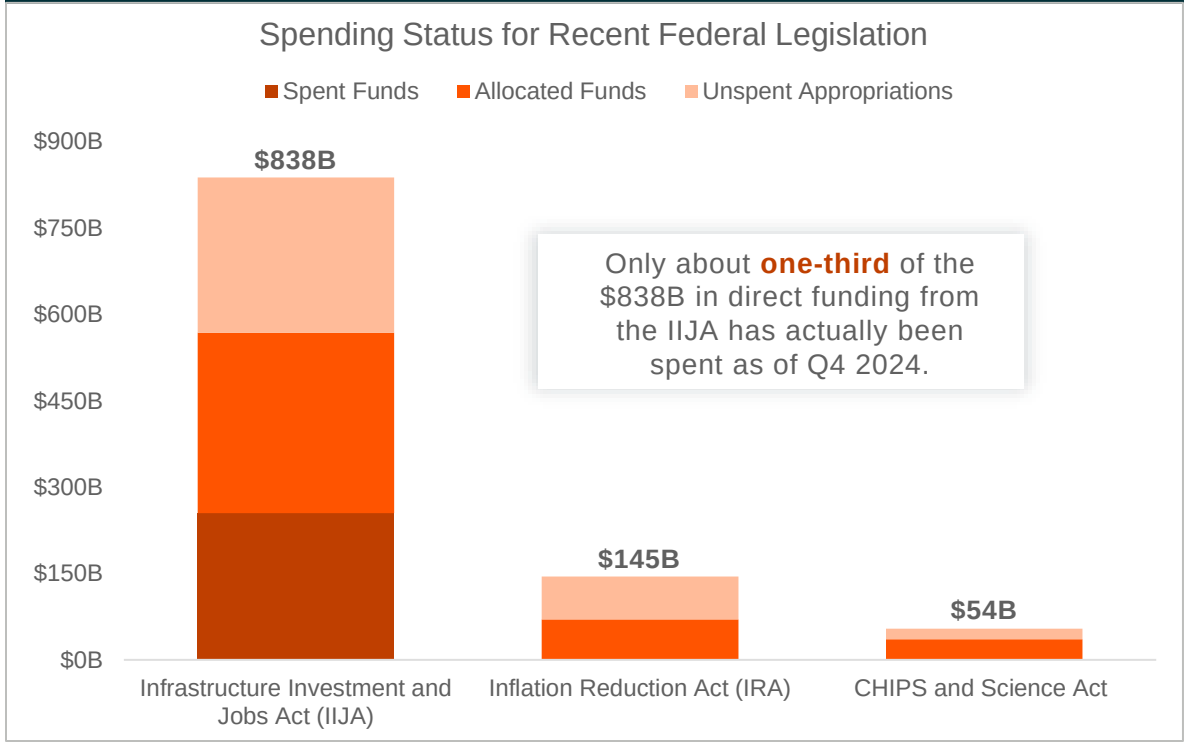


Sources: Text: 1. Forbes, Nov 2021; 2. Politico, May 2024; 3. Government of Japan, Jan 2023; 4. Morningstar, Jul 2024; 5. European Commission, Jul 2024; 6. Reuters, Apr 2024.

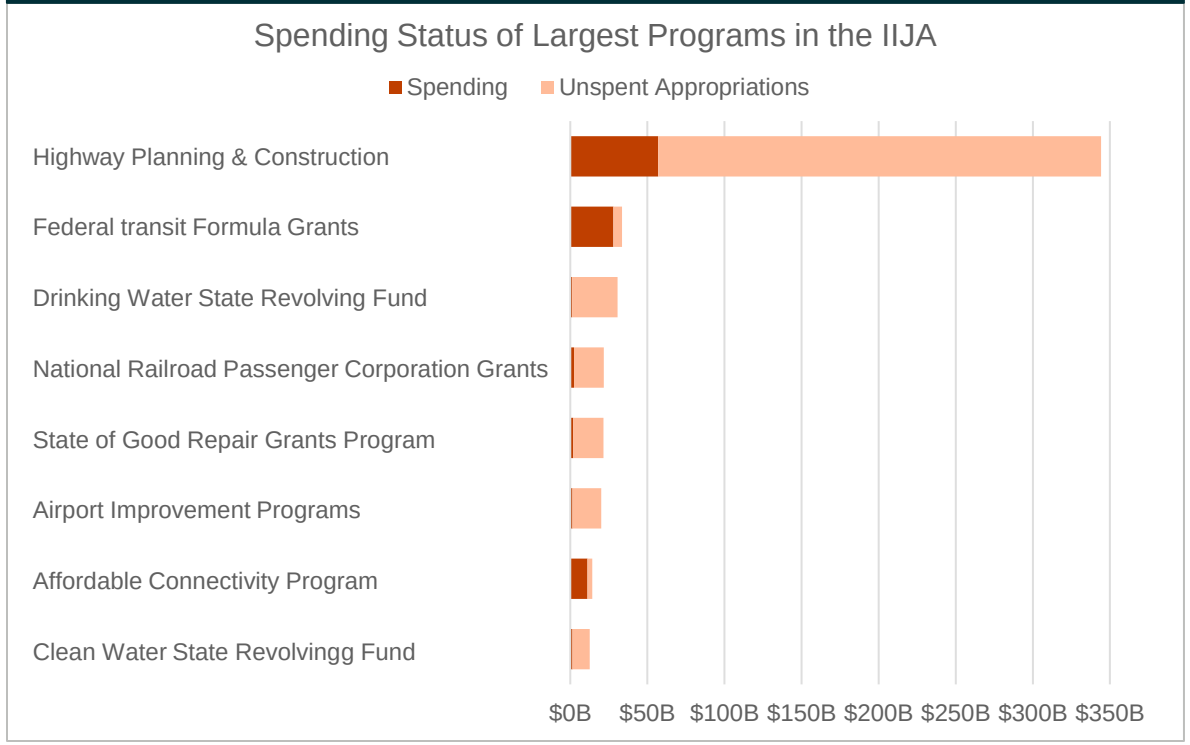
U.S. in Focus: Federal Policies Outline over $1 Trillion in Potential Public Infrastructure Funding

Nearly 35% of appropriated funds in recent federal legislation still requires allocation, and an even higher percentage remains unspent.[1,2,3] This means that legislative tailwinds for infrastructure development could last several more years.

The IIJA Has the Largest Amount of Unallocated Funds



IIJA Funds Allotted for Range of Infrastructure Assets



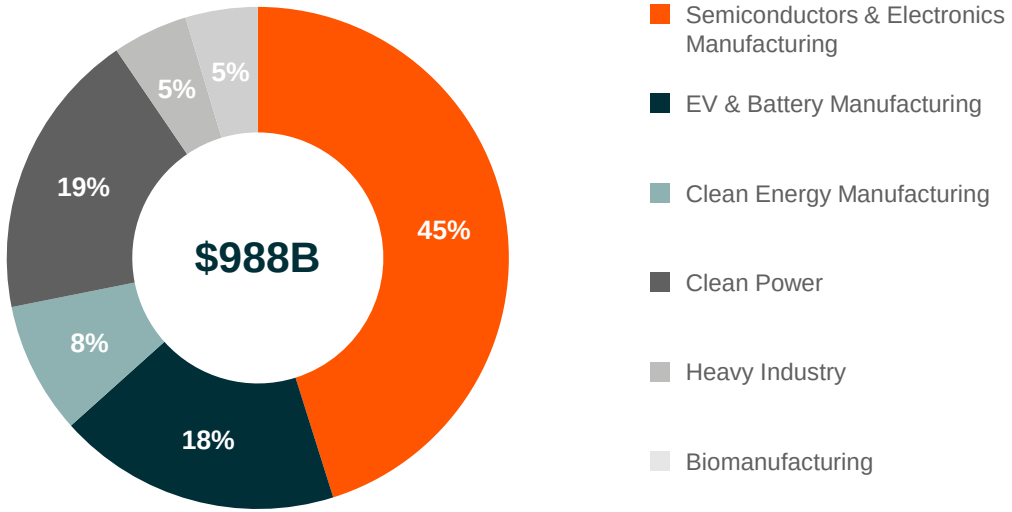
Sources: Text: 1. Politico, May 2024; 2. YahooFinance!, Aug 2024; 3. The White House, n.d., accessed on 1 Nov 2024; Charts: LHS: Global X ETFs analysis with information derived from: Politico, May 2024; NIST, n.d., accessed on 20 Nov 2024; Yahoo!Finance, Aug 2024; The White House, n.d., accessed on 1 Nov 2024 RHS: Politico, May 2024.

U.S. in Focus: Private Investments Fueling a Manufacturing Resurgence

A U.S. manufacturing boom appears well underway, driven by public funding as well as over $900 billion in private manufacturing and cleantech investments announced since the enactment of the IIJA in November 2021.[1]

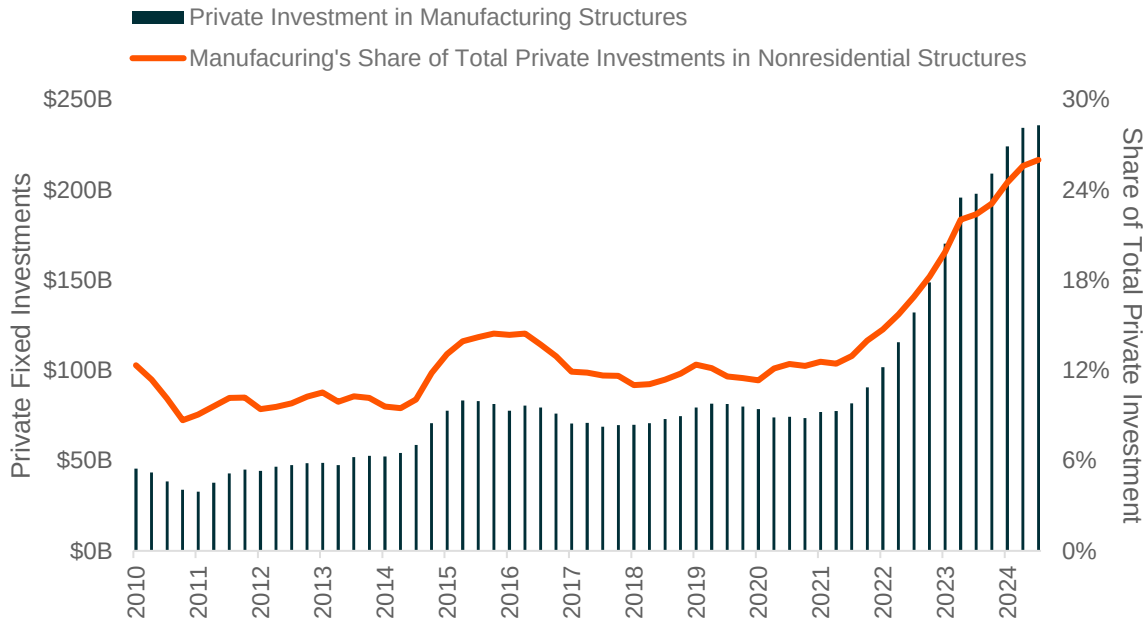
Private Investment Surge Impacting Several Industries

Announced Private Investments Since January 2021



Manufacturing's Share of Investments Doubled

Private Fixed Investment for Nonresidential Structures, Seasonally Adjusted



Sources: Text: 1. The White House, n.d., accessed on 1 Nov 2024; Charts: LHS: The White House, n.d., accessed on 1 Nov 2024; RHS: U.S Bureau of Economic Analysis, Oct 2024a; U.S Bureau of Economic Analysis, Oct 2024b.

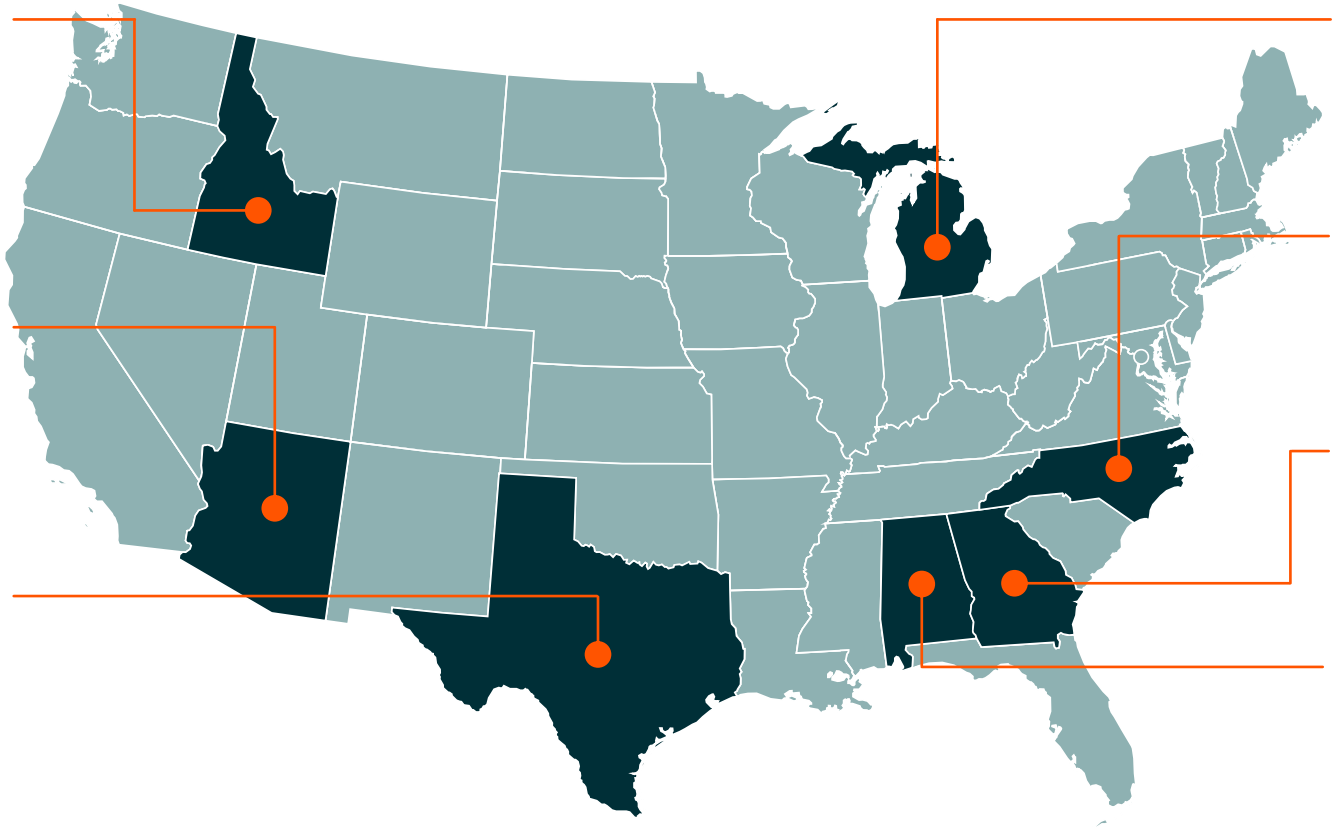
U.S. in Focus: New Manufacturing Facilities Require Ramp-Up in Infrastructure Development

Building new manufacturing facilities will likely create opportunities for companies throughout the entire infrastructure development value chain. TSMC's Arizona facilities alone could create 20,000 construction jobs.[1]

Idaho
Micron is investing $15 billion in the construction of a new fabrication facility for leading-edge memory chip manufacturing in Idaho, the first of its kind to be built in the United States in 20 years[1].

Arizona
TSMC's first three U.S.-based semiconductor manufacturing facilities are being built in Arizona. The planned investment is $65 billion.[2]

Texas
Apple is expanding its Texas operations with a new $1 billion campus in Austin. The company aims to invest $430 billion in the U.S. economy over 5 years.[3]



Michigan
Ford and General Motors have announced billions of dollars in investments toward expanding EV production in Michigan.[4]

North Carolina
Toyota has announced $13.9 billion toward its first U.S. electric vehicle battery manufacturing facility, which is being built in North Carolina.[5]

Georgia
Qcells, a subsidiary of Hanwha Group, is planning to invest a total of $2.5 billion to expand solar equipment manufacturing capacity in Georgia.[6]

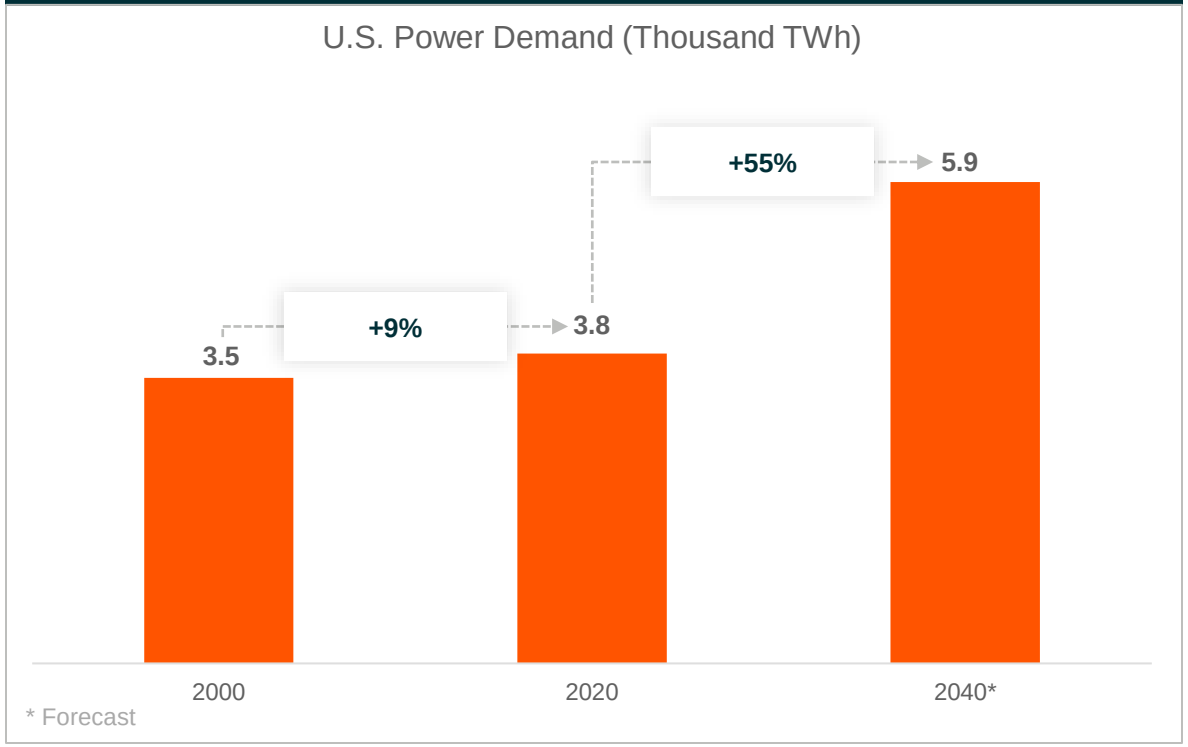
Alabama
Nucor Corp. is investing $125 million toward the construction of a new transmission tower production plant in Alabama.[7]

Sources: Text: 1. Micron, Sep 2022; 2. TSMC, Apr 2024; 3. Thomas, Mar 2024; 4. Mich Auto, Jan 2024; 5. Toyota, Oct 2023; 6. Qcells, Oct 2023; 7. Nucor, Feb 2023.

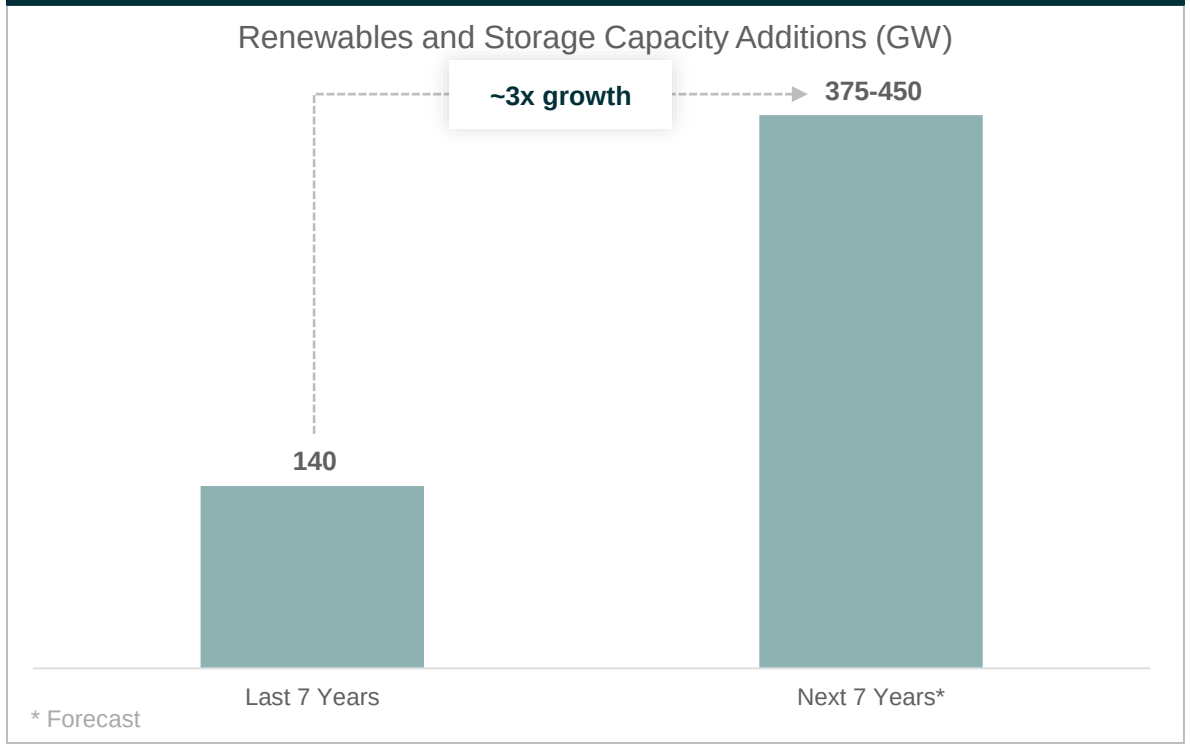
U.S. in Focus: Power Grid Is at an Inflection Point Due to Rising Demand, Shifting Resource Mix

U.S. power demand is set to rise significantly, after two decades of near-flat growth, due to increasing consumption from AI data centers, EVs, and manufacturing facilities. Meeting this demand will require new power generation assets.

Power Demand Growth Could Be 6x Higher vs. Last 20 Years



Renewables and Storage Can Help Meet New Demand

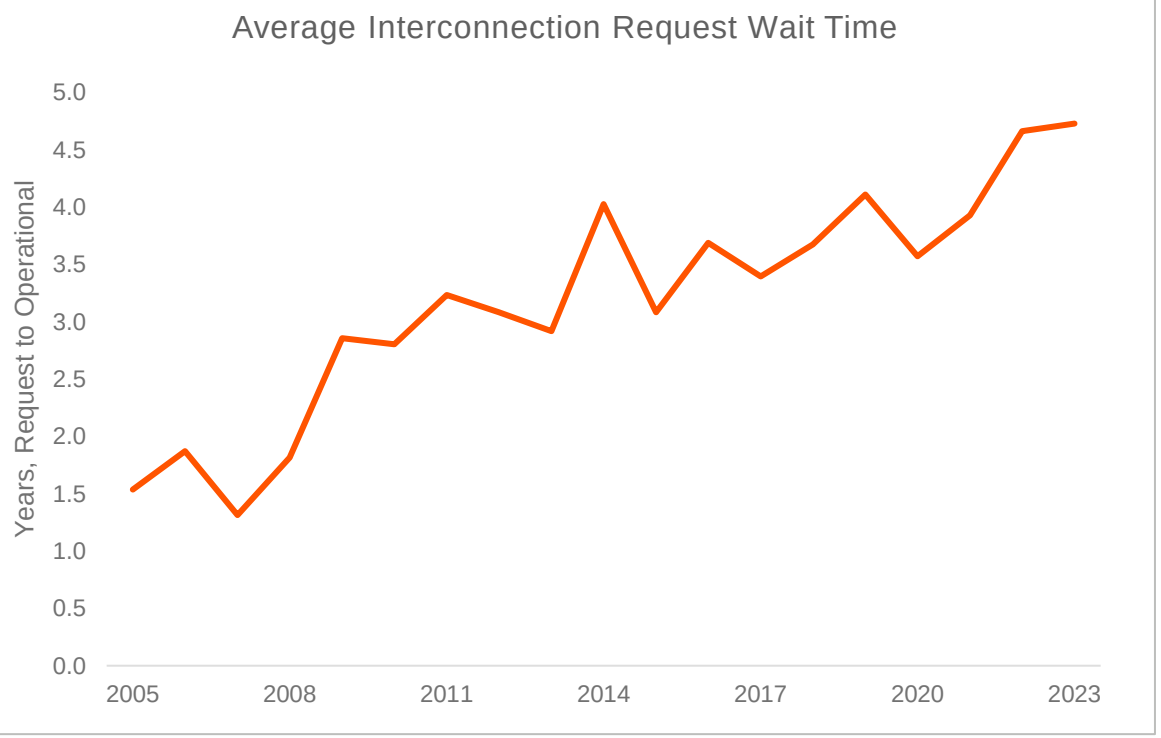


Sources: NextEra, Oct 2024.

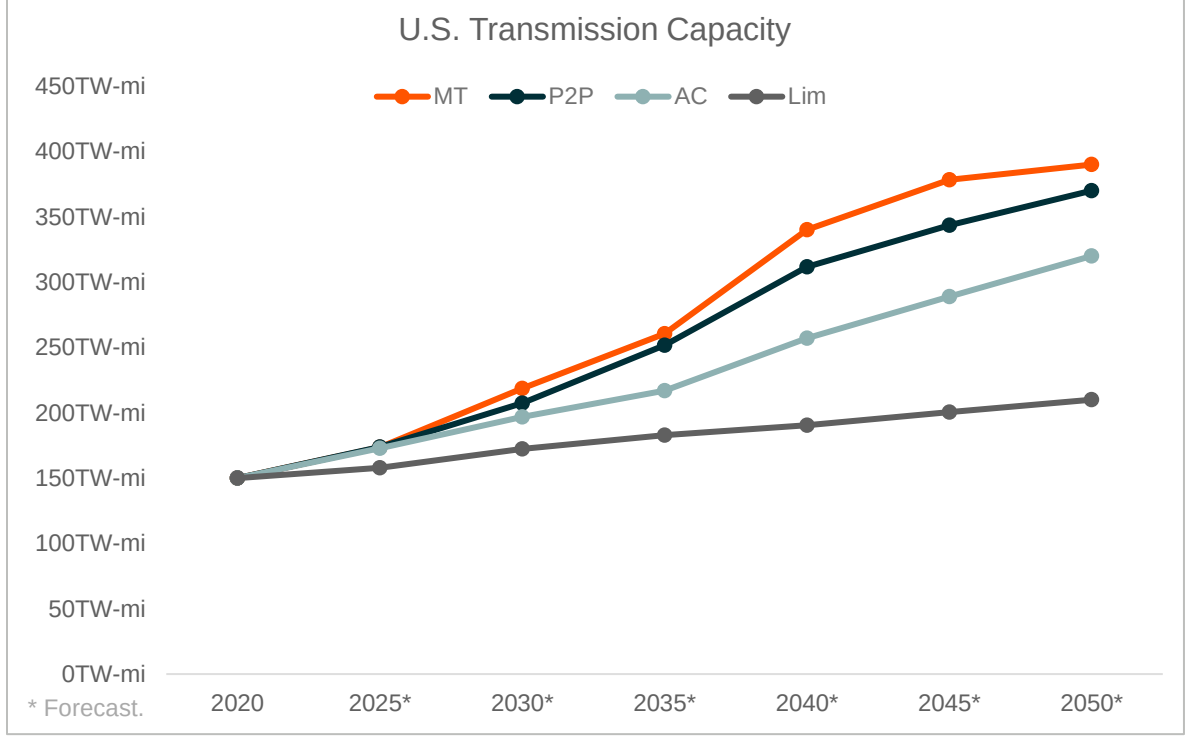
U.S. in Focus: Grid Infrastructure Needs to Expand to Support Growth and Reduce Challenges

The United States' aging grid is becoming increasingly congested, leading to longer project wait times. Increasing transmission capacity and modernizing grid infrastructure will be essential to support shifting power grid dynamics.

Developers Are Waiting Longer to Connect Projects



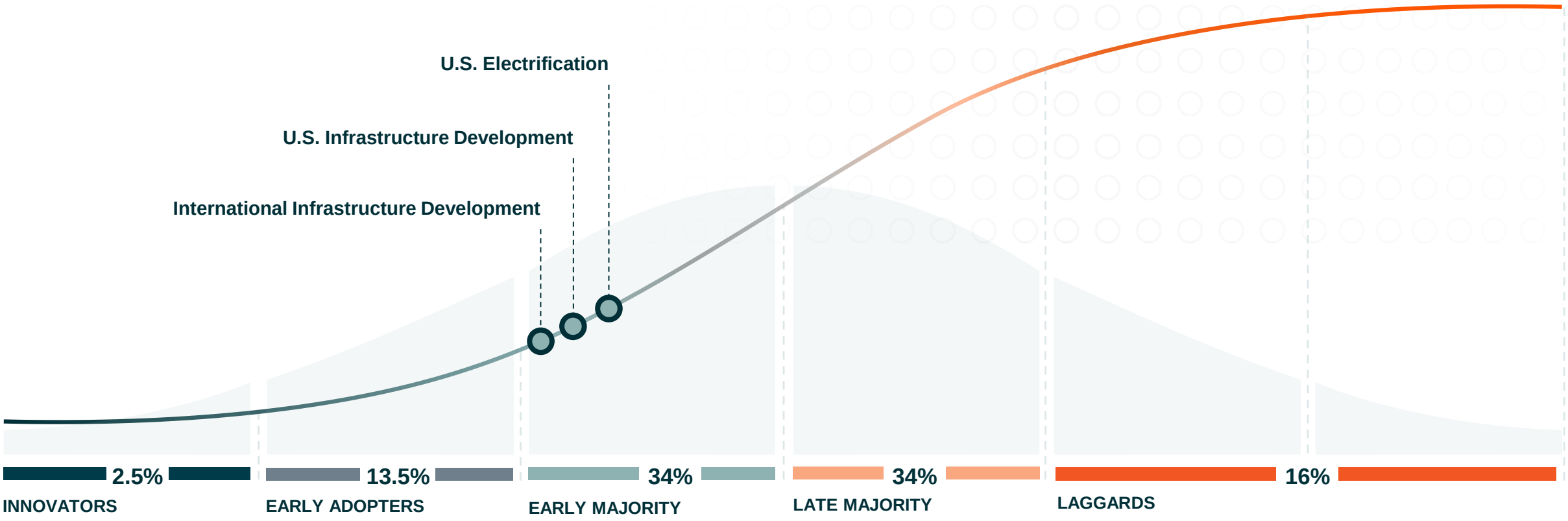
Transmission Capacity Must Increase to Support Demand



Note: For RHS chart, scenarios range from limited growth (Lim) to Accelerated Alternating Current (AC), Point-to-Point (P2P), and Multiterminal (MT).
Sources: Text: 1. IEA, Oct 2023; Charts: LHS: Berkeley Lab, Apr 2024.; RHS: U.S. Department of Energy Grid Deployment Office, Oct 2024.

S-Shaped Curve of Adoption – Infrastructure

To date, 60% of the infrastructure necessary to accommodate anticipated 2050 global population remains to be built.[1]



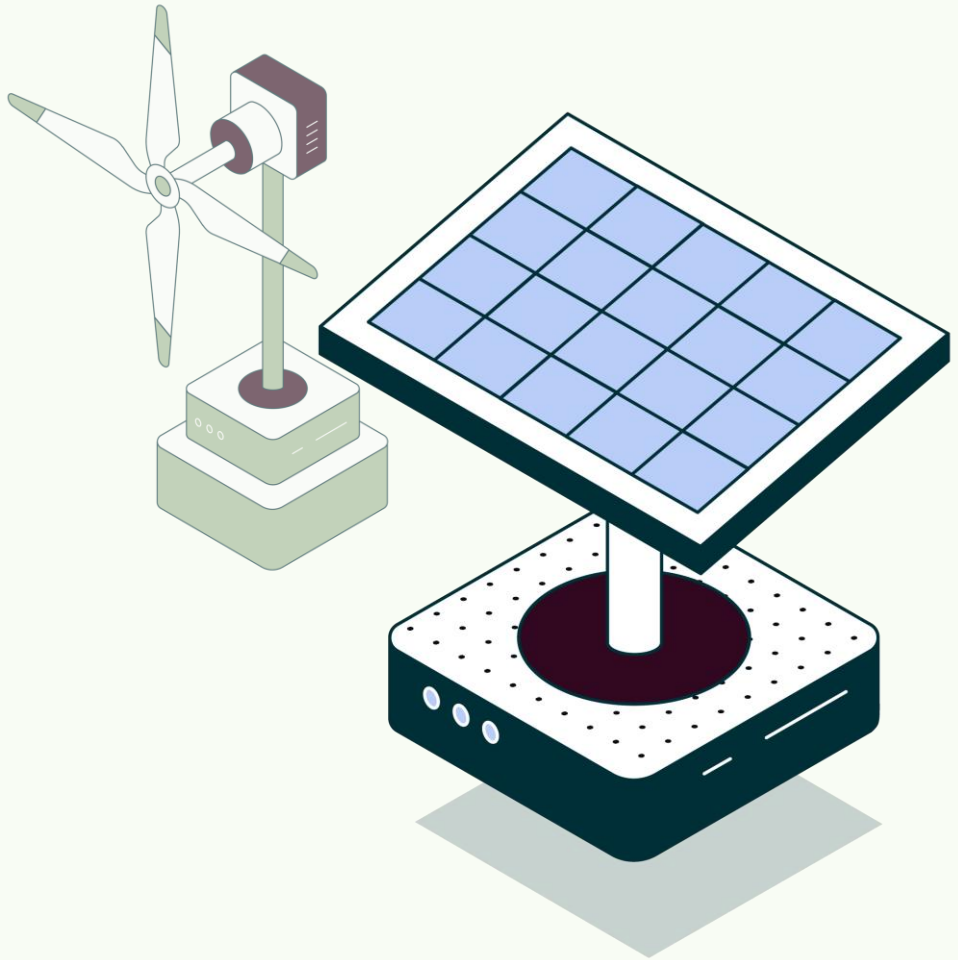
PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: 1. C40 Cities, 2024.

CHAPTER 2.2

CleanTech:
A Renewable Future



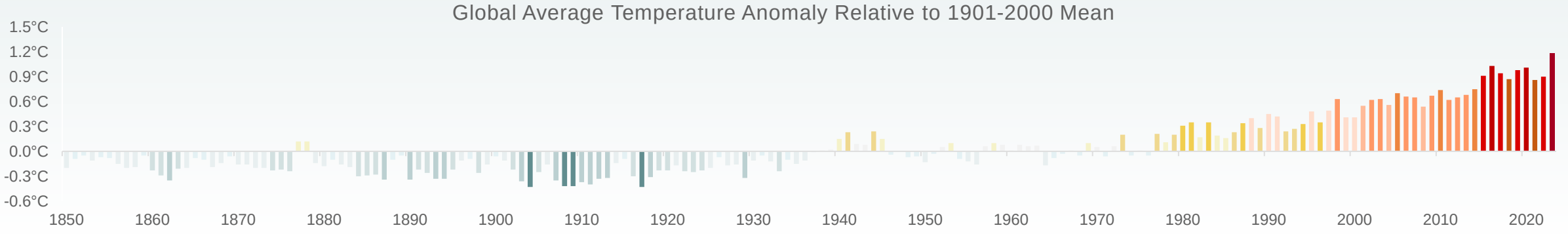
The global consensus stipulates that avoiding the worst impacts of climate change requires limiting warming to 1.5°C-2°C. Investments into the technologies that can yield significant global emission cuts and limit warming must total an estimated $150 trillion between 2023 and 2050.[1] Additional investments will be needed to help communities and industries adapt to the impacts that are already being felt at current levels of warming.

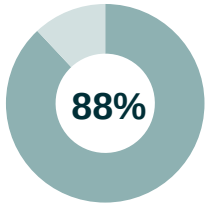
Sources: Text: 1. International Renewable Energy Agency, Jun 2023.

CleanTech: Opportunities Abound Due to Rising Temperatures Influencing Policy

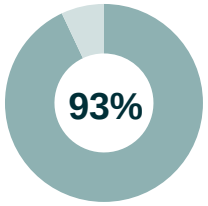
The global surface temperature is on average 1.36°C warmer than the pre-industrial period.[1] With climate records already being broken at current levels of warming, the global economy is becoming increasingly climate-focused.

Climate Policies Designed to Help Mitigate Warming Cover a Large Share of the Global Economy

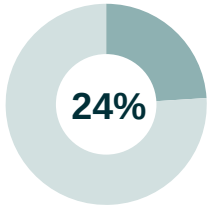




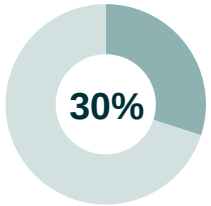
Share of global emissions covered by national net-zero targets[2]



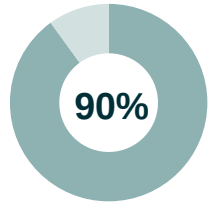
Share of global GDP covered by national net-zero targets[3]



Share of global emissions covered by carbon pricing schemes[4]



Share of countries with target dates to phase out the sale of internal combustion engine vehicles[5]



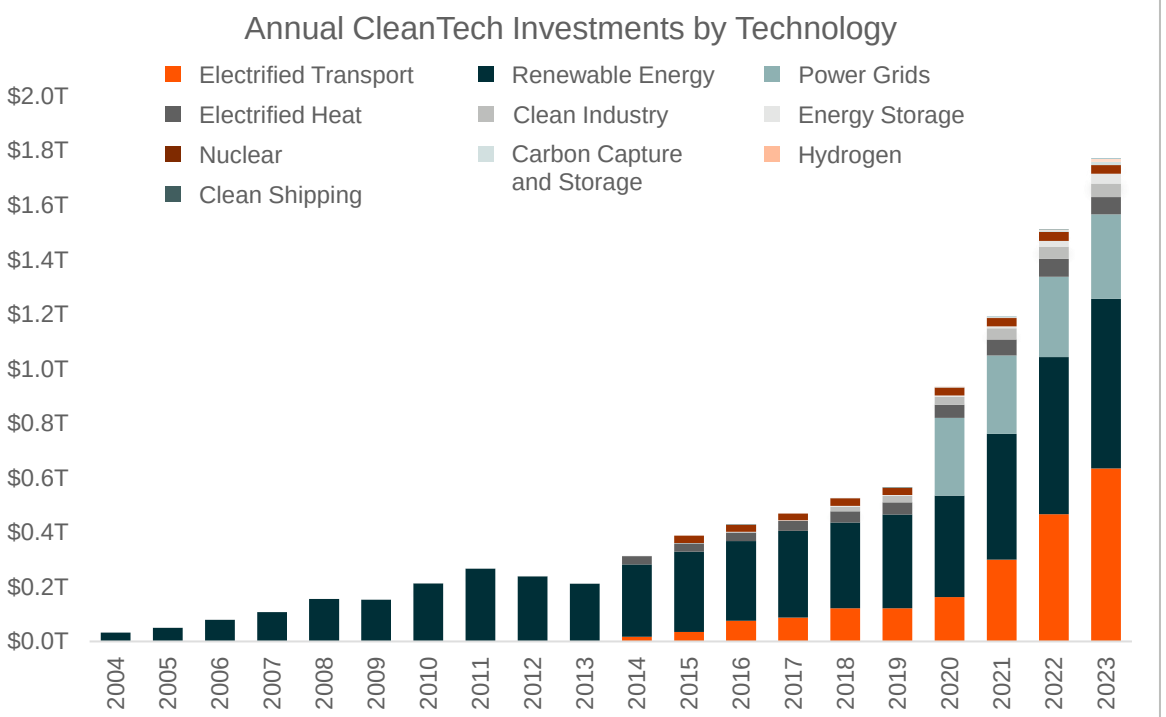
Share of car sales in 2023 where the automaker has set a future EV deployment target[6]

Sources: Text: 1. NASA, n.d., accessed on 24 Oct 2024; 2. Net Zero Tracker, n.d., accessed on 24 Oct 2024; 3. Ibid; 4. World Bank Group, Oct 2024; 5. Statista, Jul 2024; 6. IEA, Apr 2024; Charts: Top: National Centers for Environmental Information, n.d., accessed on 31 Oct 2024.

