



CHARTING DISRUPTION

GLOBAL X

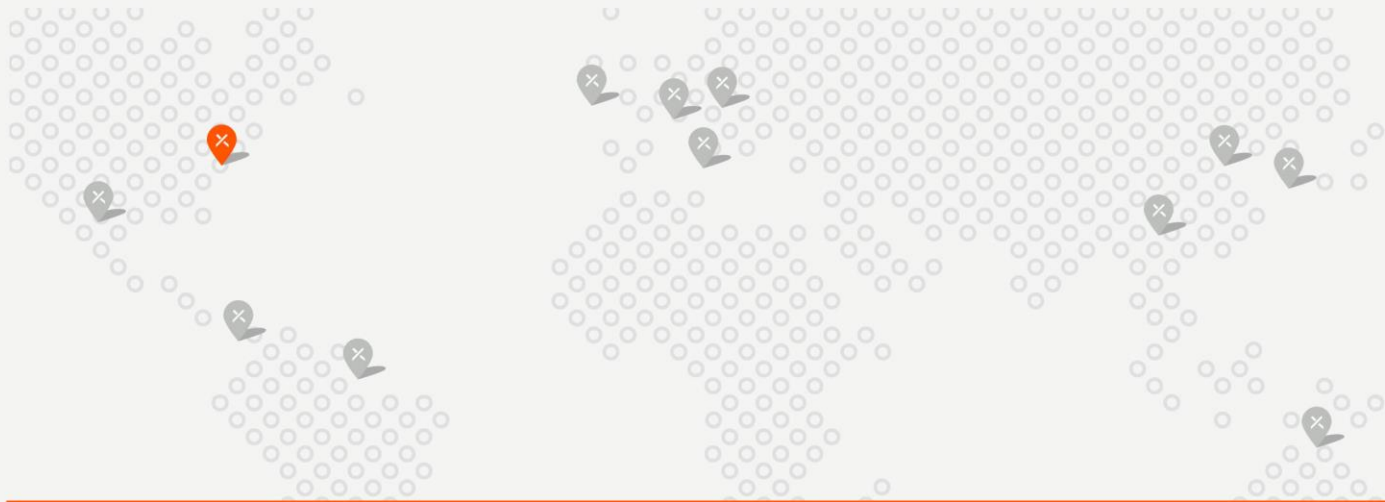
by Mirae Asset

OUTLOOK FOR
2024 AND BEYOND



For more than a decade, our mission has been empowering investors with unexplored and intelligent solutions.

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



Global X ETFs is a fully-owned subsidiary of Mirae Asset Financial Group, a global industry leader with 55 offices and over 12,000 employees worldwide. Founded in 1997 as one of Asia's pioneering fund management companies, the Group now oversees **\$565bn in client assets** across a portfolio that includes real estate, insurance, private equity, and venture capital.²

\$46bn in AUM across more than 200 ETF strategies¹

Primary Listings by Office



United States
107 ETF Listings



Europe
34 UCITS ETF & 5 Crypto ETP Listings



Australia
35 ETF Listings



Latin America
32 ETF Listings in Brazil & Colombia



Hong Kong
27 ETF Listings



Japan
36 ETF Listings

¹As of October 31, 2023 ²As of June 30, 2023
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Charting Disruption 2024

Our future constantly develops and changes right in front of us. Yet much of the potential disruption seems unimaginable—until it happens.

Our flagship research project, Charting Disruption, aims to shed a quantifiable light on what the future may hold. It's where we explore the interplay between innovation and emerging technological as well as behavioral trends that can shape financial markets and their performance.

In charting potential disruption, we think it's helpful to zoom out to get a more complete view of where technology was and how far it's come. The advances in just the last 25 years alone prove momentous and the momentum of this trend of innovation continues.

It wasn't that long ago, for example, that people found it challenging to envision a world linked through smartphones and the internet. Before too long, most people won't be able to remember life without them.

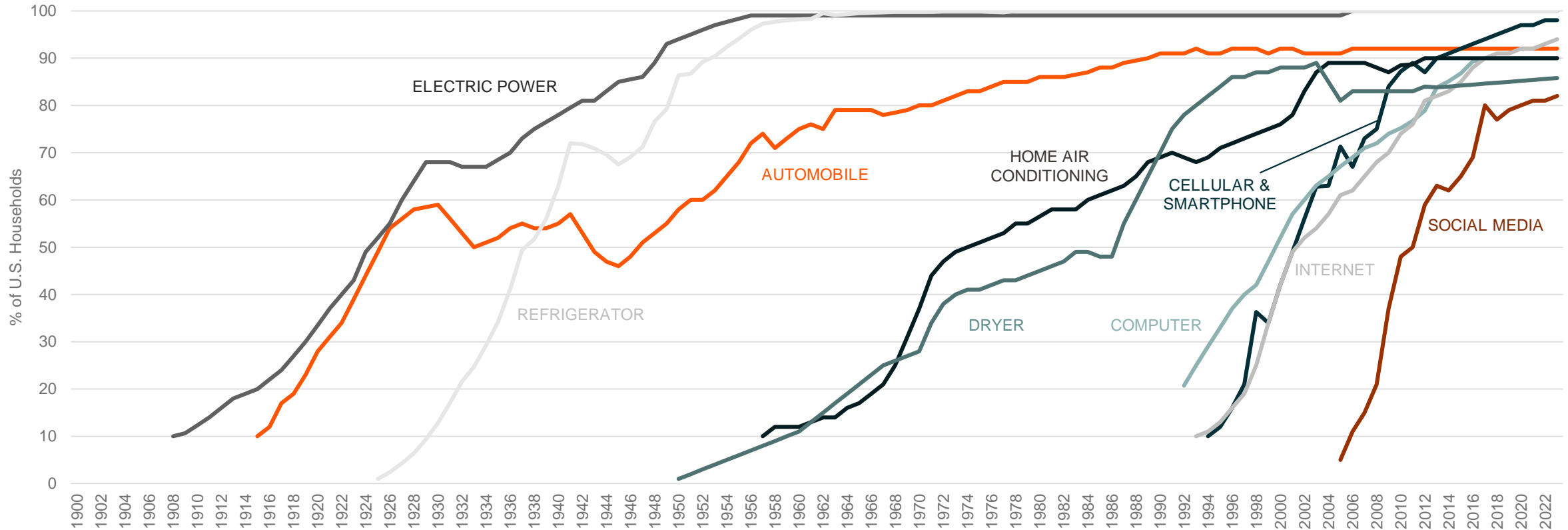
To explore the depth of changes like these, we partnered with handpicked experts in fields such as Artificial Intelligence, Digital Assets, CleanTech, Autonomous Vehicles, Genomics & Biotech, Battery Technology, and Food Innovation.

In what follows, we present unique forecasts, datasets, and analyses that reveal what we expect to disrupt our world in 2024 and beyond.

We hope you enjoy and gain a better understanding of what's possible.

Zooming Out for a Comprehensive View of Disruption

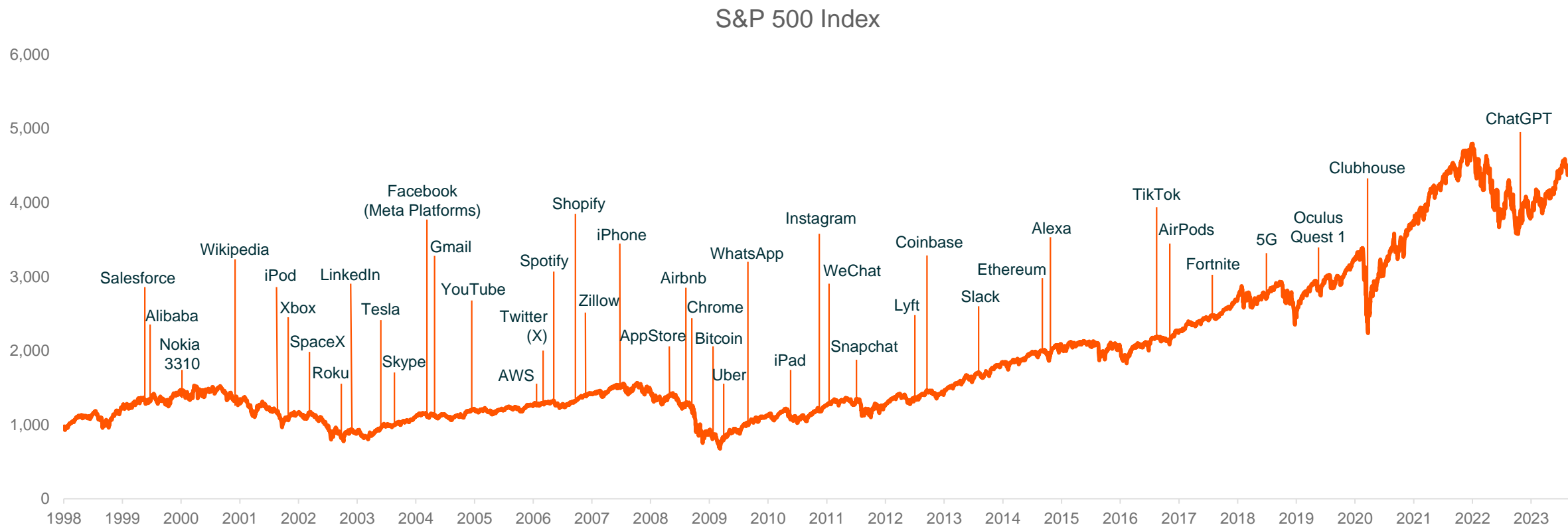
We may often underestimate how much the world can change within a lifetime. Recognizing past dramatic shifts can help us envision a vastly different world in the years or decades ahead.



Sources: Our World in Data. (2019, July 27). Share of United States Households Using Specific Technologies.

Things That Didn't Exist 25 Years Ago

Throughout market cycles, innovation has not stopped. What's familiar to us today – social media, mobile payments, or e-commerce – was unimaginable to our ancestors a few generations ago.