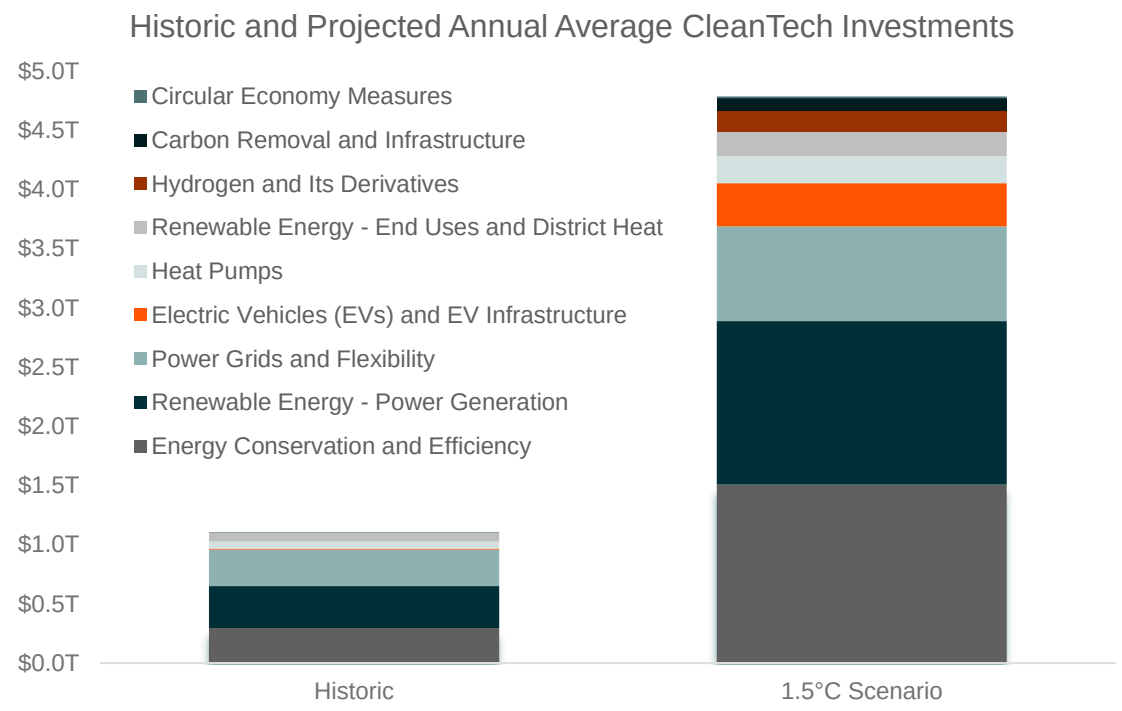
CleanTech: Current Investments Showing Growth but More Needed to Meet Climate Targets

Global investment across energy transition technologies must total an estimated $150 trillion from 2023-2050 to limit warming to 1.5°C, which is about $5 trillion annually.[1] CleanTech investment is forecast to reach $2 trillion in 2024.[2]

Global CleanTech Investments Are on the Rise



Power Grid Technologies Face Largest Investment Gap

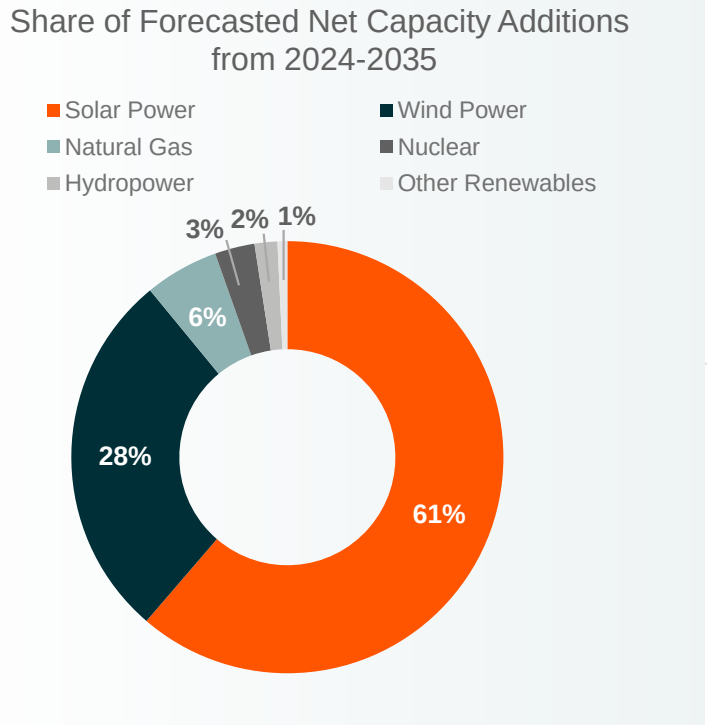


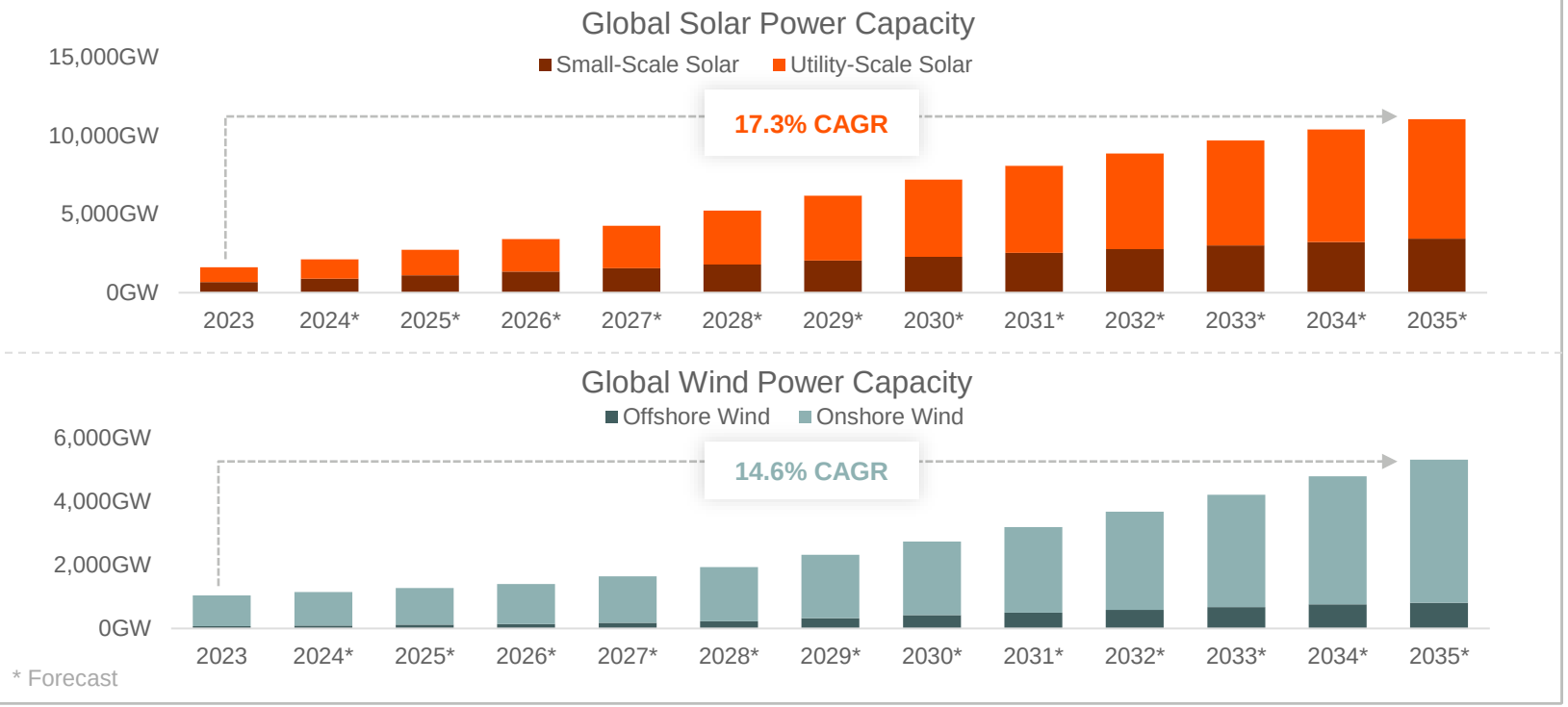
Sources: Text: 1. IRENA, Jun 2023; 2. Bloomberg, Jun 2024; Charts: LHS: BloombergNEF, Jan 2024; RHS: IRENA, Jun 2023.

Renewables: Solar and Wind Power Will Likely Continue to Drive Global Power Capacity Growth

Wind and solar are forecast to account for 89% of total capacity additions through 2035. Underlying these forecasts are favorable policy environments as well as expectations for tech advancements and further cost declines.[1]

The Utility-Scale Solar and Onshore Wind Power Segments Are Forecast to Experience the Strongest Growth





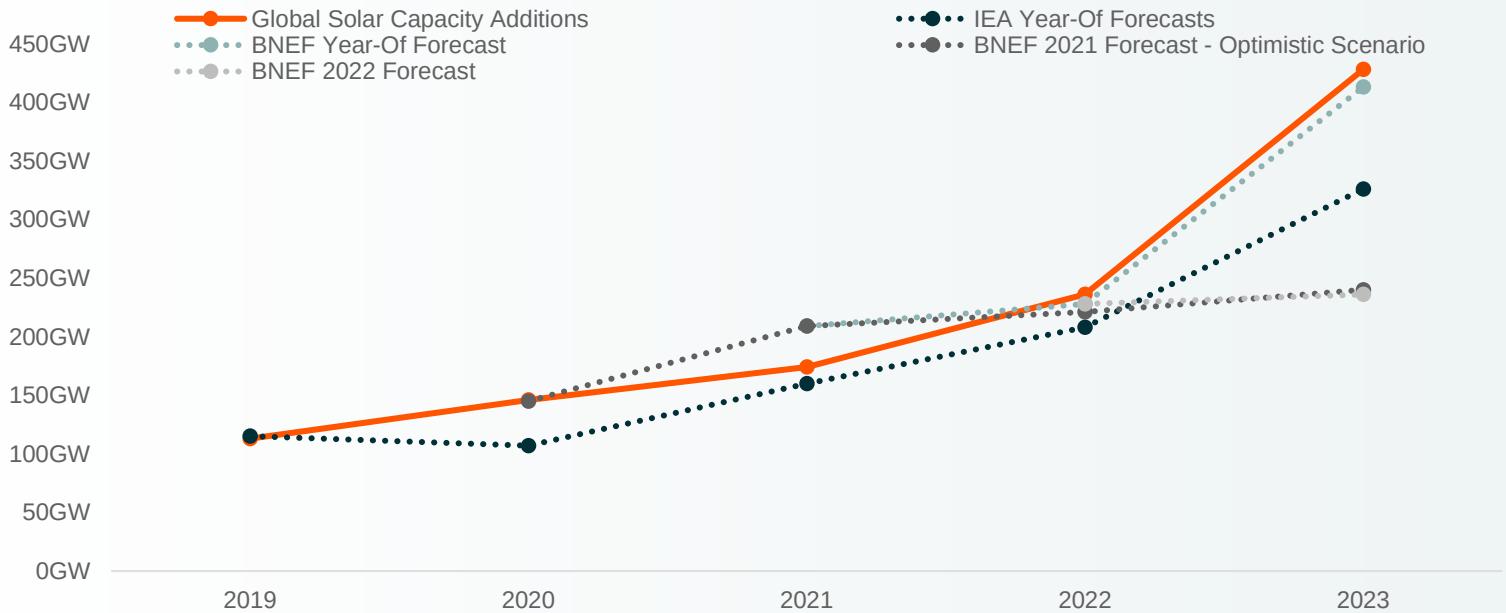
Sources: Text: 1. BloombergNEF, n.d., accessed on 30 Oct 2024; Charts: BloombergNEF, n.d., accessed on 30 Oct 2024.

Renewables: Solar Often Outperforms Forecasted Growth Rates

High interest rates, supply chain issues, and permitting are ongoing headwinds for the renewables industry, especially within the residential solar and offshore wind segments. That said, actual growth rates are often greater than forecasts.

The Solar Power Sector Has a Track Record of Outperforming Growth Forecasts, Including in 2023

Actual Solar Capacity Growth Versus Forecasted Solar Capacity Growth



Note: Year-Of Forecasts are comprised of expected growth forecasts from each year. For example, 2021 Year-Of Forecast is from H1 2021.

The Solar Industry Outperformed Forecasts in Recent Years Despite Major Headwinds

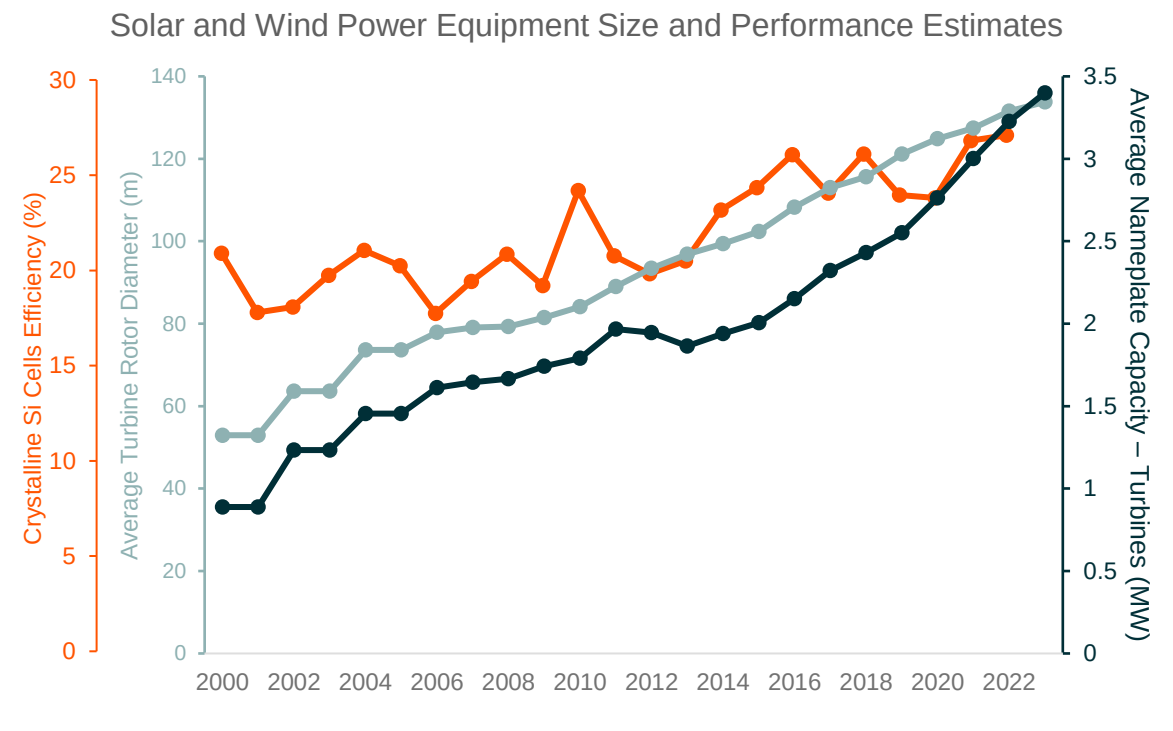
- High Interest Rates in Major Solar Markets
- Complex and Slow Permitting Processes
- Congested & Outdated Power Grids
- Supply Chain Challenges

Sources: Charts: LHS: Global X ETFs analysis with information derived from: Carbon Brief, Jun 2022; Exponential View, Aug 2024; Wood Mackenzie, Mar 2024.

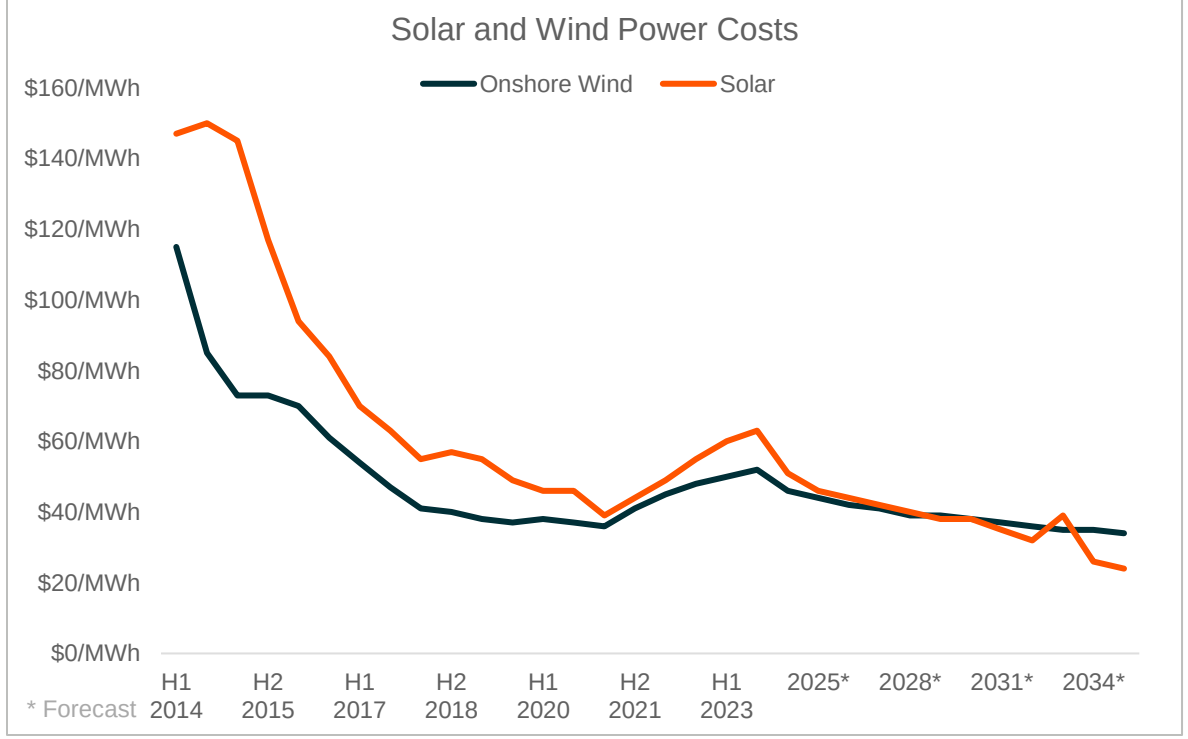
Renewables: Wind and Solar Costs Expected to Fall as Technologies Advance and Scale

Economic headwinds have been a challenge for the wind and solar industries, but costs are on a downward trend as technology advances and can make wind and solar more economically viable and resilient.

Wind and Solar Technologies Typically Improve Over Time



Tech Advancements Can Help Reduce Cost

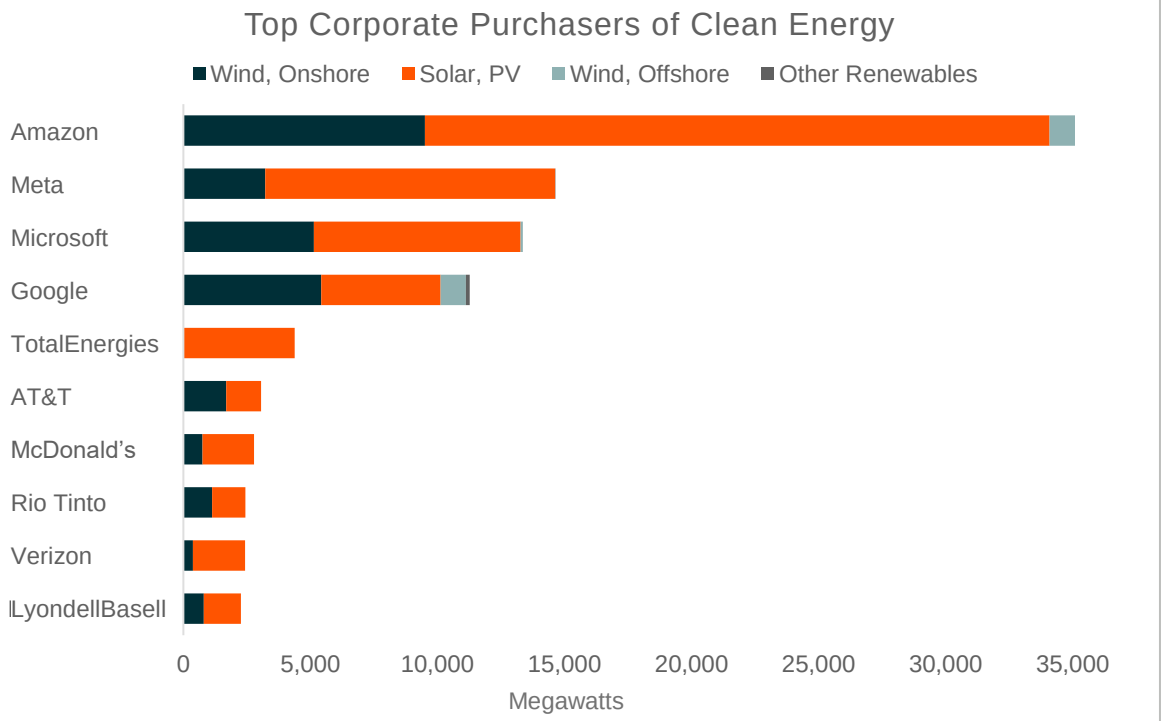


Sources: Charts: LHS: Office of Energy Efficiency & Renewable Energy, Aug 2024; National Renewable Energy Laboratory, Sep 2024; RHS: BloombergNEF, n.d., accessed on 26 Aug 2024.

Renewables: Big Tech Is Turning to Wind and Solar to Help Power Generative AI

A range of power sources could benefit from the expected rapid growth in AI-related power demand. Renewable energy may help meet the added demand while also keeping tech companies on track toward their clean energy targets.

Tech Companies Among Top Buyers of Clean Energy



AI Leaders Have Some of the Most Ambitious Climate Goals

Microsoft aims to match **100%** of its electricity consumption to zero carbon energy sources, **100%** of the time, **by 2030**.[1]

Google pledged to power its operations with carbon-free energy **24/7 by 2030**.[2]

Meta also committed to reaching **net-zero emissions** across its value chain by the end of the decade.[3]

In the News:

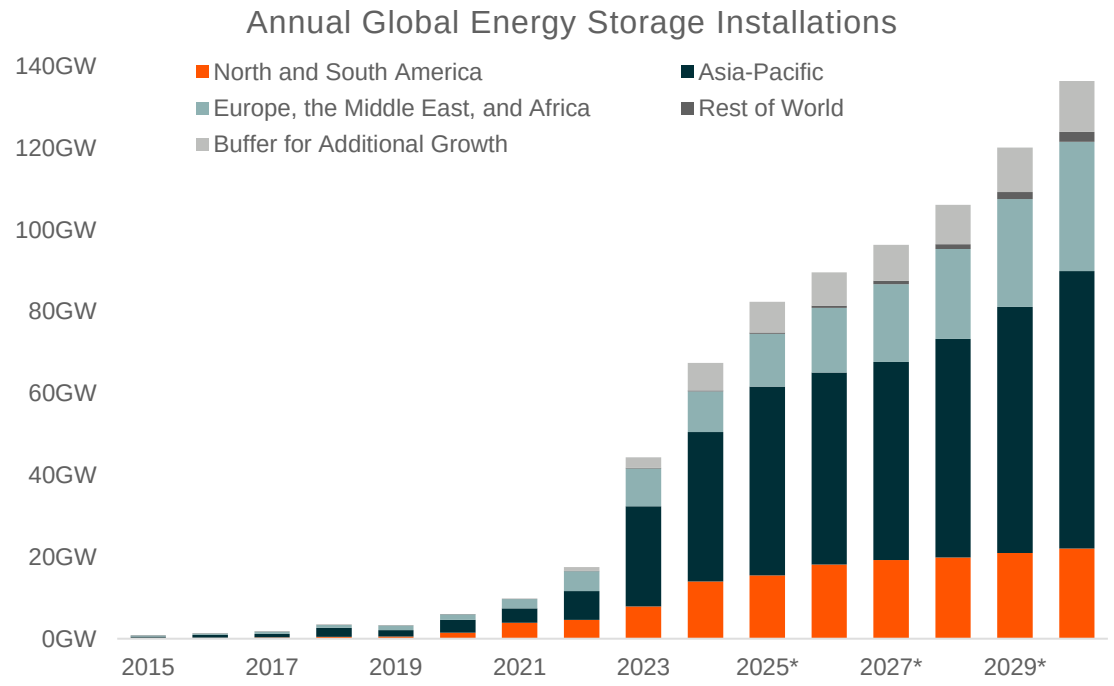
Brookfield and Microsoft ink largest-ever corporate clean energy deal for **10.5 GW**.[4]

Sources: Text: 1. Microsoft, Aug 2023; 2. Google, n.d., accessed on 24 Oct 2024; 3. Meta, Aug 2024; 4. Brookfield, May 2024; Charts: LHS: BloombergNEF, n.d., accessed on 5 Aug 2024.

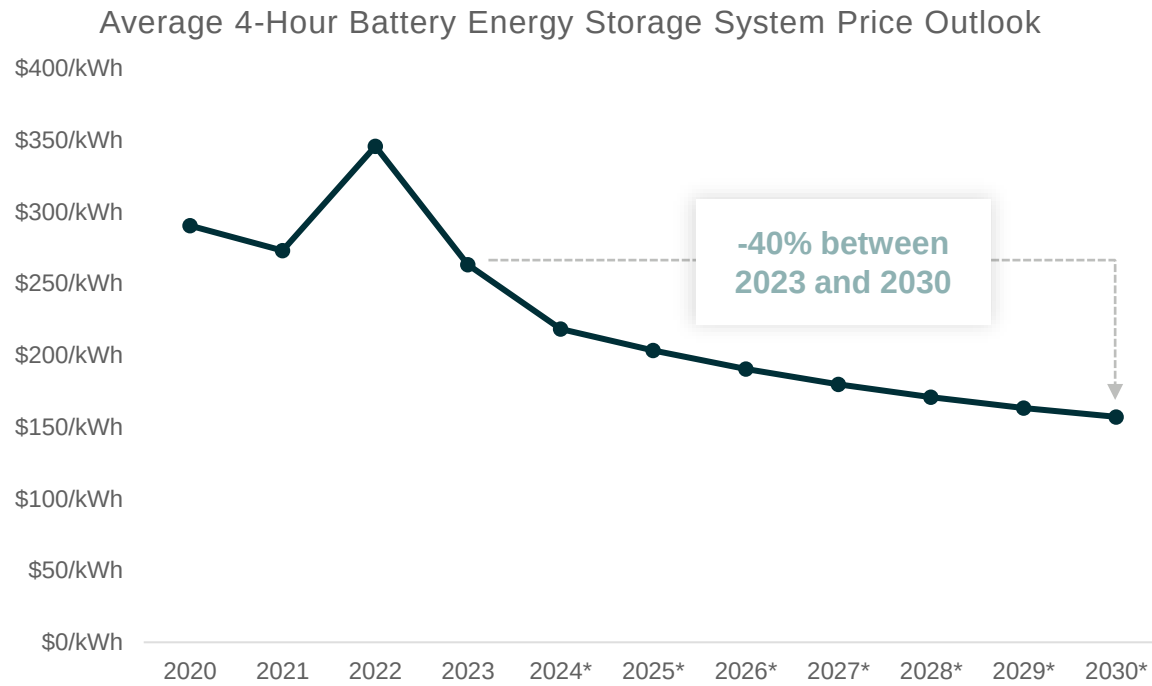
Energy Storage: Battery Systems Quickly Becoming an Integral Part of Power Grids

Robust energy storage can help mitigate the risks of wind and solar power's variability, climate change impacts, and shifting demand patterns. Factors including price declines and tech advancements are likely to drive capacity growth.

Energy Storage Industry Poised for Exponential Growth



4-Hour System Costs Could Fall 40% from 2023-2030



Sources: Charts: LHS: BloombergNEF, n.d., accessed on 31 Oct 2024; RHS: BoombergNEF, n.d., accessed on 31 Oct 2024.

Hydrogen: Developing into a Viable Alternative Fuel and Feedstock Option Across Industries

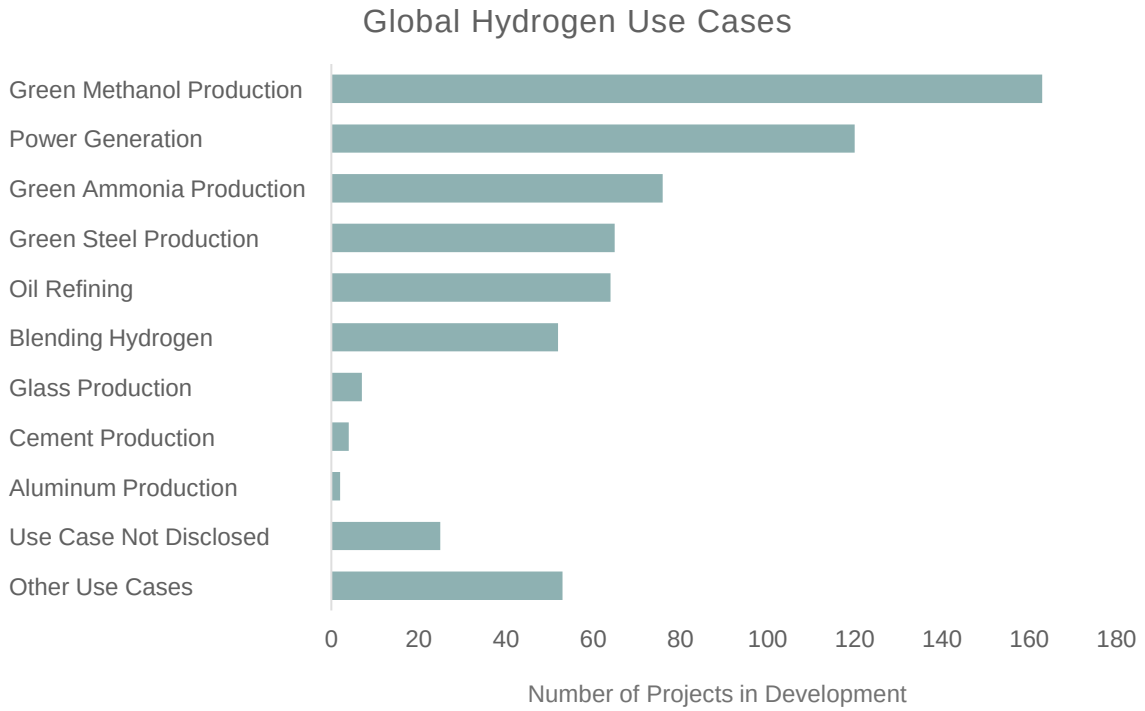
Global hydrogen (H) demand could grow from 97 million metric tons (MMt) in 2023 to around 150MMt by 2030 due to the increasing use of hydrogen as a pathway for reducing greenhouse gas emissions.[1]

Several Sectors Can Use Hydrogen for Decarbonization

Potential Hydrogen Use Cases

Fuel for	Heat for	Feedstock for
TRANSPORT	INDUSTRY	CHEMICALS
Short and Long-Haul Transport	Steel, Aluminum, Cement, Paper, Food	Fertilizers, Fuel Refining, Plastics
POWER	BUILDINGS	PRODUCTS
Power plants, Energy storage	Commercial, Residential	Steel, Glass, Metallurgy, Food

Potential Expansion of Hydrogen into New Industries



Sources: Text: 1. IEA, Oct 2024; Charts: LHS: Bloomberg, Aug 2019; RHS: BloombergNEF, n.d., accessed on 30 Oct 2024.

Hydrogen: Low-Carbon Options Showing Potential as Key Segments by the End of the Decade

The low-carbon hydrogen industry is beginning to take shape due to supportive policies around the world. While the project pipeline is advancing slower than anticipated, clean hydrogen production is forecast to grow rapidly.

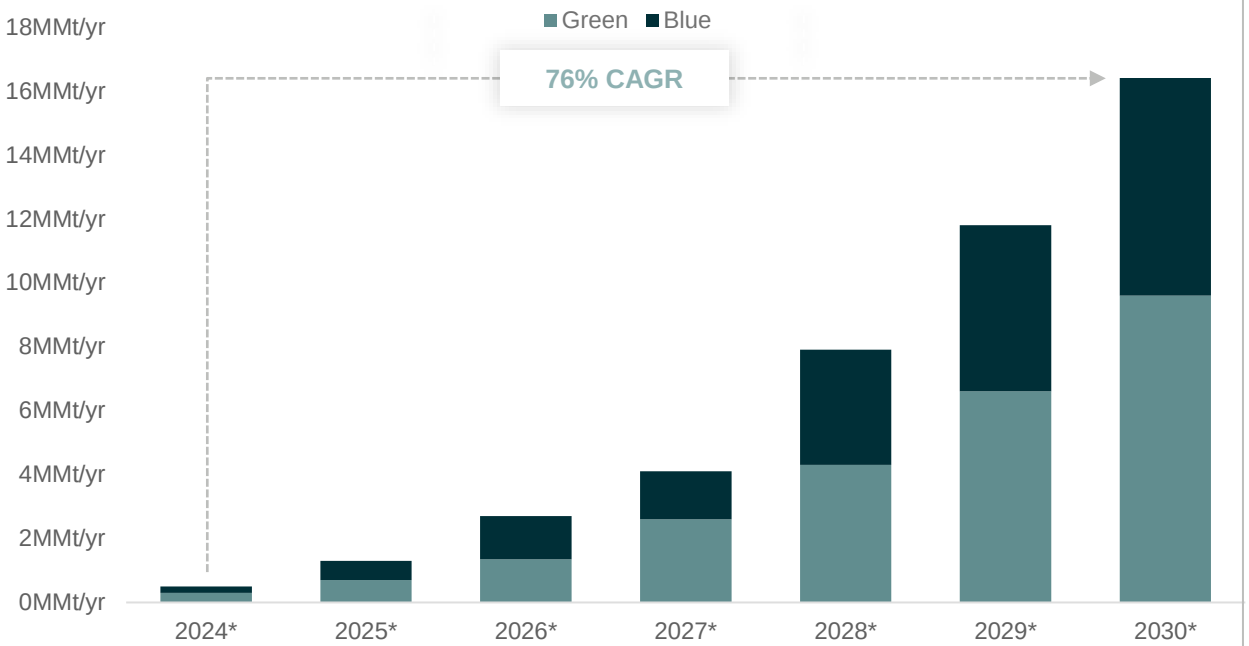
Global Low-Carbon Hydrogen Production Could Expand 30x Between 2024 and 2030

Types of Clean Hydrogen

Blue Hydrogen:
Hydrogen produced with traditional steam methane reforming processes as well as carbon capture and storage technologies.

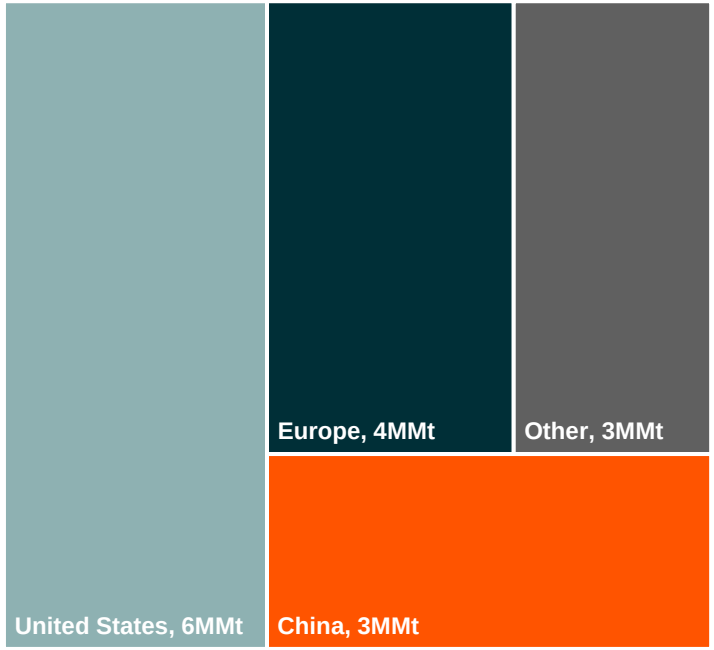
Green Hydrogen:
Hydrogen produced by splitting waters with electrolyzers that are powered by renewable electricity.

Low-Carbon Hydrogen Production Forecast



* Forecast; Note: MMt/yr = Million Metric Tons per Year

Forecasted 2030 Clean H Production, by Country

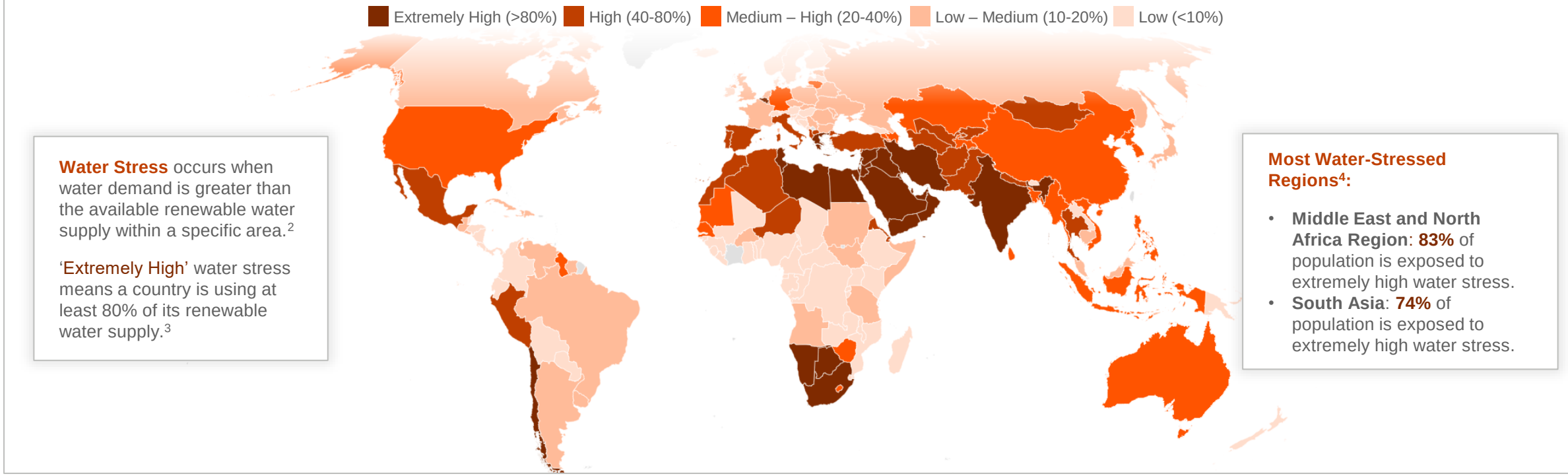


Sources: BloombergNEF, 14 May 2024; BloombergNEF, 21 May 2024; Hydrogen Insight, May 2024.

Water: Rising Demand and Supply Risks Increase Urgency for Clean Water Technologies

Access to clean water remains a critical global challenge, and future supplies could be impacted by climate change. Solving these challenges will likely require significant investments into clean water technologies.

25 Countries Accounting for One-Fourth of the Global Population Already Face Extremely High Water Stress.[1]



Water Stress occurs when water demand is greater than the available renewable water supply within a specific area.[2]

'Extremely High' water stress means a country is using at least 80% of its renewable water supply.[3]

Most Water-Stressed Regions[4]:

- **Middle East and North Africa Region**: **83%** of population is exposed to extremely high water stress.
- **South Asia**: **74%** of population is exposed to extremely high water stress.

Sources: Text: 1. WRI, Aug 2024; 2. Ibid; 3. Ibid; 4. WRI, n.d., accessed on 24 Oct 2024; Chart: WRI, n.d., accessed on 24 Oct 2024.

AgTech: AI Applications Can Help Farmers Overcome a Growing Number of Challenges

Global agriculture production will need to increase by 60-70% by 2050 to feed an expected global population of nearly 10 billion, a challenge made more complicated by resource scarcity and climate change.[1]

Precision Agriculture Technologies and Autonomous Equipment Can Optimize Farming Practices

Precision Sprayers Can Create Actionable Insights

For Fallow Ground and Traditional Agricultural Applications[2]

77%
average herbicide savings

24/7
can run operations day and night due to additional lighting

Up to 20%
potential savings in fuel cost

For Orchards, Vineyards, and Tree Nurseries[3]

Up to 50%
less water and crop protection chemicals

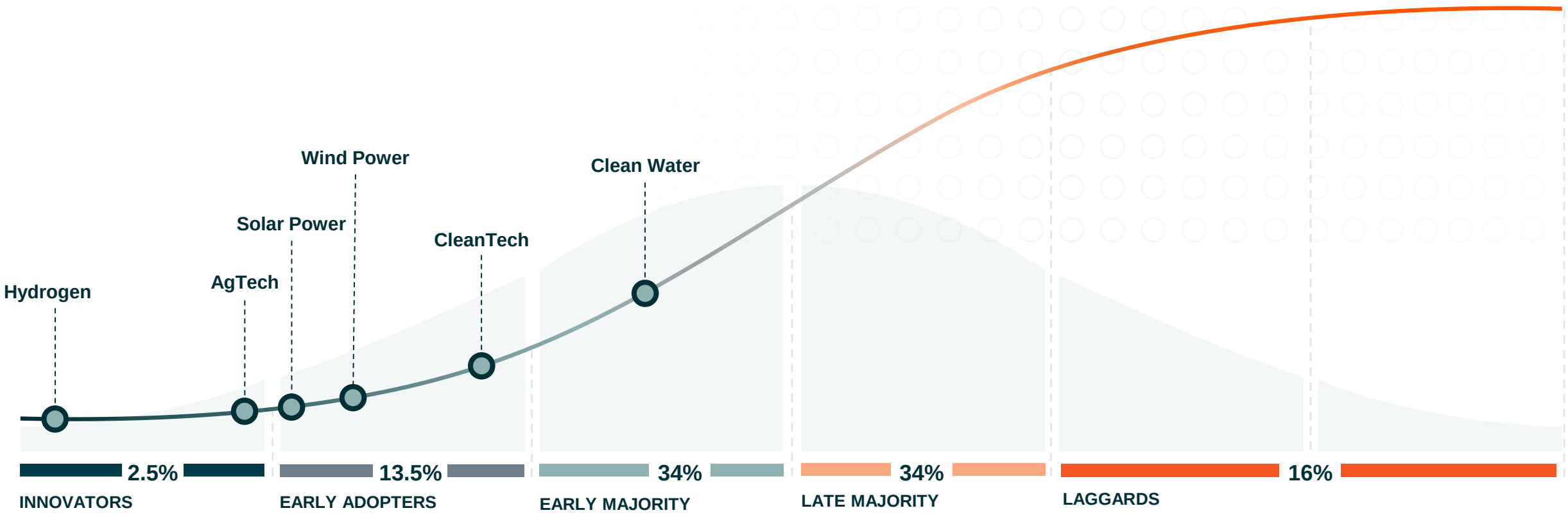
Up to 87%
reduction in airborne drift

Up to 93%
less chemical runoff

Sources: Text: 1. John Deere, 2024a; 2. John Deere, 2024b; 3. Ibid.

S-Shaped Curve of Adoption – CleanTech

Through 2050, an estimated $150 trillion in cleantech investments is needed to reduce emissions and limit warming to 1.5°C.[1]



PHASES OF ADOPTION

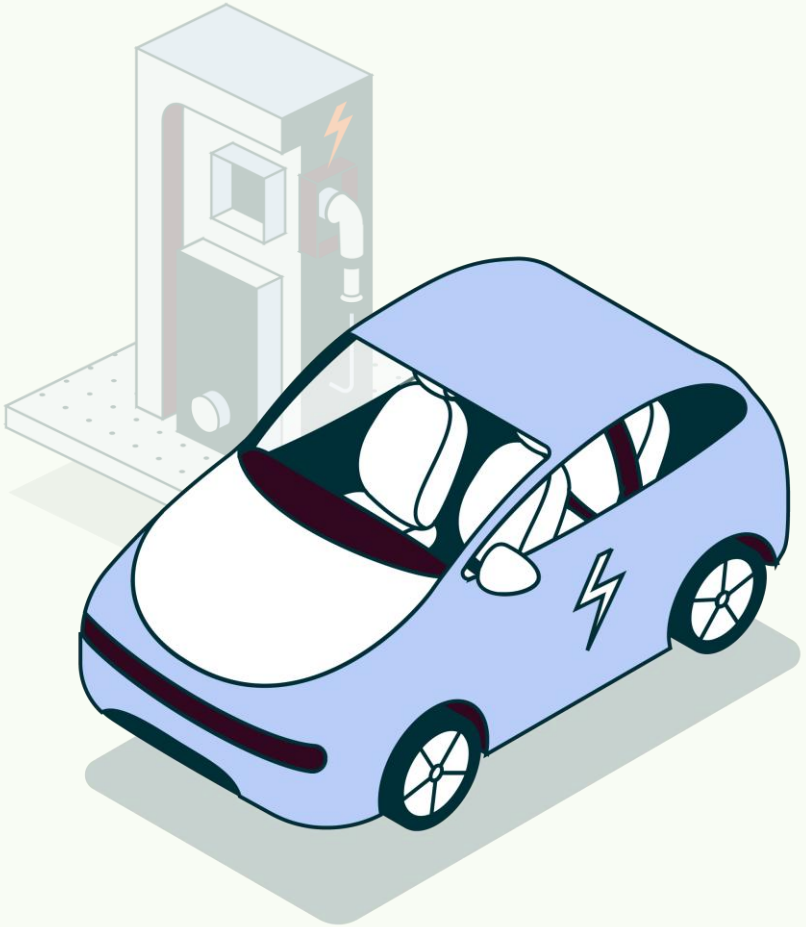
Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: 1. IRENA, June 2023.

CHAPTER 2.3

Mobility:
Driving the Next Era of Transportation

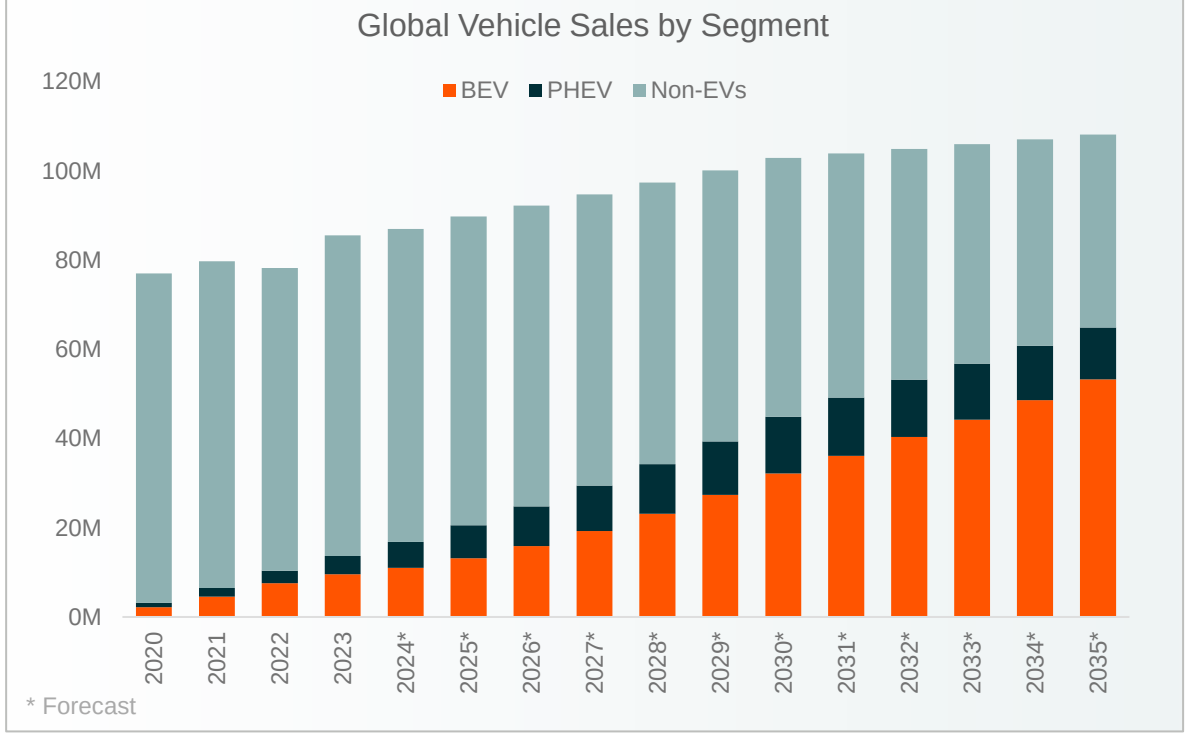
Electric vehicles (EVs) are no longer a niche segment within the automotive industry. Automakers are rolling out more affordable models, and next-gen battery tech could yield significant performance improvements in the coming years. At the center of the ongoing paradigm shift is a range of minerals required for EVs, which may not be able to keep pace as electrification accelerates.



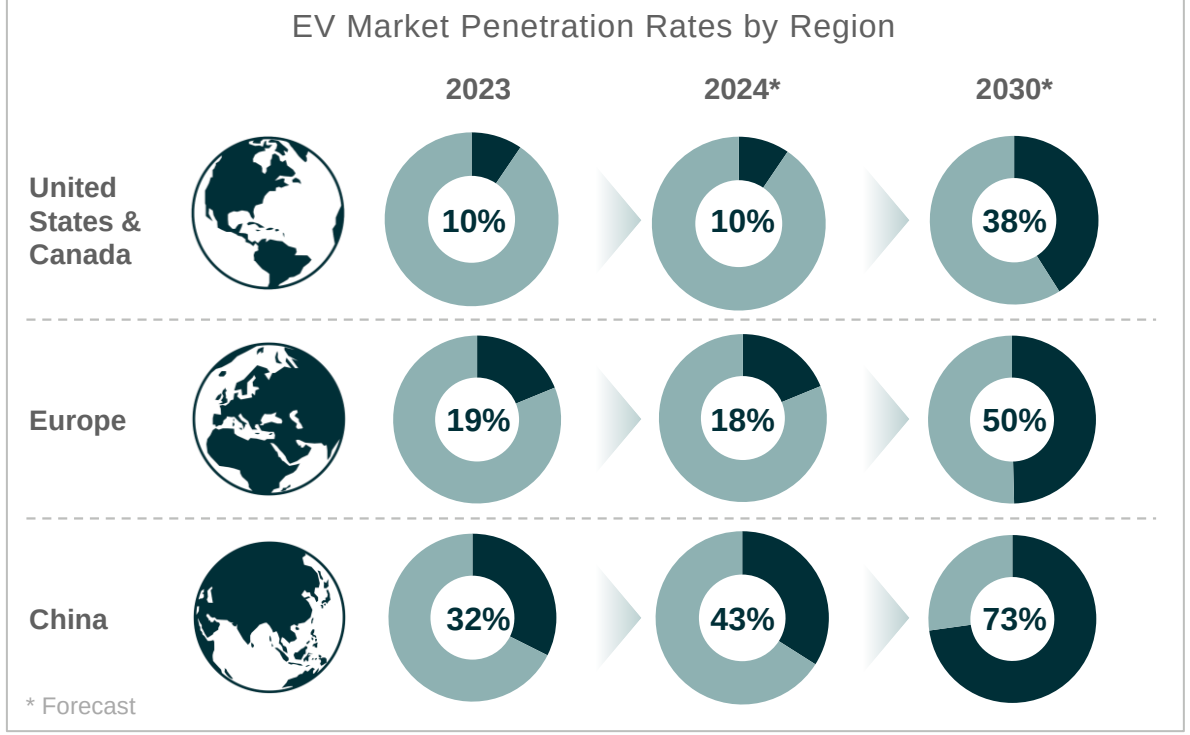
Electric Vehicles: No Longer a Niche Segment Within the Transportation Sector

Accommodative government policies, electrification efforts by automakers, technology advancements, and increased buy-in from consumers are converging to make EVs a mainstream segment.

EV Market Share Could Reach 55% by 2035



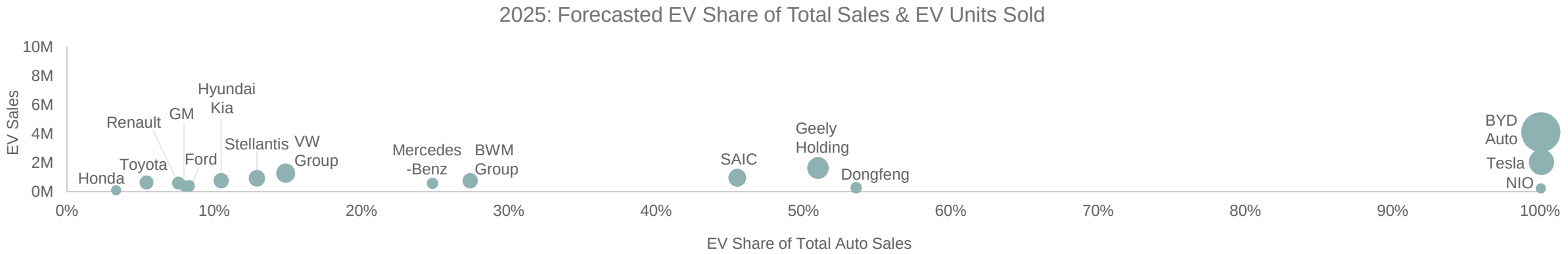
Global EV Adoption Will Likely Continue

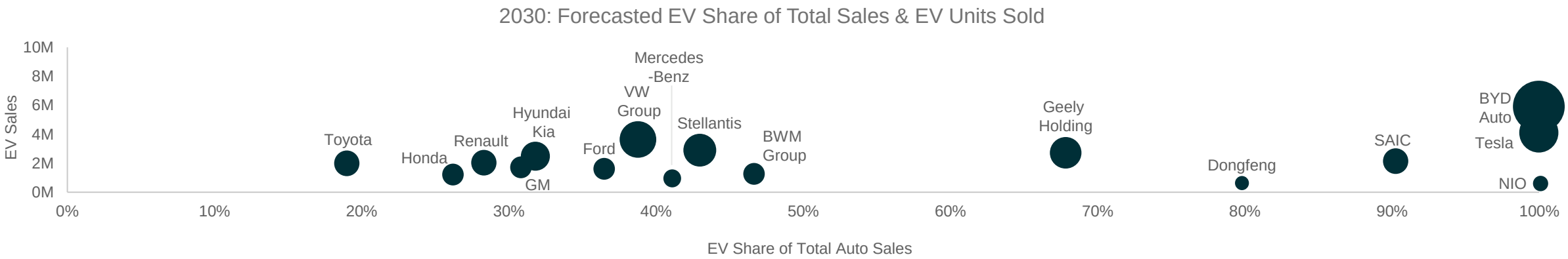


Sources: Rho Motion, Oct 2024.

Electric Vehicles: OEMs Remain Committed to Increasing EV Sales Despite Recent Challenges

Data suggests that EVs remain on track to gain sizeable market share of total sales by the end of the decade, even with several automakers scaling back their investments and pushing out their electrification timelines.



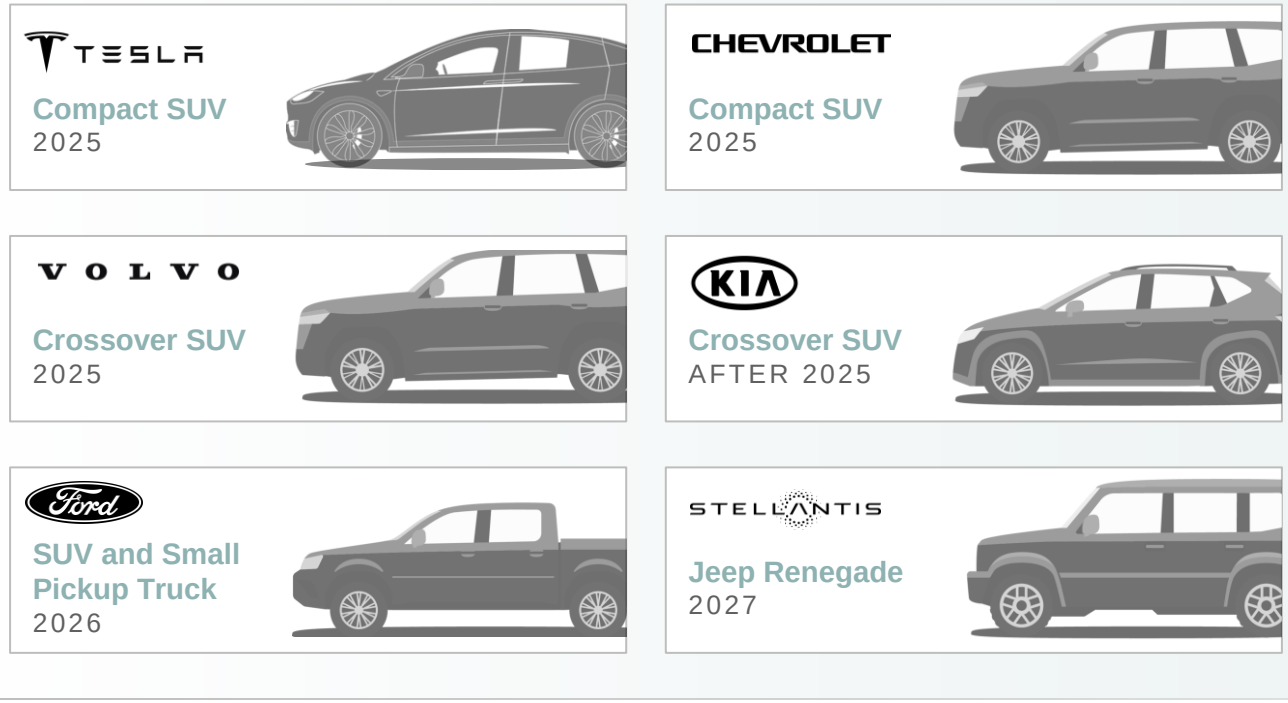


Sources: Rho Motion, June 2024.

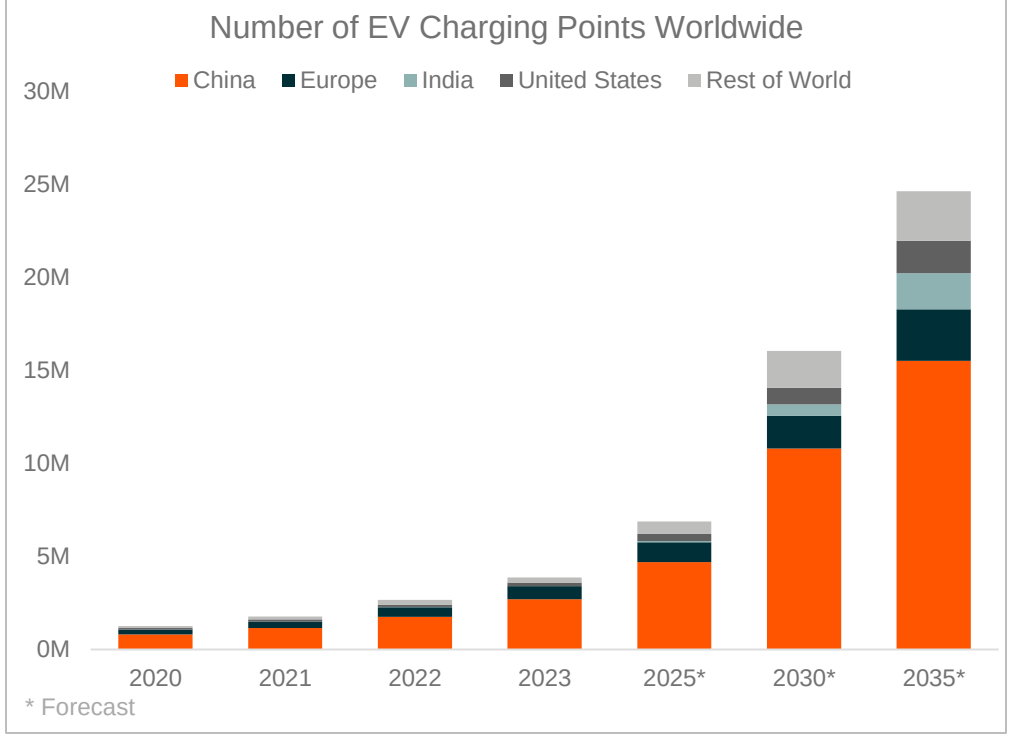
Electric Vehicles: More Affordable Models and Larger Charging Networks On the Horizon

Consumers consistently call out high EV price points and range anxiety as their two primary objections to EV purchases. Improvements on both of these fronts can act as major tailwinds to broader EV adoption.

EVs Under $35,000 Can Boost Sales in the United States



Global Charging Network Is Expanding Rapidly

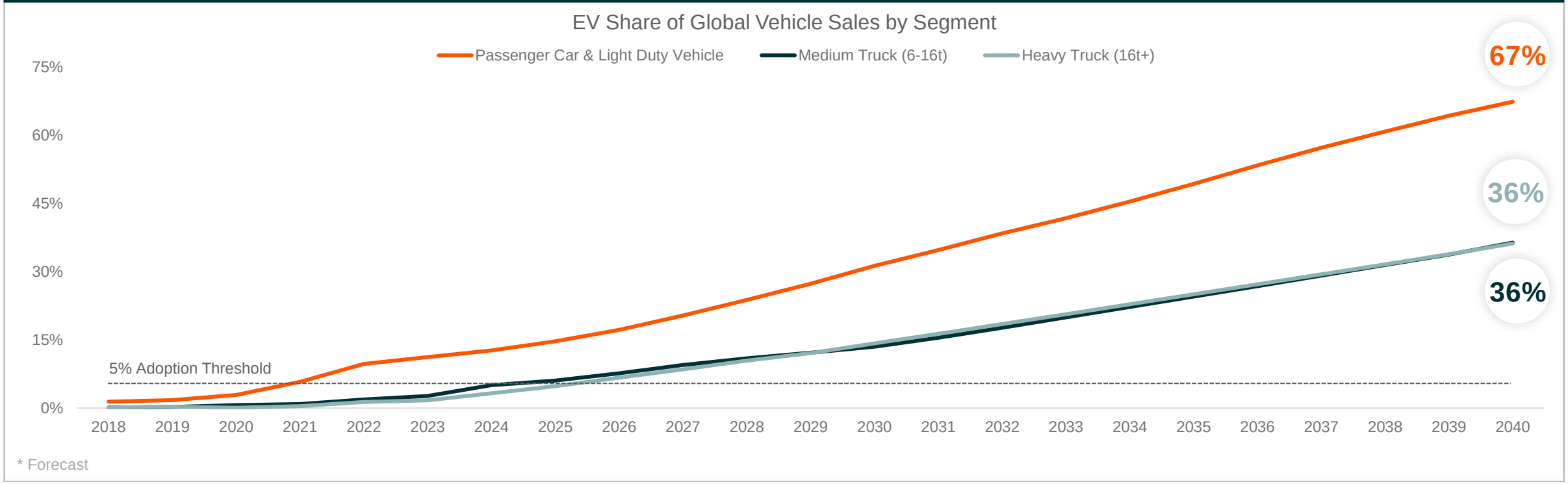


Sources: Charts: LHS: InsideEVs, Jul 2024; RHS: IEA, Apr 2024.

Electric Vehicles: The Electrified Transport Era Is More Than Passenger and Light-Duty Vehicles

While the light-duty vehicle segment is seeing the most rapid transition to EVs, trucks are following closely behind. The 5% adoption threshold, which is seen as a pivotal tipping point for EVs, is likely to be surpassed in the coming years.

EVs Could Account for One-Fourth of Medium- and Heavy-Duty Truck Sales by the Middle of the Next Decade



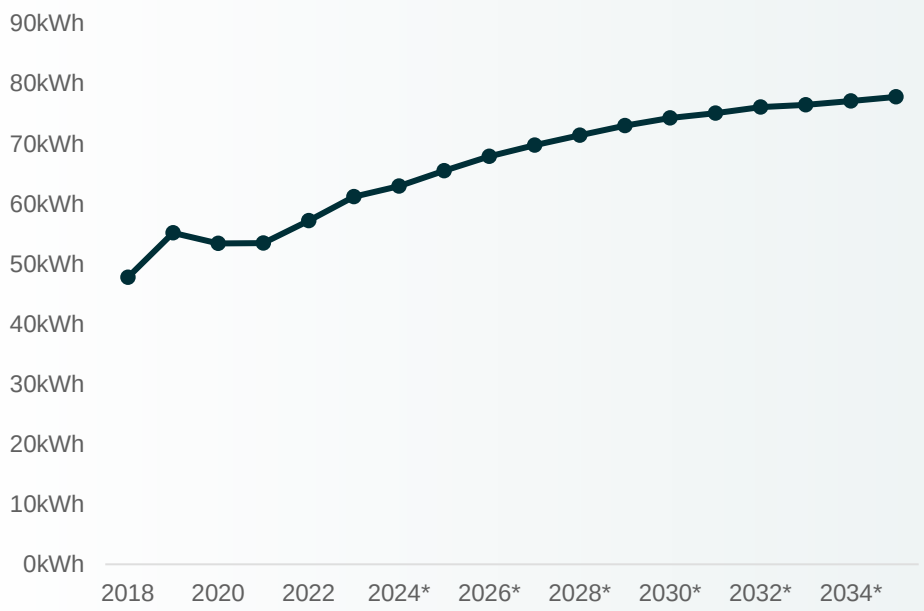
Sources: Rho Motion, Oct 2024.

Battery Tech: Expectations for Better and Cheaper Batteries Support Strong EV Sales Outlooks

The battery pack size in an average EV passenger car is expected to increase, providing drivers with longer range and better performance. At the same time, the cost for batteries is likely to decline, making EVs more affordable.

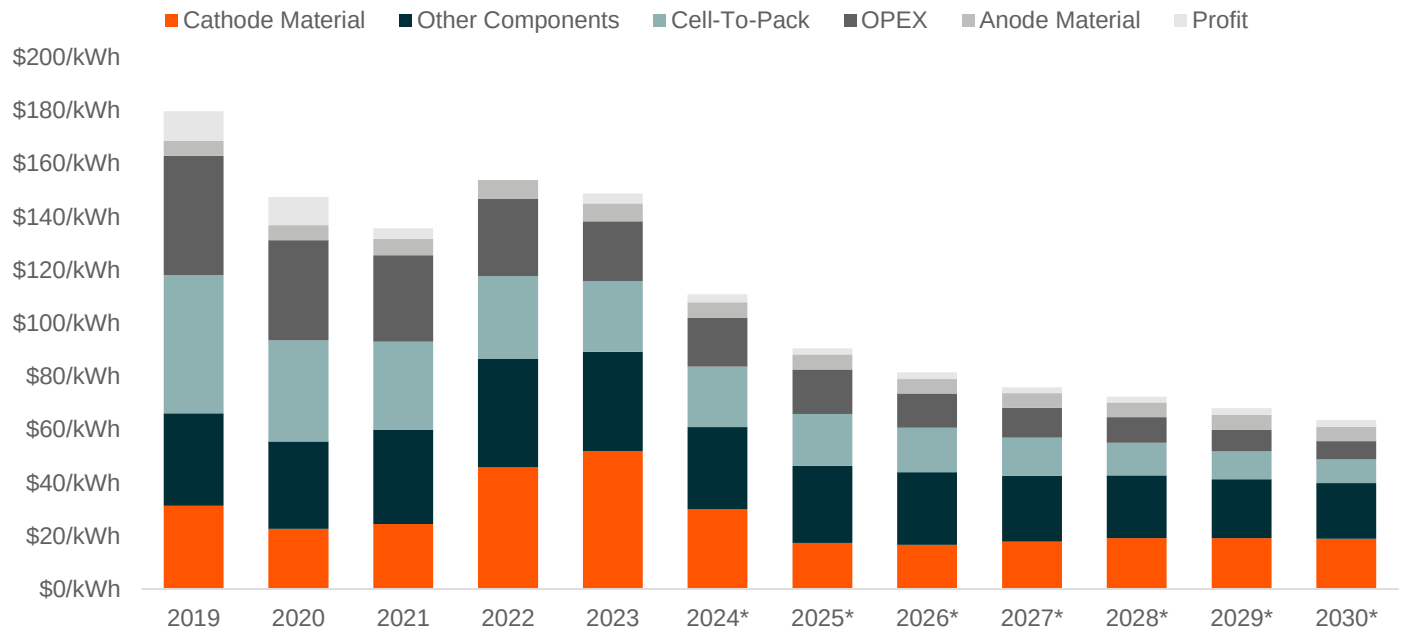
Bigger Battery Packs Can Increase EV's Range & Power and Cheaper Battery Packs Can Help Make EVs More Affordable

Average Passenger Car & Light Duty EV Battery Pack Size



* Forecast

Global Average Battery Pack Price



* Forecast

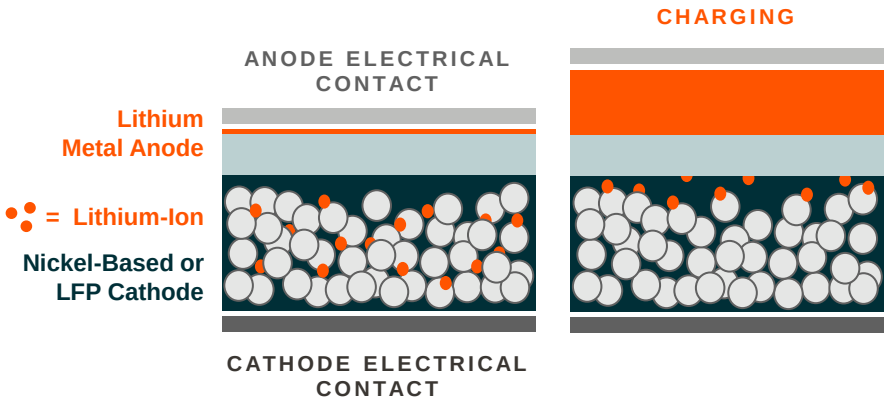
Sources: Charts: LHS: Rho Motion, Oct 2024; RHS: Goldman Sachs, Oct 2024.

Battery Tech: Solid-State Among the Most Anticipated Next-Generation Battery Technologies

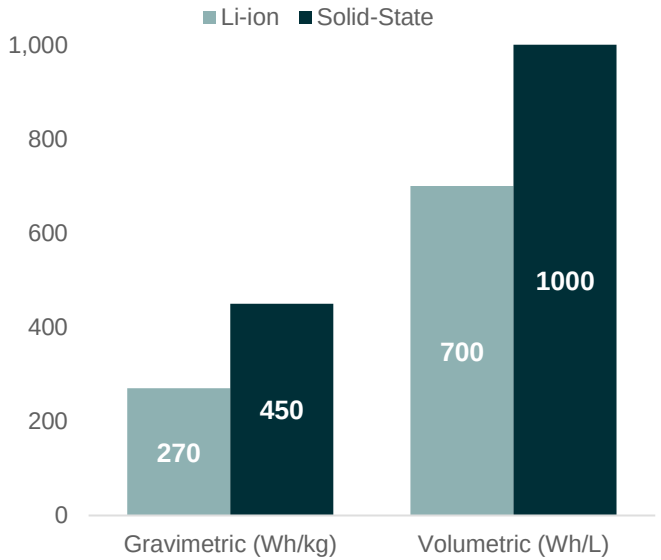
While mass commercialization is likely still years away, many automakers and battery producers are making progress on solid-state battery technologies that could yield significant improvements to the EV driving experience.

Solid-State Batteries Could Provide Several Benefits Over Current EV Battery Technologies

QuantumScape Proposed Solid-State Battery Design



Achievable Energy Density Comparison[1]



Benefits of Solid-State Batteries over Lithium-Ion

- Operates in greater temperature range
- Faster charging
- Longer lifespan
- Higher degree of freedom in shape

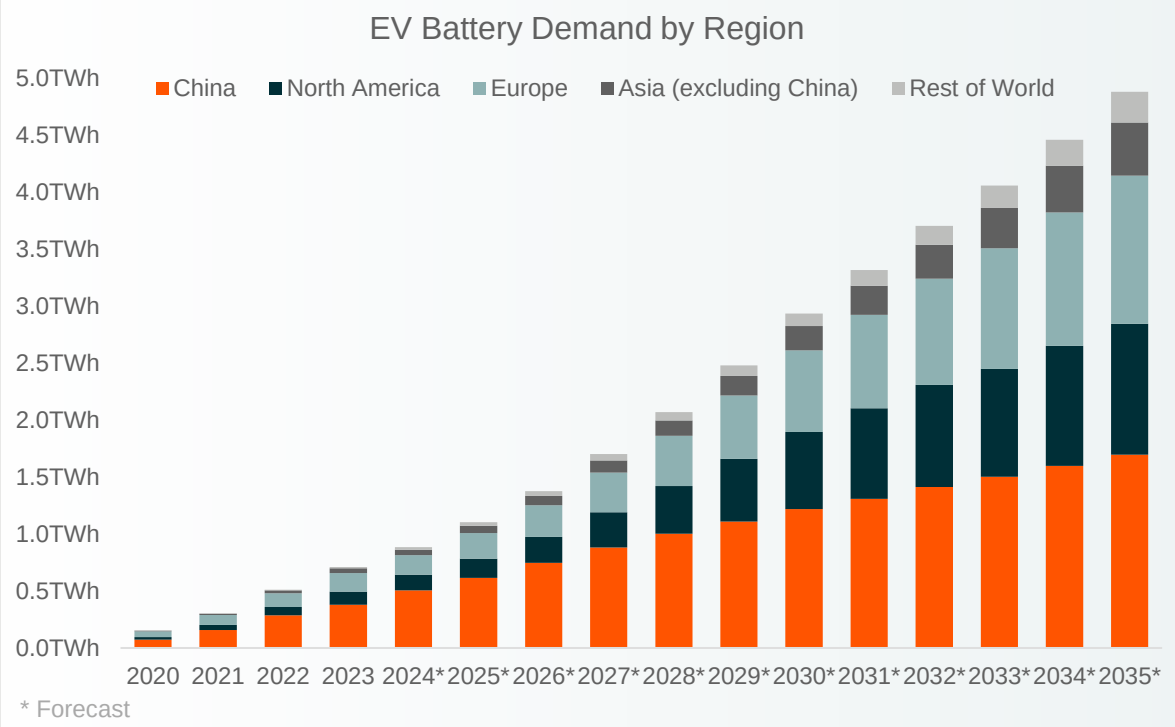
Note: Assumes an average ASSB/Sem-solid, compared to theoretical maximum NCM + Gr

Sources: Charts: LHS: Quantumscape, Aug 2023; Middle: Rho Motion, Oct 2024; Quantumscape, Aug 2023.

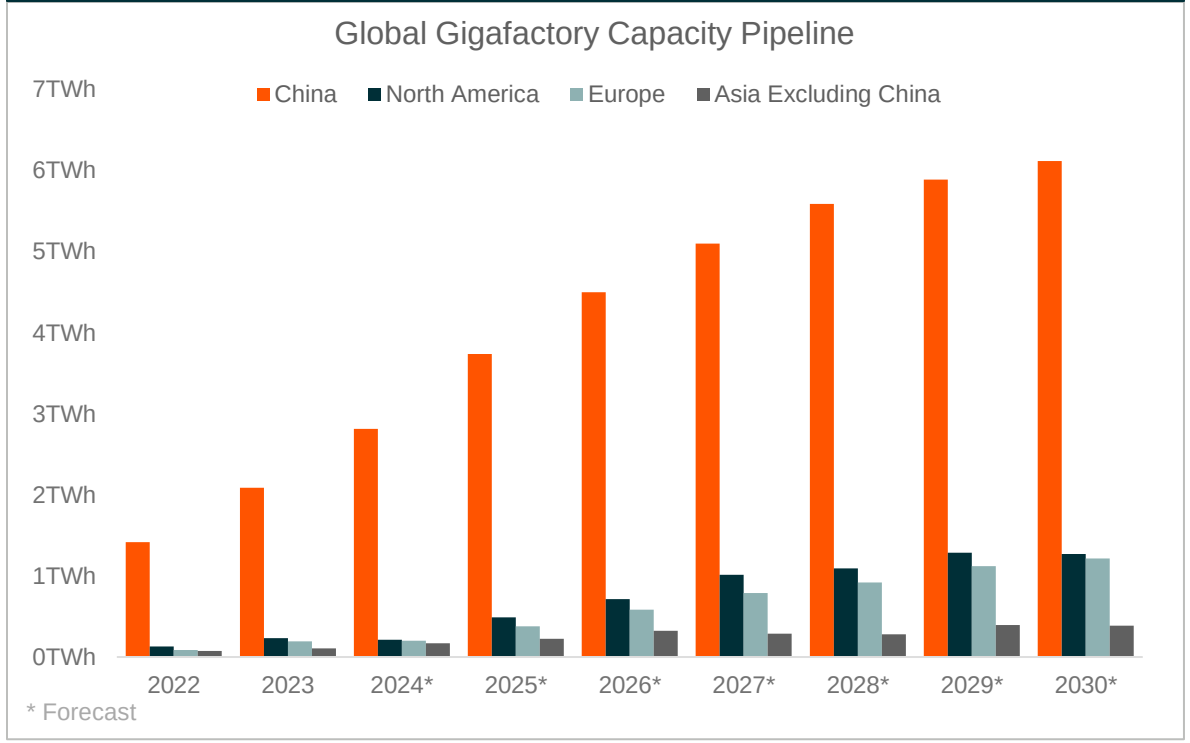
Battery Tech: Manufacturing Landscape Becoming Increasingly Global as EV Sales Rise

China is expected to remain the leader of both EV battery demand and production capacity. However, companies are investing in gigafactories in Europe and North America to meet future demand and gain access to supportive policies.

Battery Demand Is Likely to Rise as EVs Gain Market Share



EV Battery Manufacturing Is Expanding into New Regions



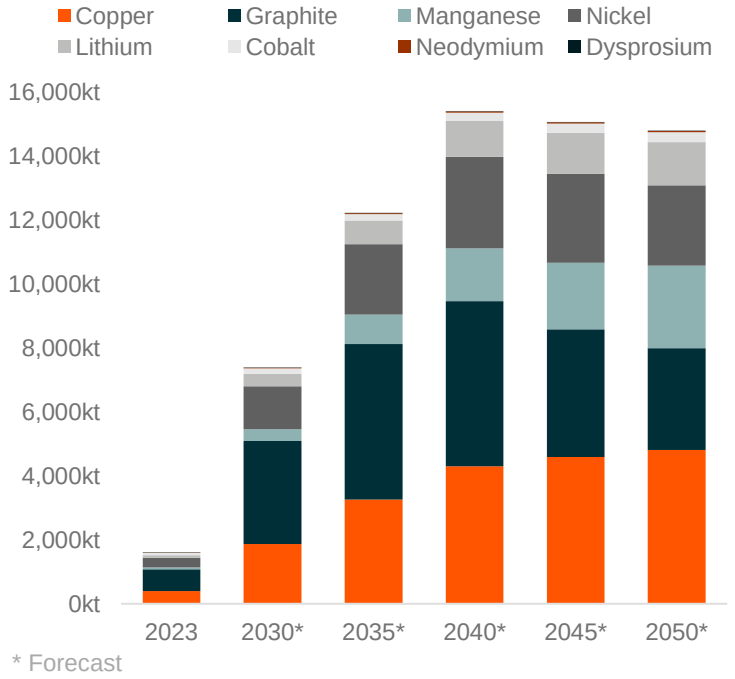
Sources: Charts: LHS: Rho Motion, Oct 2024; RHS: Benchmark Mineral Intelligence, Oct 2023.

Disruptive Materials: Supply Shortage Risks Are Growing as Clean Technologies Take Off

EVs require up to 6x more minerals than traditional internal combustion engine vehicles.[1] As a result, the auto industry could become a major growth driver for many different minerals, along with renewable energy and energy storage.

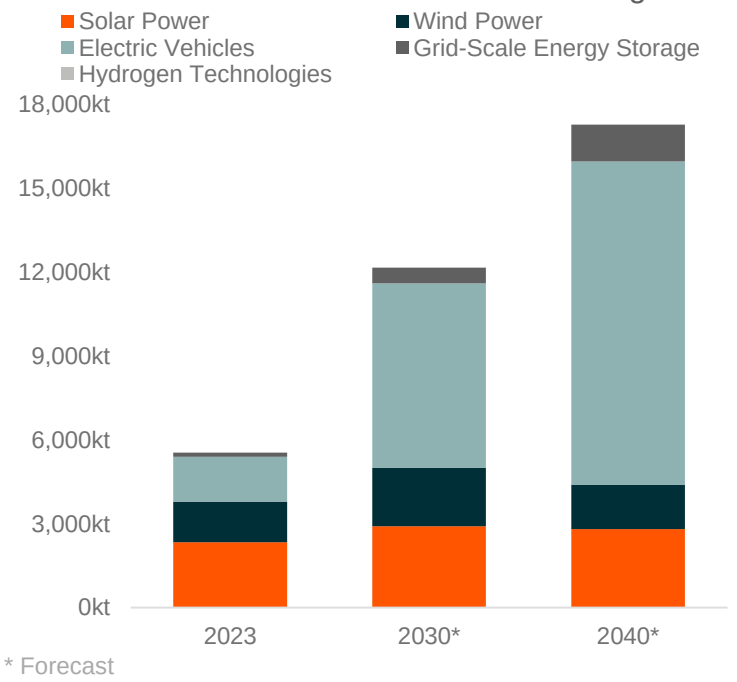
Mineral Supplies May Not Be Able to Keep Up with Demand as Electrification Gains Pace

Mineral Demand from EVs



* Forecast

Mineral Demand from Clean Technologies



* Forecast

Supply Risks from Highest to Lowest

Lithium
50%
of mines located
in areas at risk for high water stress

High

Copper
31%
Shortfall in project pipeline
vs. 2035 APS mining requirements

Medium-High

Cobalt
16%
Shortfall in project pipeline vs.
2035 APS mining requirements

Medium

Rare Earth Elements
Low Transparency
of pricing schemes

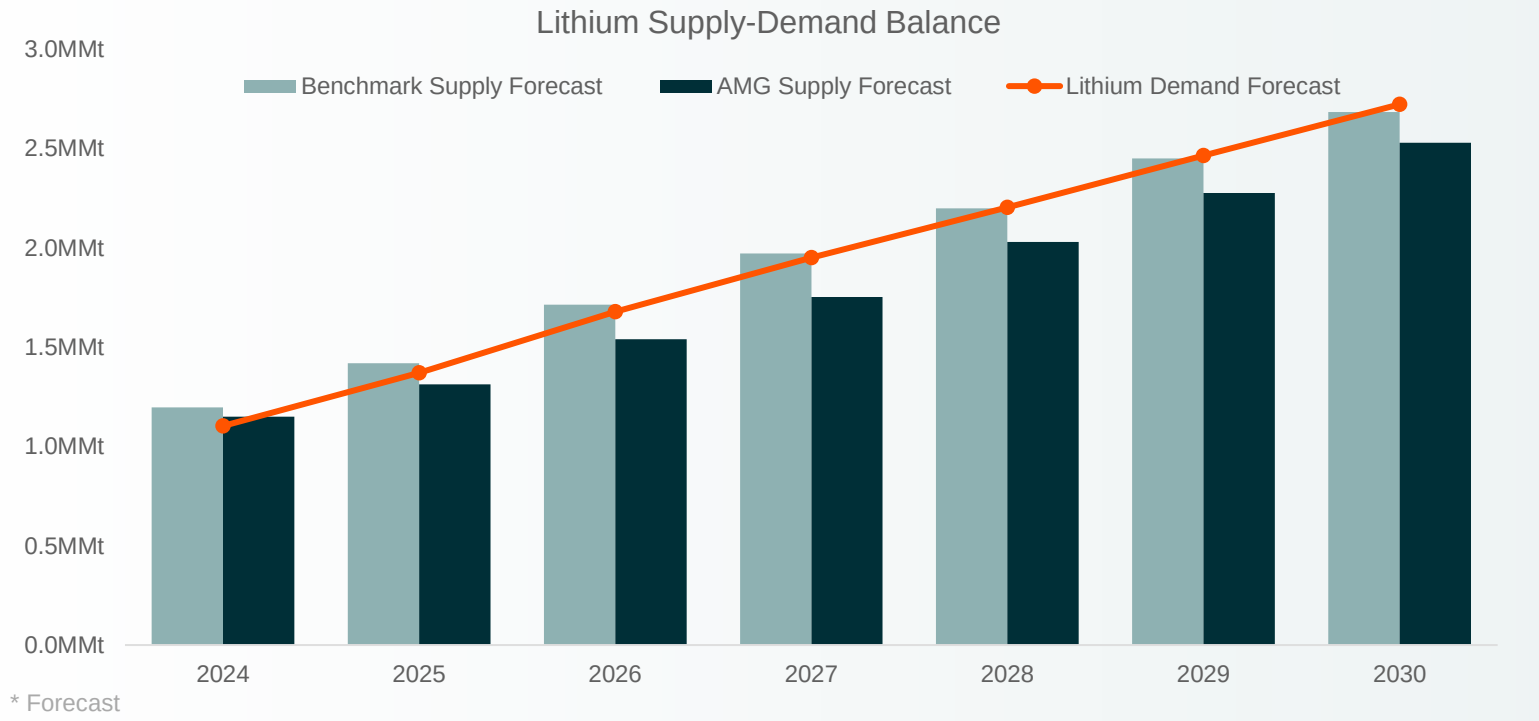
Medium-Low

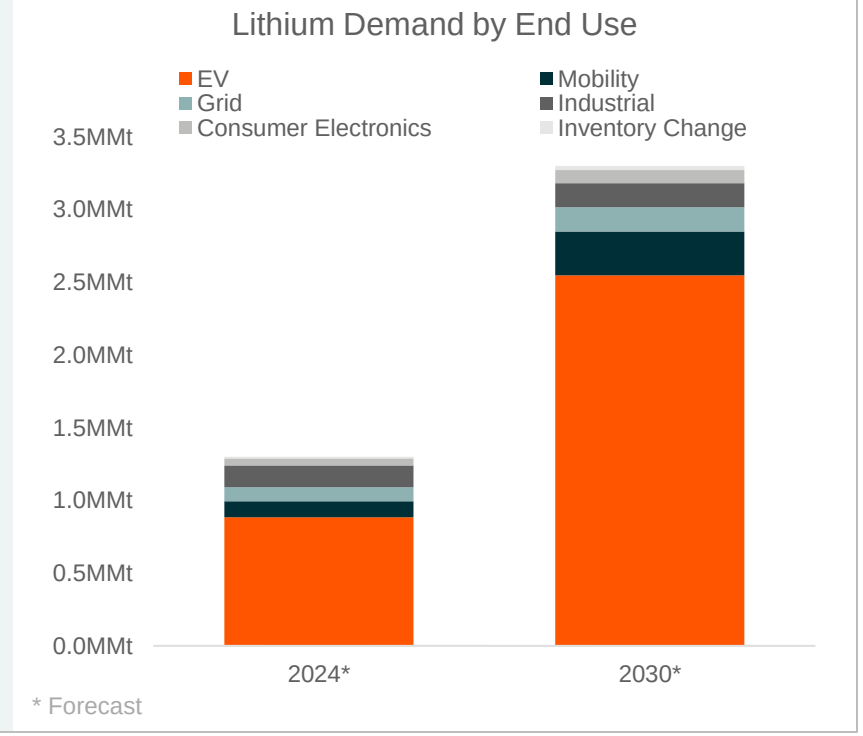
Sources: Text: 1. IEA, May 2021; Charts: LHS and Middle: IEA, May 2024a; RHS: IEA, May 2024b.