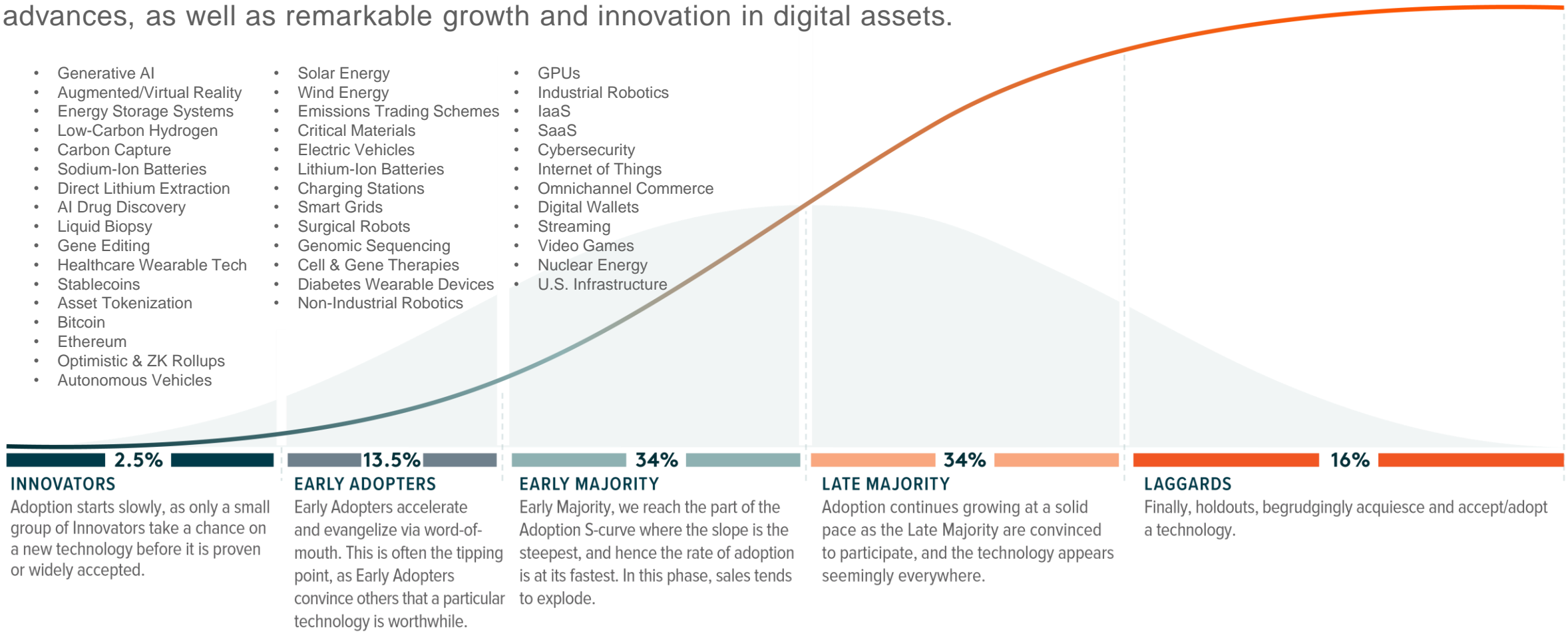


Source: Bloomberg, L.P. (n.d.). [S&P 500 Index] [Data set]. Retrieved on October 13, 2023 from Global X ETFs Bloomberg terminal.

The Unimaginable Today Will Be Familiar Tomorrow

Anticipate a future marked by groundbreaking technologies, greener solutions to global issues, pioneering medical advances, as well as remarkable growth and innovation in digital assets.

- Generative AI
- Augmented/Virtual Reality
- Energy Storage Systems
- Low-Carbon Hydrogen
- Carbon Capture
- Sodium-Ion Batteries
- Direct Lithium Extraction
- AI Drug Discovery
- Liquid Biopsy
- Gene Editing
- Healthcare Wearable Tech
- Stablecoins
- Asset Tokenization
- Bitcoin
- Ethereum
- Optimistic & ZK Rollups
- Autonomous Vehicles
- Solar Energy
- Wind Energy
- Emissions Trading Schemes
- Critical Materials
- Electric Vehicles
- Lithium-Ion Batteries
- Charging Stations
- Smart Grids
- Surgical Robots
- Genomic Sequencing
- Cell & Gene Therapies
- Diabetes Wearable Devices
- Non-Industrial Robotics
- GPUs
- Industrial Robotics
- IaaS
- SaaS
- Cybersecurity
- Internet of Things
- Omnichannel Commerce
- Digital Wallets
- Streaming
- Video Games
- Nuclear Energy
- U.S. Infrastructure



INNOVATORS

Adoption starts slowly, as only a small group of Innovators take a chance on a new technology before it is proven or widely accepted.

EARLY ADOPTERS

Early Adopters accelerate and evangelize via word-of-mouth. This is often the tipping point, as Early Adopters convince others that a particular technology is worthwhile.

EARLY MAJORITY

Early Majority, we reach the part of the Adoption S-curve where the slope is the steepest, and hence the rate of adoption is at its fastest. In this phase, sales tends to explode.

LATE MAJORITY

Adoption continues growing at a solid pace as the Late Majority are convinced to participate, and the technology appears seemingly everywhere.

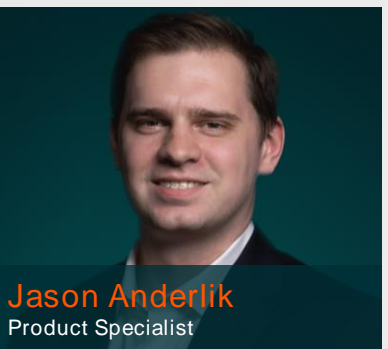
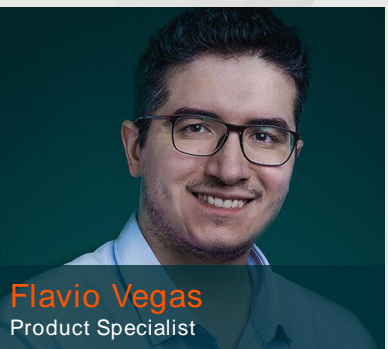
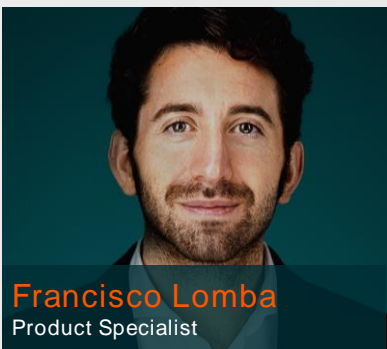
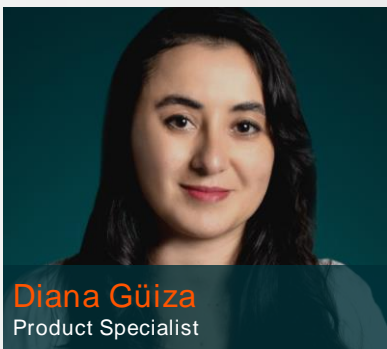
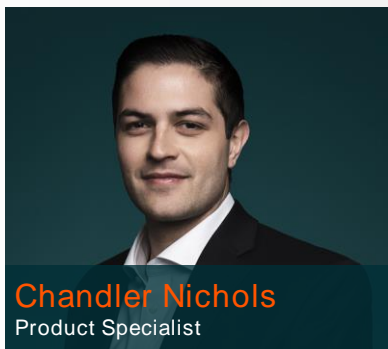
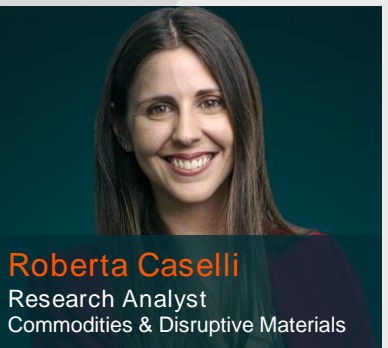
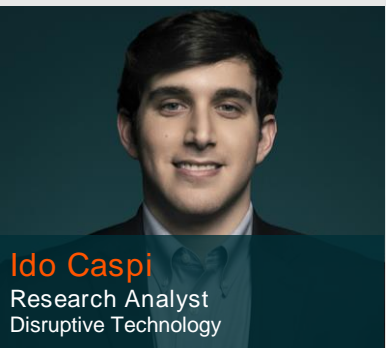
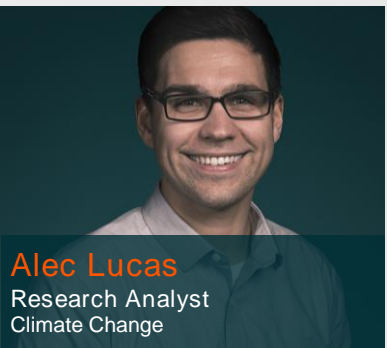
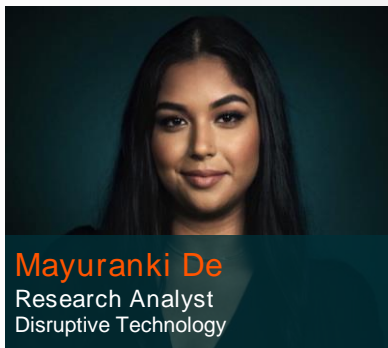
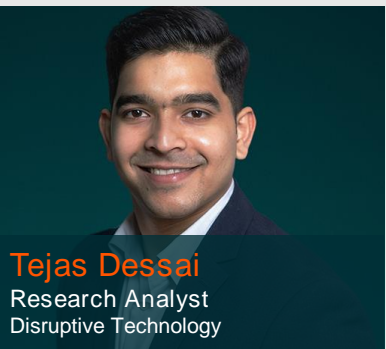
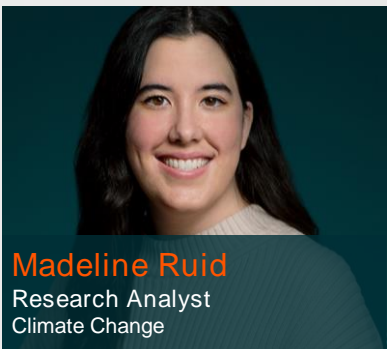
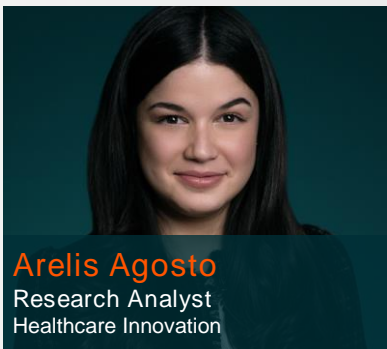
LAGGARDS

Finally, holdouts, begrudgingly acquiesce and accept/adopt a technology.