Lithium in Focus: Demand Growth Outlook Suggests Potential Return of a Supply Deficit

The inelastic nature of lithium supply, combined with expectations for robust EV demand, mean that even slight shifts in supply or demand could lead to a deficit and provide a positive boost to lithium prices.

Lithium Demand Could Once Again Surpass Supply As Demand Increases For EVs and Other CleanTech Applications



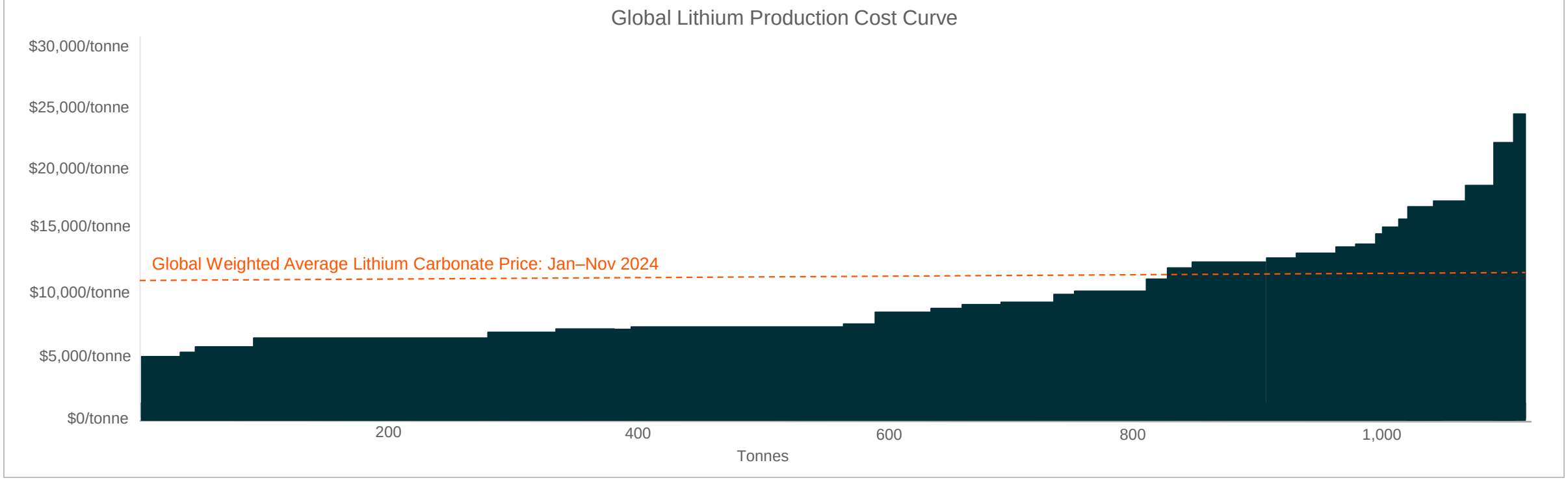


Sources: LHS Chart: AMG Critical Materials N.V., Nov 2024; RHS Chart: Albemarle, Jul 2024.

Lithium in Focus: Global Cost Curve Suggests Many Projects Well Positioned Even With Low Prices

The lithium price environment remains well below the peak in late 2022, when prices reached nearly $80,000 per tonne. However, for most operational projects, break-even is still well below recent market prices.

The Majority of Lithium Projects Have a Break-Even Under $10,000, Below the 2024 Average of $11,181 Per Tonne



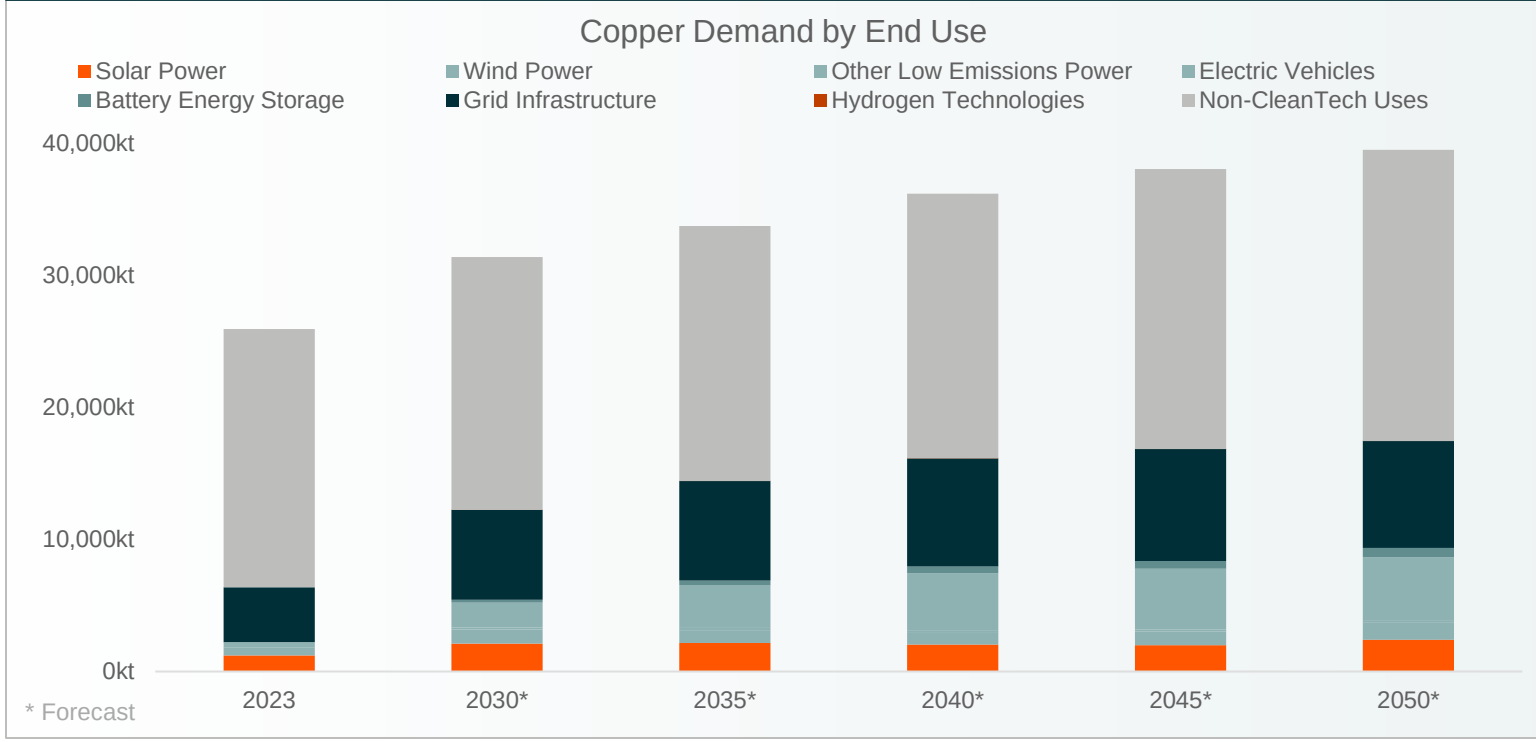
Note: Lithium cost curve for illustrative purposes only

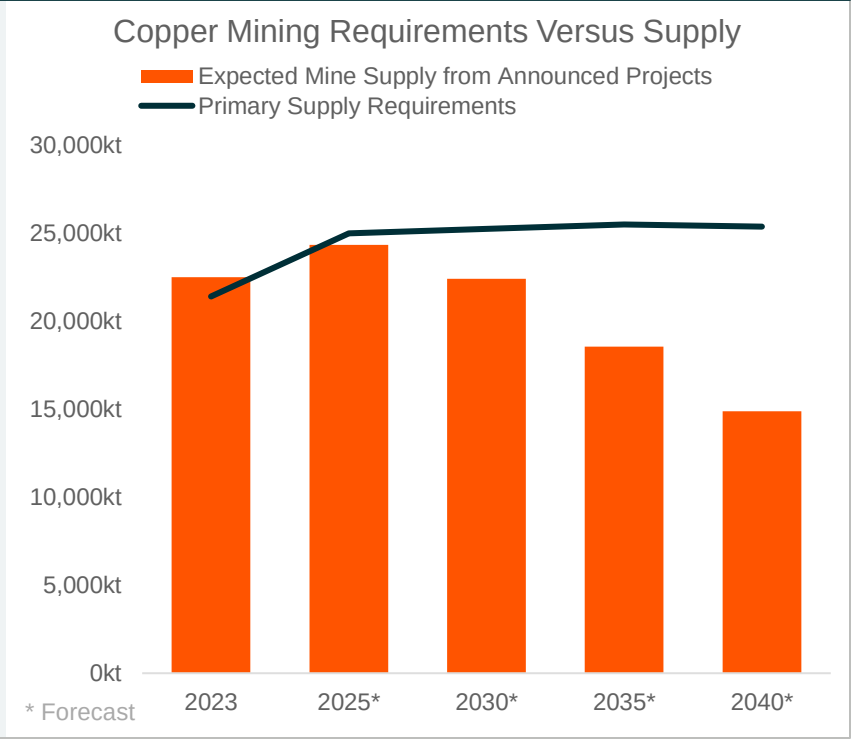
Sources: Lithium Americas, Nov 2024.; Benchmark Minerals Intelligence, n.d., accessed on 20 Nov 2024.

Copper in Focus: Clean Energy Transition Becoming an Integral Factor in Supply-Demand Dynamics

A sizeable copper shortage could form by the end of the decade as the energy transition gains speed. Copper demand from EVs alone could expand 11x between 2023 and 2040.

Share of CleanTech in Total Copper Demand Could Reach 45% by 2040, Up from 25% in 2023

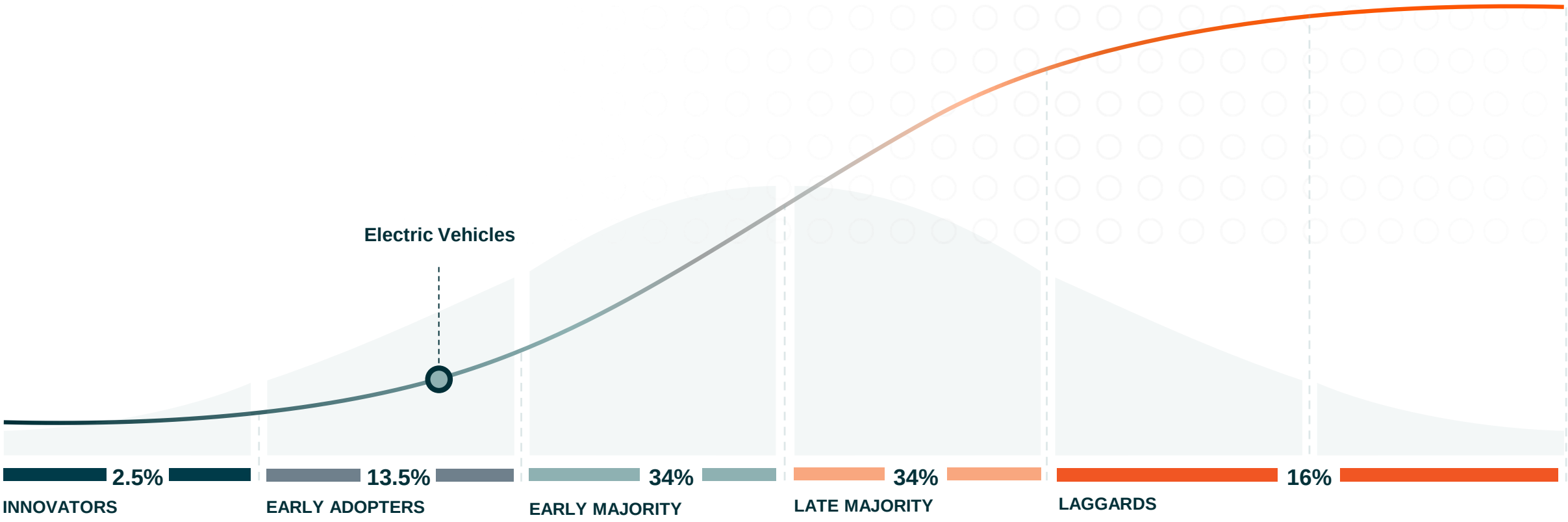




Sources: Text: IEA, May 2024a; Charts: LHS: IEA, May 2024a; RHS: IEA, May 2024a; IEA, May 2024b.

S-Shaped Curve of Adoption – Mobility

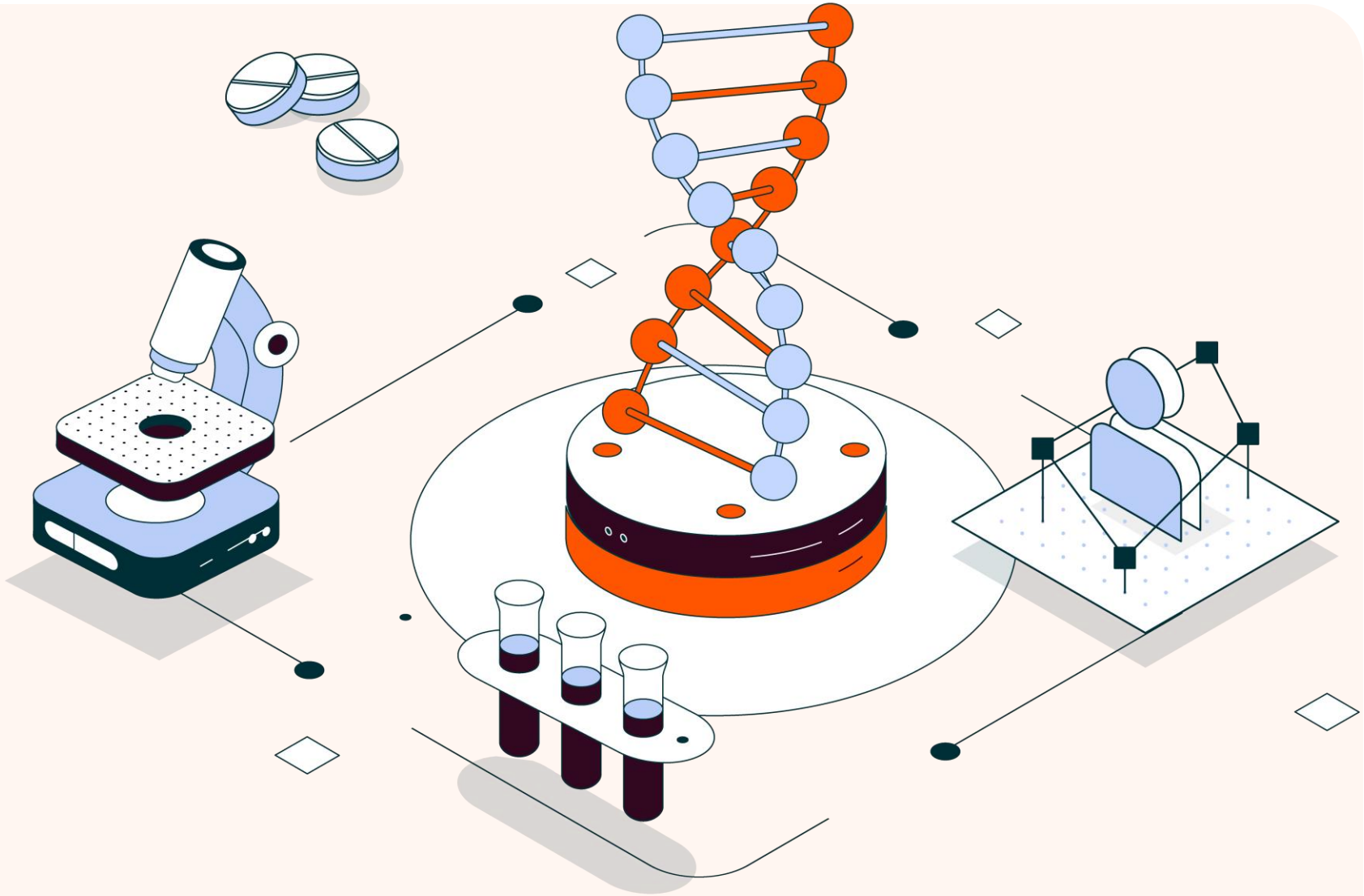
EVs could account for half of global passenger vehicle sales by 2035, up from an 11% share of global vehicle sales in 2023.[1]



PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Text: 1. Rho Motion, Oct 2024.

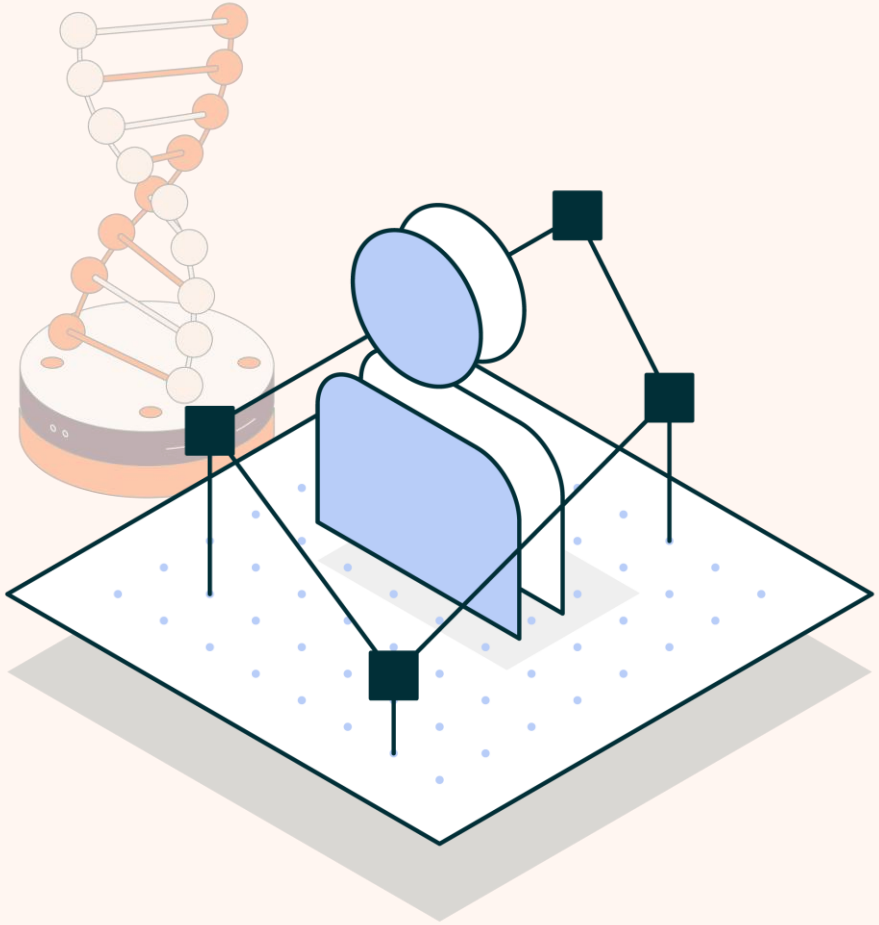


SECTION 3

Advancing Healthcare

CHAPTER 3.1

Aging Population:
Silver Opportunities

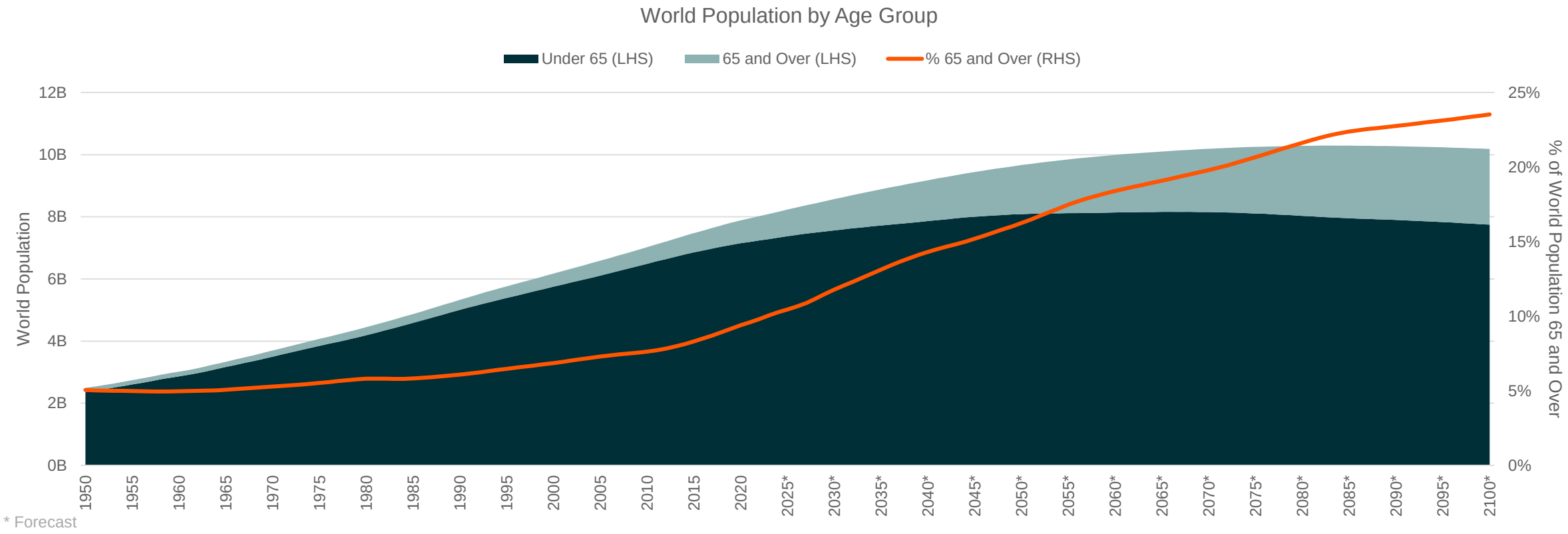


The global population is rapidly aging, with the number of adults aged 65 and older projected to double to 1.7 billion by 2053.[1] This poses significant challenges to healthcare systems worldwide due to increased chronic condition prevalence. While this trend strains already burdened infrastructure, innovations like GLP-1 treatments for obesity also show promise in managing various age-related conditions. These breakthroughs, along with advances in patient care technology, may help mitigate stress on the healthcare system and improve quality of life for older adults.

Sources: 1. United Nations, Jul 2024.

The Global Population Is Set to Age at an Accelerated Pace

Total global population is expected to grow 32% through 2100.[1] During that period, the population of those 65 and over is expected to grow 230%.[2] By 2030, all baby boomers will be 65 or older.[3]

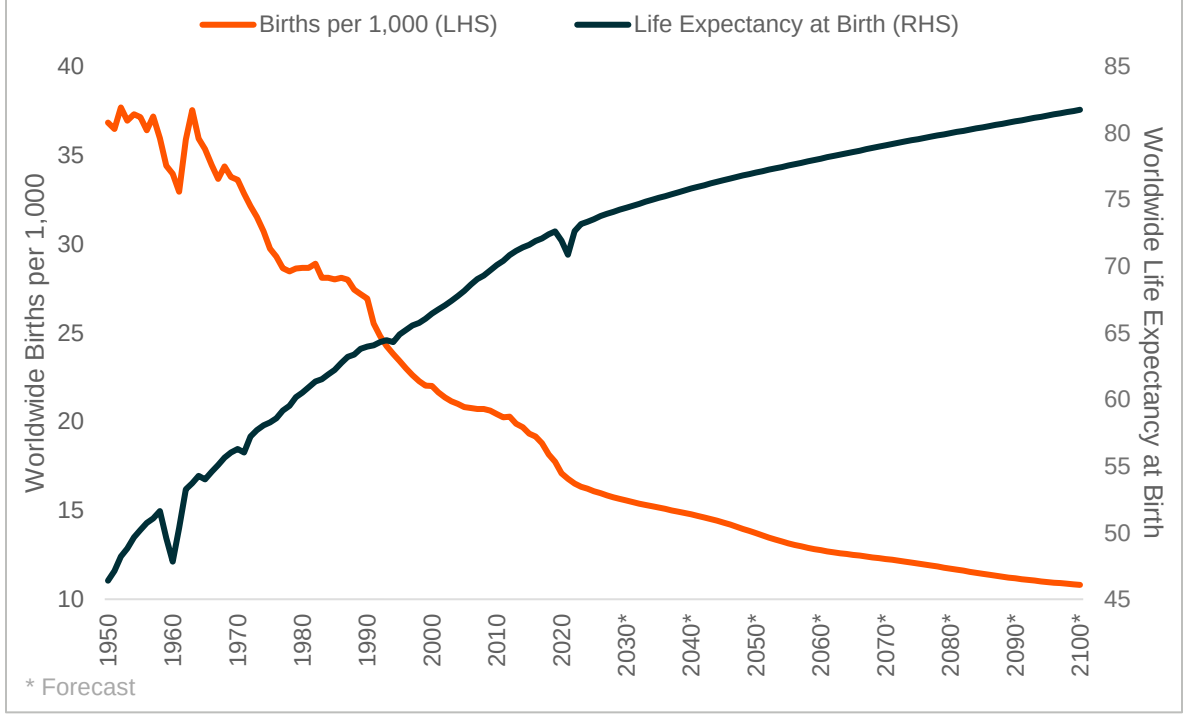


Sources: Text: 1. United Nations, Jul 2024, 2. Ibid.; 3. United States Census Bureau, Dec 2019; Chart: United Nations, Jul 2024.

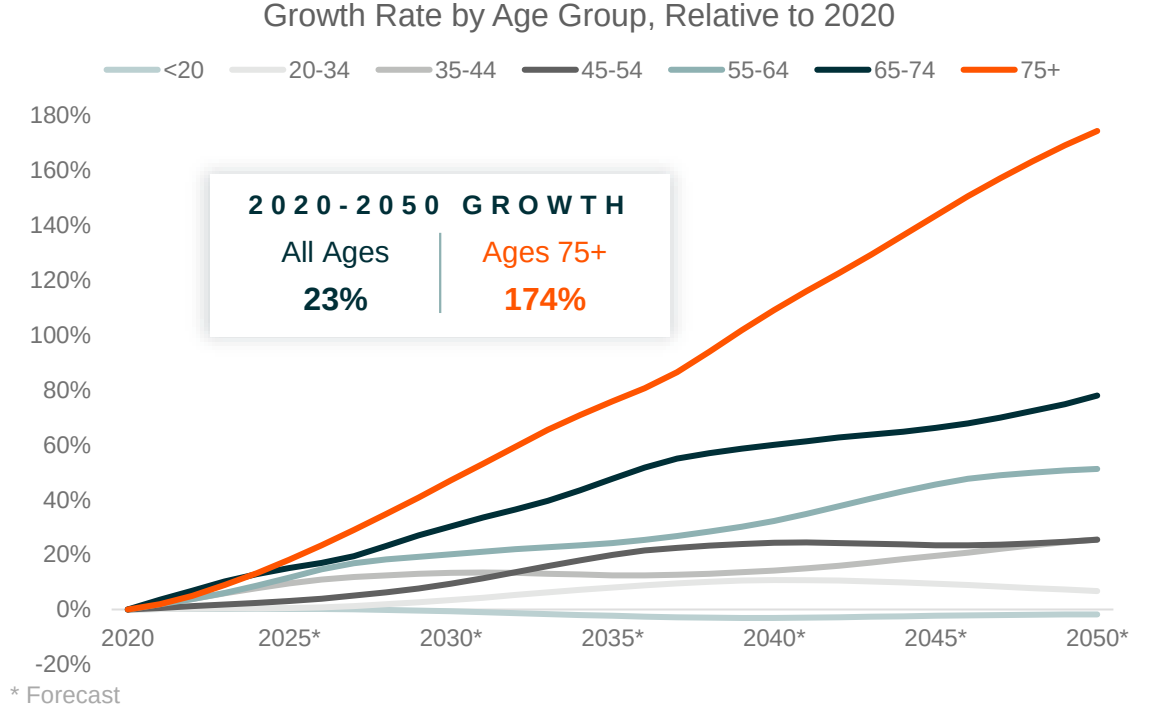
Global Shift in Demographics Intensifies

Rising life expectancy and falling birth rates worldwide are causing the 75 and over age group to grow almost eight times faster than the general population.[1]

Diverging Trends: Life Expectancy Rising as Birth Rates Decline



Individuals 75+: Fastest Growing Age Group Through 2050

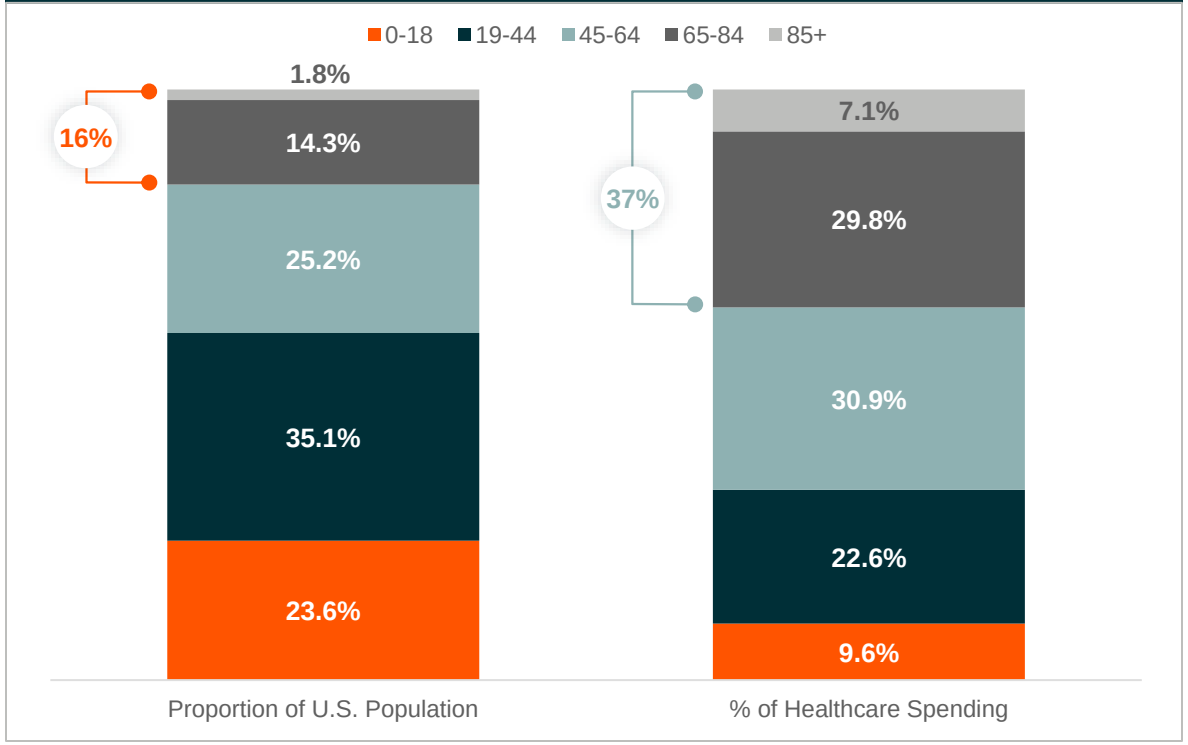


Note: In LHS chart, the outlier in 1959 is due to the Great Chinese Famine. The outlier in 2020 is due to the COVID-19 pandemic.
Sources: Text: United Nations, Jul 2024; Charts: LHS: United Nations, Jul 2024; RHS: United Nations, Jul 2024.

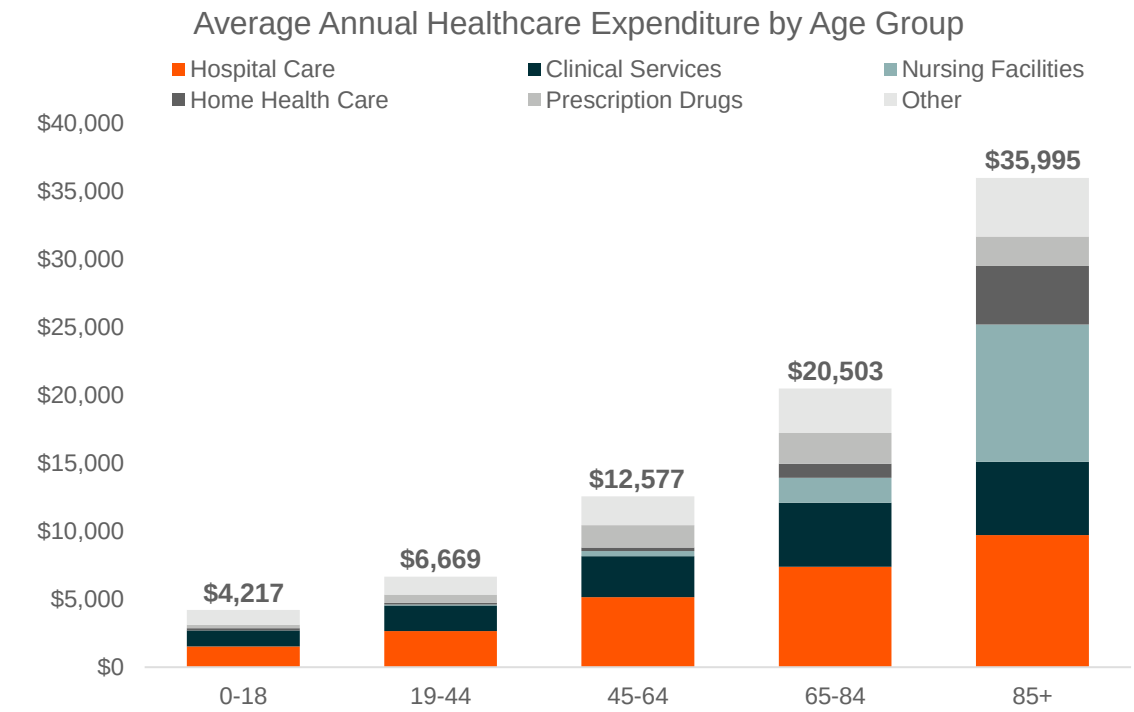
Aging Population's Health Challenge: Older Adults Make Up a Greater Proportion of Health Spend

In the United States, the 65 and older group accounts for 16% of the population and approximately 37% of all healthcare spending.[1,2] Both figures are expected to rise.

Older Adults Dominate U.S. Healthcare Spending



Annual Healthcare Spend Increases Drastically with Age



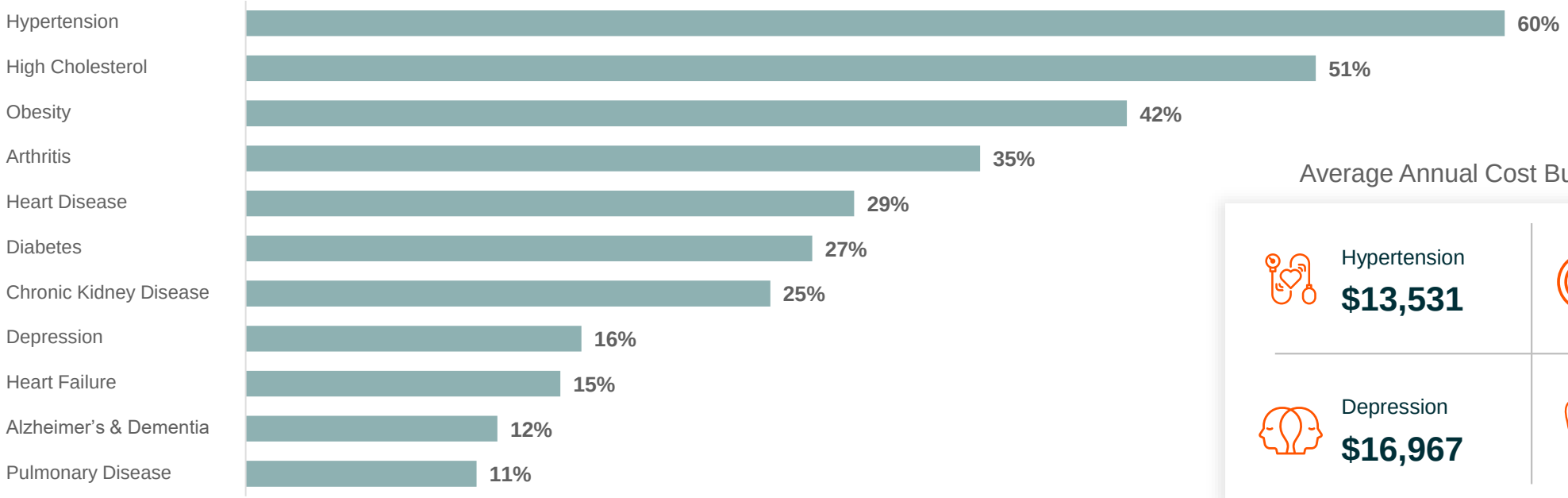
Sources: Text: 1. United Nations, Jul 2024; 2. CMS, Sep 2024; Charts: LHS: CMS, Sep 2024; United Nations, Jul 2024; RHS: CMS, Sep 2024.

Chronic Conditions Add Complexity to Elder Care

Healthcare demand among the elderly largely correlates with a higher incidence of chronic illness. An estimated 95% of individuals 60 and older have at least one chronic condition, while 79% have two or more.[1]

Older Adults Face Distinct Health Challenges with High Incidence of Chronic Conditions

Most Common Chronic Conditions for Adults 65+



Average Annual Cost Burden per Patient

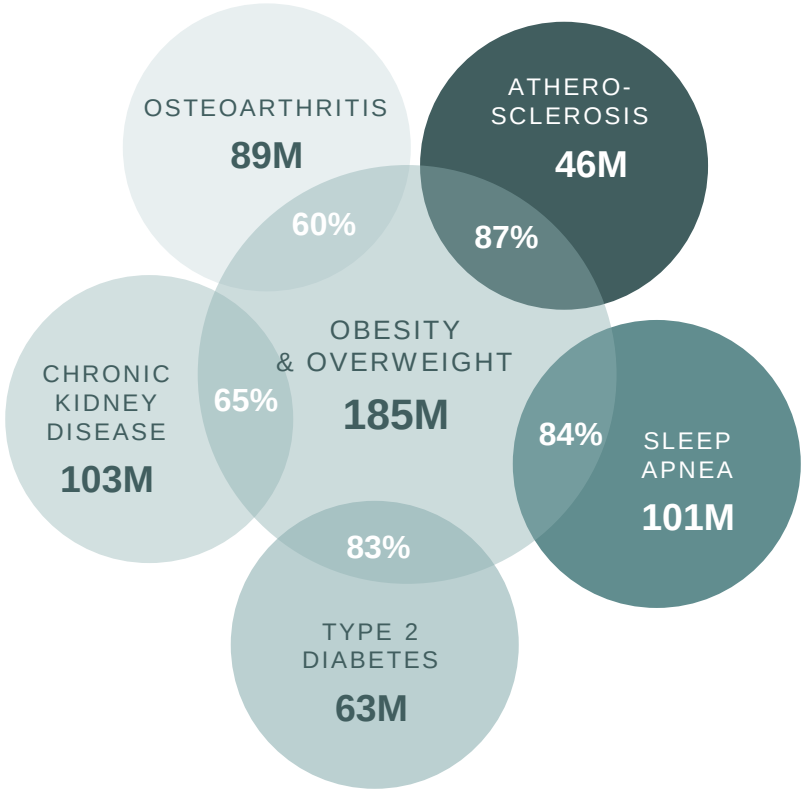
Hypertension **$13,531**	Diabetes **$20,137**
Depression **$16,967**	Alzheimer's & Dementia **$48,701**

Sources: Text: 1. National Council on Aging, May 2024; Charts: LHS: National Council on Aging, May 2024. RHS: LeadingAge LTSS Center @UMass Boston & National Council on Aging, Apr 2022.

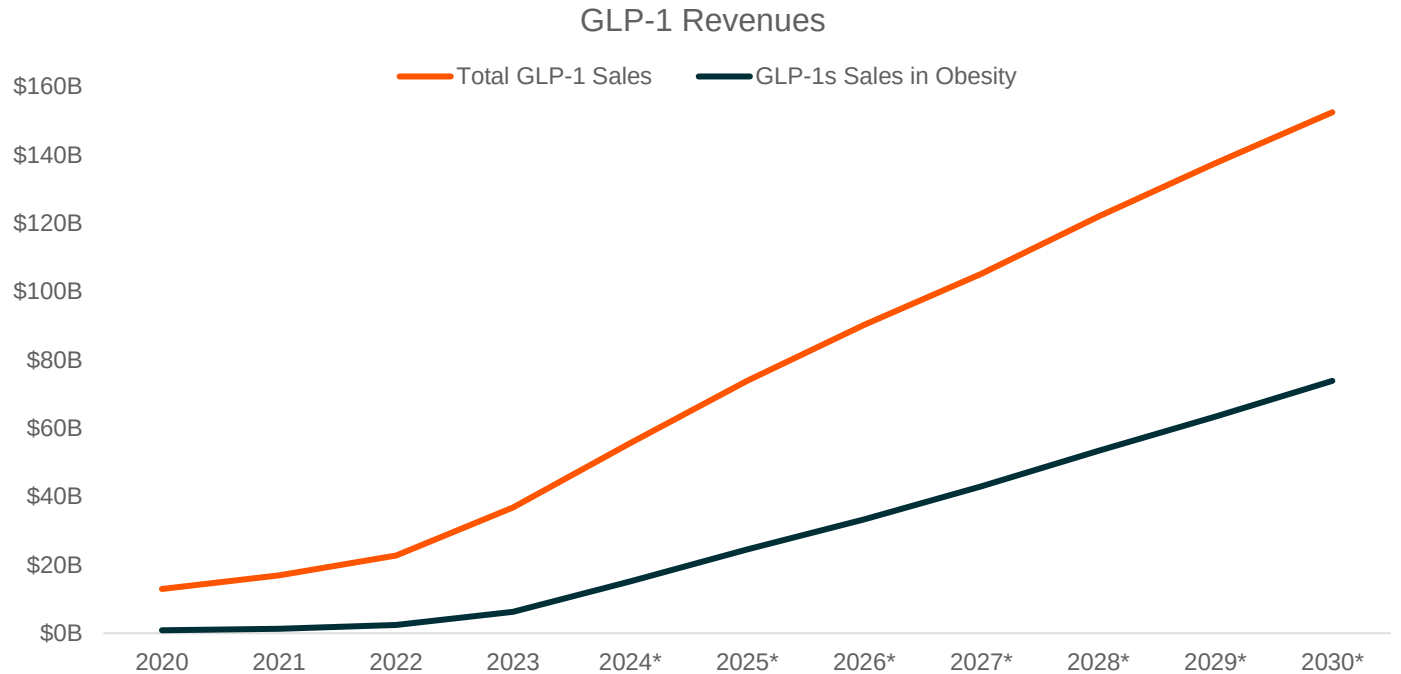
Growing Overlap in Chronic Conditions Opens the Door for a Broader Solution

The rising prevalence of obesity has led to a surge in associated health problems. New treatments targeting obesity show promise not only for weight reduction but also for addressing multiple chronic conditions common in older adults.