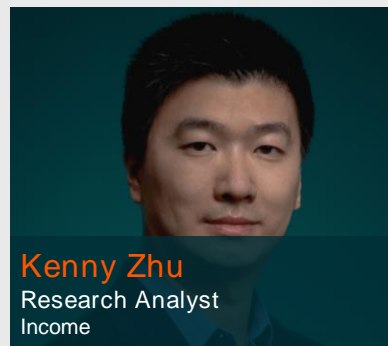
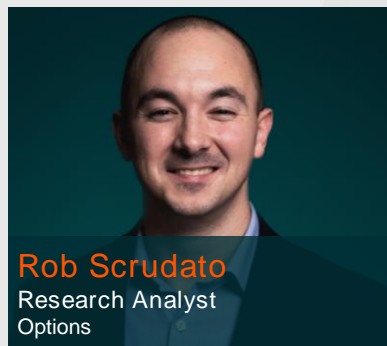
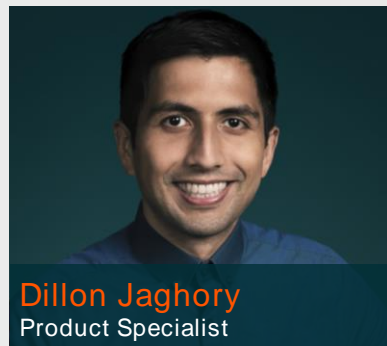
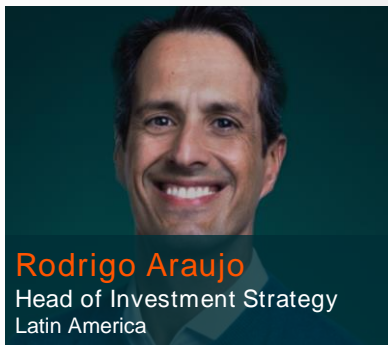
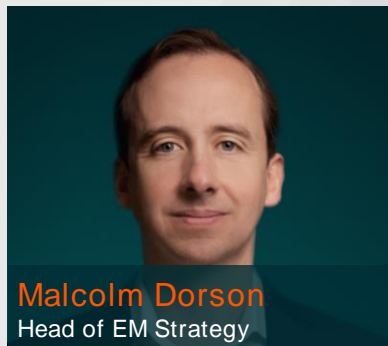
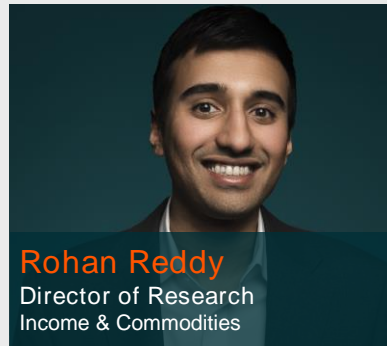
PHASES OF ADOPTION

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

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Supported By



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Table of Contents

- 01 [Infrastructure, Reimagined](#)
A New Era for the U.S. Economy
- 02 [Artificial Intelligence](#)
Generative AI's Transformative Power
- 03 [Robotics](#)
The Rise of Smart Machines
- 04 [An Electric Future](#)
Greener Transportation & Battery Tech Innovation
- 05 [CleanTech & Beyond](#)
The Push for Net Zero Emissions
- 06 [Cloud Computing](#)
Navigating New Realms
- 07 [Digitizing Medicine](#)
AI, Surgical Robots & More
- 08 [Therapeutics](#)
Shaping Personalized Medicine
- 09 [Decoding the Human Genome](#)
Secrets of Our Genetic Blueprint
- 10 [Clicks & Commerce](#)
What's Next for the Internet Economy
- 11 [Unlocking Digital Assets](#)
Alternative Currencies & Stores of Value
- 12 [Ethereum's Blueprint](#)
Exploring Infrastructure Upgrades
- 13 [Blockchain Trends](#)
Applications of the Technology
- 14 [Pixels, Unleashed](#)
Interactive Entertainment in the Age of Bits

Earth's Evolution

Infrastructure, Reimagined

A New Era for the U.S. Economy

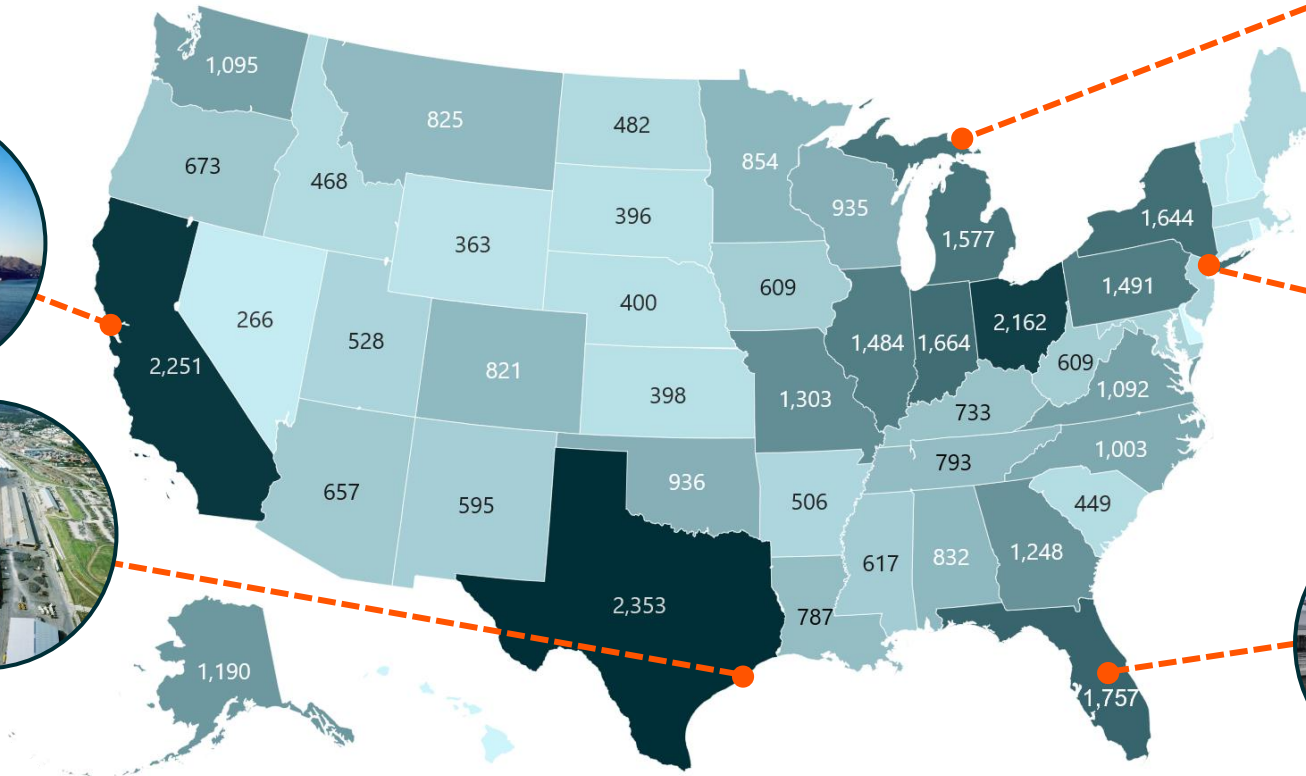
American infrastructure is top of mind, as recent legislation works to rebuild deteriorating assets and positions the United States for a return to industrial growth. These bills combine to produce a generational investment in U.S. infrastructure and could add momentum to trends such as the manufacturing boom and long-standing need to overhaul the grid.



Mobilization of the Infrastructure Investment and Jobs Act (IIJA) Continues Across the Country

Rollout of the IIJA remains in its early stages, yet nearly \$400 billion in funding has been announced at the state level that will be directed toward over 40,000 IIJA-related projects.¹

Number of Announced IIJA Projects by State*



Golden Gate Bridge

\$400 million awarded from competitive Bridge Investment Program to renovate and retrofit the bridge and boost resilience against earthquakes.²



Port of Houston

\$143 million provided by the Army Corps of Engineers from the IIJA to help expand a segment of the Houston Ship Channel.³



Soo Locks

\$650 million through various IIJA programs will help repair and expand this critical connection between Lake Superior and the lower Great Lakes.⁴



Hudson River Tunnel

\$6.9 billion in federal funding, the most ever secured for a mass-transit project, is for an effort to expand and renovate the Northeast Corridor rail line in New Jersey and New York.⁵



Orlando International Airport

\$69 million will go towards two terminal expansion projects, including construction of new gates and expansion of a connector bridge.⁶



Sources: Text: 1. The White House, 2023-9; 2. The White House, 2023-September; 3. Business & Industry Connection, 2022; 4. Center for American Progress, 2023; 5. ENRMidAtlantic, 2023; 6. The White House, 2023-May; Charts: The White House, 2023

Inflation Reduction Act (IRA) and CHIPS Act Are Already Driving Investment in Disruptive Tech

By incentivizing the buildout of domestic supply chains for disruptive technologies, the IRA and CHIPS Act are driving private investment and boosting outlooks for construction companies that could make these projects a reality.

The IRA and CHIPS Act are designed to boost U.S. competitiveness in disruptive technologies like renewable energy, EV batteries, and semiconductors. Since passage of the bills in August 2022, private commitment in these areas total \$577 billion.¹

The U.S. gigafactory project pipeline exceeded Europe's for the first time in May 2023.² To put this in context, in August 2022, Europe's pipeline capacity was roughly 50% larger than the United States'.³ This major shift is largely attributable to the IRA.

Private Investments Made Since August 2022 in the United States*

EV & Battery

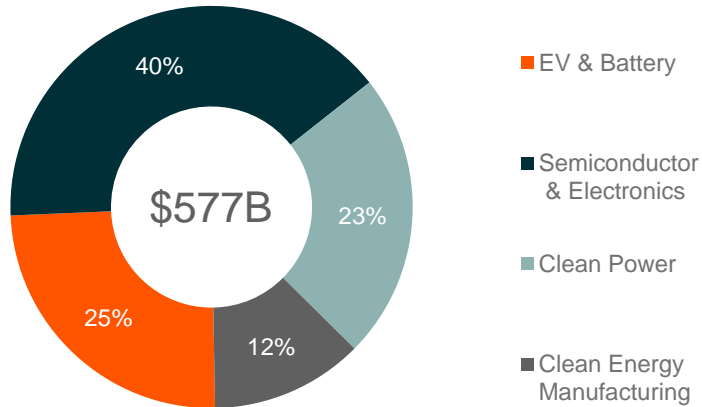
Top States:

- 1. Georgia: \$24B
- 2. Michigan: \$19B
- 3. Tennessee: \$16B

Semiconductor & Electronics

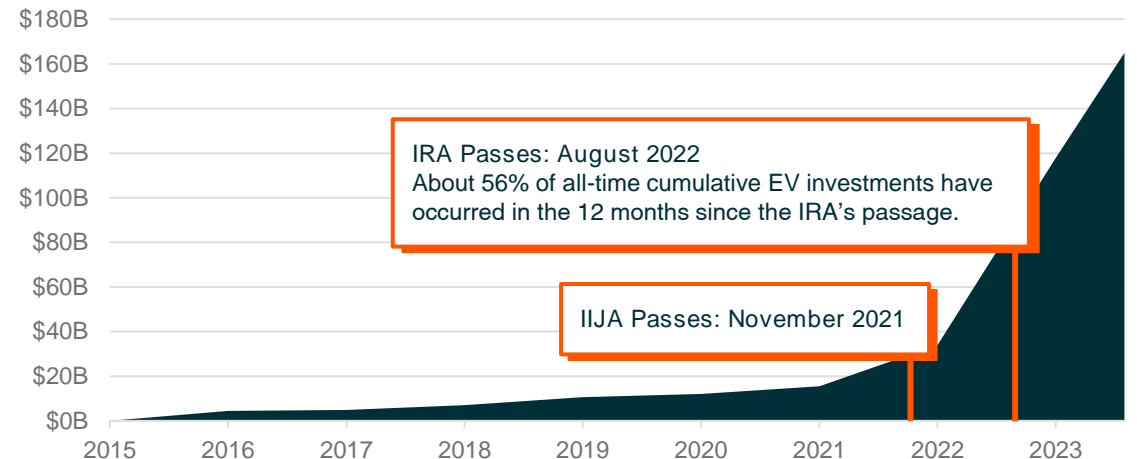
Top States:

- 1. Arizona: \$61B
- 2. Texas: \$52B
- 3. New York: \$41B



*As of November 2023

Cumulative Private EV & Battery Tech Investments in the United States



Sources: Text: 1. The White House, 2023; 2. Benchmark Mineral Intelligence, 2023; 3. Ibid.; Charts: Left: The White House, 2023; Right: Environmental Defense Fund, 2023.

Inflation Reduction Act and CHIPS Act Project Highlights

The IRA and CHIPS Act changed the equation for U.S. CleanTech and semiconductor projects, ushering in a wave of new investment. Projects at various stages of construction are racing ahead to take advantage of the new incentives.



TSMC – Arizona Semiconductor Fabs: In response to the CHIPS Act, semiconductor giant TSMC announced a second chip factory in Arizona, upping total investments in the state to \$40 billion.¹



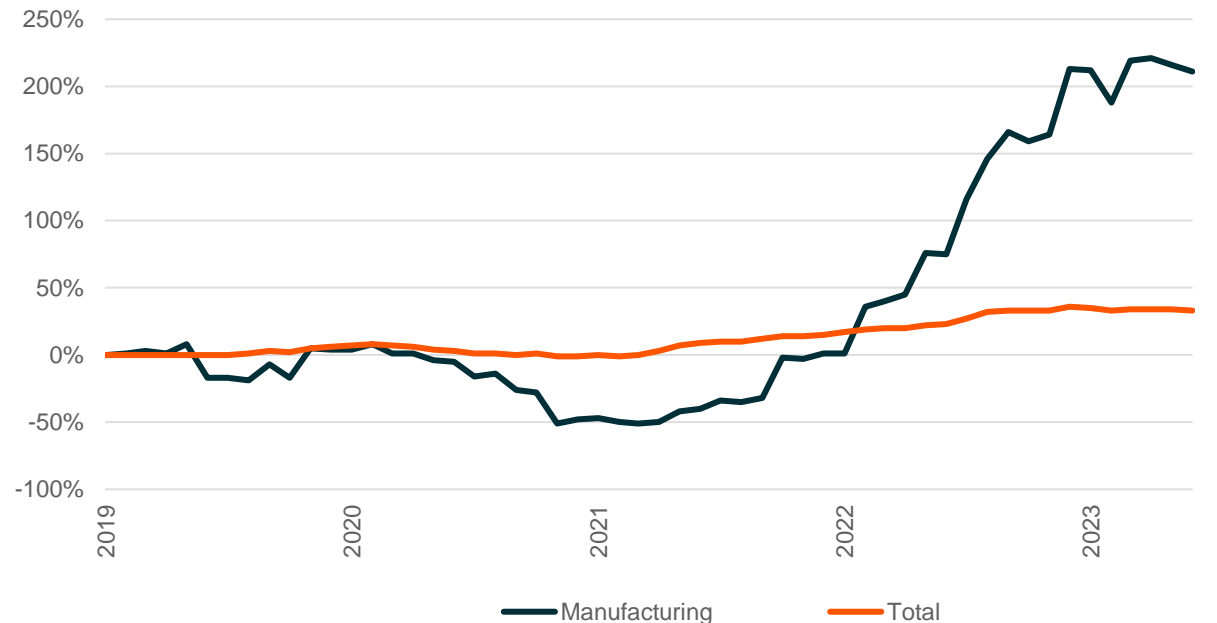
LG Energy Solution – Ohio Battery Plant: Honda and LG Energy Solution committed \$3.5 billion toward a joint venture EV battery plant in Ohio.² LG Energy Solution is also working on major factories in Arizona and Georgia.



Hanwha Qcells – Georgia Solar Factory: Korean solar company Hanwha Qcells plans to invest \$2.5 billion to build a cell and panel manufacturing complex in Georgia and increase capacity in the region to 60,000 panels per day.³

Manufacturing Spending Fueled Growth in Construction Starts

Percent Change in U.S. Construction Starts Since January 2019



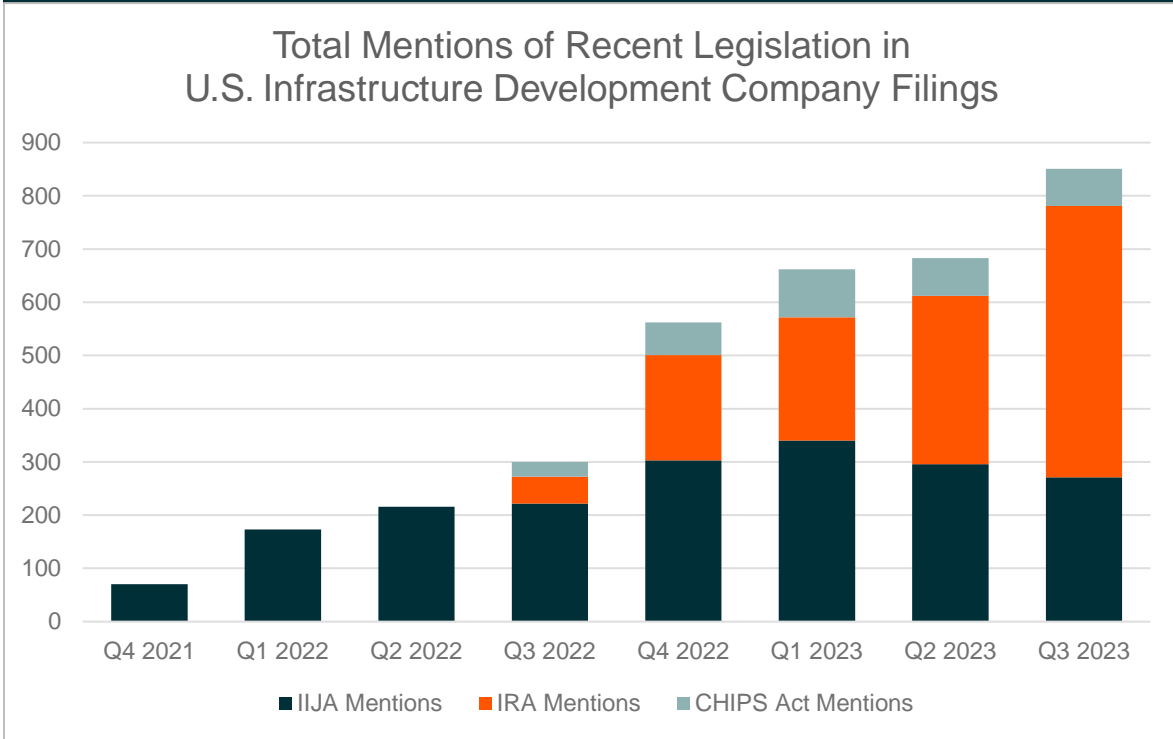
*2023 data as of June 2023

Sources: Text: 1. Taiwan Semiconductor Manufacturing Company (TSMC), 2022; 2. Honda, 2023; 3. Canary Media, 2023; Charts: Construction Dive, 2023

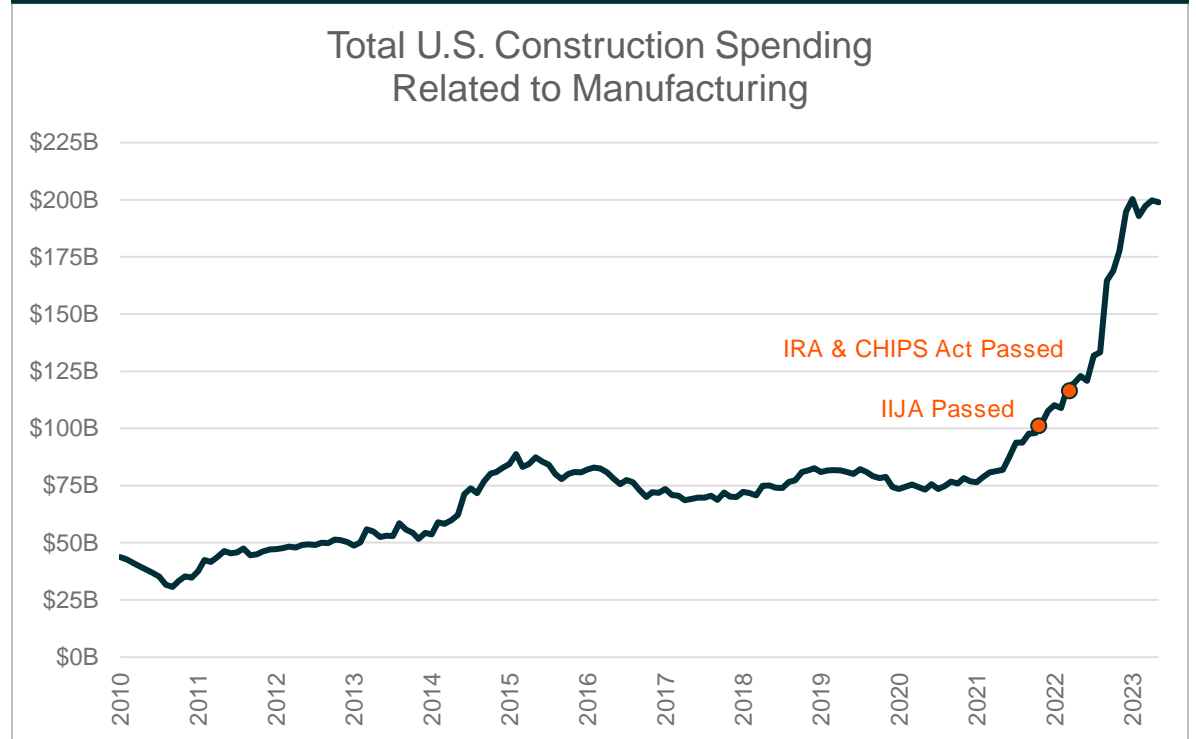
Recent Legislation Is Likely to Build More Momentum for U.S. Infrastructure

Management guidance from U.S. infrastructure companies continues to indicate that the benefits from the IIJA, IRA, and CHIPS Act are likely to begin in earnest in late 2023 and early 2024.