Projected 2030 Co-Morbidity Prevalence



Obesity Treatments Target More Than Just Weight Loss

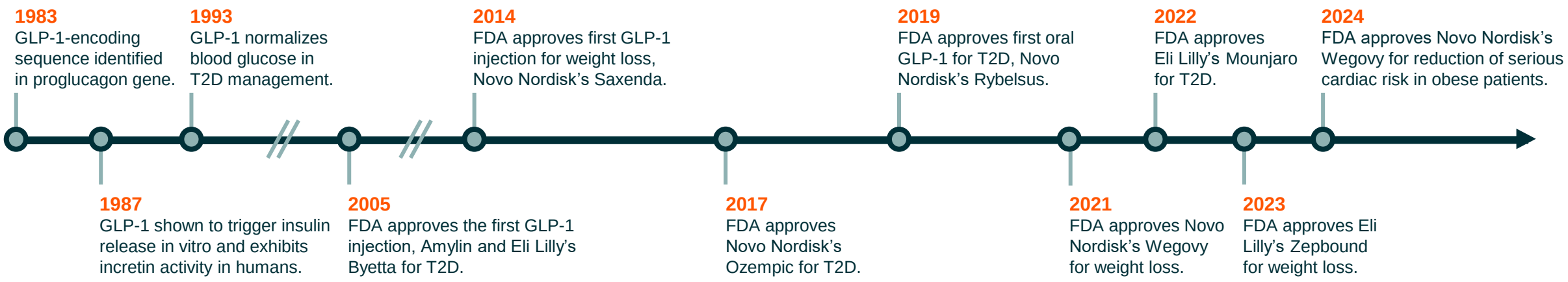


Note: GLP-1 = Glucagon-Like Peptide 1

Sources: Charts: LHS: Evaluate Pharma, Aug 2024; RHS: Evaluate Pharma, n.d., accessed on 1 Nov 2024.

GLP-1s: A Breakthrough Years in the Making

Though seemingly a new category, GLP-1s have been studied for over 30 years. They were developed to treat type 2 diabetes (T2D), and weight loss seen in patients on GLP-1s opened the door for their use in obesity.

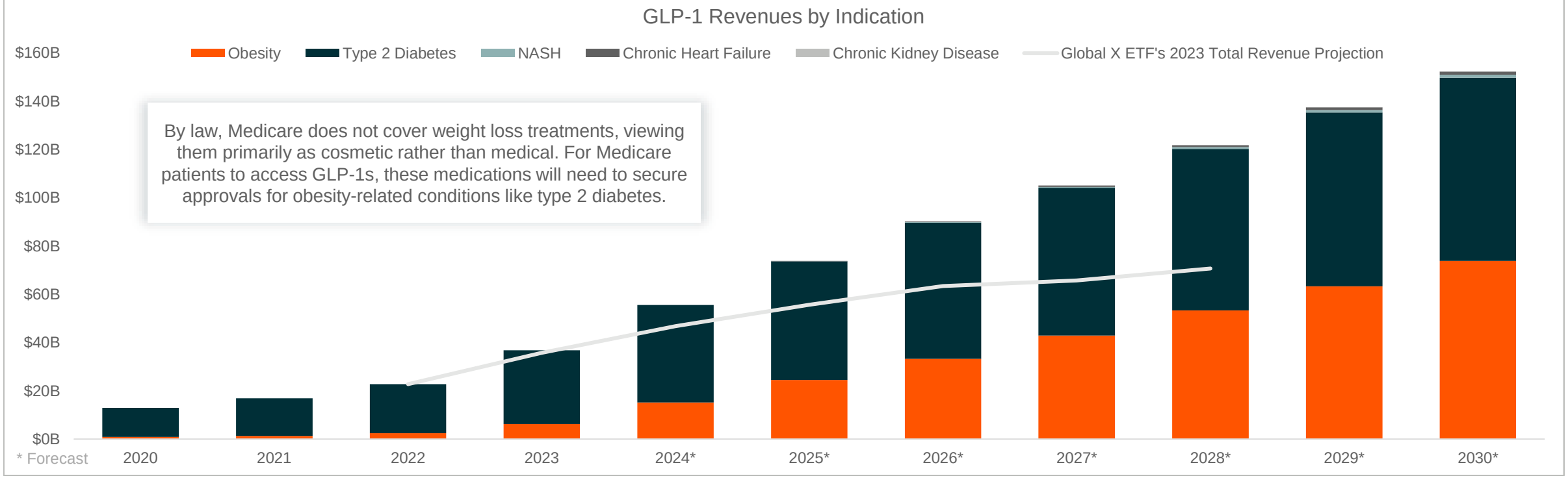


Sources: Biopharma PEG, Feb 2023; Eli Lilly and Company, Jan 2024; Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b.

GLP-1s: A Starting Point for Improved Health Outcomes in Age-Related Conditions

GLP-1 treatments have achieved weight loss up to 22.5%, comparable to bariatric surgeries.[1] While obesity and diabetes dominate GLP-1, research suggests potential benefits for a broader set of patients.

Three Additional Diseases Projected to Generate Revenues Through 2030

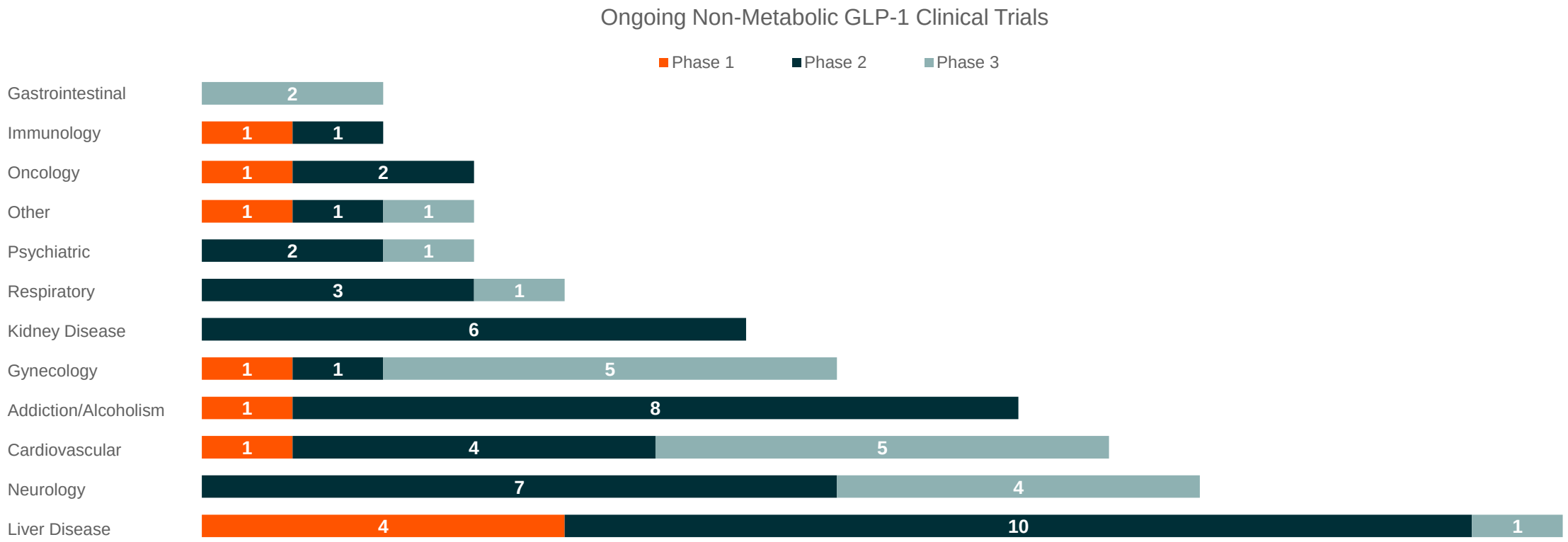


Note: NASH = Nonalcoholic Steatohepatitis

Sources: Text: 1. Eli Lilly and Company, Apr 2022; Chart: Evaluate Pharma, n.d., accessed 1 Nov 2024; Global X ETFs projections from December 2023, based on Evaluate Pharma data.

GLP-1s: Ongoing Clinical Trials Cast an Even Wider Net

Though non-metabolic illnesses are expected to account for a smaller portion of expected GLP-1 revenues through 2030, FDA approvals in these categories are expected to play a pivotal role in broader adoption of GLP-1 treatments.



Sources: National Library of Medicine, National Center for Biotechnology Information, n.d.

GLP-1s: Not Just Ozempic

The entire GLP-1 category is often colloquially referred to as Ozempic, given the drug's widespread popularity. The category, however, has 13 total approved drugs, and 17 others are expected to be approved through 2030.[1]

Top 12 GLP-1s, by Projected 2030 Revenue

Product	Company	U.S. Status	Dosing Form	Frequency	Mechanism of Action	2023 Revenue	2030* Revenue
Mounjaro	Lilly	Approved		Weekly	GLP-1 + GIP	$5.16B	$31.80B
Ozempic	novo nordisk	Approved		Weekly	GLP-1	$13.90B	$25.14B
Cagrisema	novo nordisk	Phase 3		Weekly	GLP-1 + Amylin	$0.00B	$21.02B
Zepbound	Lilly	Approved		Weekly	GLP-1 + GIP	$0.18B	$20.26B
Wegovy	novo nordisk	Approved		Weekly	GLP-1	$4.55B	$17.89B
Rybelsus	novo nordisk	Approved		Daily	GLP-1	$2.72B	$9.35B
Orforglipron	Lilly	Phase 3		Daily	GLP-1	$0.00B	$8.67B
Retatrutide	Lilly	Phase 3		Weekly	GLP-1 + GIP + GCGR	$0.00B	$5.68B
MariTide	AMGEN	Phase 2		Monthly	GLP-1 + GIP	$0.00B	$4.20B
Trulicity	Lilly	Approved		Weekly	GLP-1	$7.13B	$1.33B
Mazdutide	Innovent	Phase 2		Weekly	GLP-1R + GCGR	$0.00B	$1.25B
VK2735	VIKING THERAPEUTICS	Phase 2		Weekly	GLP-1 + GIP	$0.00B	$1.18B

* Forecast

Sources: Text: Evaluate Pharma, n.d.b; Chart: Evaluate Pharma, n.d.a, n.d.b, n.d.c, n.d.d, n.d.e, n.d.f, n.d.g, n.d.h, n.d.i, n.d.j, n.d.k, n.d.l, accessed on 1 Nov 2024; FDA, Nov 2023; FDA, Jan 2024; STAT+, Sep 2024.

GLP-1s: Defining the Next Generation of Weight Loss Treatments

Growing demand for GLP-1s has buoyed revenue projections and optimism for what's to come. Next-generation formulations aim to boost adherence, potentially yielding economic benefits through the prevention of chronic diseases.

Costs related to the treatment of chronic conditions make up 90% of Medicare spend each year.[1] GLP-1 treatments have the potential to ease those pressures by helping prevent chronic conditions associated with obesity.

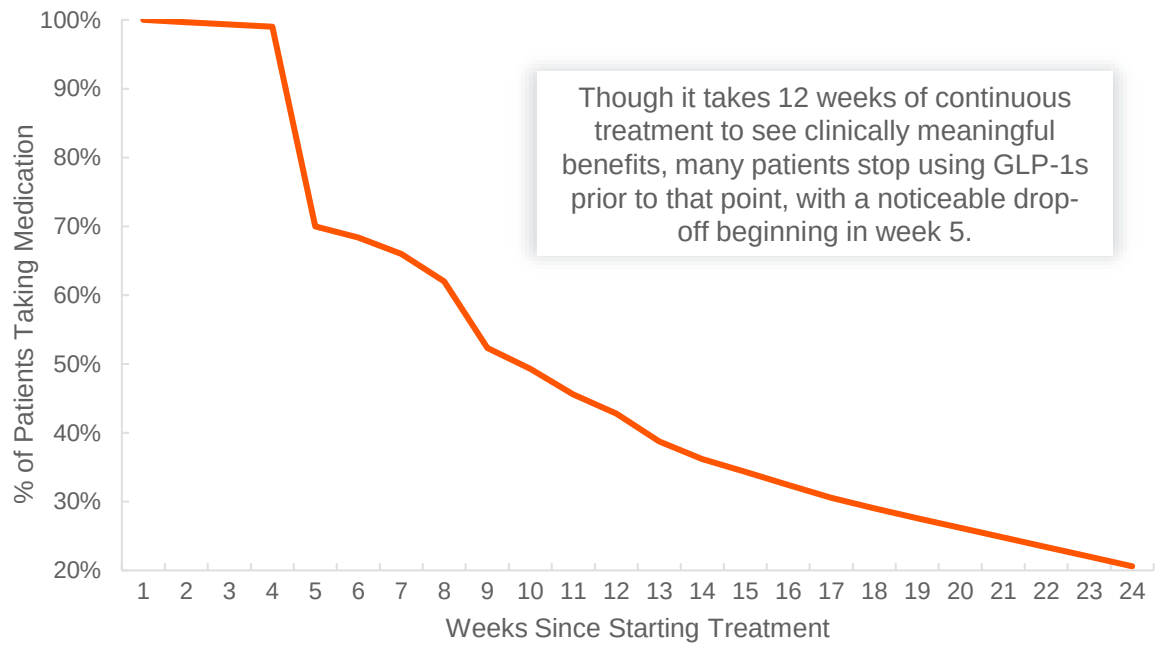
100,000 PEOPLE > **15%** OF THEIR BODY WEIGHT = **$85 million** IN SAVINGS OVER FIVE YEARS[2]

Factors to Watch in Next-Generation GLP-1s

- Less Frequent Dosing
- More Dosing Options
- Fewer Side Effects
- Muscle Preservation
- Sustained Weight Loss After Discontinuation
- Obesity Prevention

GLP-1s Need Time to Work

Time to Treatment Discontinuation in Patients on GLP-1 for Weight Loss

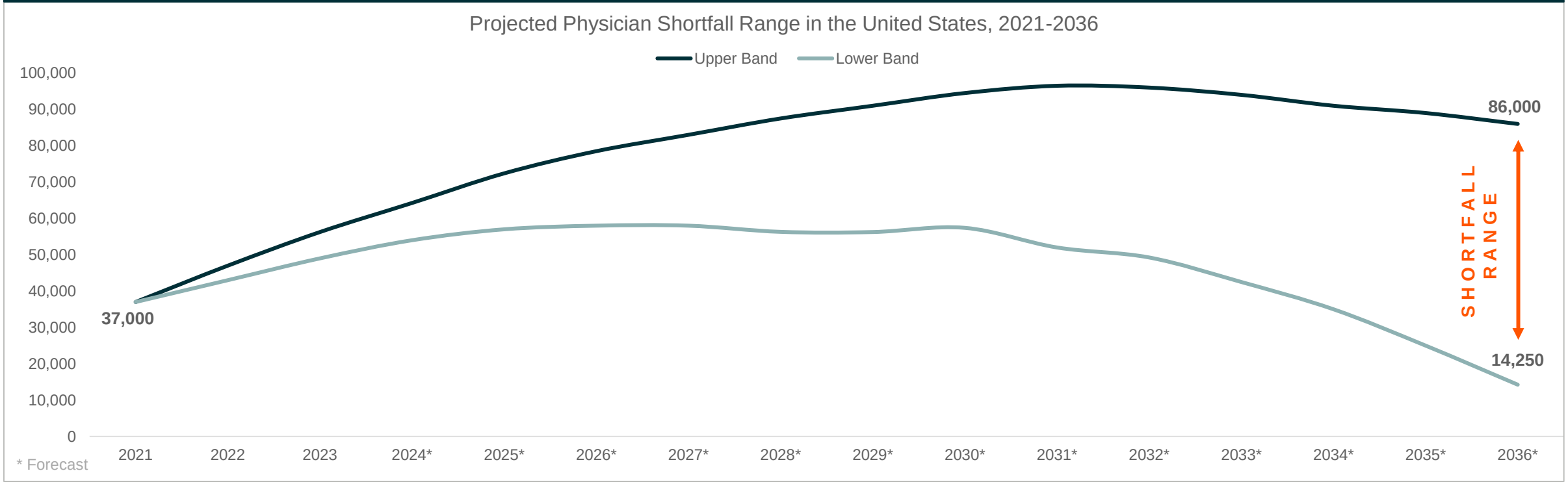


Sources: Text: 1. CDC, Jul 2024; 2. STAT+, Oct 2023; Chart: Blue Cross Blue Shield Association, May 2024.

Beyond Chronic Care, Other Solutions Are Needed to Meet Rising Healthcare Demand

The U.S. healthcare system faces a physician shortage that is set to intensify just as the nation's healthcare needs grow. Over the next decade, a third of U.S. doctors are expected to retire.[1]

Shortage of Doctors in 2036: Best-Case Scenario Projected at 14,250 and Worst-Case Scenario at 86,000

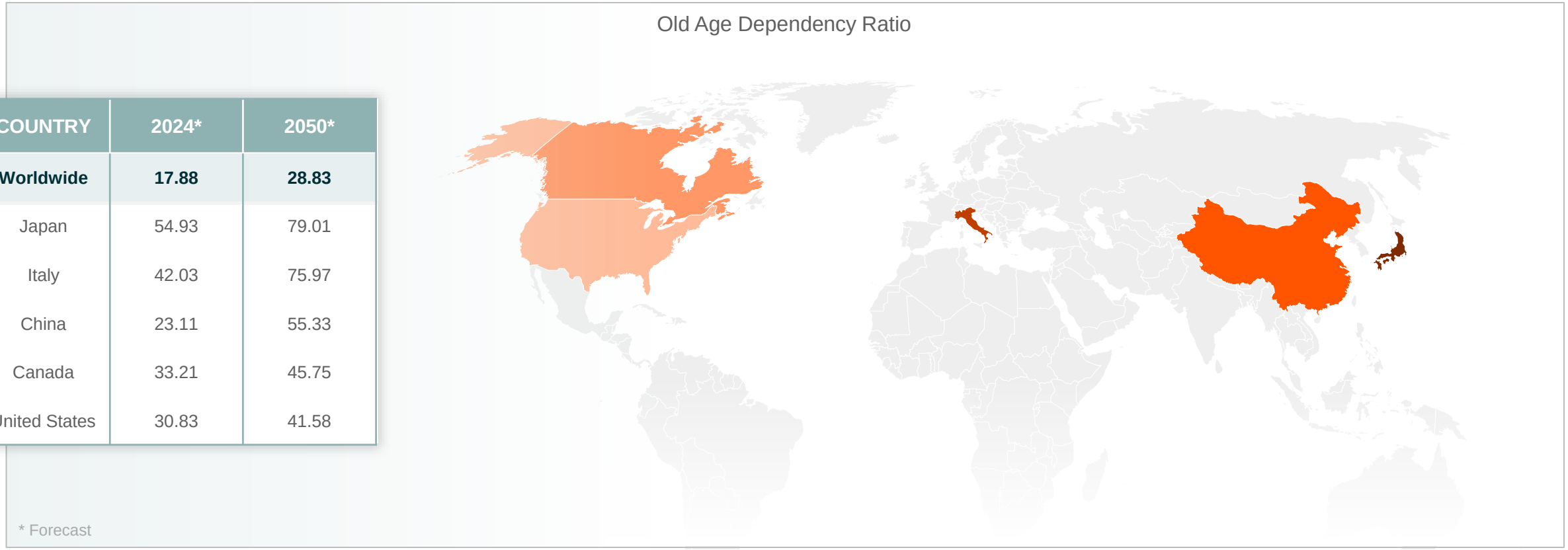


Sources: Text: 1. Association of American Medical Colleges, Mar 2024; Chart: Association of American Medical Colleges, Mar 2024.

The Hidden Costs of Aging for Caregivers Are Likely to Grow More Prominent

U.S. unpaid family caregiving costs surpass $600 billion annually.[1] With the elderly population (65+) projected to outpace working-age adults (20-64), demand for senior care facilities is set to increase.[2]

COUNTRY	2024*	2050*
Worldwide	**17.88**	**28.83**
Japan	54.93	79.01
Italy	42.03	75.97
China	23.11	55.33
Canada	33.21	45.75
United States	30.83	41.58



* Forecast

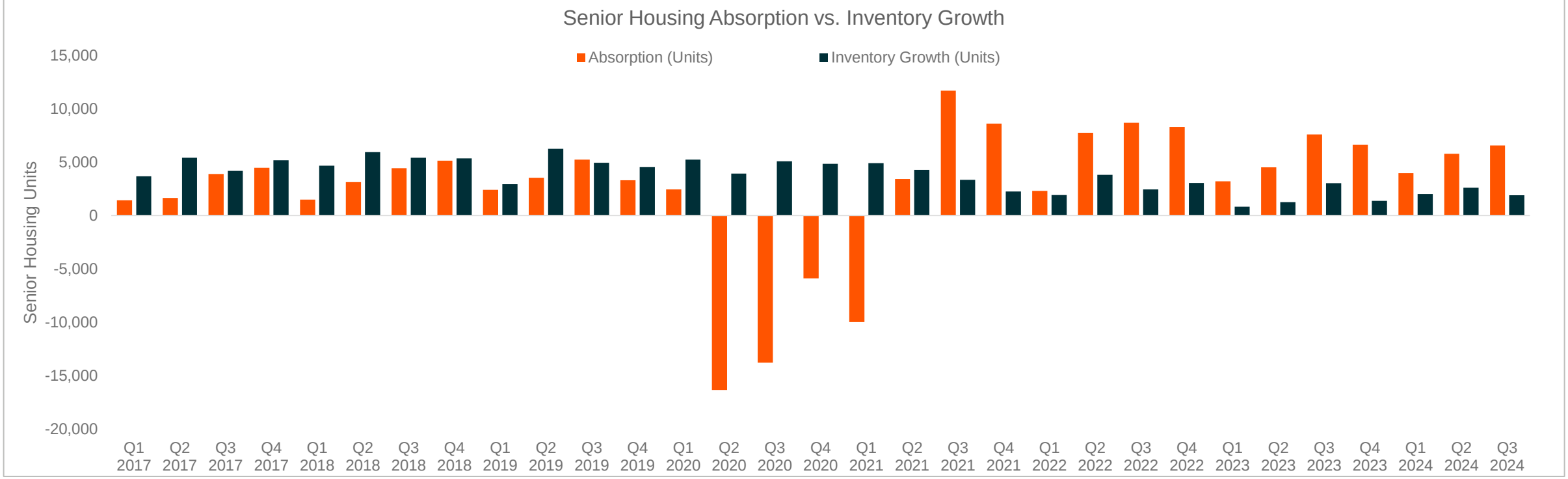
Note: The Old-Age Dependency Ratio is defined as the elderly population (65+) per 100 working age adults (20-64).
Sources: Text: 1. AARP, Mar 2023. 2. United Nations, Jul 2024; Chart: United Nations, Jul 2024.

GLOBAL X
by Mirae Asset

Shortage of Senior Living Options Is Likely to Grow More Acute

Nearly 70% of adults 65 and older will require long-term care in their lifetime.[1] Expected growth in patients 80+ will stretch the industry thin as new unit development lags.

Senior Housing Demand Has Outpaced New Unit Development



Sources: Text: 1. HHS, DALTCP, and Urban Institute, Apr 2019; Chart: Bloomberg, n.d., accessed on 1 Nov 2024.

Technological Advancements Can Help Bridge the Care Gap

With caregivers already in short supply, technology can play a pivotal role in facilitating healthcare for the elderly. Wearable sensors, for example, are particularly beneficial for older adults.

Elderly Patients Are a Good Fit for Wearable Devices

Improved wearable monitoring capabilities can allow medical personnel to tailor patient care and prioritize their efforts.

Sensors can alert emergency services, medical personnel, and loved ones when appropriate.

Automatic administration can help reduce patient guesswork and assist elderly patients who might often forget to take medication.

Cardiovascular

Heart disease is the leading cause of death in elderly patients in the United States.[1]

Arrythmias

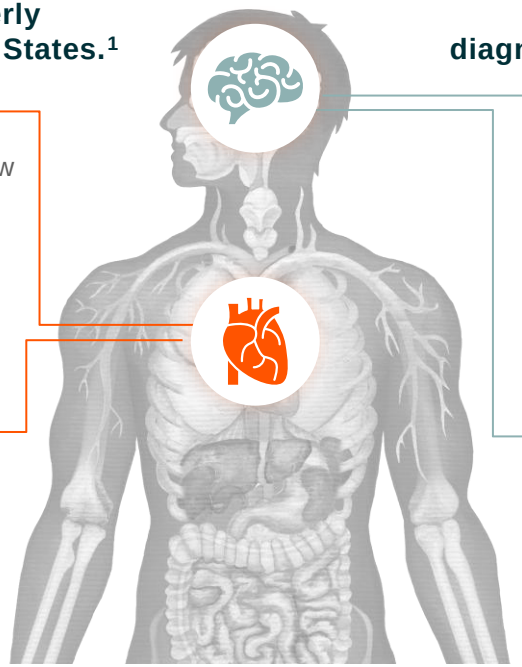
Wearable devices can now detect 99% of arrythmias via patches vs. 47% efficacy with traditional devices.[2]

Blood Pressure Monitoring

Sensors can measure blood pressure levels as often as every 15 minutes.[3]

Neurology

Neurological disorders are notoriously difficult to diagnose, monitor, and treat.



Sleep Quality & Stroke Prevention

Wearable sleep trackers can help diagnose and monitor sleep disorders, like sleep apnea, in the comfort of a patient's home.

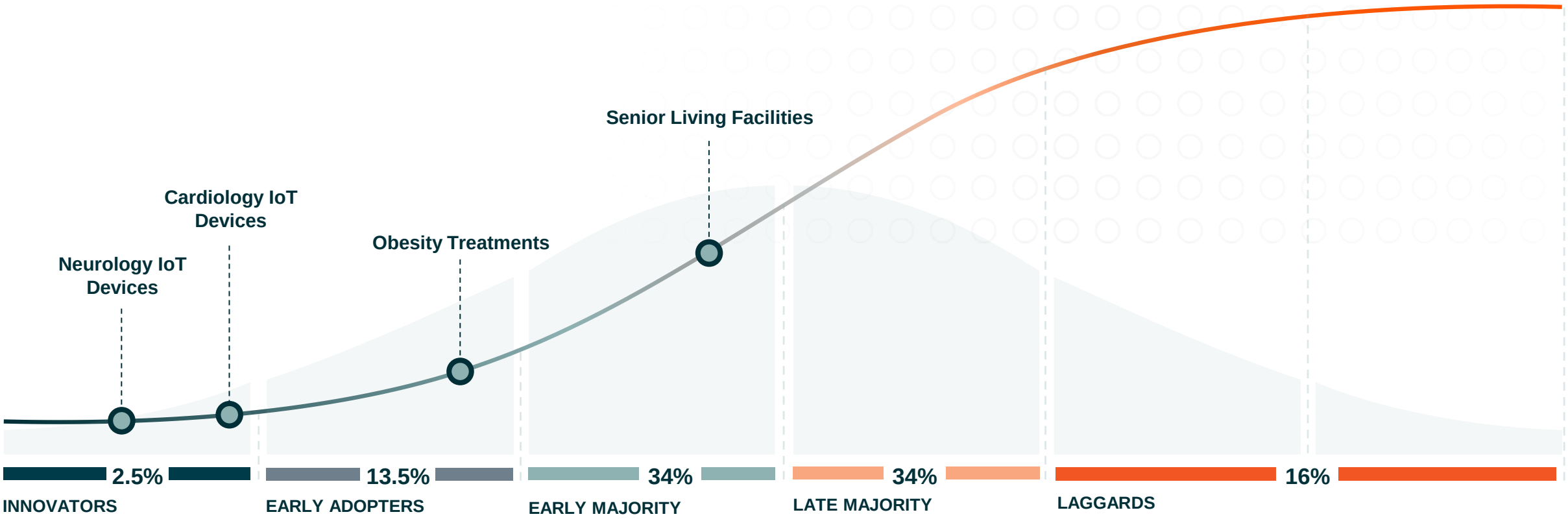
Fall Detection & Head Trauma

Sensors can detect impacts and measure the force and direction of injuries.

Sources: Text: 1. NCHS, CDC, Mar 2024; 2. American Heart Association, Jan 2019; 3. Cleveland Clinic, Mar 2023.

S-Shaped Curve of Adoption – Aging Population

The global population is rapidly aging, with adults 65 and older projected to reach 1.7 billion by 2053, driving urgent demand for life-saving medical innovations.[1]



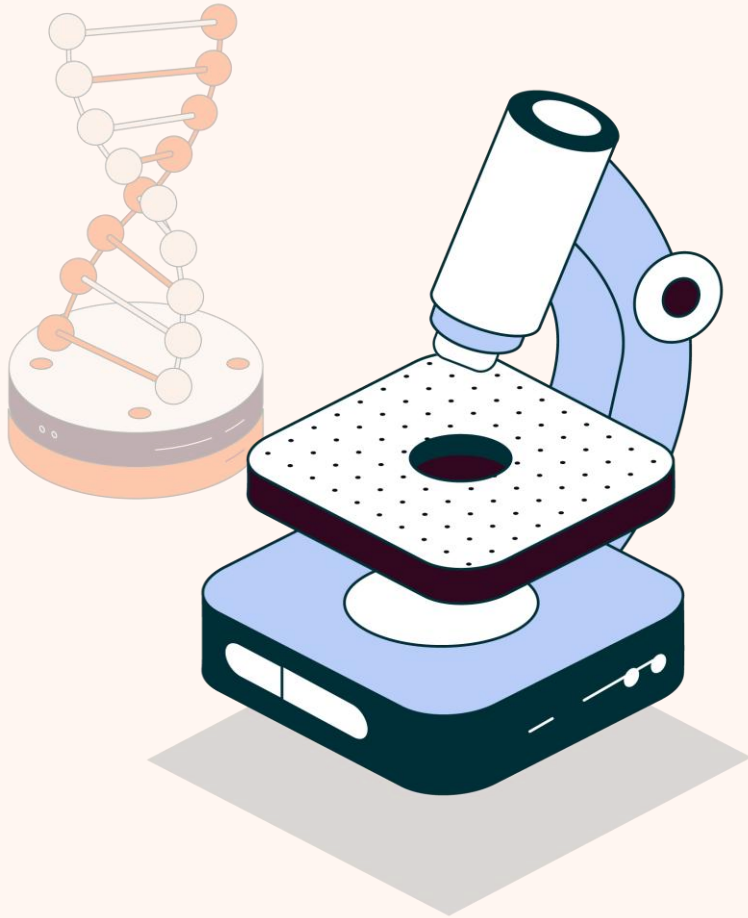
PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: United Nations, Jul 2024

CHAPTER 3.2

Tech-Enabled Health:
Revolutionizing the Standard of Care



Limitations in healthcare supply relative to ballooning demand for care continue to exacerbate inefficiencies across the healthcare industry. Though preventative care approaches, particularly in addressing the root causes of chronic illnesses, demonstrate improved patient outcomes, these interventions alone cannot meet growing healthcare needs. The widening gap between care supply and demand necessitates technological innovation and implementation. Strategic deployment of healthcare technology solutions will be crucial in augmenting provider capacity, streamlining care delivery, and ensuring sustainable access to quality healthcare services.

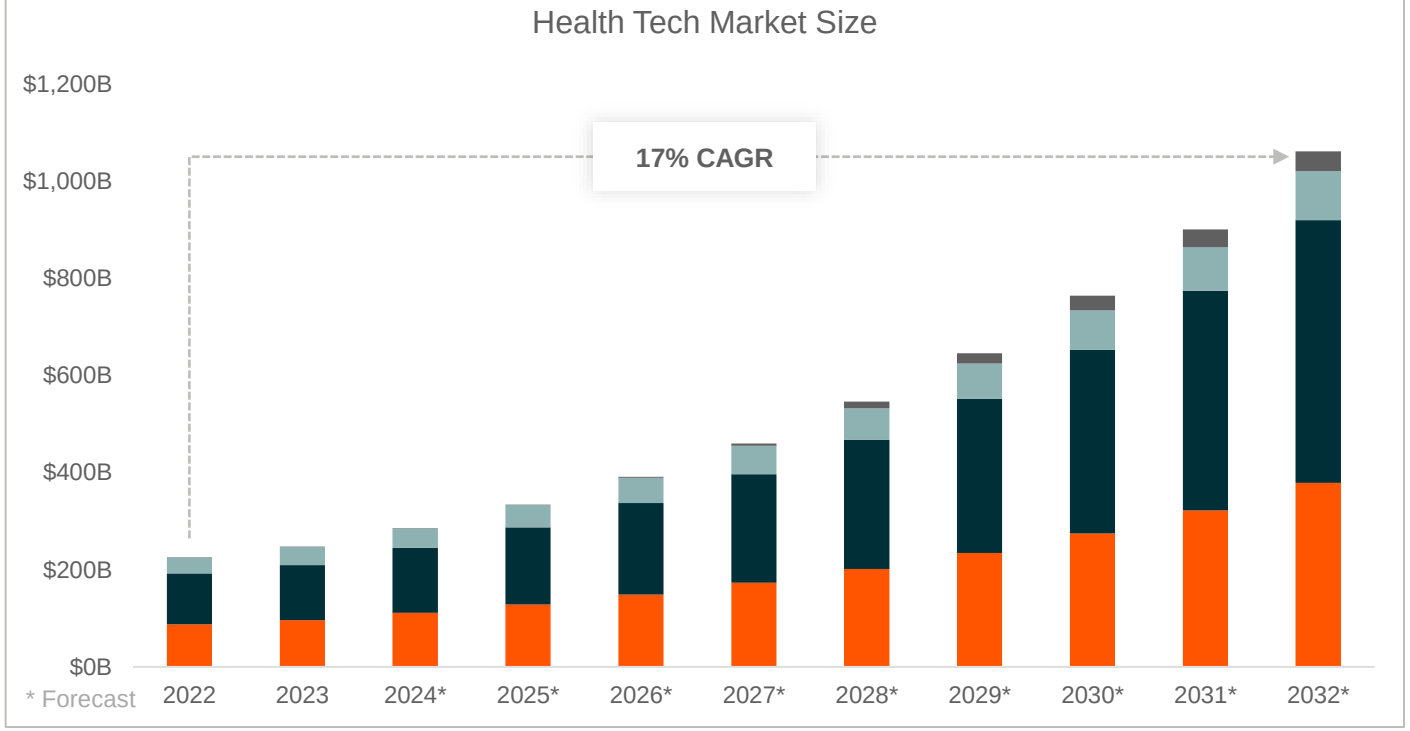
Tech-Enabled Health: Driving Efficiency and Improving Patient Care

Historically, healthcare has been slow to adopt new technologies, but growing demand means the sector must now embrace innovation. A growing set of technologies are expected to play a pivotal role in improving patient care.

Growing Toolkit of Health Tech

AI-Enabled Drug Discovery: Accelerating medical research by predicting drug interactions, analyzing molecular data, and identifying potential treatments	**122% CAGR**
Smart Medical Devices: AI-powered medical hardware including wearables and surgical robotics that enhance patient outcomes	**16% CAGR**
Tech-Enabled Consumer Care: Solutions that improve access to care through virtual services, remote monitoring, and online pharmacies.	**18% CAGR**
Healthcare Analytics & Software Solutions: Data analysis and automation tools that optimize clinical workflows and administrative processes.	**12% CAGR**

Rapid Expansion Is Narrowing the Gap Between Supply and Demand

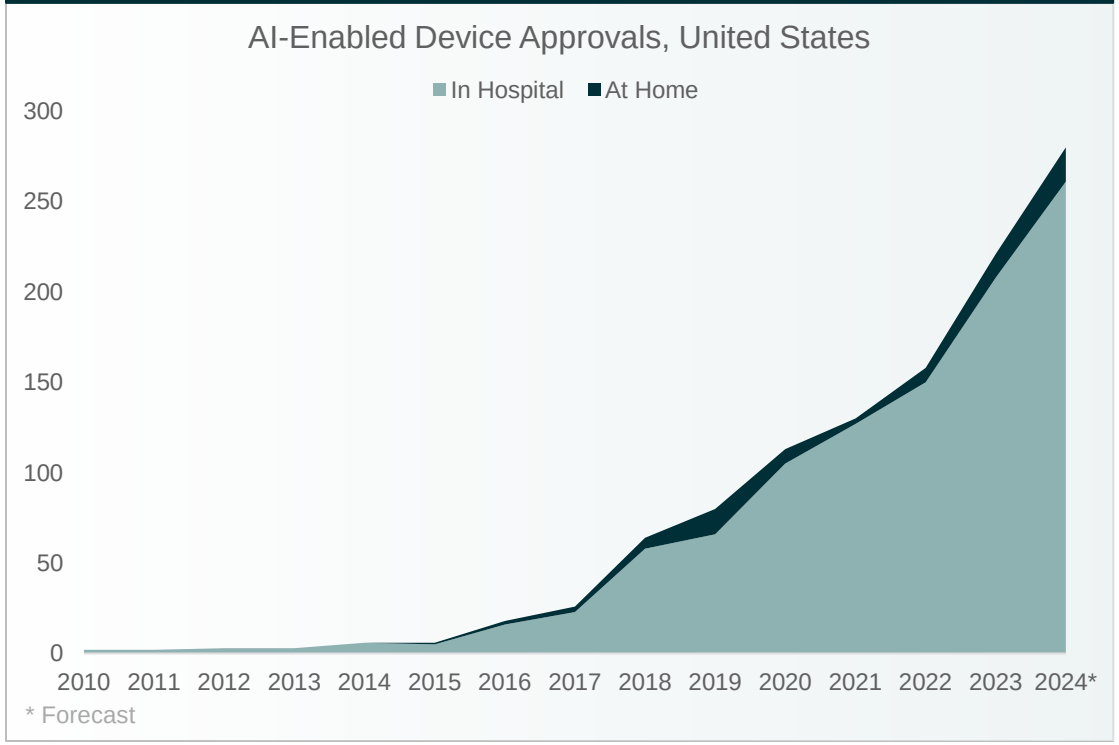


Sources: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Grand View Research, 2023a; Grand View Research 2023b; Grand View Research 2024; Insight Partners, 2023; Markets and Markets, May 2022; Markets and Markets Aug 2024; Precedence Research Sep 2024a; Precedence Research Sep 2024b; Statista, Sep 2024.

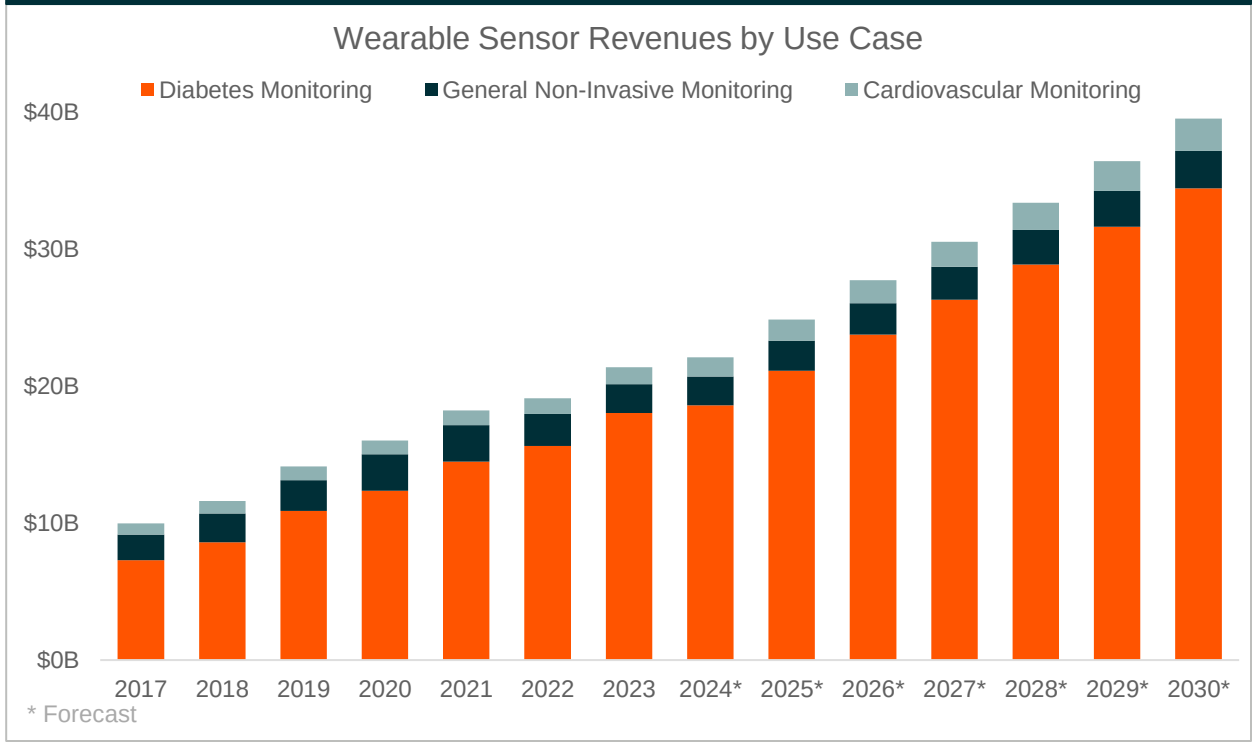
Smart Medical Devices: Wearable Sensors Bring Innovative Technology Directly to the Patient

Regulatory acceptance of AI-enabled medical devices paves the way for expanded use of wearable sensors. These devices integrate into patients' lives, enabling round-the-clock health monitoring without sacrificing comfort.