Mentions of Infrastructure Bills Rising on Earnings Calls



Legislation Already Boosting Manufacturing Construction



Sources: Charts: Left: FactSet, 2023; Right: U.S. Census Bureau, 2023

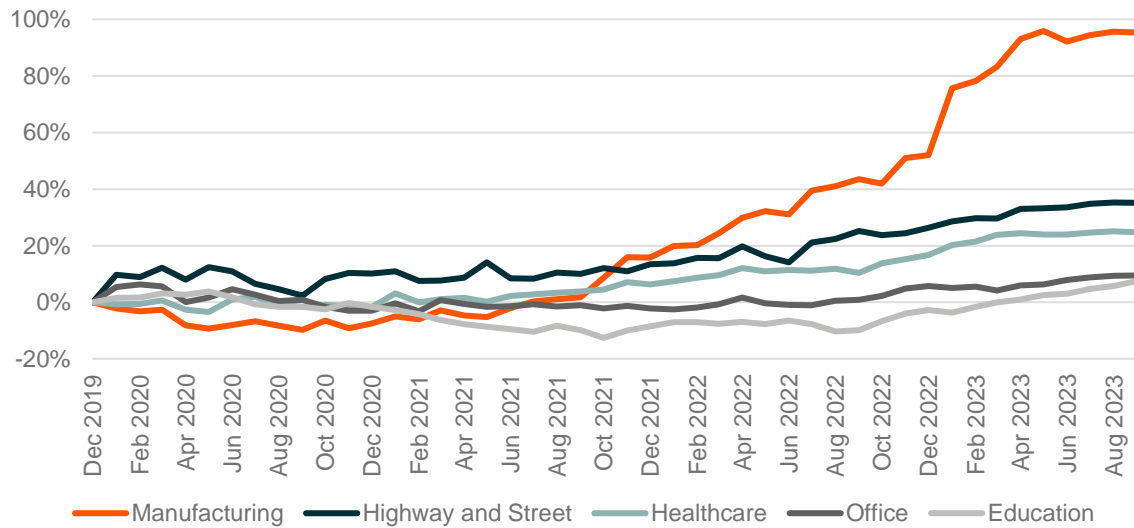
Onshoring Trend Tied to U.S. Industrial Production's New Path

After years of stagnation, a new era of U.S. industrial production growth is materializing, spurred by deglobalization and historic investments. Domestic reshoring is a multi-year trend that could boost demand for infrastructure development.

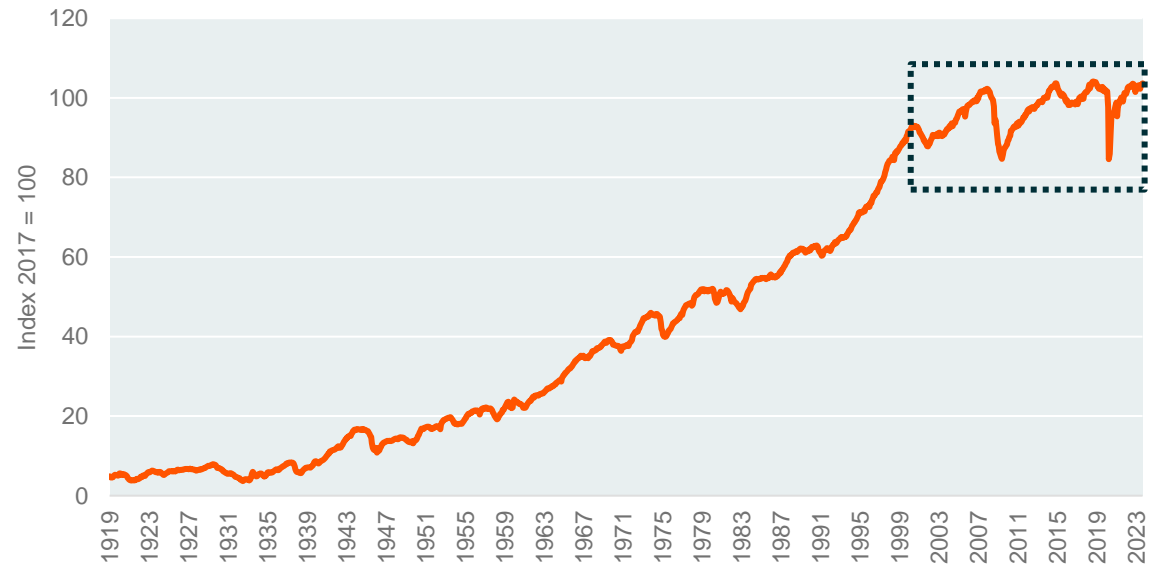
U.S. spending on manufacturing construction is elevated compared to history and has outpaced growth in other segments since the beginning of the COVID-19 pandemic. U.S. construction spending on manufacturing reached a record \$108 billion in 2022.¹

For 80 years, rapid industrial production growth defined the U.S. economy. Starting in the early 2000s, though, the U.S. industrial production machine began a two-decade stagnation. This dynamic could change if deglobalization continues to gain momentum.

Cumulative Percentage Change in U.S. Construction Spending Levels by Category Since December 2019



U.S. Industrial Production: Total Index



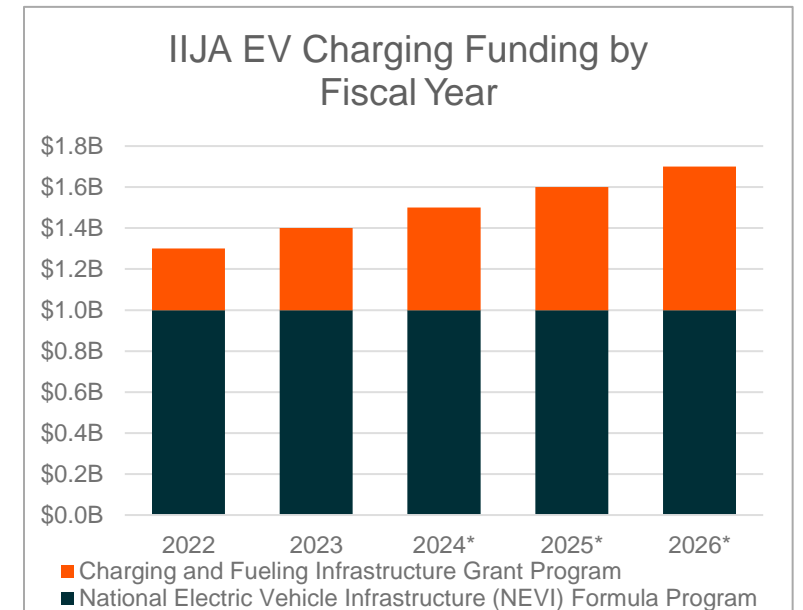
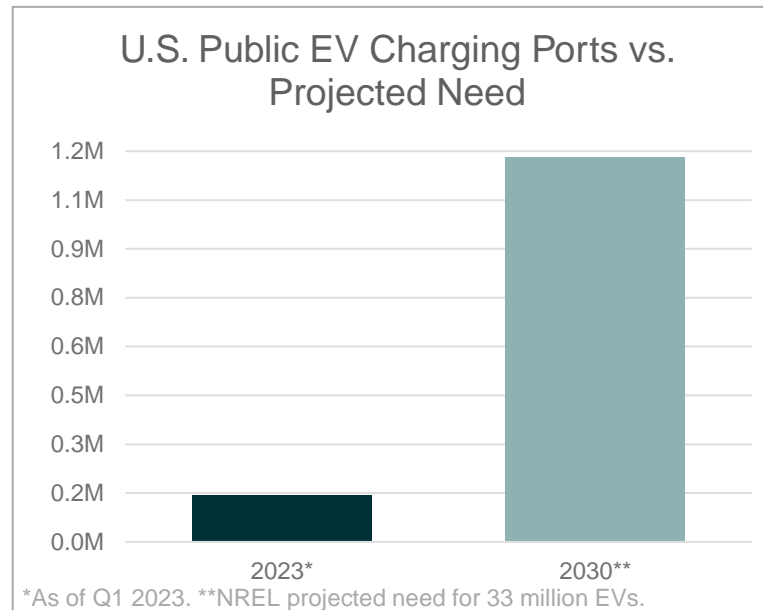
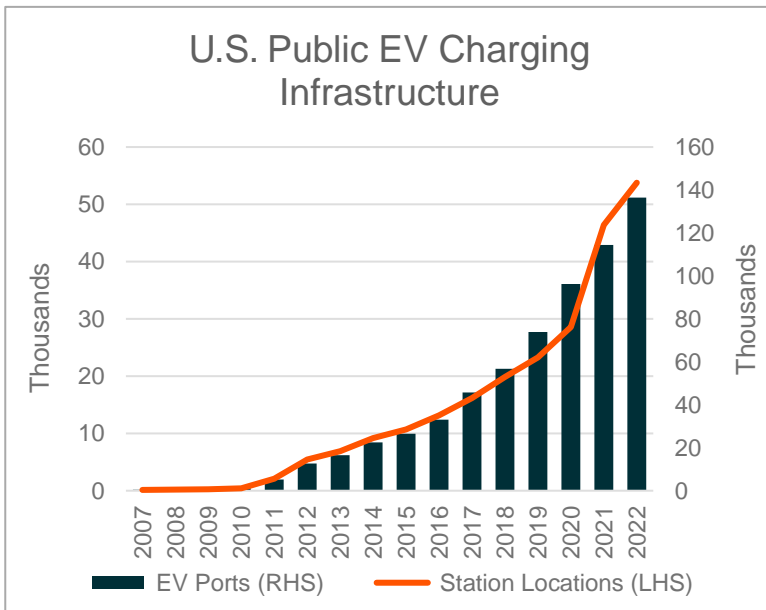
Sources: Text: 1. The Wall Street Journal, 2023; Charts: Left: U.S. Census Bureau, 2023-Sep; Right: U.S. Census Bureau, 2023-Sep

U.S. Charging Network Buildout Creates Opportunities for Infrastructure Companies

The United States boasts one of the largest EV charging systems in the world, but many more chargers are needed for full-scale adoption. Progress on a national network could benefit companies that offer relevant equipment and services.

Charging deployment could boost demand for companies like Eaton Corp or Hubbell that offer charging-aligned equipment. Construction and engineering firms also stand to benefit. In June 2022, AECOM won a contract to execute Arizona's IJEA EV charging program.¹

The IJEA directs \$7.5 billion toward public EV charging infrastructure through the National Electric Infrastructure Formula (NEVI) Program and the Charging and Fueling Grant Program.² Both initiatives cover up to 80% of project costs.³



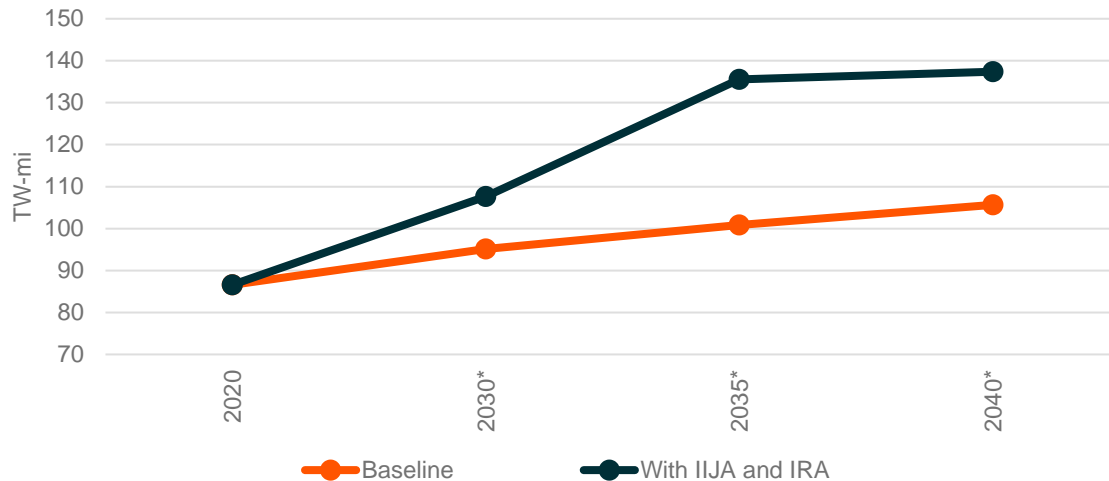
Sources: Text: 1. AECOM, 2022; 2. Bipartisan Policy Center, 2022; 3. Ibid.; Charts: Left: Alternative Fuels Data Center, 2023; Middle: Alternative Fuels Data Center, 2023; National Renewable Energy Laboratory, 2023; Right: Bipartisan Policy Center, 2022

Transmission Infrastructure Is Required for Grid Modernization

The U.S. grid needs an upgrade, given the energy transition and the fact that over 70% of transmission lines are at least 25 years old.¹ In coming decades, structurally high demand for grid expansion and improvement is possible.

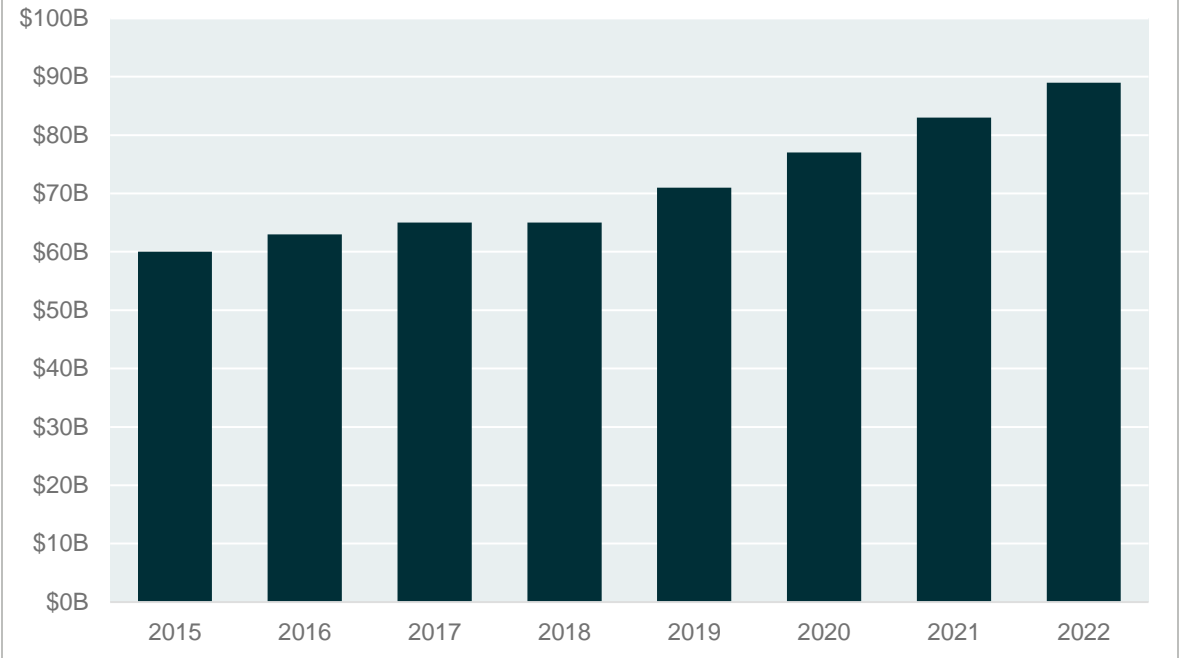
Transmission infrastructure is key for a healthy grid that can support fluctuations in electricity from renewable energy and EVs. The DOE estimates that 47,300 GW-miles of new transmission are needed by 2035 to meet clean technology goals, a 57% addition against 2023.²

Total Transmission Capacity in Contiguous United States Under Different Growth Scenarios



U.S. Grid Investments Are on an Upward Trajectory

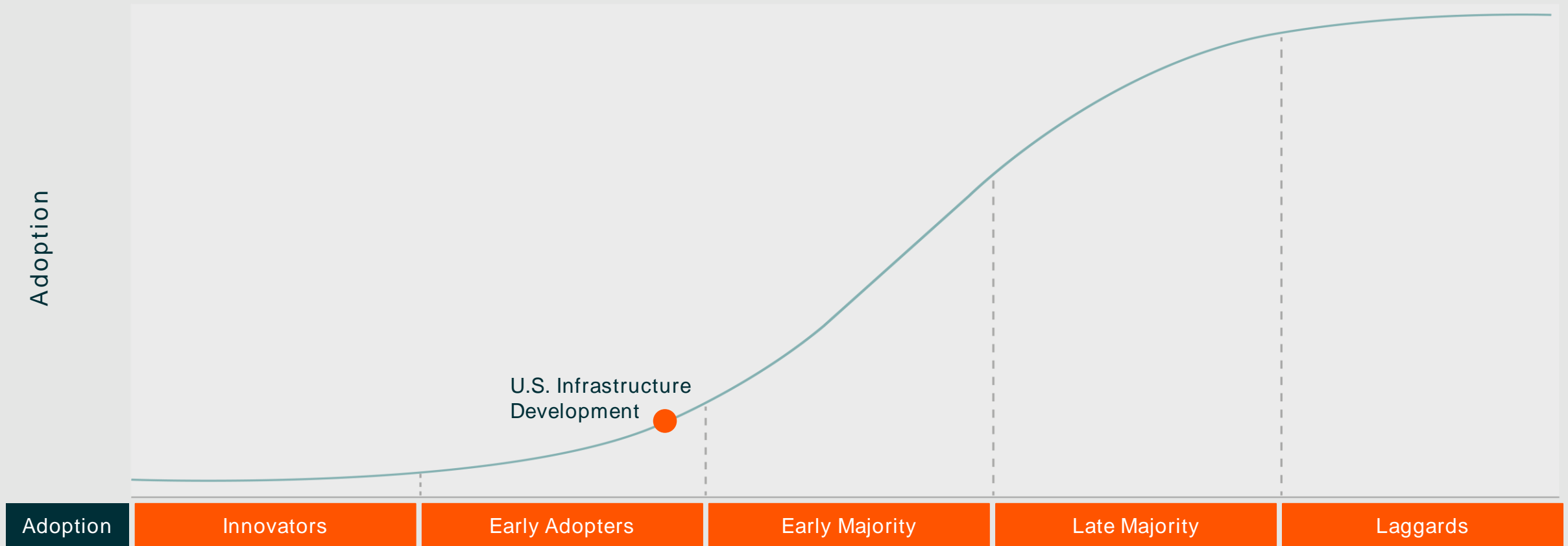
Historical U.S. Grid Investments



Sources: Text: 1. The White House, 2022; 2. U.S. Department of Energy, 2023; Charts: Left: U.S. Department of Energy, 2023; Right: International Energy Agency, 2023

Infrastructure, Reimagined: S-Shaped Curve of Adoption

A total overhaul of U.S. infrastructure is many years and trillions of dollars away. Compared to the opportunity, the theme remains in the early stages of adoption.



Note: For illustrative purposes only.

Paradigm-Shifting Technologies

Artificial Intelligence

Generative AI's Transformative Power

Large Language Models (LLMs) mark a revolutionary change in artificial intelligence's (AI's) development, as they make sophisticated AI accessible, integrable, and widely distributable. While early proof of concepts present only a hint of what's possible with generative AI, they clearly show that we're on the cusp of a new paradigm where consumer experiences and enterprise applications are intelligent and interactive by design. We expect this shift to create new markets amid a multi-trillion-dollar explosion of economic value.