AI-Enabled Medical Device Approvals on the Rise



Wearable Sensors: A Growing Segment of AI-Enabled Devices

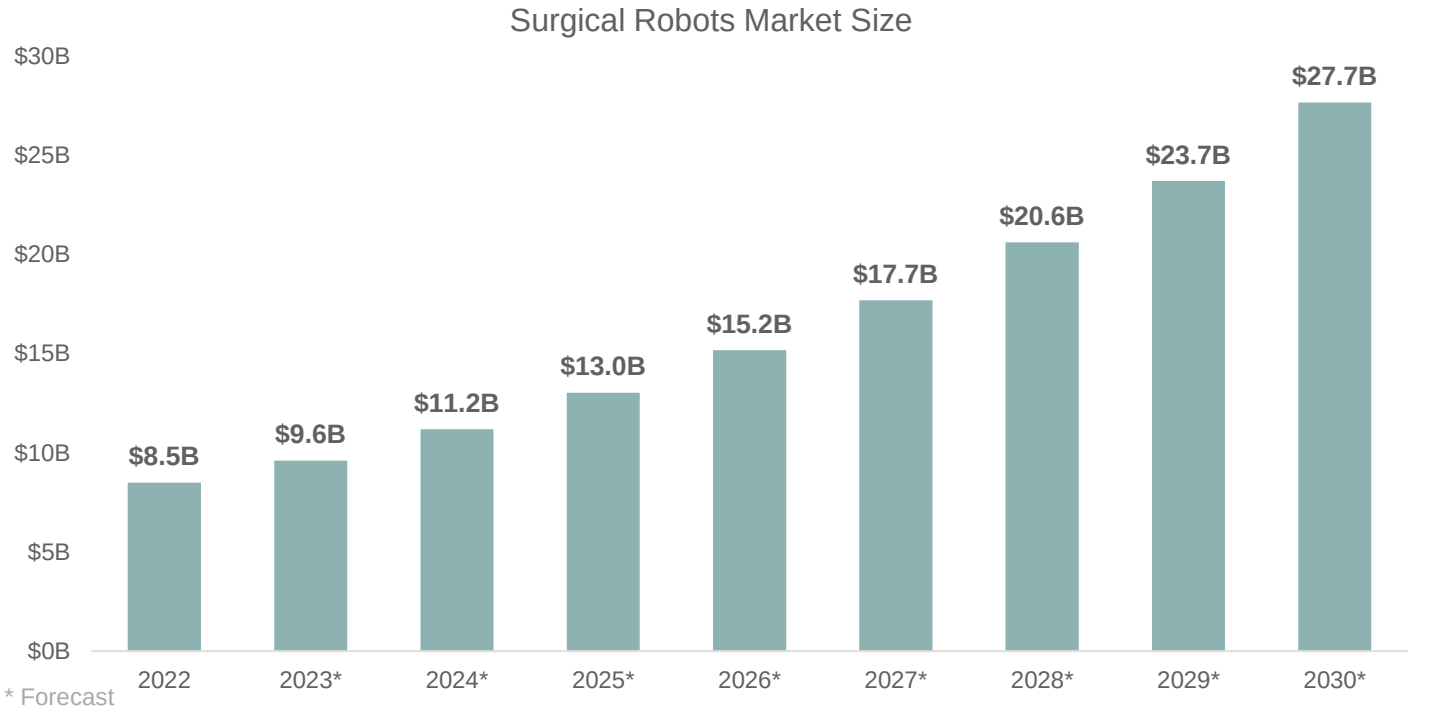


Sources: Charts: LHS: FDA, Aug 2024; RHS: Evaluate Pharma, n.d.a, accessed on 1 Nov 2024; Evaluate Pharma, n.d.b, accessed on 1 Nov 2024; Evaluate Pharma, n.d.c, accessed on 1 Nov 2024.

Smart Medical Devices: Surgical Robots Apply Novel Hardware and AI to Improve Patient Outcomes

Surgical robots have been around for over 20 years, but with more powerful technology they now help with more complex surgeries, accelerating growth.

Accelerating Adoption of Robotic Surgeries



Tailwinds

Better Outcomes: Key benefits include shorter hospital stays, smaller surgical scars, lower risk of infection, and less pain during recovery.[1]

Leasing Models: Alternative financing options, particularly leasing arrangements, make robotic surgery systems more accessible to hospitals. Leasing accounts for about 60% of Intuitive Surgical's placements.[2]

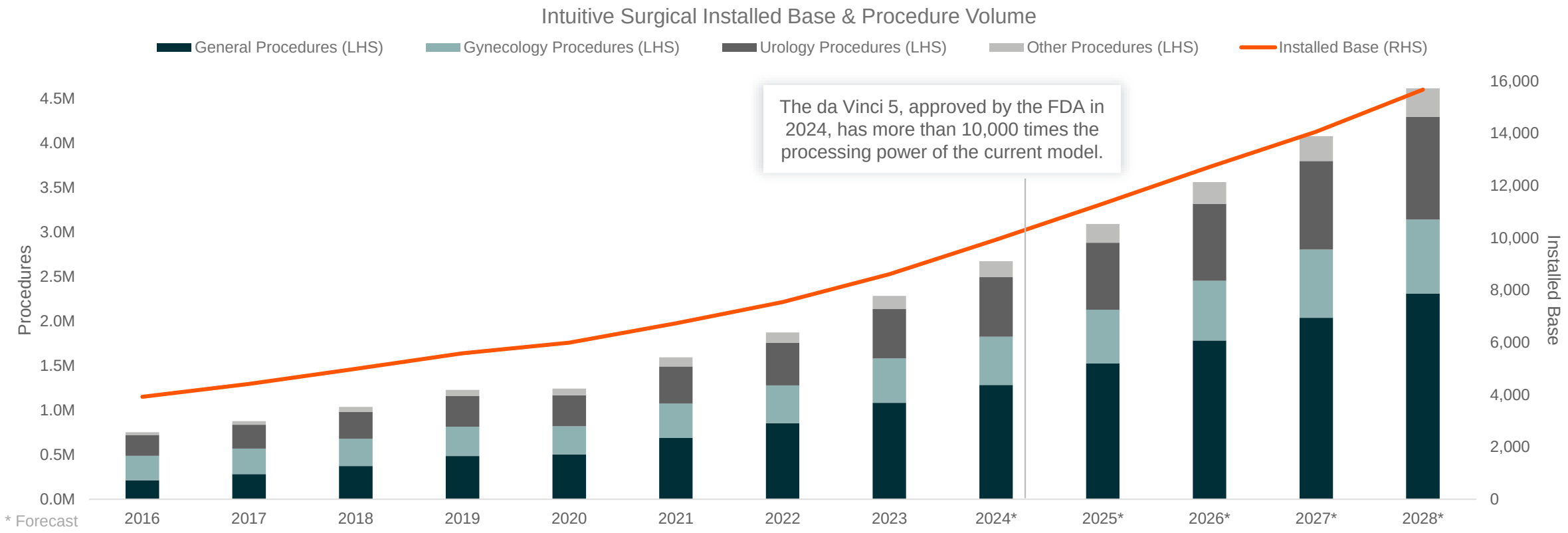
Expense Reduction: Robotic surgical systems help hospitals reduce expenses through decreased lengths of stay and complication rates, while potentially alleviating staffing shortages.

Growing Demand for Surgeries: By 2030, hip and knee replacements are expected to increase by 142% and 190%, respectively.[3] By that time, two out of three hip replacements are expected to be performed robotically.[4]

Sources: Text: 1. Cleveland Clinic, Apr 2024; 2. Intuitive Surgical, Oct 2024; 3. Arthritis Foundation, n.d.; 4. Cleveland Clinic, Nov 2023; Chart: Markets and Markets, Aug 2024.

Smart Medical Devices: Surgical Robot Adoption Accelerating

Since the approval of Intuitive Surgical's da Vinci system in 2000, robot-assisted surgeries have transformed specific areas of medicine, particularly general, urological, and gynecological procedures.



Sources: Bloomberg, n.d., accessed on 1 Nov 2024; Intuitive Surgical, Jan 2024; Intuitive Surgical, Feb 2023; Intuitive Surgical, Feb 2022; Intuitive Surgical, Feb 2021; Intuitive Surgical, Feb 2020; Intuitive Surgical, Feb 2019; Intuitive Surgical, Feb 2018; Intuitive Surgical, Feb 2017.

Smart Medical Devices: Technology Is Being Deployed Behind the Scenes at Accelerating Pace

Automated dispensing systems integrated with healthcare IT are transforming pharmacies in a rapidly expanding $90 billion market.[1]

Medication adherence and accurate dispensing are fundamental to patient outcomes, yet healthcare systems face mounting pressures from staffing shortages. Automated systems can play a pivotal role in helping the industry scale.

Current Healthcare Challenges

85%
of U.S. hospitals are facing pharmacy technician shortages.[2]

$500B per year
in costs related to nonoptimal medication adherence.[3]

75%
of pharmacists' tasks are non-clinical.[4]

Measured Impact of Automation

54%
reduction in nurse medication retrieval time.[5]

75%
pharmacists time savings.[6]

30%
greater inventory capacity.[7]

Sources: 1. Omnicell, Oct 2024; 2. Omnicell, Sep 2022; 3. Ibid.; 4. Omnicell, Oct 2024; 5. Ibid.; 6. Ibid.; 7. Omnicell, n.d., accessed on 1 Nov 2024.

Healthcare Analytics & Software Solutions: Existing Siloed Solutions Exacerbate the Problem

The healthcare industry has been slow to adopt digital solutions. An estimated 80% of U.S. healthcare documents are still sent via snail mail and fax.[1] More documents are digital, but processes remain inefficient, leading to doctor burnout.

Healthcare Needs Automation

Physicians spend an estimated 39% of their time documenting patient information in electronic medical records (EMRs).[2]

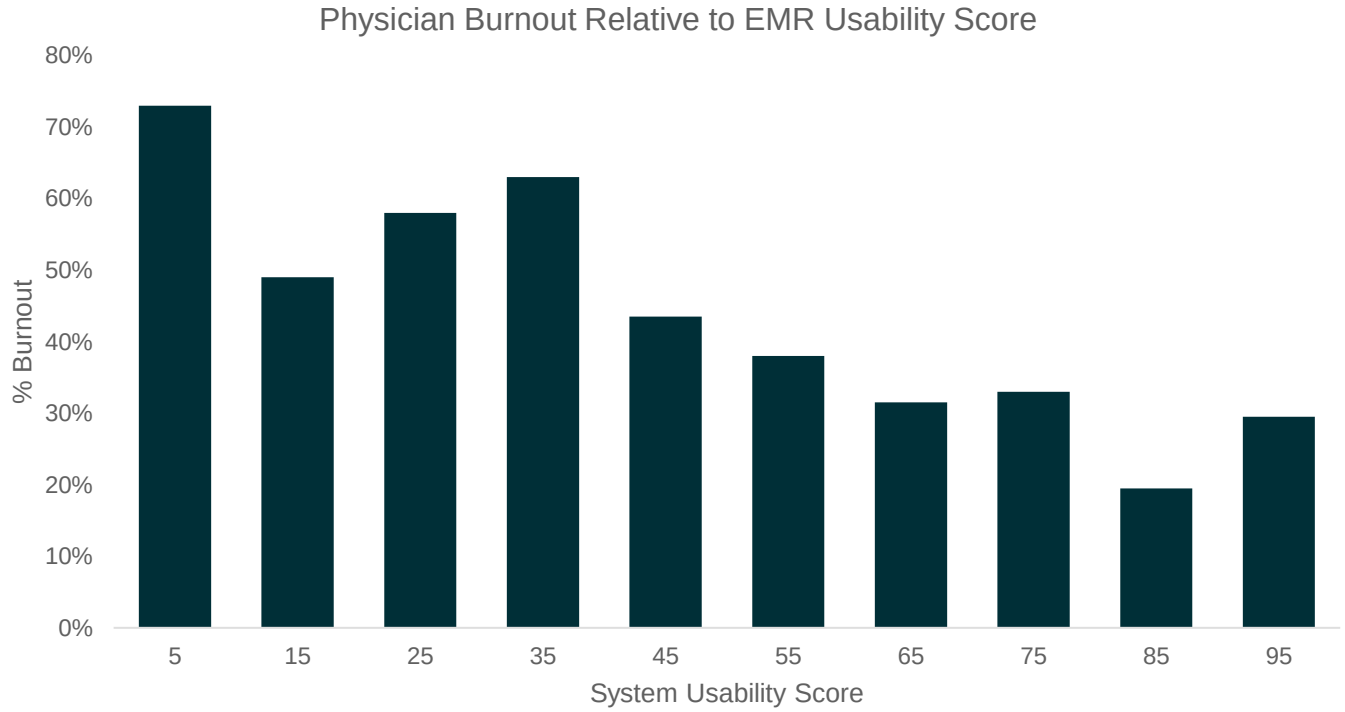
45% of doctors report that it is difficult to document patient care in EMRs.[3]

77% of medical personnel often finish documentation after hours.[4]

75% of medical staff believe that the time required for documentation impedes patient care.[5]

Unsurprisingly, 78% of physicians report burnout and fatigue related to health IT systems.[6]

Physician Burnout Drops 3% per EMR Usability Point Gained[7]



Sources: Text: 1. Doximity, Jun 2023; 2. Becker's Hospital Review, Apr 2023; 3. American Medical Informatics Association, Jun 2024; 4. Ibid.; 5. Ibid.; 6. Doximity, Jun 2023; 7. Mayo Clinic Proceedings, Mar 2020; Chart: Mayo Clinic Proceedings, Mar 2020.

Healthcare Analytics & Software Solutions: Data Integration Benefits Patient and Providers

To help physicians free up time for patient care, multiple digital health companies have been prioritizing the automation and interoperability of patient records.

DATA SOURCES

- Patient Reported Outcomes
- Clinical Data from EHR Systems
- Radiology Images & Reports
- Germline Molecular Data
- ECG & Other Cardio Data
- Pathology Slides
- Insurance Claims

Data Integration + Artificial Intelligence

OUTPUT

Patient Monitoring & Connectivity Hub

Patients can monitor their vitals and administer emergency medication as needed.

Hospital Care Prioritization

Hospitals can monitor patient vitals and flag when assistance is needed.

Treatment Guidance

Doctors can track real-world data and adjust treatment accordingly.

Operational Benefit to Doctors

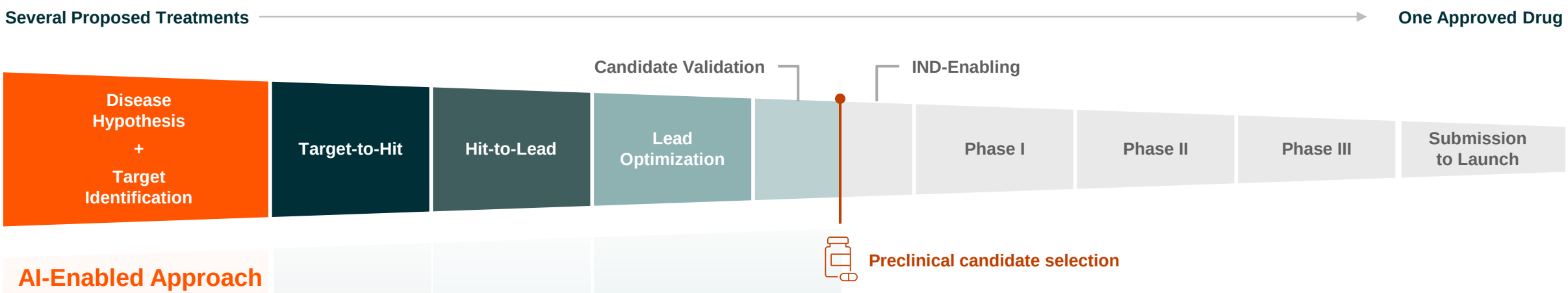
- Streamlined communication between medical stakeholders eliminates redundant documentation
- AI-powered transcription automates visit summaries and clinical notes
- Intelligent chatbots enable rapid coordination among healthcare teams

Care Benefit to Patients

- Centralized tracking of diagnostic tests and results across multiple providers
- Global knowledge sharing of successful treatment approaches and care protocols
- Data-driven identification of care gaps and treatment optimization
- Automated summarization of relevant medical research for patient education
- Improved matching of patients with appropriate clinical trials

From Lab to Trials: AI's Game-Changing Impact on Drug Discovery

Despite technological advancements, developing a new medicine still takes 10-15 years and costs $1.3 billion on average.[1,2] Only one in ten investigational drugs, however, makes it to market.[3]



Empowered by a strong repertoire of healthcare information, AI stands to facilitate faster development of drugs.

Sources: Text: 1. PhRMA, 2021; 2. Journal of the American Medical Association, 2020; 3. NIH, 2019. Chart: Insilico Medicine, 2021.

AI Drug Discovery: Expected to Be Fastest Growing Generative AI (Gen-AI) Segment Through 2032

Gen-AI has the potential to accelerate drug discovery, leading to cost efficiencies and more affordable medicines. By 2032, drug-discovery gen-AI tools can add $41 billion in software spending and reduce a new drug's time to market.

Benefit to Pharmaceutical Industry:
AI Improves Unit Economics for Drug Development

By running millions of scenarios, AI software could reduce the cost of preclinical drug development by 20-40% as well as accelerate design and validation of drug candidates by as much as 15 times.[2,3]

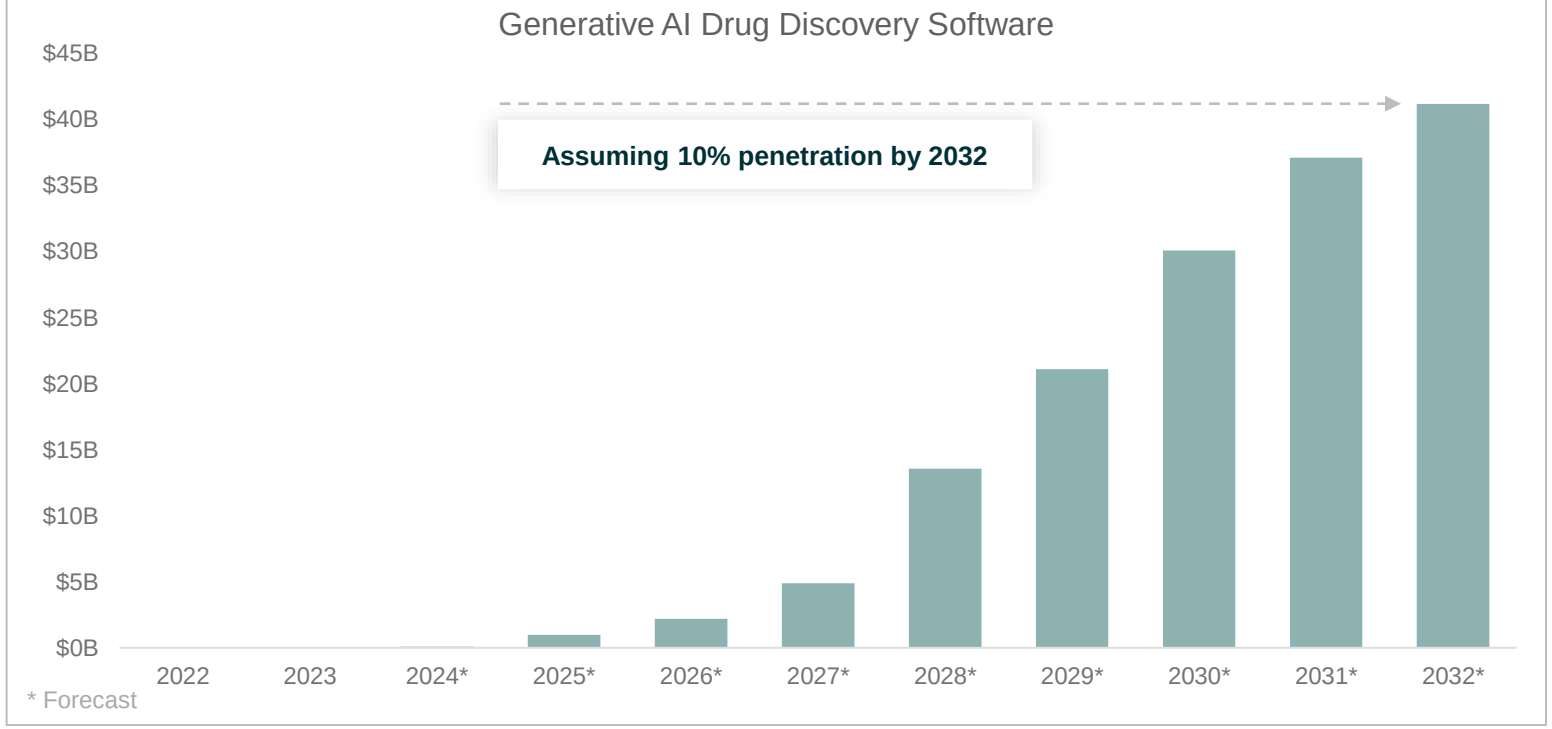
Benefit to AI Drug Discovery Software Providers:
Kickstarting a New Industry

AI-enabled software for drug discovery is expected to be the fastest growing gen-AI segment through 2032, growing at a 121% compound annual growth rate.[4]

Benefit to Tech Industry:
Rallying Behind Healthcare AI

Chip makers are prioritizing healthcare development to meet drug discovery demands. NVIDIA has partnered with hundreds of pharmaceutical and genomic firms, with healthcare now contributing an estimated $1 billion to its annual revenue.[5]

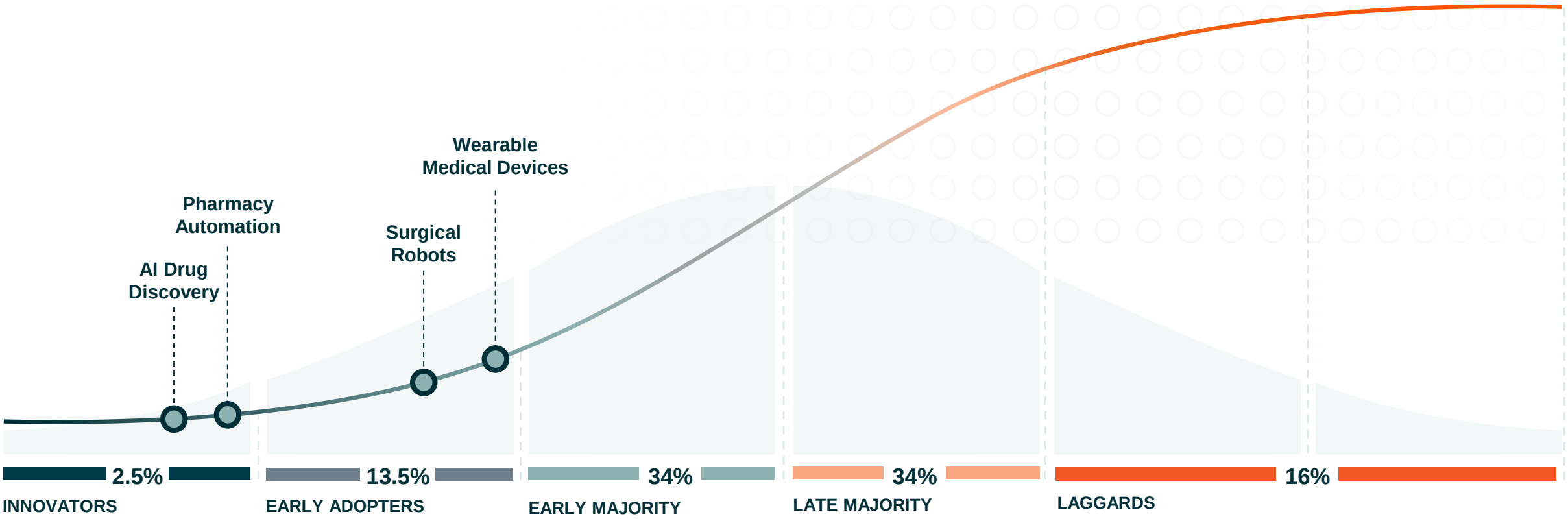
AI Drug Discovery Software Poised to Disrupt the Healthcare Industry



Sources: Text: 1. Bloomberg Intelligence, Aug 2024; 2. Morgan Stanley, Sep 2022; 3.Colangelo, Sep 2019; 4. Bloomberg Intelligence, Aug 2024; 5. NVIDIA, Mar 2024; Chart: Bloomberg Intelligence, Aug 2024.

S-Shaped Curve of Adoption – Tech-Enabled Health

We expect the Health Tech industry to reach $1.1 trillion, up from $286 billion in 2024.



PHASES OF ADOPTION

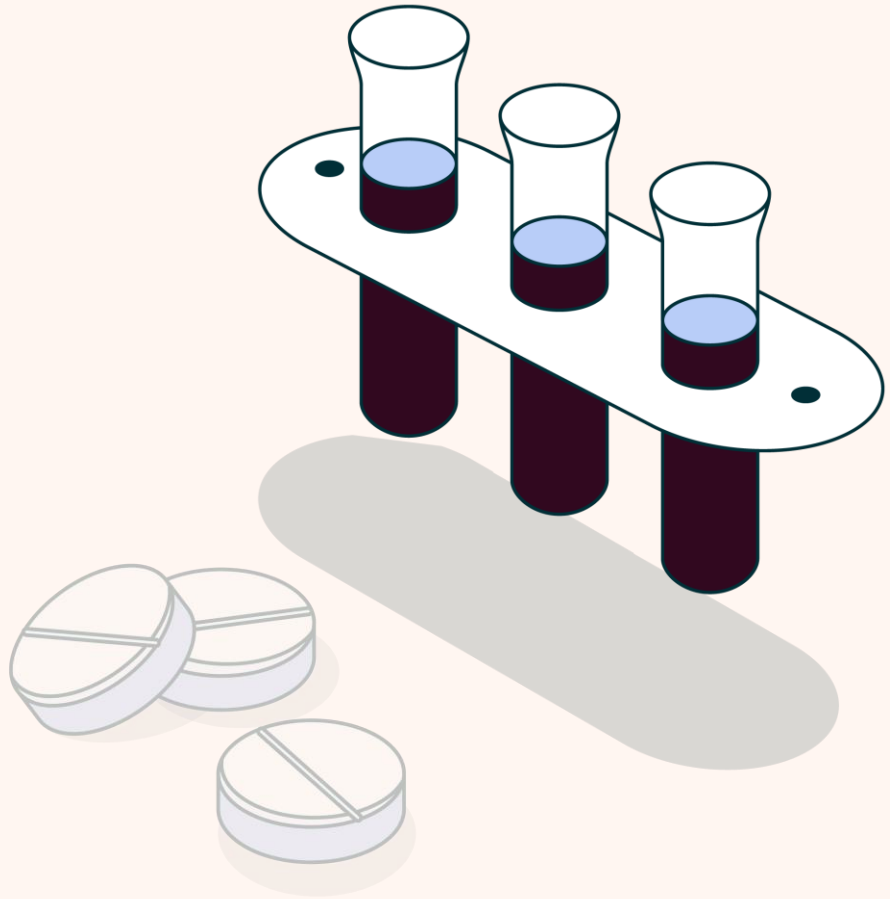
Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Sources: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Grand View Research, 2023a; Grand View Research 2023b; Grand View Research 2024; Insight Partners, 2023; Markets and Markets, May 2022; Markets and Markets Aug 2024; Precedence Research Sep 2024a; Precedence Research Sep 2024b; Statista, Sep 2024.

CHAPTER 3.3

Genomics:
A New Age of Medicine

Genomic technologies have opened the door for a new era of drug discovery. Such advancements are transforming disease management and illness prevention, resulting in superior patient outcomes. Newer genomic treatments, like gene therapies and genomic editing, offer near-cures for highly cumbersome illnesses.



An Arsenal of Investigational Technologies to Combat Illnesses

The pharmaceutical industry now has numerous technologies to address, and potentially cure, common diseases.

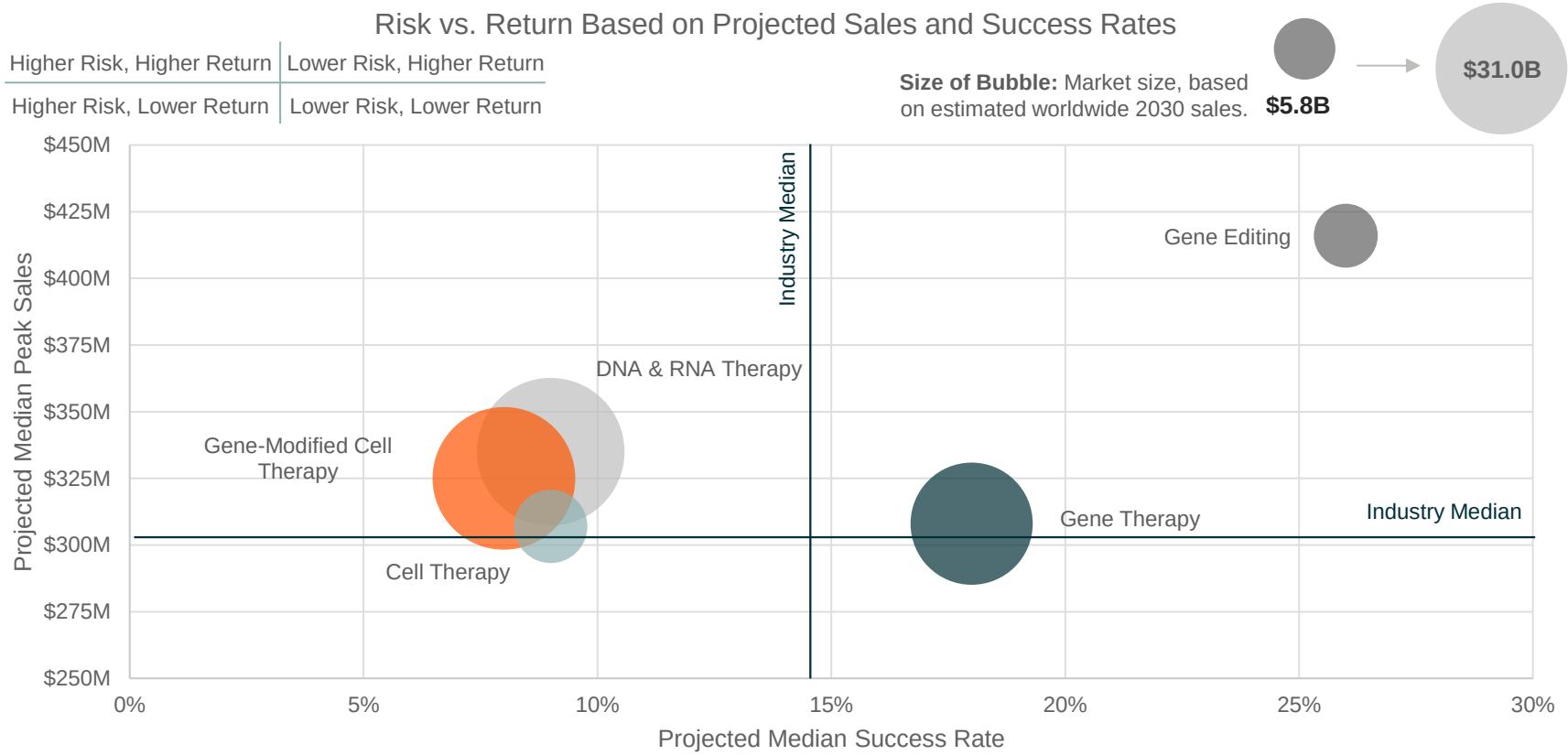
Gene-Modified Cell Therapy: Transplanting genetically modified cells to fight disease.

Gene Therapy: Replacing a defective or missing gene in a patient's cells with a healthy version of that gene.

Cell Therapy: Transplanting healthy human cells to replace or repair damaged tissue and/or cells.

Gene Editing: Editing parts of the genome by removing, adding, or altering sections of DNA.

DNA & RNA Therapy: Providing instructions to the body's RNA for making proteins or turning genes on and off.

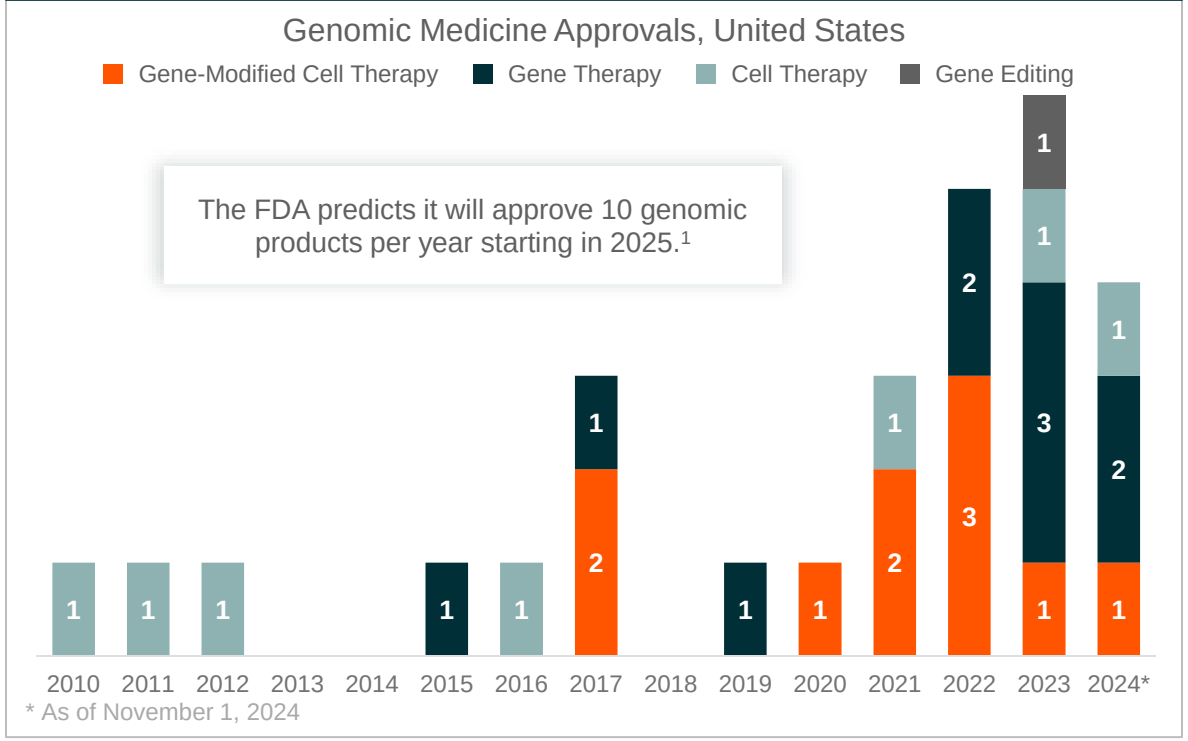


Source: Evaluate Pharma, n.d., accessed on 1 Nov 2024.

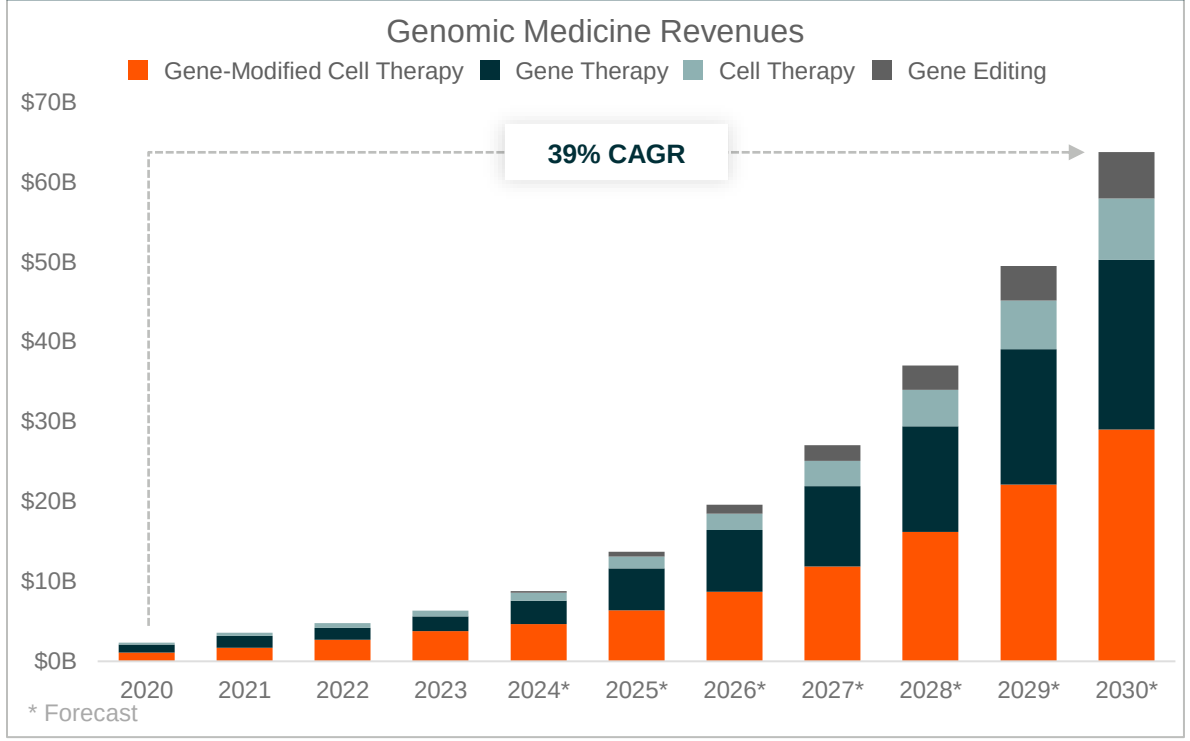
Genomic Medicines: Approvals Provide Runway for Growth

Growing regulatory acceptance is expected to pave the way forward for widespread adoption of genomic medicines.

Approvals Ramping Up: Validating Technology



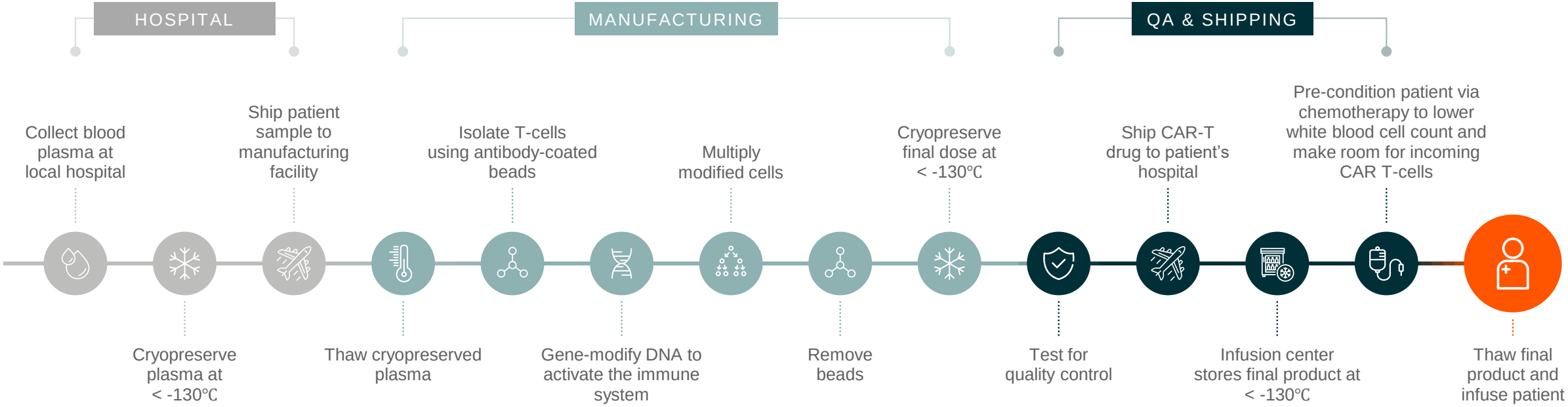
Genomic Medicines Sales Expected to Surge



Sources: Text: FDA, Jan 2019; Charts: LHS: FDA, Aug 2024; RHS: Evaluate Pharma, n.d.a, accessed 1 Nov 2024; Evaluate Pharma, n.d.b, accessed on 1 Nov 2024; Evaluate Pharma, n.d.c, accessed 1 Nov 2024; Evaluate Pharma, n.d.d, accessed 1 Nov 2024.

Manufacturing Is Complicated, but New Models Can Reduce Costs

Manufacturing can take 2-3 weeks for cell therapies and up to 3 months for gene therapies, with input costs ranging from $100,000 to $300,000 per dose.[1,2,3] A donor-derived model could decrease manufacturing costs by 95%.[4]



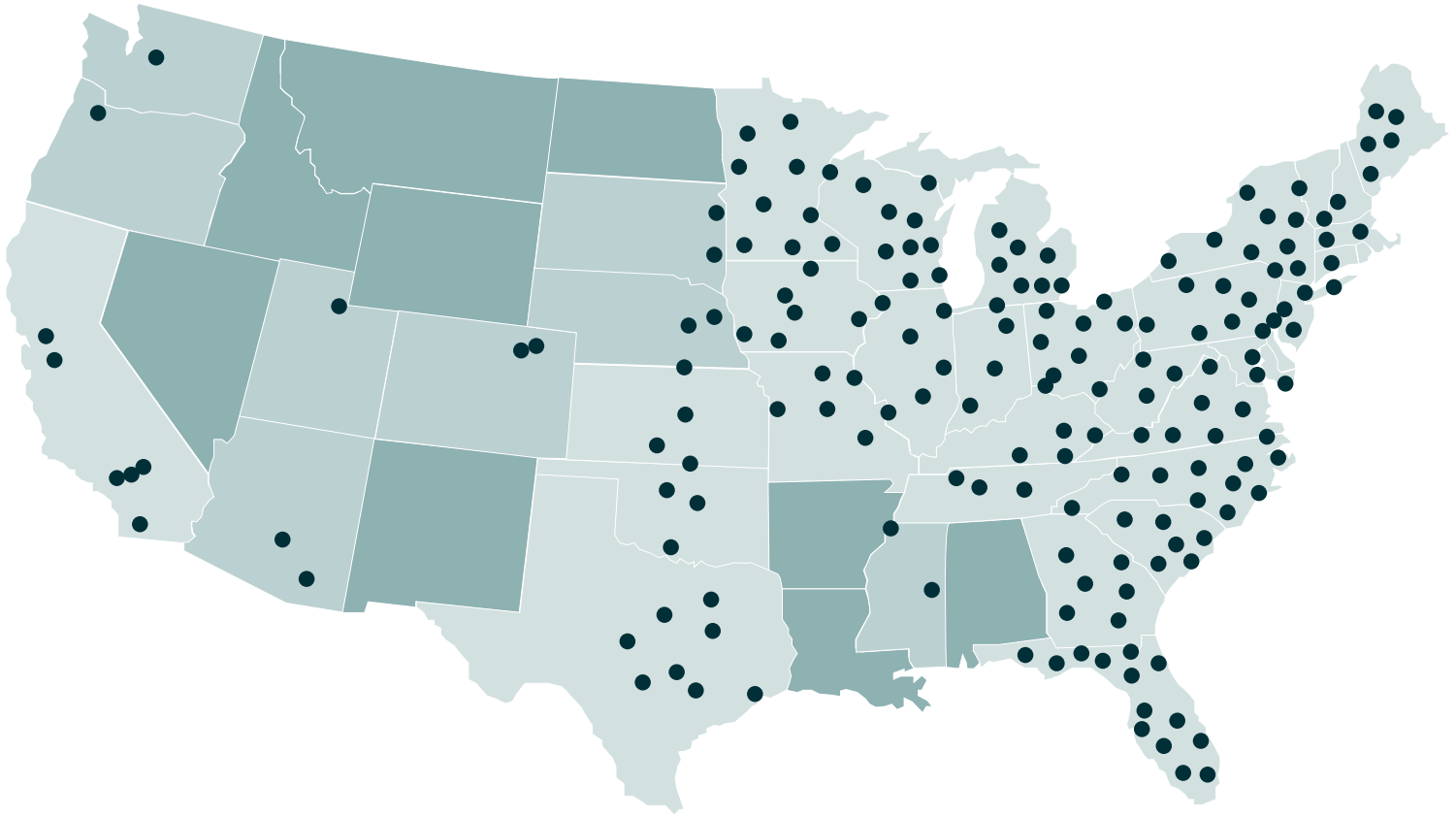
Sources: Text: 1. University of Pittsburgh Medical Center, 2024; 2. Bluebird Bio, Jan 2023; 3. Genetic Engineering & Biotechnology News, Oct 2023; 4. International Society for Cell & Gene Therapy, Feb 2019.