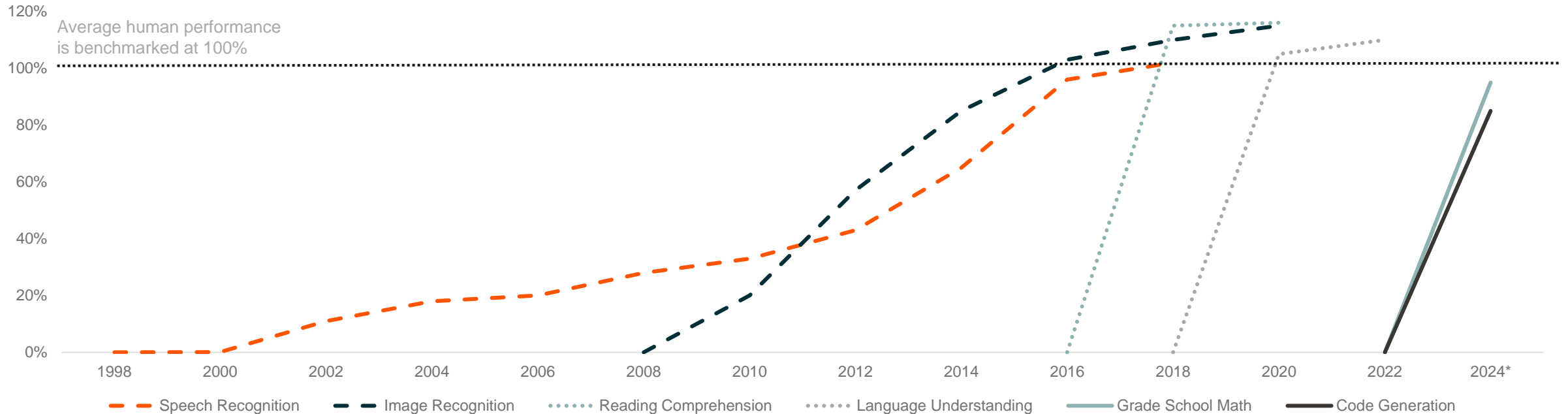


AI Already Outperforms Humans in Numerous Categories

AI's performance superiority is evident for tasks like reading comprehension and language understanding, and the pace of its development for more novel tasks is accelerating. However, Artificial General Intelligence (AGI) is still years away.

AI Is Likely to Surpass Humans in All Performance Benchmarks by the End of This Decade

AI Performance on Benchmarks, Relative to Human Performance



* Forecast

Note: For each benchmark, the maximally performing baseline reported in the benchmark paper is taken as the "starting point", which is set at 0%. Human performance is set at 100%.

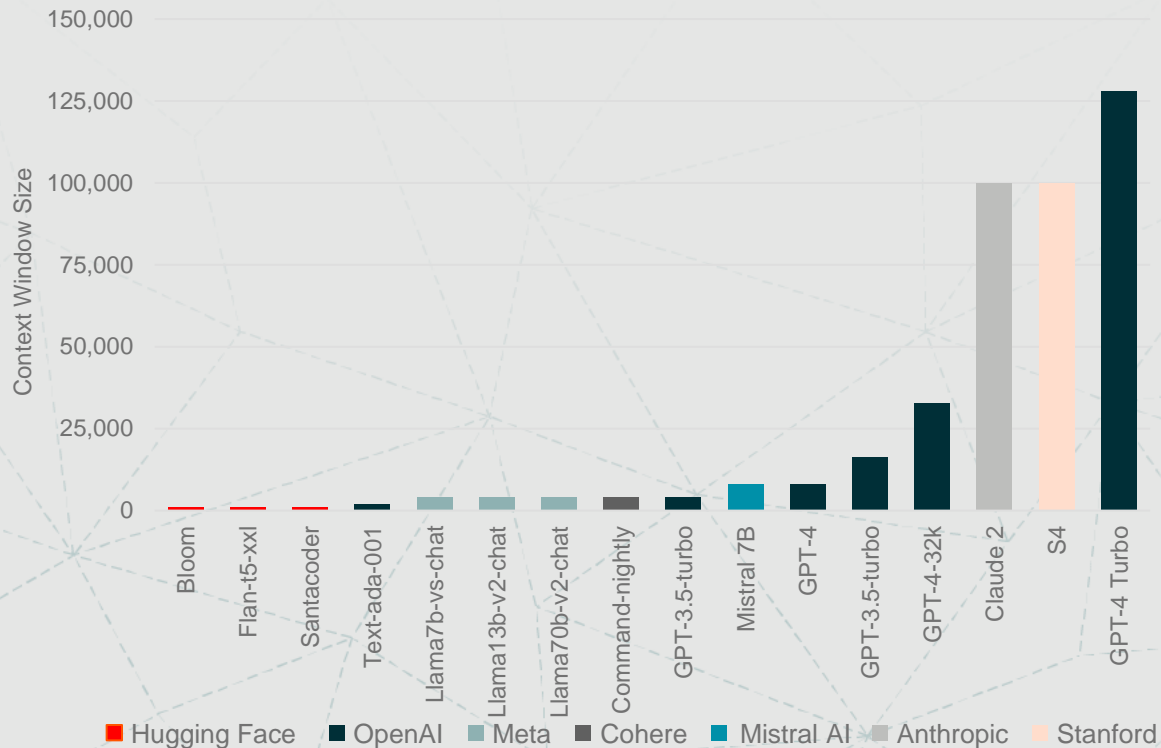
Sources: Kiela, Thrusch, Ethayarajh, & Singh, 2023; Henshall, 2023

Advancements in Transformer Models Can Propel Increased Adoption

Andrew Carr

LLMs based on the attention mechanism come with high computational costs. Emerging model paradigms will focus on improving model accuracy and increasing context sizes while keeping costs and hallucinations at a minimum.

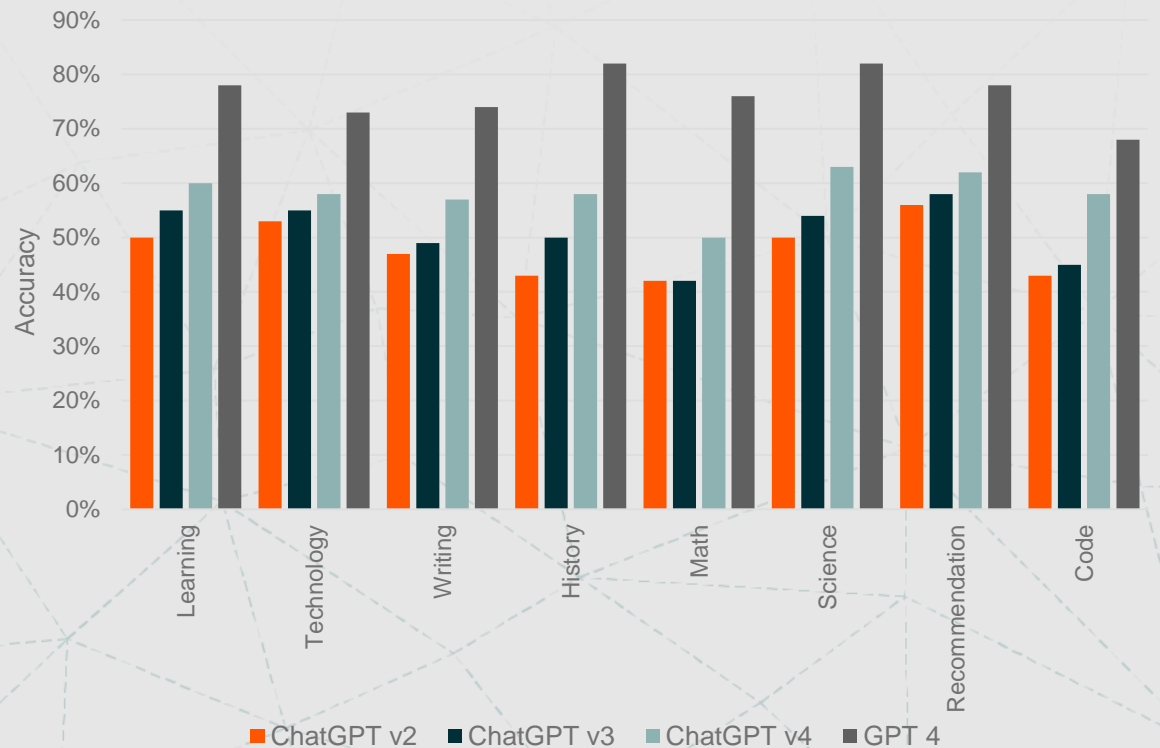
Large Language Model Context Sizes



Note: The context window is the number of tokens the model can take as input. Attention mechanisms allow the model to selectively focus on specific parts of the input most important for making a prediction.

Sources: Charts: Left: Greyling, 2023; Right: OpenAI, 2023

OpenAI Internal Accuracy Evaluation by Category

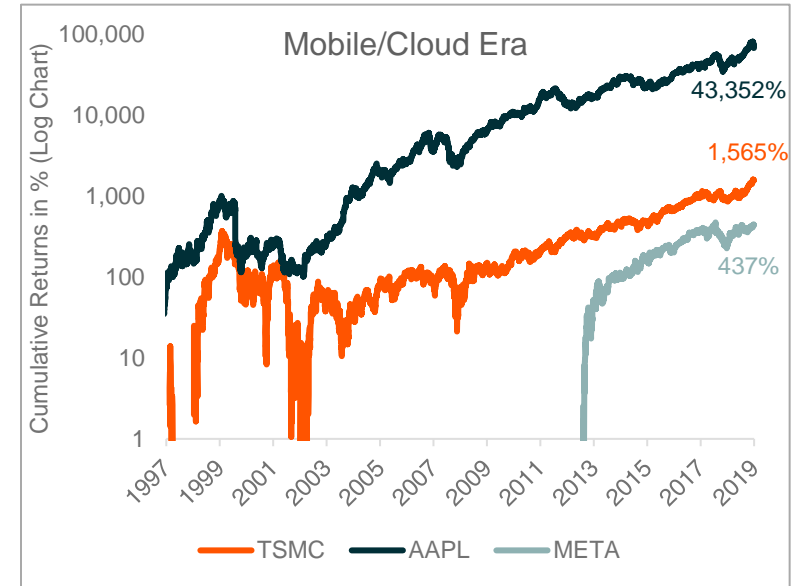
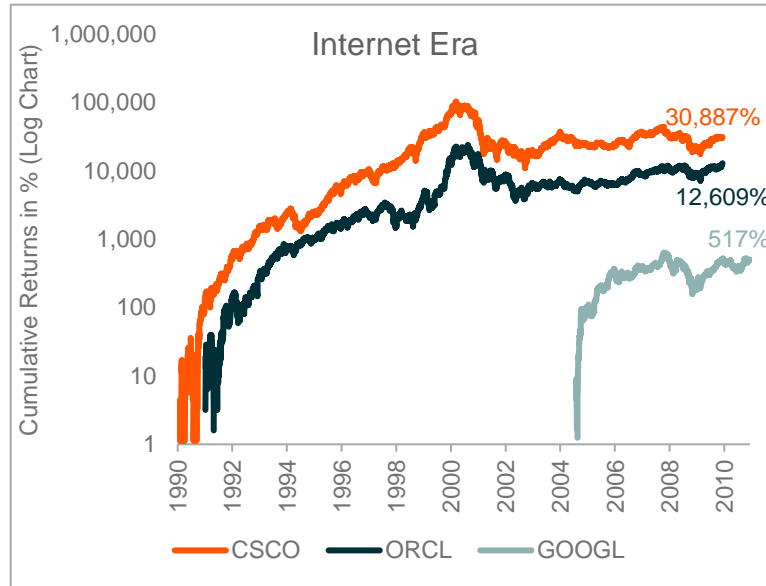
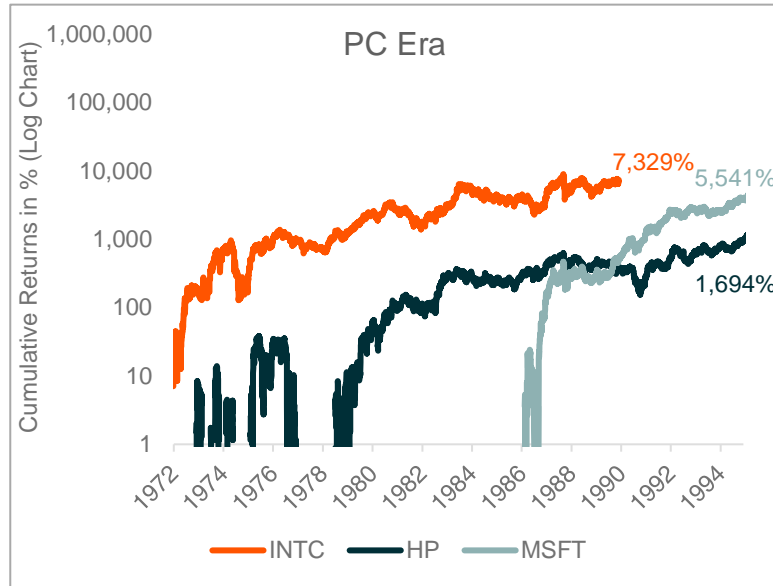