Laying the Foundation: Certified Treatment Centers Essential to Increase Access

A growing network of certified treatment centers brings expert gene therapy care closer to patients while working toward high treatment quality and outcomes.

Novartis' Kymriah Approved Treatment Centers

Kymriah is a CAR-T cell therapy approved in 2017 for the treatment of a common form of leukemia.



Source: Novartis, 2024.

Genomic Medicines Offer Clear Benefits: Foundational Efforts Pave the Way for Next Generation

Most genomic medicines treat illnesses with a very limited alternatives. In illnesses where other treatment options exist, however, studies already show quality of life and economic advantages.

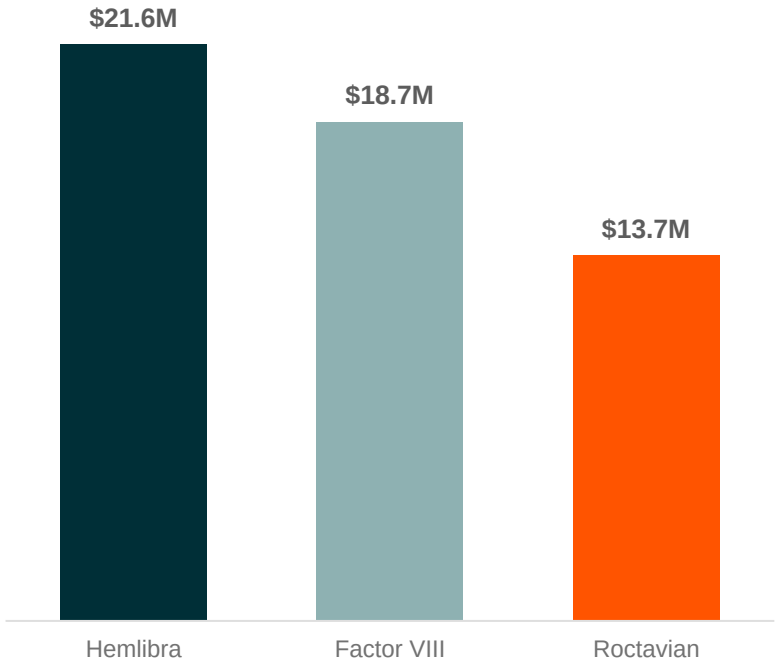
Case Study: Hemophilia A

Hemophilia A is a genetic disorder caused by missing or defective Factor VIII, a clotting protein. This disorder can result in spontaneous bleeding or disproportionate bleeding following an injury.

	Factor VIII	Hemlibra	Roctavian
Therapy Type	Coagulation Protein	Monoclonal Antibody	Gene Therapy
Dosing Form	Infusion	Injection	Infusion
Doing Frequency	3-4 times per week	Once weekly	Once
Cost	$265,000[1]	$482,000[2]	$2,500,000[3]
Lifetime Cost of Care	$18.7M[4]	$21.6M[5]	$13.7M[6]

The infrequency of administration compared to alternative treatments awards Roctavian significant lifetime cost-of-care savings up to $7.9 million.[7]

Lifetime Cost of Care: Hemophilia A



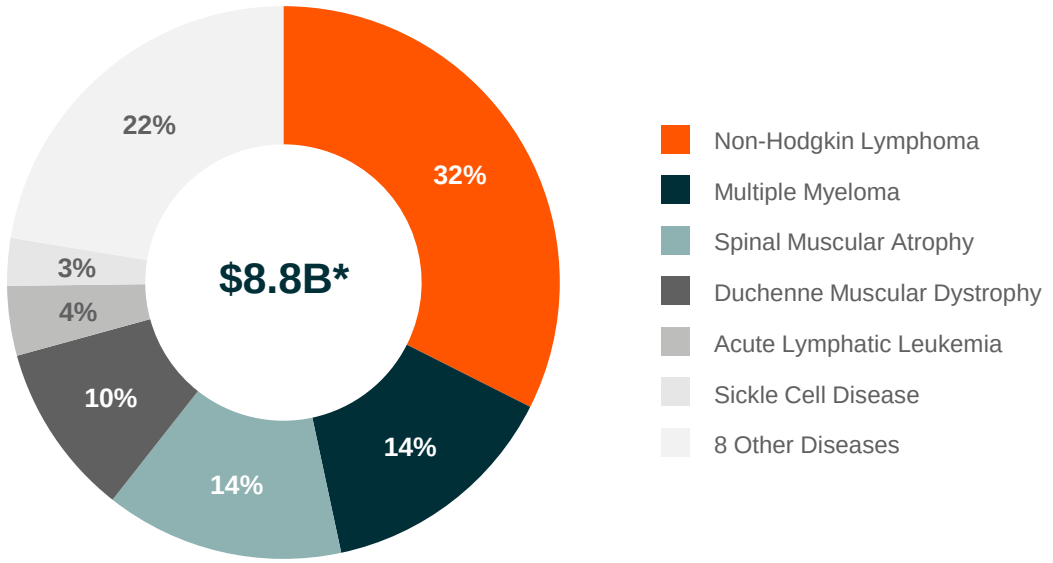
Sources: 1. National Institute of Health, March 2021. 2. Fierce Healthcare, 2018. 3. Bloomberg Intelligence, 2023. 4. National Institute of Health, May 2021. 5. Ibid. 6. Ibid. 7. Ibid. Chart: National Institute of Health, May 2021.

Genomic Medicine's Reach Is Currently Limited, but Development Points to Expanded Scope

Development of genomic medicines has primarily centered around blood-based illnesses and rare diseases. With growing regulatory acceptance, the industry now looks to expand the technology's reach to larger patient pools.

Currently, High Concentration in Small Group of Diseases

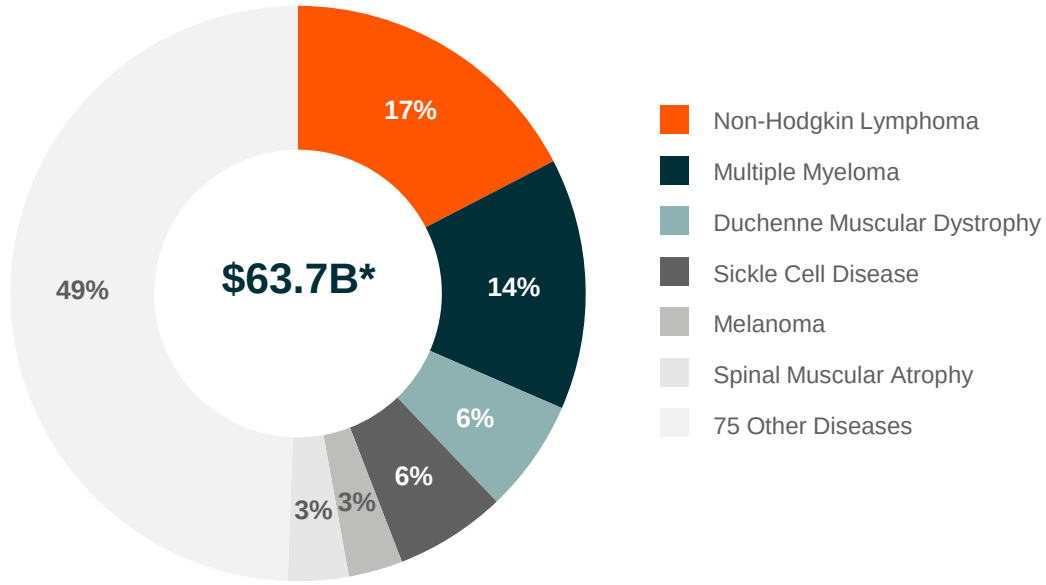
2024 Genomic Medicine Revenue by Illness



* Forecast

Moving Forward, Greater Importance on New Illnesses

2030 Genomic Medicine Revenue by Illness

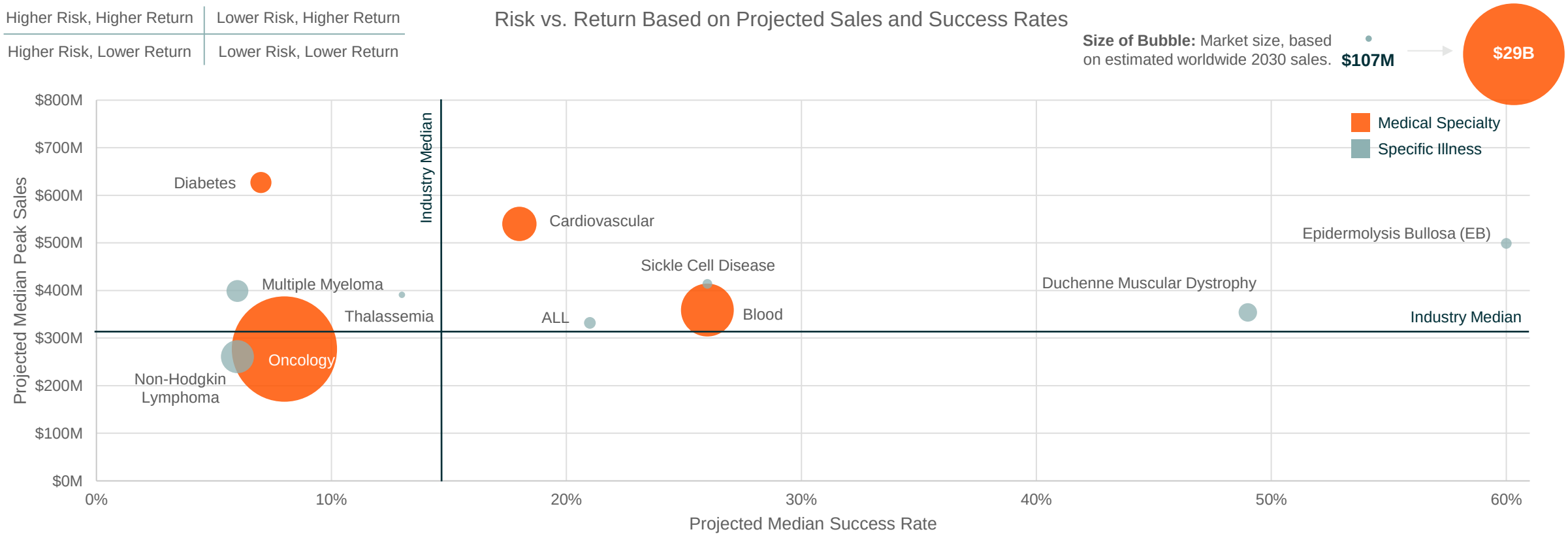


* Forecast

Sources: Charts: Evaluate Pharma, n.d.a, accessed 1 Nov 2024; Evaluate Pharma, n.d.b, accessed on 1 Nov 2024; Evaluate Pharma, n.d.c, accessed on 1 Nov 2024; Evaluate Pharma, n.d.d, accessed on 1 Nov 2024; Evaluate Pharma, n.d.e, accessed on 1 Nov 2024.

Next Frontier of Innovation: Expanding Genomic Medicines' Impact

With growing regulatory acceptance and proven efficacy data, the industry is now focused on bringing genomics to other common illnesses.

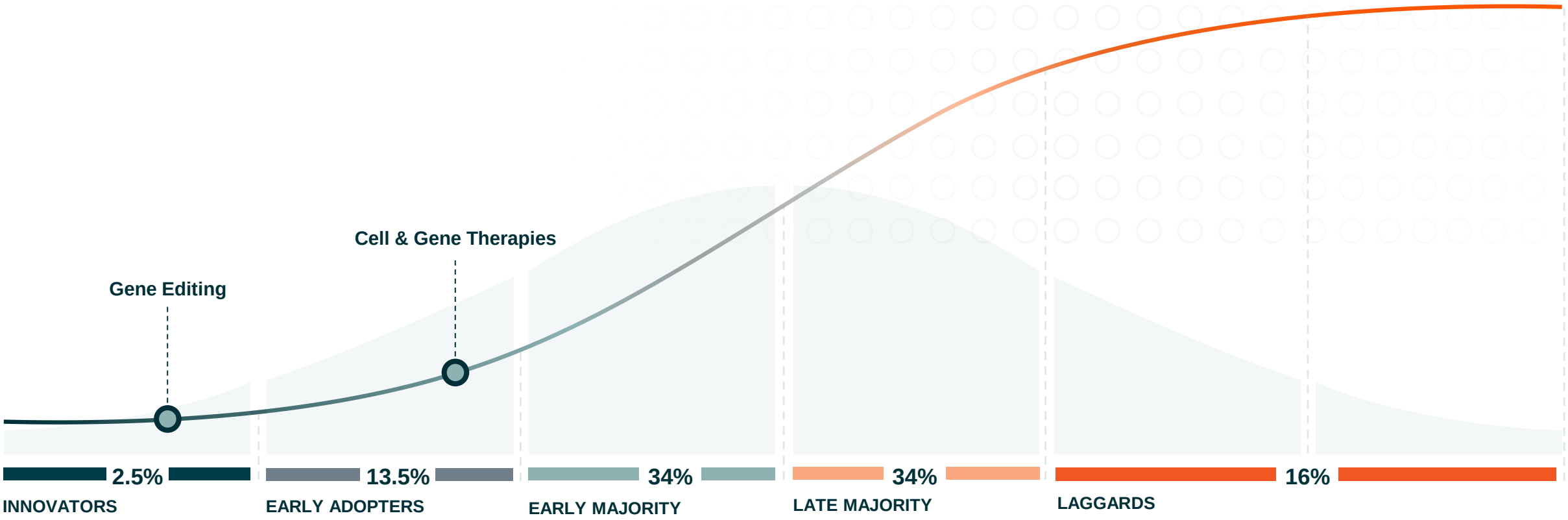


Note: ALL = Acute Lymphatic Leukemia

Sources: Evaluate Pharma, n.d.a, accessed on 1 Nov 2024; Evaluate Pharma, n.d.b, accessed on 1 Nov 2024.

S-Shaped Curve of Adoption – Genomics

We expect genomic medicines to comprise 6.5% of the $1.47 trillion pharmaceutical market in 2030, up from 1.6% of the $927 billion market in 2024.



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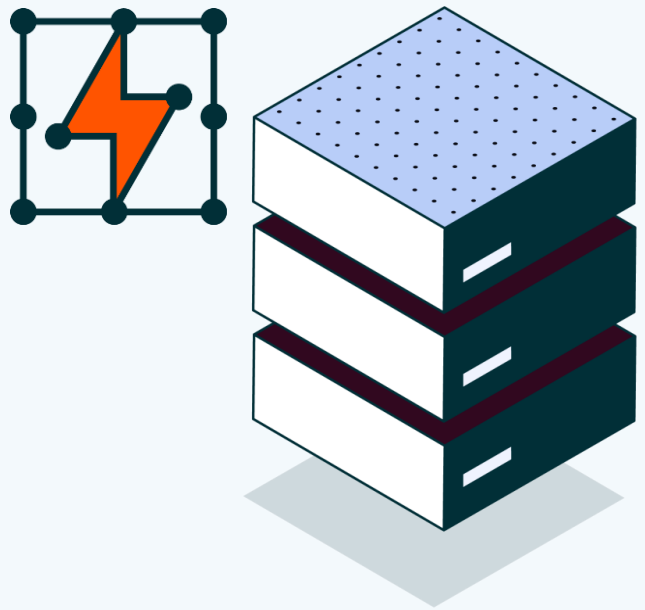
Sources: Evaluate Pharma, n.d.a, n.d.b, n.d.c, n.d.d, n.d.e, n.d.f, accessed on 1 Nov 2024.

CHARTING DISRUPTION 2025

Appendix: AI Infrastructure



AI Infrastructure: Sources

AI Poised to Increase Productivity at a Greater Rate Than the Internet Since Inception
- Bloomberg, L.P. (n.d.). Financial Data. Data as of November 19, 2024.
- FRED Economic Data. (2024, September 5). Nonfarm Business Sector: Labor Productivity (Output per Hour) for All Workers. Federal Reserve Bank of St. Louis.
- Seydl, J., & Linden, J. (2024, 16 July). How AI Can Boost Productivity and Jump Start Growth. JP Morgan.

AI Investment: The CapEx Race Is On to Build the Infrastructure that AI Needs, Led by Big Tech

Text
- Kindig, B. (2024, August 8). Big Tech Battles on AI, Here's the Winner. Forbes.

Charts
- Bloomberg, L.P. (n.d.). AMZN, GOOGL, MSFT, META Financial Data. Data as of November 1, 2024.
- FactSet. (n.d.). AMZN, GOOGL, MSFT, META Financial Data. Data accessed on November 1, 2024.
- Hui, C. (2024, July 15). Opinion: 'The S&P 500 Is an Accident Waiting to Happen' — But It Could Be a Long Wait. MarketWatch.

AI Investment: Infrastructure Spending Set to Benefit a Broad Data Center Ecosystem
- Flaningam, E. (2024, February 4). A Primer on Data Centers. Public Comps.

Custom ASICs and AI Inferencing Chips Expected to Boost AI Server Market Alongside GPUs

Text
- Boughedda, S. (2024, June 6). Broadcom Has Recently Won Google's Next-Gen AI ASIC Chip Design: JP Morgan. Investing.com.

Charts
- Janukowicz, J., Rau, S., Soo, K. K., Burns, E., & Hoff, B. (2024, February). Outlook for AI Semiconductors and Storage Components in IT Infrastructure. International Data Corporation (IDC).
- Morgan, T. P. (2024, July 15). Ongoing Saga: How Much Money Will Be Spent on AI Chips? The Next Platform.

Modern GPU Clusters Require Specialized Networking, Storage, and Power Systems
- Bloomberg. (2024, March 21). Broadcom's AI Investor Day Takeaways [Company News].
- Ceylan, B. (2024, March 14). GPU Cluster: Key Things to Know & 5 Use Cases. AI Multiple Research.

AI Investment: Record U.S. Data Center Construction Activity Already Spurred by AI Demand

Text
- Synergy Research Group. (2024, April 17). Hyperscale Data Centers Hit the Thousand Mark; Total Capacity Is Doubling Every Four Years.

Charts
- CBRE Group, Inc. (2024, March 7). CBRE Report: North American Data Center Pricing Nears Record Highs, Driven by Strong Demand and Limited Availability.
- Synergy Research Group. (2024, April 17). Hyperscale Data Centers Hit Thousand Mark; Total Capacity Is Doubling Every Four Years.

AI Investment: Rising Demand and Capacity Crunch Have Existing Data Centers Priced at Premiums

Text
- CBRE. (2024, August 19). North America Data Center Trends H1 2024: Cloud & AI Providers Drive Demand.
- Sunbird. (2024, June 21). Colo Vacancy Rates Near Record Low: What Can You Do?

Charts
- CBRE. (2024, August 19). North America Data Center Trends H1 2024: Cloud & AI Providers Drive Demand.

AI Infrastructure: Sources

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Text

- CBRE. (2024, August 19). North America Data Center Trends H1 2024: Cloud & AI Providers Drive Demand.
- Sunbird. (2024, June 21). Colo Vacancy Rates Near Record Low: What Can You Do?

Charts

- CBRE. (2024, August 19). North America Data Center Trends H1 2024: Cloud & AI Providers Drive Demand.

AI Investment: Data Center REITs Leverage Scale Advantages, Deliver Strong Market Performance

Text

- Nareit. (2024). Annual Index Values & Returns: Complete History of Annual Returns by Investment Sector and Property Sector. Accessed on October 23, 2024.
- Slickcharts. (2024). S&P 500 Total Returns. Accessed on October 23, 2024.

Charts

- Nareit. (2024). Annual Index Values & Returns: Complete History of Annual Returns by Investment Sector and Property Sector. Accessed on October 23, 2024.
- Slickcharts. (2024). S&P 500 Total Returns. Accessed on October 23, 2024.

Energy Needs: Growing Data Center Footprint Impacts Global Energy Demand and Supply Dynamic

Text

- Anderson, J. (2024, April 1). Utilities Face Challenges, Opportunities from AI-Driven Data Center Power Demand Growth: Report. S&P Global.
- Goldman Sachs. (2024, May 14). AI Is Poised to Drive 160% Increase in Data Center Power Demand.

Charts

- Enerdata. (2024). Electricity domestic consumption. Accessed on October 25, 2024.
- Energy Central. (2024, June 25). The U.S. Data Center Energy Train Wreck.
- Goldman Sachs. (2024, May 14). AI Is Poised to Drive 160% Increase in Data Center Power Demand.

U.S. Data Center Capacity Is Expected to Grow to 35 Gigawatts (GW) by 2030

Text

- Gooding, M. (2024, January 15). Newmark: US Data Center Power Consumption to Double by 2030. Data Center Dynamics.

Charts

- Howland, E. (2024, May 24). US Power Demand Expected to Jump 2.7% This Summer, Plus 5 Other Takeaways from FERC's Open Meeting. Utility Dive.
- The Goldman Sachs Group, Inc. (2024, April 28). Generational Growth: AI, Data Centers and the Coming US Power Demand Surge.

Tech Giants Tap Nuclear Power for Growing Data Center Power Demands

- Butler, J. (2023, August 15). Green Energy Partners Partners with Nuclear Power Provider IP3 for Virginia Project. Data Centre Dynamics.
- Judge, P. (2023, June 30). Microsoft Signs 24/7 Nuclear Power Deal with Constellation for Boydton Data Center. Data Centre Dynamics.
- Nuclear News. (2024, March 7). Amazon Buys Nuclear-Powered Data Center from Talen.
- Purcell, T., & Engage, L. (2024, June 13). Amazon Provides Details for Lake Anna Tech Campus. Lake Anna Life.

AI Infrastructure: Sources

Energy Needs: Liquid Cooling and Power Management Essential to Handle Accelerated Computing

Text

- Flaningam, E. (2024, February 4). A Primer on Data Centers. Public Comps.
- Wanner-Thavornsuk, J., & Kehrein, P. (2024, June 17). Data Center Clouds Could Rain Revenue for Water Companies. Robeco.

Charts

- Global Market Insights. (2024, April). Data Center Cooling Market - By Component (Solution, Service), By Cooling Technique (Rack/Row-Based, Room-Based), By End Use (BFSI, Colocation, Energy, Government, Healthcare, Manufacturing, IT & Telecom), by Data Center Size, Forecast 2024 – 2032: Report ID: GMI423.
- Wanner-Thavornsuk, J., & Kehrein, P. (2024, June 17). Data Center Clouds Could Rain Revenue for Water Companies. Robeco.

Beyond Data Centers: Demand for Accelerated Computing Likely to Extend Beyond Generative AI

- Morgan, T. P. (2023, October 13). Everyone Is Chasing What Nvidia Already Has. The Next Platform.

Beyond Data Centers: Infrastructure Between Data Centers and End Users Critical for Adoption of AI

- Moniem Tech. (2021, June 8). Simplified Architecture for a Cellular Network.

Deployment of Macro and Small Cell Towers Likely to Accelerate Due to AI-Driven Traffic

- Ruby, D. (2024, January 19). 69 Mobile Internet Traffic Statistics for 2024 (Worldwide Usage). DemandSage.
- Taylor, P. (2024, July 8), Number of Telecom Towers in the U.S. as of 2024, by Company. Statista.
- Wireless Estimator. (2024, October 4). Top 100 Tower Companies in the U.S.

Beyond Data Centers: Dominant U.S. Cell Tower Operators Display Attractive Financials

- Bloomberg L.P. (n.d.). AMT, CCI, SBAC Company Financial Data. Data as of October 30, 2024.
- Wireless Estimator. (2024, October 4). Top 100 Tower Companies in the U.S.

Beyond Data Centers: AI Could Spur Personal Device Upgrade Cycle and Boost Smartphone Sales

Text

- Solis, P., Ma, B., Mainelli, T., & Reith, R. (2024, February 19). The Future of Next-Gen AI Smartphones. International Data Corporation (IDC).

Charts

- Laricchia, F. (2024, May 17). Active Apply iPhone Smartphone Units Globally 2008-2023. Statista.
- Solis, P., Ma, B., Mainelli, T., & Reith, R. (2024, February 19). The Future of Next-Gen AI Smartphones. International Data Corporation (IDC).

Beyond Data Centers: Edge AI Extends to IoT and the Broader Installed Base of Connected Devices

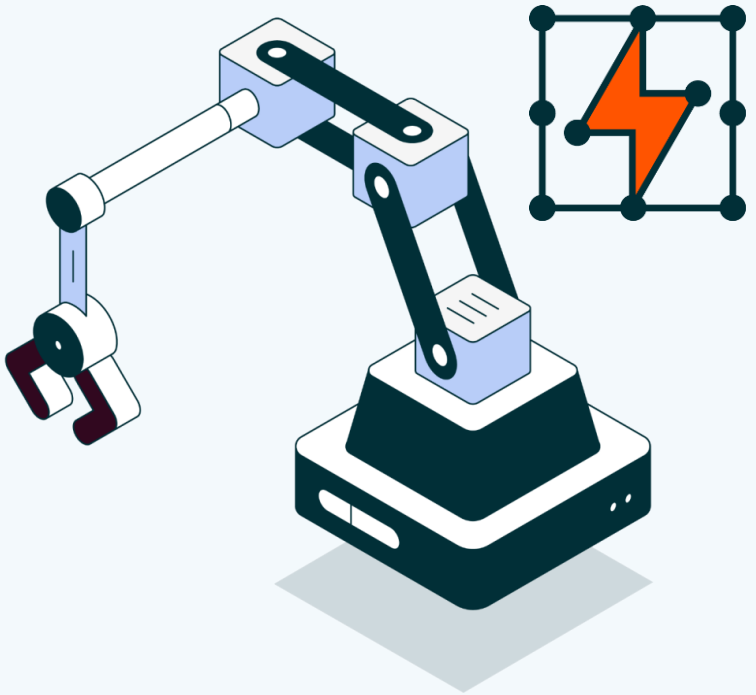
- Ericsson. (n.d.). Ericsson Mobility Visualizer. Accessed on July 1, 2024.
- Lamboley, L. (2024, January 19). 27 Remote Patient Monitoring Statistics Every Practice Should Know. Prevounce.

S-Shaped Curve of Adoption – AI Infrastructure

- Bloomberg Intelligence. (2024, March 8). Generative AI Races Toward $1.3 Trillion in Revenue by 2032.

CHARTING DISRUPTION 2025

Appendix: Robotics



Robotics: Sources

Robotics: Breakthroughs in Automation

- Fukuda, T., Dario, P., & Yang, G-Z. (2017, December 20). Humanoid Robotics – History, Current State of the Art, and Challenges. Science Robotics: Volume 2, Issue 13.
- Goldman Sachs. (2022, November 15). Humanoid Robots: Sooner Than You Might Think.
- Macquarie. (2023, February 23). Are We Turning a Corner on the Humanoid Robot Age?
- The Feed. (2024, January 22). Elon Musk Expects 1 Billion Humanoid Robots by 2040s. The Economic Times.

Robotic Adoption: North American Industrial Robot Sales Jump as Manufacturing Enters a New Era

- IFR Press Room. (2024, April 30). U.S. Companies Invest Heavily in Robots - IFR Preliminary Results. International Federation of Robotics (IFR).

Robotic Automation Is Key to Staying Competitive

- Klump, R., Jurkat, A., & Schneider, F. (2021, November 1). Tracking the Rise of Robots: A Survey of the IFR Database and Its Applications. MPR A Paper No. 110390. Goethe University, Frankfurt.
- Trading Economics. (2024). United States Average Hourly Wages in Manufacturing.

Robotic Adoption: AI Enhancements Boost Momentum for Robotics in the Service Industry

Text

- Gurman, M. (2024, April 3). Apple Explores Home Robotics as Potential 'Next Big Thing' After Car Fizzles. Bloomberg.
- Retail Insight Network. (2023, October 25). Amazon to Begin Testing Agility's Bipedal Robot, Digit.
- Statista. (2024, March). Service Robotics – Worldwide.
- Whooley, S. (2024, June 6). Intuitive Earns Updated FDA Labeling on da Vinci X, Xi, for Radical Prostatectomy. The Robot Report.

Charts

- IFR Pressroom. (2022, October 26). Sales of Robots for the Service Sector Grew by 37% Worldwide.
- Statista. (2024, March). Service Robotics – Worldwide.

Consumer-Grade Humanoids Expected to Deliver the Next Robotics Breakthrough

- Fukuda, T., Dario, P., & Yang, G-Z. (2017, December 20). Humanoid Robotics – History, Current State of the Art, and Challenges. Science Robotics: Volume 2, Issue 13.
- Goldman Sachs. (2022, November 15). Humanoid Robots: Sooner Than You Might Think.
- Macquarie. (2023, February 23). Are We Turning a Corner on the Humanoid Robot Age?
- The Feed. (2024, January 22). Elon Musk Expects 1 Billion Humanoid Robots by 2040s. The Economic Times.

Humanoid Integration Could Mirror Early Automobile Adoption, with Similar Market Potential

Text

- Islam, O. (2024, August 9). The Economics of Humanoid Robot Production: Future Trends and Challenges. Robozaps.
- Whisbi Marketing Team. (2022, February 1). The History of Car Sales. Whisbi.

Charts

- Fukuda, T., Dario, P., & Yang, G-Z. (2017, December 20). Humanoid Robotics – History, Current State of the Art, and Challenges. Science Robotics: Volume 2, Issue 13.
- Goldman Sachs. (2022, November 15). Humanoid Robots: Sooner Than You Might Think.
- Mende, M., Scott, M. L., van Doorn, J., Grewal, D., & Shanks, I. (2019, April 22). Service Robots Rising: How Humanoid Robots Influence Service Experiences and Elicit Compensatory Consumer Responses. Journal of Marketing Research: Volume 56, Issue 4, pp. 535-556.
- The Feed. (2024, January 22). Elon Musk Expects 1 Billion Humanoid Robots by 2040s. The Economic Times.

Robotics: Sources

Humanoid Integration Could Mirror Early Automobile Adoption, With Similar Market Potential (continued)

Charts

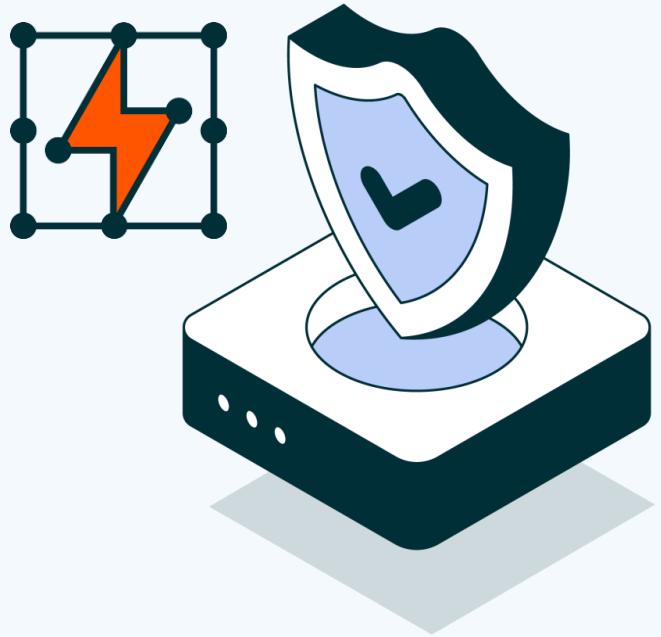
- Van der List, B. (2023, August 15). Boston Dynamics Wants to Change the World with Its State-of-the-Art Robots. Strategy + Business.
- Whisbi Marketing Team. (2022, February 1). The History of Car Sales. Whisbi.

S-Shaped Curve of Adoption – Robotics

- Islam, O. (2024, August 9). The Economics of Humanoid Robot Production: Future Trends and Challenges. Robozaps.

CHARTING DISRUPTION 2025

Appendix: Defense Technology



Defense Technology: Sources

Defense Technology: Shield of Innovation
- Stockholm International Peace Research Institute (SIPRI). (2024, April 22). Global Military Spending Surges Amid War, Rising Tensions and Insecurity.

Defense Spending: Mapping Global Conflicts and Military Expenditures

Text
- Center for Preventative Action. (n.d.). Global Conflict Tracker. Council on Foreign Relations. Accessed on October 24, 2024.
- Dyvik, E. H. (2024, July 4). Countries with the Highest Military Spending 2023. Statista.

Charts
- Center for Preventative Action. (n.d.). Global Conflict Tracker. Council on Foreign Relations. Accessed on October 24, 2024.
- Dyvik, E. H. (2024, July 4). Countries with the Highest Military Spending 2023. Statista.

Defense Spending Worldwide Adds Up to Trillions of Dollars

Text
- Stockholm International Peace Research Institute (SIPRI). (2024, April 22). Global Military Spending Surges Amid War, Rising Tensions and Insecurity.

Charts
- Stockholm International Peace Research Institute (SIPRI). (2024, April 22). Global Military Spending Surges Amid War, Rising Tensions and Insecurity.

Defense Spending: Emerging U.S. Military and Defense Initiatives Spur Increase

Text
- Congressional Budget Office. (2022, May 25). The Budget and Economic Outlook: 2022 to 2032.
- Rainey, M. (2023, May 30). What's in the Fiscal Responsibility Act of 2023. The Fiscal Times.

Charts
- Congressional Budget Office. (2022, May 25). The Budget and Economic Outlook: 2022 to 2032.

Defense Spending: North Atlantic Treaty Organization (NATO) Allies Pledge to Invest 2% of GDP

Text
- North Atlantic Treaty Organization (NATO). (2024, July 26). Funding NATO.

Charts
- North Atlantic Treaty Organization (NATO). (2024, June 17). Defence Expenditure of NATO Countries (2014-2024).

Intensifying Defense Investments and Commitments Is a Global Phenomenon

Text
- Dotson, J. (2023, September 20). Taiwan Announces an Increased Defense Budget for 2024. Global Taiwan Institute.
- Tian, N., da Dilva, D. L., Liang, X., & Scaarazzato, L. (2024, April). Trends in World Military Expenditure, 2023. Stockholm International Peace Research Institute (SIPRI).

Charts
- Dotson, J. (2023, September 20). Taiwan Announces an Increased Defense Budget for 2024. Global Taiwan Institute.
- Tian, N., da Dilva, D. L., Liang, X., & Scaarazzato, L. (2024, April). Trends in World Military Expenditure, 2023. Stockholm International Peace Research Institute (SIPRI).

Defense Technology: Sources

Defense Spending: Growth Expected to Help Digital Solutions and Cybersecurity Investments

- Congressional Budget Office. (2024, June 18). An Update to the Budget and Economic Outlook: 2024 to 2034.
- Cost Assessment and Program Evaluation (CAPE) in the Office of the Secretary of Defense (OSD). (2023, May). Department of Defense Information Technology and Cyberspace Activities Budget Overview: President's Budget (PB) 2024 Budget Request. U.S. Department of Defense.
- GovWin IQ. (2024, May 8). Defense IT and Cyberspace Activities FY 2025 Budget Highlights.

AI Also Poised to Emerge as Beneficiary of Growing Defense Tech Spend

- Precedence Research. (2023, July 6). Artificial Intelligence in Military Market Size to Rise USD 22.62 Bn by 2032.
- Reilly, B. (2024, March 5). Pentagon's Priority on AI spending Could Shield It from Cuts. Roll Call.

Unmanned Aerial Systems and Drones Potentially Change the Economics of War

- Reguly, E. (2024, February 9). How Cheap Drones Are Transforming Ukraine's War Against Russia. The Globe and Mail.
- Zafra, M., Hunder, M., Rao, A., & Kiyada, S. (2024, March 26). How Drone Combat in Ukraine Is Changing Combat. Reuters.

Spending on Drones and Autonomous Aerial Vehicles Expected to Grow at a 13% CAGR

Text

- AeroVironment. (2024, June 26). AeroVironment Announces Fiscal 2024 Fourth Quarter and Fiscal Year Results.
- Fortune Business Insights. (2024, October 14). Military Drone Market Size, Share & Russia-Ukraine War Impact Analysis, By Product Type (Fixed Wing, Hybrid & Rotary Wing), By Range (Visual Line of Sight, Extended Visual Line of Sight,& Beyond Line of Sight), By Technology (Remotely Operated Drones, Semi-Autonomous Drones, Autonomous Drones), By System (Airframe, Avionics, Propulsion, Payload, Software), By Application (Intelligence, Surveillance Reconnaissance,& Targeting, Combat Operations, Battle Damage Management), & Regional Forecast, 2024-2032. Report ID: FBI102181.

Charts

- AeroVironment. (2024, June 26). AeroVironment Announces Fiscal 2024 Fourth Quarter and Fiscal Year Results.
- Fortune Business Insights. (2024, October 14). Military Drone Market Size, Share & Russia-Ukraine War Impact Analysis, By Product Type (Fixed Wing, Hybrid & Rotary Wing), By Range (Visual Line of Sight, Extended Visual Line of Sight,& Beyond Line of Sight), By Technology (Remotely Operated Drones, Semi-Autonomous Drones, Autonomous Drones), By System (Airframe, Avionics, Propulsion, Payload, Software), By Application (Intelligence, Surveillance Reconnaissance,& Targeting, Combat Operations, Battle Damage Management), & Regional Forecast, 2024-2032. Report ID: FBI102181.

Autonomous Robotic Combat Vehicles Set to Revolutionize Ground Operations

Text

- Congressional Research Service. (2024, July 23). The Army's Robotic Combat Vehicle (RCV) Program. IF11876 · VERSION 12 – Updated.
- Defence IQ. (2024, January). Armoured Vehicles Global Market Report 2024-2028. International Armoured Vehicles.

Charts

- Defence IQ. (2024, January). Armoured Vehicles Global Market Report 2024-2028. International Armoured Vehicles.

Defense Provides a Target Market for Software Companies as Capabilities Expand

Text

- Cost Assessment and Program Evaluation (CAPE) in the Office of the Secretary of Defense (OSD). (2023, May). Department of Defense Information Technology and Cyberspace Activities Budget Overview: President's Budget (PB) 2024 Budget Request. U.S. Department of Defense.
- Palantir Investor Relations. (2024, February 5). Palantir Reports Its Fifth Consecutive Quarter of GAAP Profitability; Fourth Quarter GAAP EPS of $0.04. Palantir.

Defense Technology: Sources

Defense Provides a Target Market for Software Companies as Capabilities Expand (continued)

Charts

- Companies Market Cap (n.d). Palantir. Accessed on August 22, 2024.
- Cost Assessment and Program Evaluation (CAPE) in the Office of the Secretary of Defense (OSD). (2023, May). Department of Defense Information Technology and Cyberspace Activities Budget Overview: President's Budget (PB) 2024 Budget Request. U.S. Department of Defense.
- Palantir Investor Relations. (2024, February 5). Palantir Reports Its Fifth Consecutive Quarter of GAAP Profitability; Fourth Quarter GAAP EPS of $0.04. Palantir.

Government Cybersecurity Investments Prioritize Safeguarding Critical State Infrastructure

Text

- Burgan, C. (2024, March 11). Biden's FY25 Budget: $13B for Cyber; CISA Gets $103M Increase, TMF Sees $125M Cut. MeriTalk.
- Curran, J. (2023, April 25). Fed CISO Pegs FY24 Zero Trust Spending Bid Near $12B, Worried About Cuts. MeriTalk.
- Cybersecurity & Infrastructure Security Agency (CISA). (2024). State and Local Cybersecurity Grant Program.
- Demarest, C. (2024, March 11). Pentagon Seeks $14.5 Billion for Cyber Spending Including Zero Trust. C4ISRNET.
- Lopez, C. T. (2022, November 28). DOD Releases Path to Cyber Security Through Zero Trust Architecture. U.S. Department of Defense.
- Silk, T. (2023, September 29). Maximizing the Proposed Fiscal 2024 Budget Starts with Zero Trust. Federal News Network.

Charts

- Degges, I. (2024, April 1). A Look Into Key Policies & Strategies Shaping US Cybersecurity Efforts. GovCon Wire.
- Hill, M. (2022, September 29). 22 Notable Government Cybersecurity Initiatives in 2022. CSO.
- Zandt, F. (2024, March 26). The Sectors Most Targeted by Cybercrime. Statista.

Cybersecurity Leaders Offer Stickier Growth and Better Operating Profile Than Broader Cloud

- Meritech Capital. (n.d.). Meritech SaaS Index. Accessed on August 20, 2024.

Software Growth Likely to Increase Cybersecurity Spending by Over 2x to $437 Billion by 2030

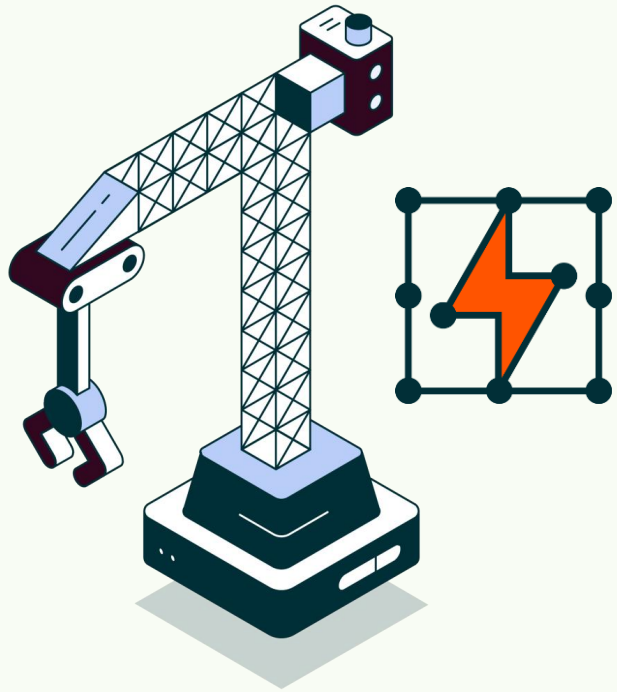
- Gartner. (2024, August 28). Gartner Forecasts Global Information Security Spending to Grow 15% in 2025.

S-Shaped Curve of Adoption – Defense Technology

- Stockholm International Peace Research Institute (SIPRI). (2024, April 22). Global Military Spending Surges Amid War, Rising Tensions and Insecurity.

CHARTING DISRUPTION 2025

Appendix: Infrastructure



Infrastructure: Sources

Infrastructure Development: At the Center of Several Structural Forces
- Brookfield. (2024, June 17). Why Infrastructure Is a Compelling Investment for All Cycles.

Climate Change: Extreme Weather Events Pose Significant Risks to Global Infrastructure

Text
- Nuccitelli, D. (2024, October 9). Climate change made Hurricane Helene and other 2024 disasters more damaging, scientists find. Yale Climate Connections.
- Organisation for Economic Co-operation and Development (OECD). (2024, April 9). Infrastructure for a Climate-Resilient Future.
- Tandon, A. (2023, August 22). Eastern Canada Wildfires: Climate Change Doubled Likelihood of 'Extreme Fire Weather'. Carbon Brief.
- Tandon, A. (2024, March 21). Climate Change Made West Africa's 'Danger Humid Heatwave' 10 Times More Likely. Carbon Brief.
- World Weather Attribution. (2024, September 25). Climate Change and High Exposure Increased Costs and Disruption to Lives and Livelihoods from Flooding Associated with Exceptionally Heavy Rainfall in Central Europe.

Charts
- Charlton, E. (2023, November 29). This Is What the Climate Crisis Is Costing Economies Around the World. World Economic Forum.

Electrification of Power and Transport: Significant Grid Investments Are Required

Text
- Farhat, E., Savic, M., MacDonald, F., & Chediak, M. (2024, July 14). The World's Power Grids Are Failing as the Planet Warms. BloombergNEF.

Charts
- Farhat, E., Savic, M., MacDonald, F., & Chediak, M. (2024, July 14). The World's Power Grids Are Failing as the Planet Warms. BloombergNEF.

Disruptive Technologies: Infrastructure Investment Needed to Support Expected Growth Rates
- International Energy Association (IEA). (2024, April 23). Global EV Outlook 2024: Outlook for Electric Vehicle Charging Infrastructure.
- Szlezak, W., & Peisch, A. (2024, February). Data Centers: The Hubs of Digital Infrastructure. Kohlberg, Kravis, Roberts, & Co. L.P. (KKR).

Global Fragmentation: Manufacturing Investments Likely as Nations Prioritize Self Sufficiency
- Environmental Defense Fund (EDF). (2024, March 8). U.S. Is World Leader in Recent Electric Vehicle Manufacturing Investments.
- Global Trade Alert. (n.d.). Global Dynamics: Number of Implemented Interventions Since November 2008. Accessed on August 14, 2024.

Aging Infrastructure Assets: A Common Concern Across Developed Economies

Text
- American Society of Civil Engineers. (2021, March 3). 2021 Report Card for America's Infrastructure.
- Smart City Korea. (2024, March 7). Japan's aging infrastructure maintenance, response to digitalization.

Charts
- International Energy Agency (IEA). (2023, October 17). Electricity Grids and Secure Energy Transitions.

Shifting Demographics: Increasing Population, Especially in Urban Areas

Text
- Our World in Data. (2024, July 15). Population by World Region.

Charts
- Our World in Data. (2024, January 17). Urban and Rural Population Projected to 2050. World, 10,000 BCE to 2050.
- Our World in Data. (2024, July 15). Population by world region.

Infrastructure: Sources

Infrastructure Development: Government Planning Trillions In Current and Future Investments

- Directorate-General for Mobility and Transport. (2024, July 17). EU to Invest Record €7 billion into Sustainable, Safe and Smart Transport Infrastructure. European Commission.
- Government of Japan. (2023, January). Overview of Japan's Green Transformation (GX).
- Latson, S., Overly, S., Rivard, R., Hendel, J. & Mui, C. (2024, May 8). Biden's Big Bet Hits Reality. Politico.
- Mukherjee, P. (2024, April 2). Canada Launches $6bln Housing Fund in Bid to Quell Housing Crisis. Reuters.
- Ochoa, F. N. (2024, July 24). India Outlines Plans to Spend Billions on Infrastructure, Jobs in New Budget. Morningstar.
- Ponciano, J. (2021, November 15). Everything In the $1.2 Trillion Infrastructure Bill: New Roads, Electric School Buses And More. Forbes.

U.S. in Focus: Federal Policies Outline over $1 Trillion in Potential Public Infrastructure Funding

Text

- Latson, S., Overly, S., Rivard, R., Hendel, J. & Mui, C. (2024, May 8). Biden's Big Bet Hits Reality. Politico.
- The White House. (n.d.). Investing in America: Build.gov. Accessed on November 1, 2024.
- Yahoo!Finance. (2024, August 7). Q3 2024 Jacobs Solutions Inc Earnings Call.

Charts

- Latson, S., Overly, S., Rivard, R., Hendel, J. & Mui, C. (2024, May 8). Biden's Big Bet Hits Reality. Politico.
- National Institute of Standards and Technology (NIST). (n.d.). Chips for America. Accessed on November 20, 2024.
- The White House. (n.d.). Investing in America: Build.gov. Accessed on November 1, 2024.
- Yahoo!Finance. (2024, August 7). Q3 2024 Jacobs Solutions Inc Earnings Call.

U.S. in Focus: Private Investments Fueling a Manufacturing Resurgence

Text

- The White House. (n.d.). Investing in America: Invest.gov. Accessed on November 1, 2024.

Charts

- The White House. (n.d.). Investing in America: Invest.gov. Accessed on November 1, 2024.
- U.S. Bureau of Economic Analysis. (2024a, October 30). Private Fixed Investment: Nonresidential: Structures. Federal Reserve Economic Data (FRED).
- U.S. Bureau of Economic Analysis. (2024b, October 30). Private Fixed Investment: Nonresidential: Structures: Manufacturing. Federal Reserve Economic Data (FRED).

U.S. in Focus: New Manufacturing Facilities Require Ramp Up in Infrastructure Development

- Micron. (2022, September 1). Micron to Invest $15 Billion in New Idaho Fab, Bringing Leading-Edge Memory Manufacturing to the US.
- Nucor. (2023, February 22). Nucor to Build New Transmission Tower Production Plant in Alabama.
- Qcells. (2023, October 13). Qcells North America Completes Dalton Factory Expansion.
- Ross, L. (2024, March 3). Is Apple Bringing Jobs, Production Back to U.S.? Thomas.
- Toyota. (2023, October 31). Toyota Supercharges North Carolina Battery Plant with New $8 Billion Investment.
- TSMC. (2024, April 8). TSMC Arizona and U.S. Department of Commerce Announce up to US$6.6 Billion in Proposed CHIPS Act Direct Funding, the Company Plans Third Leading-Edge Fab in Phoenix.
- White, R. (2024, January 2). 'Future May be Further Out': Michigan Plays Long Game on Electric Vehicles. Mich Auto.

Infrastructure: Sources

U.S. in Focus: Power Grid Is at an Inflection Point Due to Rising Demand, Shifting Resource Mix

- NextEra. (2024, October 23). Third Quarter 2024: Earnings Conference Call. [Presentation]

U.S. in Focus: Grid Infrastructure Needs to Expand to Support Growth and Reduce Challenges

Text

- International Energy Agency (IEA). (2023, October 17). Electricity Grids and Secure Energy Transitions.

Charts

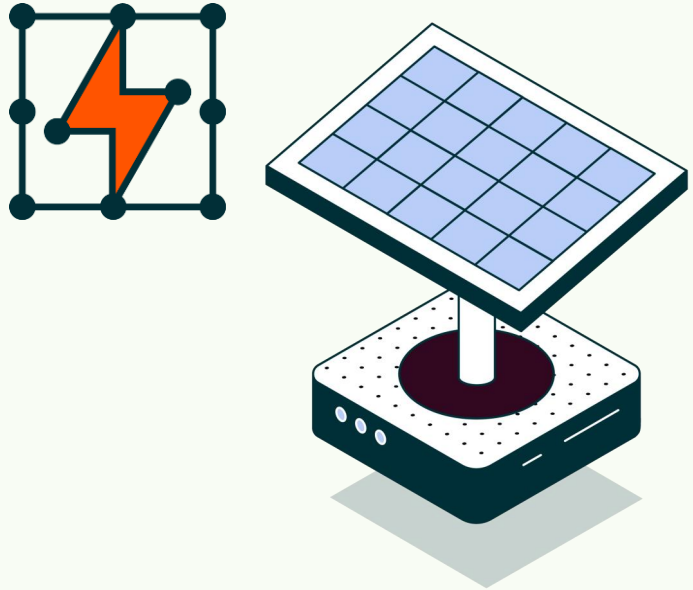
- Berkeley Lab. (2024, April 10). Grid connection backlog grows by 30% in 2023, dominated by requests for solar, wind, and energy storage.
- U.S. Department of Energy, Grid Deployment Office. (2024, October 3). National Transmission Planning Study.

S-Shaped Curve of Adoption – Infrastructure

- C40 Cities. (2024). Energy & Buildings.

CHARTING DISRUPTION 2025

Appendix: CleanTech



CleanTech: Sources

CleanTech: A Renewable Future

Text

- International Renewable Energy Agency (IRENA). (2023, June). World Energy Transitions Outlook 2023: 1.5 °C Pathway.

CleanTech: Opportunities Abound Due to Rising Temperatures Influencing Policy

Text

- Buchholz, K. (2024, July 19). Combustion Going Bust: Global Phase-outs of Gasoline Cars. Statista.
- International Energy Agency (IEA). (2024, April). Global EV Outlook 2024.
- National Aeronautics and Space Administration (NASA). (n.d.). Global Temperature. Accessed October 24, 2024.
- Net Zero Tracker. (n.d.). Data Explorer. Accessed October 24, 2024.
- World Bank Group. (n.d.). State and Trends of Carbon Pricing Dashboard. Accessed October 24, 2024.

Charts

- National Centers for Environmental Information. (n.d.). Climate at a Glance Global Time Series. Accessed October 31, 2024.

CleanTech: Current Investments Showing Growth but More Needed to Meet Climate Targets

Text

- International Renewable Energy Agency (IRENA). (2023, June). World Energy Transitions Outlook 2023: 1.5 °C Pathway.
- Smith, G. (2024, June 6). Clean Energy Investment Set to Run at Double Fossil-Fuel Spend. Bloomberg.

Charts

- BloombergNEF. (2024, January 30). Energy Transition Investment Trends.
- International Renewable Energy Agency (IRENA). (2023, June). World Energy Transitions Outlook 2023: 1.5 °C Pathway.

Renewables: Solar and Wind Power Will Likely Continue to Drive Global Power Capacity Growth

- BloombergNEF. (2024, May 21). New Energy Outlook 2024.

Renewables: Solar Often Outperforms Forecasted Growth Rates

- Azhar, A., & Warren, N. (2024, August 18). Too Much Exponential?; AI Scientists; Digital Simulacra; Moving Stones and Forging People ++ #487. Exponential View.
- Gabbatiss, J. (2022, June 12). Analysis: IEA's Renewables Forecast Grows 76% in Two Years After 'Largest Ever' Revision. Carbon Brief.
- Monge, J. (2024, March 19). Global Solar PV Installed Capacity Will More Than Triple in the Next Ten Years. Wood Mackenzie.

Renewables: Wind and Solar Costs Expected to Fall as Technologies Advance and Scale

- BloombergNEF. (n.d.).LCOE, $/MWh, Forecast Mid [Data Set]. Accessed August 26, 2024.
- National Renewable Energy Laboratory (NREL). (n.d.). Best Research-Cell Efficiency Chart. Accessed September 20, 2024.
- Wind Energy Technologies Office. (2024, August 28). Land-Based Wind Market Report: 2024 Edition. Office of Energy Efficiency & Renewable Energy.

Renewables: Big Tech Is Turning to Wind and Solar to Help Power Generative AI

Text

- Brookfield. (2024, May 1). Brookfield and Microsoft Collaborating to Deliver Over 10.5 GW of New Renewable Power Capacity Globally.
- Google Sustainability. (n.d.). Net-zero carbon. Accessed October 24, 2024.
- Meta. (2024, August). 2024 Sustainability Report.

CleanTech: Sources

Renewables: Big Tech Is Turning to Wind and Solar to Help Power Generative AI (continued)

Text

- Patron, M. (2023, August 16). Advocating for Decarbonization of the Power Sector. Microsoft.

Chart

- BloombergNEF. (n.d.). Corporate Power Purchase Agreements, MW [Data Set]. Accessed on August 5, 2024.

Energy Storage: Battery Systems Quickly Becoming an Integral Part of Power Grids

- BloombergNEF. (n.d.). Annual Global Energy Storage Installations, MW [Data Set]. Accessed on October 31, 2024.
- BloombergNEF. (n.d.). Low Case Capex for Four-Hour AC Energy Storage System at Beginning of Life, Real 2022, #$/kWh [Data Set]. Accessed August 18, 2024.

Hydrogen: Developing Into a Viable Alternative Fuel and Feedstock Option Across Industries

- BloombergNEF. (n.d.). Hydrogen Demand Segments [Data Set]. Accessed on October 30, 2024.
- International Energy Agency (IEA). (2024, October). Global Hydrogen Review 2024.
- Mathis, W., & Thornhill, J. (2019, August 21). Hydrogen's Plunging Price Boosts Role as Climate Solution. Bloomberg.

Hydrogen: Low-Carbon Options Showing Potential as Key Segments by the End of the Decade

- BloombergNEF. (2024, May 14). Hydrogen Supply Outlook 2024: A Reality Check.
- BloombergNEF. (2024, May 21). New Energy Outlook 2024.
- Collins, L. (2024, May 23). US and Europe Will Lead Global Clean Hydrogen Production in 2030, with Little Support from Exporting Nations: BNEF. Hydrogen Insight.

Water: Rising Demand and Supply Risks Increase Urgency for Clean Water Technologies

- Kuzma, S., & Saccoccia, L.. (2024, August 16). 25 Countries, Housing One-quarter of the Population, Face Extremely High Water Stress. World Resources Institute (WRI).
- World Resources Institute (WRI). (n.d.). Aqueduct Water Risk Atlas. Accessed October 24, 2024.

AgTech: AI Applications Can Help Farmers Overcome a Growing Number of Challenges

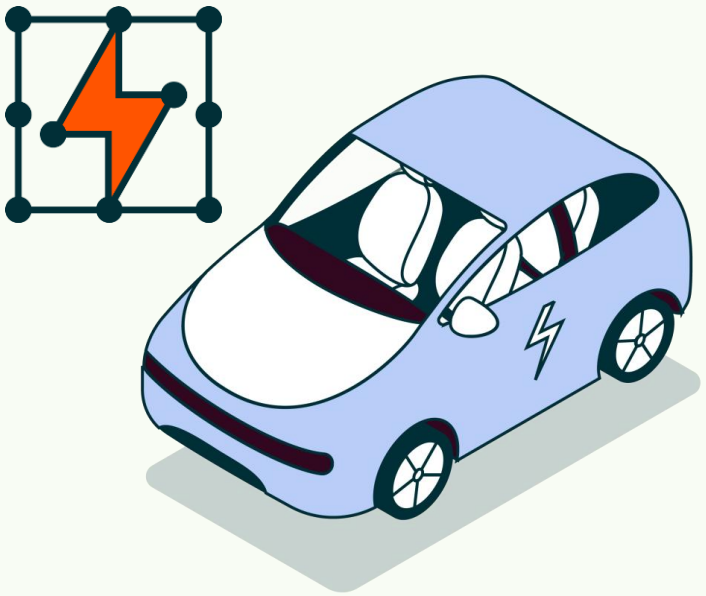
- John Deere. (2024a). Technology & Innovation.
- John Deere. (2024b). See & Spray Select: Broadcast and Targeted Spray on Fallow Ground.

S-Shaped Curve of Adoption – CleanTech

- International Renewable Energy Agency (IRENA). (2023, June). World Energy Transitions Outlook 2023: 1.5 °C Pathway.

CHARTING DISRUPTION 2025

Appendix: Mobility



Mobility: Sources

Electric Vehicles: EVs No Longer a Niche Segment Within the Transportation Sector
- Rho Motion. (2024, October). EV & Battery Quarterly Outlook: Q3 2024.

Electric Vehicles: OEMs Remain Committed to Increasing EV Sales Despite Recent Challenges
- Rho Motion. (2024, June). EV & Battery Quarterly Outlook: Q2 2024.

Electric Vehicles: More Affordable Models and Larger Charging Networks on the Horizon
- International Energy Agency (IEA). (2024, April 23). Global EV Data Explorer.
- Levin, T. (2024, July 19). The Affordable New Electric Cars Coming in 2025, 2026 and Beyond. InsideEVs.

Electric Vehicles: The Electrified Transport Era Is More Than Passenger and Light-Duty Vehicles
- Rho Motion. (2024, October). EV & Battery Quarterly Outlook: Q3 2024.

Battery Tech: Expectations for Better and Cheaper Batteries Support Strong EV Sales Outlooks
- Goldman Sachs. (2024, October 7). Electric vehicle battery prices are expected to fall almost 50% by 2026.
- Rho Motion. (2024, October). EV & Battery Quarterly Outlook: Q3 2024.

Battery Tech: Solid-State Among the Most Anticipated Next-Gen Battery Technologies
- Quantumscape. (2023, August 1). Investor Presentation: August 2023.
- Rho Motion. (2024, October 17). Solid State Technology: Unraveling the Current Landscape and Confronting Challenges.

Battery Tech: Manufacturing Landscape Becoming Increasingly Global as EVs Sales Rise
- Benchmark Source. (2023, October 31). Where Are the World's Gigafactories? Benchmark Mineral Intelligence.
- Rho Motion. (2024, October). EV & Battery Quarterly Outlook: Q3 2024.

Disruptive Materials: Supply Shortage Risks Growing for Key Battery Minerals as Clean Technologies Take Off
- International Energy Agency (IEA). (2021, May 5). Minerals used in electric cars compared to conventional cars.
- International Energy Agency (IEA). (2024a, May 17). Critical Minerals Data Explorer.
- International Energy Agency (IEA). (2024b, May 17). Global Critical Minerals Outlook 2024.

Lithium in Focus: Demand Growth Outlook Suggests the Potential Return of a Supply Deficit
- AMG Critical Materials N.V. (2024, November). The Energy of Nature: Investor Presentation | Third Quarter 2024.
- Albemarle. (2024, July 31). Albemarle Reports Second Quarter 2024 Results.

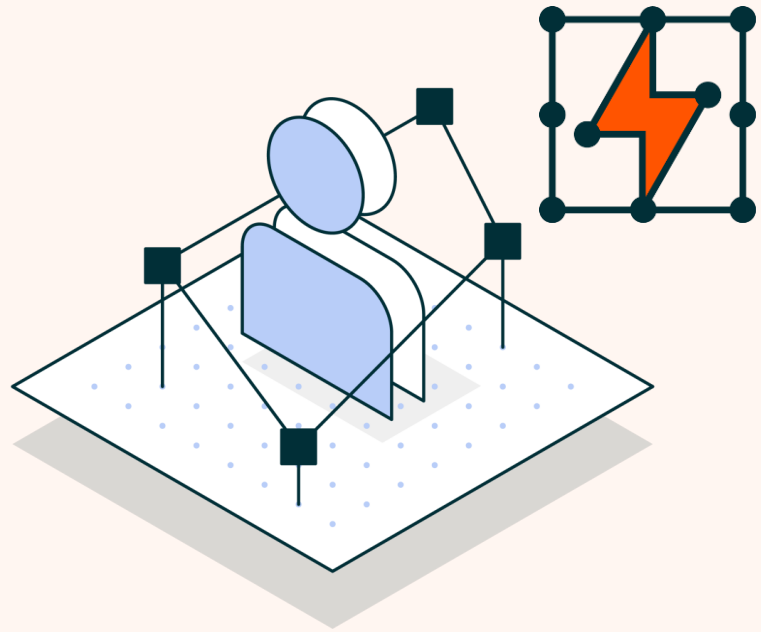
Lithium in Focus: Global Cost Curve Suggests Many Projects Well Positioned Even With Low Prices
- Benchmark Minerals Intelligence. (n.d.). Lithium Prices. Accessed November 20, 2024.
- Lithium Americas. (2024, November 7). Corporate Presentation: November 2024.

Copper in Focus: Clean Energy Transition Becoming an Integral Factor in Supply-Demand Dynamics
- International Energy Agency (IEA). (2024a, May 17). Critical Minerals Data Explorer.
- International Energy Agency (IEA). (2024b, May 17). Copper.

S-Shaped Curve of Adoption – Mobility
- Rho Motion. (2024, October). EV & Battery Quarterly Outlook: Q3 2024.

CHARTING DISRUPTION 2025

Appendix: Aging Population



Aging Population: Sources

Aging Population: Silver Opportunities
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

The Global Population Is Set to Age at an Accelerated Pace

Text
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.
- United States Census Bureau. (2019, December 10). By 2030, All Baby Boomers Will Be Age 65 or Older.

Charts
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Global Shift in Demographics Intensifies

Text
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Charts
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Aging Population's Health Challenge: Older Adults Make Up a Greater Proportion of Health Spend

Text
- Centers for Medicare & Medicaid Services (CMS). (2024, September 10). National Health Expenditures by Age and Sex.
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Charts
- Centers for Medicare & Medicaid Services (CMS). (2024, September 10). National Health Expenditures by Age and Sex.
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Chronic Conditions Add Complexity to Elder Care

Text
- National Council on Aging. (2024, May 30). The Top 10 Most Common Chronic Conditions in Older Adults.

Charts
- National Council on Aging. (2024, May 30). The Top 10 Most Common Chronic Conditions in Older Adults.
- Tavares, J. L., Cohen, M. A., Silberman, S., & Popham, L. (2022, April). Measuring Disease Cost Burden Among Older Adults in the U.S. LeadingAge LTSS Center @UMass Boston & National Council on Aging.

Growing Overlap in Chronic Conditions Opens the Door for a Broad Solution
- Evaluate Pharma. (2024, August 5). Obesity: The Next Questions.
- Evaluate Pharma. (n.d.). GLP-1 Sales by Indication. Accessed November 1, 2024.

GLP-1s: A Breakthrough Years in the Making
- Biopharma PEG. (2023, February 16). GLP-1R Agonists for Weight Loss.
- Eli Lilly and Company. (2024, January 9). J.P. Morgan Healthcare Conference Presentation. 42nd Annual J.P. Morgan Healthcare Conference.
- Evaluate Pharma. (n.d.a). Glucagon-Like Peptide (GLP) 1 Agonist: Sales by Indication. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Glucagon-Like Peptide (GLP) 1 & Gastric Inhibitory Polypeptide (GIP) Dual Agonist. Accessed November 1, 2024.

Aging Population: Sources

GLP-1s: A Starting Point for Improved Health Outcomes in Age-Related Conditions

Text

- Eli Lilly and Company. (2022, April 28). Lilly's Tirzepatide Delivered Up to 22.5% Weight Loss in Adults with Obesity or Overweight with SURMOUNT-1.

Charts

- Evaluate Pharma. (n.d.). GLP-1 Sales by Indication. Accessed November 1, 2024.
- Global X ETFs projections from December 2023, based on Evaluate Pharma data.

GLP-1s: Ongoing Clinical Trials Cast an Even Wider Net

- National Library of Medicine, National Center for Biotechnology Information. (n.d.). ClinicalTrials.gov Trial Search. Accessed November 1, 2024.

GLP-1s: Not Just Ozempic

Text

- Evaluate Pharma. (n.d.b). GLP-1 Sales by Indication. Accessed November 1, 2024.

Charts

- Evaluate Pharma. (n.d.a). Cagrisema: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). GLP-1 Sales by Indication. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). MariTide: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.d). Mazdutide: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.e). Mounjaro: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.f). Orforglipron: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.g). Ozempic: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.h). Retatrutide: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.i). Rybelsus: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.j). Trulicity: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.k). VK2735: Product Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.l). Zepbound: Product Overview. Accessed November 1, 2024.
- STAT+. (2024, September 5). Obesity Drug Tracker.
- U.S. Food and Drug Administration (FDA). (2023, November 8). FDA Approves New Medication for Chronic Weight Management. U.S. Department of Health and Human Services.
- U.S. Food and Drug Administration (FDA). (2024, January 10). Medications Containing Semaglutide Marketed for Type 2 Diabetes or Weight Loss. U.S. Department of Health and Human Services.

GLP-1s: Defining the Next Generation of Weight Loss Treatments

Text

- U.S. Centers for Disease Control and Prevention (CDC). (2024, July 12). Fast Facts: Health and Economic Costs of Chronic Conditions.
- Chen, Elaine. (2023, October 17). Our Expensive Obesity Drugs Are Worth It, Novo Nordisk and Eli Lilly Argue in Raft of Studies. STAT+.

Charts

- Blue Health Intelligence. (2024, May). Issue Brief: Real-World Trends in GLP-1 Treatment Persistence and Prescribing for Weight Management. Blue Cross Blue Shield Association.

Aging Population: Sources

Beyond Chronic Care, Other Solutions Are Needed to Meet Rising Healthcare Demand

Text

- GlobalData Plc. (2024, March). The Complexities of Physician Supply and Demand: Projections from 2021 to 2036. Association of American Medical Colleges.

Charts

- GlobalData Plc. (2024, March). The Complexities of Physician Supply and Demand: Projections from 2021 to 2036. Association of American Medical Colleges.

The Hidden Costs of Aging for Caregivers Are Likely to Grow More Prominent

Text

- Reinhard, S. C., Caldera, S., Houser, A., & Choula, R. (2023, March 8). Valuing the Invaluable: Strengthening Supports for Family Caregivers. American Association of Retired Persons (AARP).
- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Charts

- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

Shortage of Senior Living Options Is Likely to Grow More Acute

Text

- Johnson, R. W. (2019, April 3). What Is the Lifetime Risk of Needing and Receiving Long-Term Services and Supports? U.S. Department of Health and Human Services (HHS), Office of Disability, Aging and Long-Term Care Policy (DALTCP) and the Urban Institute.

Charts

- Bloomberg, L.P. (n.d.). Healthcare REIT Dashboard. Data as of November 1, 2024.

Technological Advancements Can Help Bridge the Care Gap

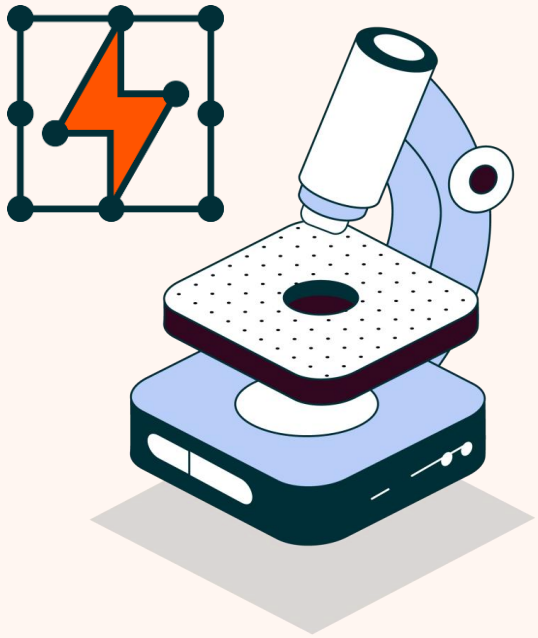
- American Heart Association News. (2019, January 31). Cardiovascular Diseases Affect Nearly Half of American Adults, Statistics Show. American Heart Association.
- Cleveland Clinic. (2024, March 6). 24-Hour Ambulatory Blood Pressure Monitoring.
- Kochanek, K. D., Murphy, S. L., Xu, J., & Arias, E. (2024, March). Mortality in the United States, 2022 - NCHS Data Brief No. 492. National Center for Health Statistics, U.S. Centers for Disease Control and Prevention (NCHS, CDC).

S-Shaped Curve of Adoption – Aging Population

- Department of Economic and Social Affairs / Population Division. (2024, July). World Population Prospects 2024. United Nations.

CHARTING DISRUPTION 2025

Appendix: Tech-Enabled Health



Tech-Enabled Health: Sources

Tech-Enabled Health: Driving Efficiency and Improving Patient Care

- Evaluate Pharma. (n.d.a). Cardiovascular Monitoring & Diagnostic Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Diabetic Care WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). Non-Invasive Monitoring Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Grand View Research. (2023a). Clinical Trial Management Services Market Size, Share & Trends Analysis Report by Services (Regulatory submissions, Medical Writing), by Indication (Oncology, Diabetes), by End-use, by Region, and Segment Forecasts, 2024 – 2030. Report ID: GVR-4-68039-993-8.
- Grand View Research. (2023b). Insurtech Market Size, Share & Trends Analysis Report by Type (Auto, Business, Health, Home, Specialty, Travel), by Service (Consulting, Support & Maintenance, Managed Services), by Technology, by End Use, by Region, and Segment Forecasts, 2023 - 2030. Report ID: GVR-4-68038-093-4.
- Grand View Research. (2024). Telemedicine Market Size, Share & Trends Analysis Report By Component (Products, Services), By Modality, By Application (Teleradiology, Telepsychiatry), By Delivery Mode, By Facility, By End User, By Region, And Segment Forecasts, 2024 – 2030. Report ID: GVR-1-68038-313-3.
- Insight Partners. (2023). Medical Scheduling Software Market Size & Share: Report 2028. Report Code: TIPHE100001414
- Markets and Markets. (2022, May). Pharmacy Automation Market by Product (Automated Medication Dispensing & Storage Systems, Table-Top Counters, Retrieval Systems, Medication Compounding), End User (Inpatient, Outpatient (Fast-Track Clinics), Retail Pharmacies) & Region – Global Forecast to 2027. Report Code: MD 2624.
- Markets and Markets. (2024, August). Surgical Robots Market by Product (Instruments & Accessories, Systems, Services), Application (Urological Surgery, Gynecological Surgery, Orthopedic Surgery, Neurosurgery), End User (Hospitals, Ambulatory Surgery Centers) & Region – Global Forecast to 2029. Report Code: MD 6781.
- Precedence Research. (2024b, September). Electronic Health Records Market Size, Share, and Trends 2024 to 2034. Report Code: 1379.
- Precedence Research. (2024a, September). U.S. Revenue Cycle Management Market Size, Share and Trends 2024 to 2034. Report Code: 2431.
- Statista. (2024, September). Online Pharmacy – Worldwide.

Smart Medical Devices: Wearable Sensors Bring Innovative Technology Directly to the Patient

- Evaluate Pharma. (n.d.a). Cardiovascular Monitoring & Diagnostic Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Diabetic Care WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). Non-Invasive Monitoring Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- U.S. Food and Drug Administration (FDA). (2024, August 7). Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices.

Smart Medical Devices: Surgical Robots Apply Novel Hardware and AI to Improve Patient Outcomes

Text

- Cleveland Clinic. (2023, November 29). What We've Learned From 10,000 Robot-Assisted Total Joint Replacements.
- Cleveland Clinic. (2024, April 30). Robotic Surgery.
- Intuitive Surgical. (2024, October 18). Quarterly Report, 2024 Q3.
- Rath, L. (n.d.). Outlook for Joint Replacements. Arthritis Foundation. Accessed November 1, 2024.

Charts

- Markets and Markets. (2024, August). Surgical Robots Market Revenue Trends and Growth Drivers. Report Code: MD6781.

Smart Medical Devices: Surgical Robot Adoption Accelerating

- Bloomberg, L.P. (n.d.). ISRG: Intuitive Surgical Inc. Data as of November 1, 2024.
- Intuitive Surgical. (2017, February 6). 2016 Annual Report.
- Intuitive Surgical. (2018, February 2). 2017 Annual Report.
- Intuitive Surgical. (2019, February 4). 2018 Annual Report.

Tech-Enabled Health: Sources

Smart Medical Devices: Surgical Robot Adoption Accelerating (continued)

- Intuitive Surgical. (2020, February 7). 2019 Annual Report.
- Intuitive Surgical. (2021, February 10). 2020 Annual Report.
- Intuitive Surgical. (2022, February 3). 2021 Annual Report.
- Intuitive Surgical. (2023, February 10). 2022 Annual Report.
- Intuitive Surgical. (2024, January 31). 2023 Annual Report.

Smart Medical Devices: Technology Is Being Deployed Behind the Scenes at Accelerating Pace

- Omnicell. (2022, September 20). Omnicell Investor Day Presentation.
- Omnicell. (2024, October 30). Investor Presentation.
- Omnicell. (n.d.). ADC Efficiency by the Numbers: XT #1 Nurse-Recommended Brand. Accessed November 1, 2024.

Healthcare Analytics & Software Solutions: Existing Siloed Solutions Exacerbate the Problem

Text

- American Medical Informatics Association. (2024, June 3). AMIA Survey Underscores Impact of Excessive Documentation Burden.
- Cass, A. (2023, April 19). The Hours 23 Physician Specialties Spend on Paperwork, Administration. Becker's Hospital Review.
- Doximity. (2023, June 6). Investor Day 2023 [Presentation].
- Melnick, E. R., Dyrbye, L. N., Sinsky, C. A., Trockel, M., West, C. P., Nedelec, L., Tutty, M. A., & Shanafelt, T. (2020, March). The Association Between Perceived Electronic Health Record Usability and Professional Burnout Among US Physicians. Mayo Clinic Proceedings, Volume 95, Issue 3: pp. 476-487.

Charts

- Melnick, E. R., Dyrbye, L. N., Sinsky, C. A., Trockel, M., West, C. P., Nedelec, L., Tutty, M. A., & Shanafelt, T. (2020, March). The Association Between Perceived Electronic Health Record Usability and Professional Burnout Among US Physicians. Mayo Clinic Proceedings, Volume 95, Issue 3: pp. 476-487.

From Lab to Trials: AI's Game-Changing Impact on Drug Discovery

Text

- PhRMA. (2021, September 20). Industry Profile 2021.
- Van Norman, G. A. (2019, June 24). Phase II Trials in Drug Development and Adaptive Trial Design. JACC: Basic to Translational Science, Volume 4, Issue 3: pp. 428-437.
- Wouters, O. J., McKee, M., & Luyten, J. (2020, March 3). Estimated Research and Development Investment Needed to Bring a New Medicine to Market, 2009-2018. Journal of the American Medical Association, Volume 323, Issue 9: pp. 844-853.

Charts

- Insilico Medicine. (2021, February 24). Linking Biology and Chemistry with AI.

AI Drug Discovery: Expected to Be Fastest Growing Generative AI (Gen-AI) Segment Through 2032

Text

- Bloomberg Intelligence. (2024, August 14). Generative-AI Revenue Potential.
- Colangelo, M. (2019, September 3). For the First Time, AI Designs and Validates New Drug Candidate in Days. LinkedIn.
- Morgan Stanley. (2022, September 9). Why Artificial Intelligence Could Speed Drug Discovery.
- NVIDIA. (2024, March 5). TD Cowen's 44th Annual Health Care Conference.

Charts

- Bloomberg Intelligence. (2024, August 14). Generative-AI Revenue Potential.

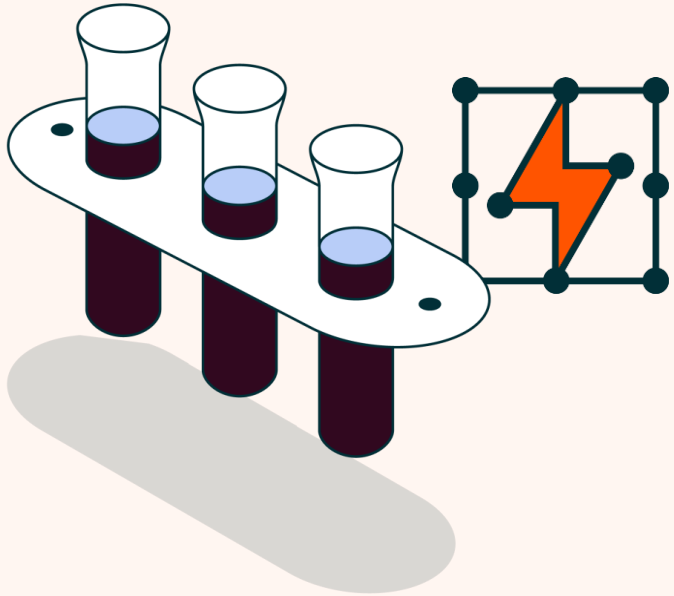
Tech-Enabled Health: Sources

S-Shaped Curve of Adoption – Tech-Enabled Health

- Evaluate Pharma. (n.d.a). Cardiovascular Monitoring & Diagnostic Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Diabetic Care WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). Non-Invasive Monitoring Devices WW Consensus Sales Forecasts. Accessed November 1, 2024.
- Grand View Research. (2023a). Clinical Trial Management Services Market Size, Share & Trends Analysis Report by Services (Regulatory submissions, Medical Writing), by Indication (Oncology, Diabetes), by End-use, by Region, and Segment Forecasts, 2024 – 2030. Report ID: GVR-4-68039-993-8.
- Grand View Research. (2023b). Insurtech Market Size, Share & Trends Analysis Report by Type (Auto, Business, Health, Home, Specialty, Travel), by Service (Consulting, Support & Maintenance, Managed Services), by Technology, by End Use, by Region, and Segment Forecasts, 2023 - 2030. Report ID: GVR-4-68038-093-4.
- Grand View Research. (2024). Telemedicine Market Size, Share & Trends Analysis Report By Component (Products, Services), By Modality, By Application (Teleradiology, Telepsychiatry), By Delivery Mode, By Facility, By End User, By Region, And Segment Forecasts, 2024 – 2030. Report ID: GVR-1-68038-313-3.
- Insight Partners. (2023). Medical Scheduling Software Market Size & Share: Report 2028. Report Code: TIPHE100001414
- Markets and Markets. (2022, May). Pharmacy Automation Market by Product (Automated Medication Dispensing & Storage Systems, Table-Top Counters, Retrieval Systems, Medication Compounding), End User (Inpatient, Outpatient (Fast-Track Clinics), Retail Pharmacies) & Region – Global Forecast to 2027. Report Code: MD 2624.
- Markets and Markets. (2024, August). Surgical Robots Market by Product (Instruments & Accessories, Systems, Services), Application (Urological Surgery, Gynecological Surgery, Orthopedic Surgery, Neurosurgery), End User (Hospitals, Ambulatory Surgery Centers) & Region – Global Forecast to 2029. Report Code: MD 6781.
- Precedence Research. (2024b, September). Electronic Health Records Market Size, Share, and Trends 2024 to 2034. Report Code: 1379.
- Precedence Research. (2024a, September). U.S. Revenue Cycle Management Market Size, Share and Trends 2024 to 2034. Report Code: 2431.
- Statista. (2024, September). Online Pharmacy – Worldwide.

CHARTING DISRUPTION 2025

Appendix: Genomics



Genomics: Sources

An Arsenal of Investigational Technologies to Combat Illnesses

- Evaluate Pharma. (n.d.). Evaluate Omnium: Risk & Return Overview. Accessed November 1, 2024.

Genomic Medicines: Approvals Provide Runway for Growth

Text

- Gottlieb, S. (2019, January 15). Statement from FDA Commissioner Scott Gottlieb, M.D. and Peter Marks, M.D., Ph.D., Director of the Center for Biologics Evaluation and Research on New Policies to Advance Development of Safe and Effective Cell and Gene Therapies. U.S. Food and Drug Administration.

Charts

- Evaluate Pharma. (n.d.a). Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Gene Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). Gene-Modified Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.d). Genome Editing: Technology Overview. Accessed November 1, 2024.
- U.S. Food and Drug Administration (FDA). (2024, August 2). Approved Cellular and Gene Therapy Products.

Manufacturing Is Complicated, but New Models Can Reduce Costs

- Bluebird Bio. (2023, January 12). J.P. Morgan Healthcare Conference Presentation.
- Harrison, R. P., Zylberberg, E., Ellison, S., & Levine, B. L. (2019, February 12). Chimeric Antigen Receptor – T Cell Therapy Manufacturing: Modelling the Effect of Offshore Production on Aggregate Cost of Goods. International Society for Cell & Gene Therapy, Volume 21, Issue 2: pp. 224-233.
- Macdonald, G. J. (2023, October 4). Cell & Gene Therapy Costs Drive Deals. Genetic Engineering & Biotechnology News.
- University of Pittsburgh Medical Center. (2024). FDA-Approved CAR T Cell Therapies. Hillman Cancer Center.

Laying the Foundation: Certified Treatment Centers Essential to Increase Access

- Novartis. (2024). Find a KYMRIAH Treatment Center. Accessed November 1, 2024.

Genomic Medicines Offer Clear Benefits: Foundational Efforts Pave the Way for Next-Generation

Text

- Bloomberg Intelligence. (2023, August 31). Refund Pacts Can Help Sell Pricey Cell, Gene Therapies.
- Croteau, S. E., Cook, K., Sheikh, L., Chawla, A., Sammon, J., Solari, P., Kim, B., Hinds, D. & Thornburg, C. D. (2021, March). Health Care Resource Utilization and Costs Among Adult Patients with Hemophilia A on Factor VIII Prophylaxis: An Administrative Claims Analysis. Journal of Managed Care & Specialty Pharmacy, Volume 27, Issue 3: pp. 316-326.
- Garrison, L. P., Jiao, B., & Dabbous, O. (2021, May). Gene Therapy May Not Be as Expensive as People Think: Challenges in Assessing the Value of Single and Short-term Therapies. Journal of Managed Care & Specialty Pharmacy, Volume 27, Issue 5.
- Weintraub, A. (2018, January 30). Roche's Pricey New Hemophilia Drug Hemlibra Gets a Rare Blessing from U.S. Cost Watchdogs. Fierce Pharma.

Charts

- Garrison, L. P., Jiao, B., & Dabbous, O. (2021, May). Gene Therapy May Not Be as Expensive as People Think: Challenges in Assessing the Value of Single and Short-term Therapies. Journal of Managed Care & Specialty Pharmacy, Volume 27, Issue 5.

Genomic Medicine's Reach Is Currently Limited, But Not for Long

- Evaluate Pharma. (n.d.a). Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). DNA & RNA Therapy: Technology Overview. Accessed November 1, 2024.

Genomics: Sources

Genomic Medicine's Reach Is Currently Limited, But Not for Long (continued)

- Evaluate Pharma. (n.d.c). Gene Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.d). Gene-Modified Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.e). Genome Editing: Technology Overview. Accessed November 1, 2024.

Next Frontier of Innovation: Expanding Genomic Medicines' Impact

- Evaluate Pharma. (n.d.a). Evaluate Omnium: Risk & Return Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). Genomic Medicine Revenues by Indication. Accessed November 1, 2024.

S-Shaped Curve of Adoption – Genomics

- Evaluate Pharma. (n.d.a). Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.b). DNA & RNA Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.c). Gene Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.d). Gene-Modified Cell Therapy: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.e). Genome Editing: Technology Overview. Accessed November 1, 2024.
- Evaluate Pharma. (n.d.f). Market Explorer | Sales by Indication. Accessed November 1, 2024.

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