Note: An accuracy of 1.0 means the model's answers are judged to agree with human ideal responses for all questions in the evaluation.

Generative AI to Deliver Another Major Technological Paradigm Shift

Technological paradigm shifts rely on the convergence of three elements: compute, data/infrastructure, and interface. Companies that met the demand of their respective categories in previous shifts have become market winners.

Compute Layers Compute Eras	Personal Computers (PCs)	Internet	Mobile/Cloud	AI
Compute	Intel	Intel, Cisco	Samsung, Qualcomm, TSMC	Nvidia, ARM
Data / Infrastructure / Device	Hewlett-Packard (HP)	Cisco, Oracle	AWS, iOS, Android	AWS, Azure, GCP
Interface	Microsoft	Google, Amazon	Meta, Apple, Google, Samsung	OpenAI, TBD

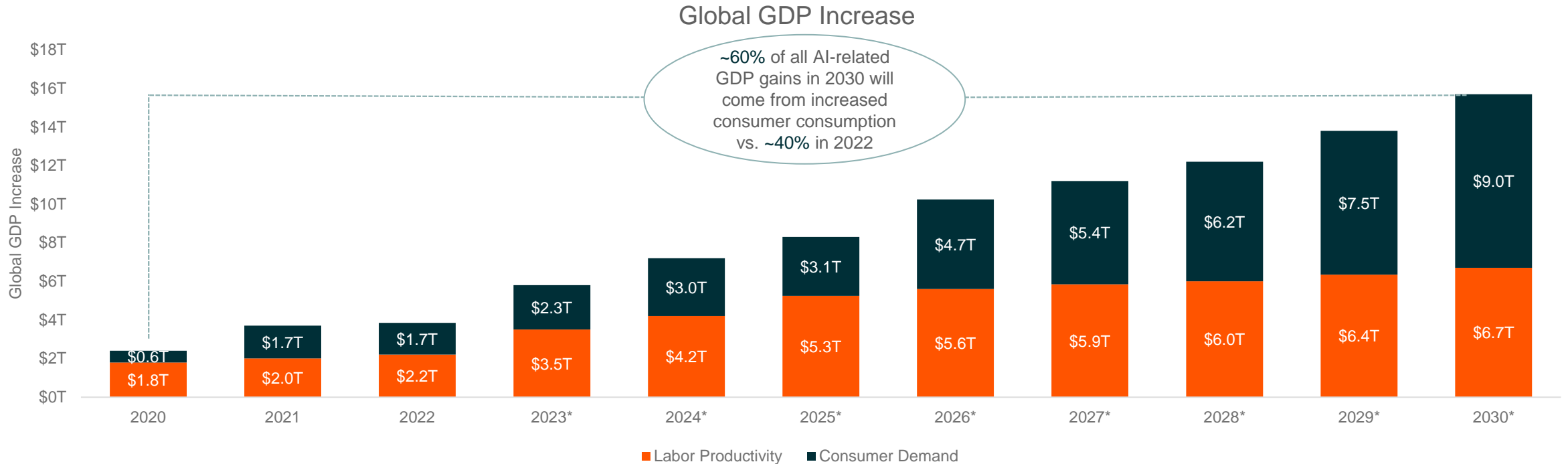


Sources: Charts: Top: The Deload, 2023; Bottom: FactSet, n.d.

AI's Rapid Advancement Could Add \$16 Trillion to the Global Economy by 2030¹

Initial growth will primarily stem from productivity gains before gradually shifting to an expansion driven by increased consumer demand.

Generative AI Will Enhance Labor Productivity and Could Drive Higher Consumer Demand Through Improved Product Quality



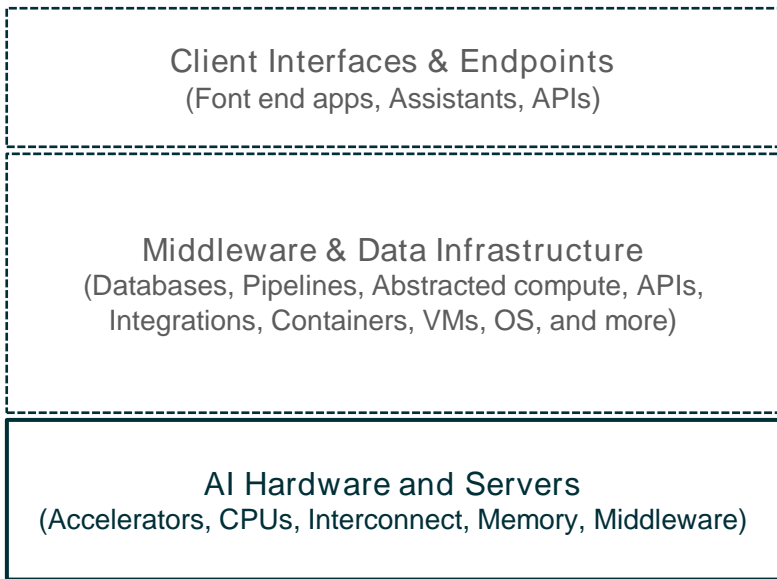
Sources: Text: 1 Bank of America, 2023; Chart: Bank of America, 2023; Medium, 2023

Revamp of AI Processing Infrastructure Presents New Opportunities for Chipmakers

As data center systems transition to computational infrastructure that can handle AI-first workloads, we expect new opportunities to emerge for disruptive chipmakers.



AI Computational Stack



	NVIDIA	intel	Qualcomm	AMD	MARVELL
AI Cores	H100, A100	Gaudi 2	AI 100	MI250, MI300	
CPUs	Nvidia Grace CPU	Intel Core, Xe	Phoenix Core (Nuvia)	AMD Threadripper	Marvell ThunderX, ARMADA
Interconnect Systems	InfiniBand, NV Link	Quick Path Interconnect		Infinity Fabric	SerDes
High Bandwidth Memory	HBM3, HBM3E	Sapphire Rapids HBM		HBM DRAM, GDDR5	
Abstraction Layer (Software)	CUDA Software Architecture	Third Party Frameworks like OpenCL		OpenCL, GPUFORT	CUDA for ThunderX

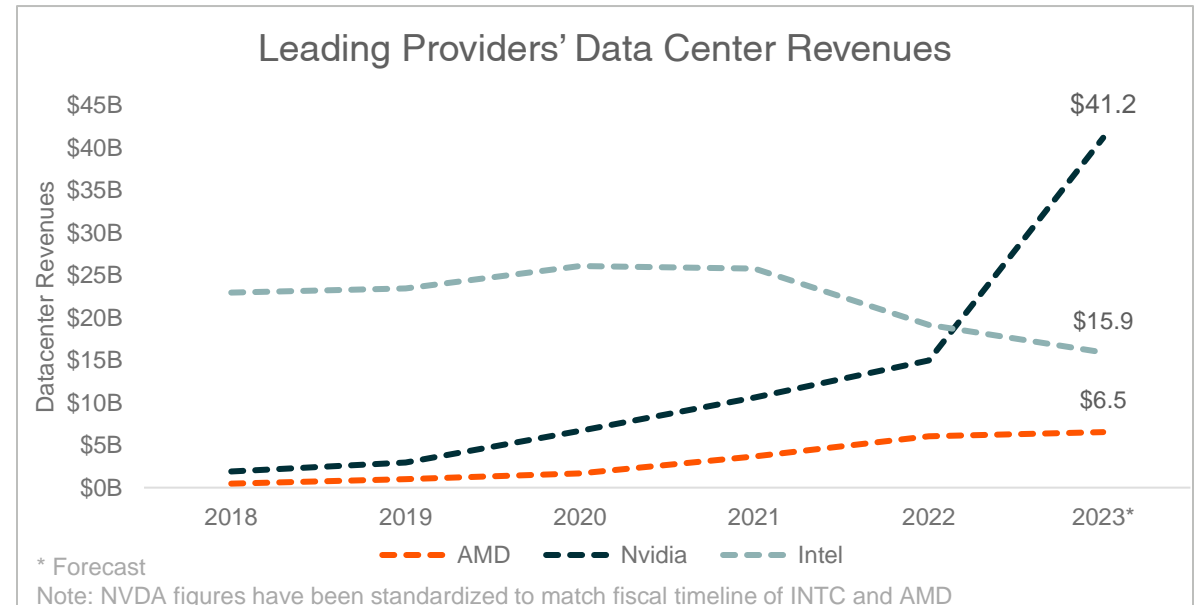
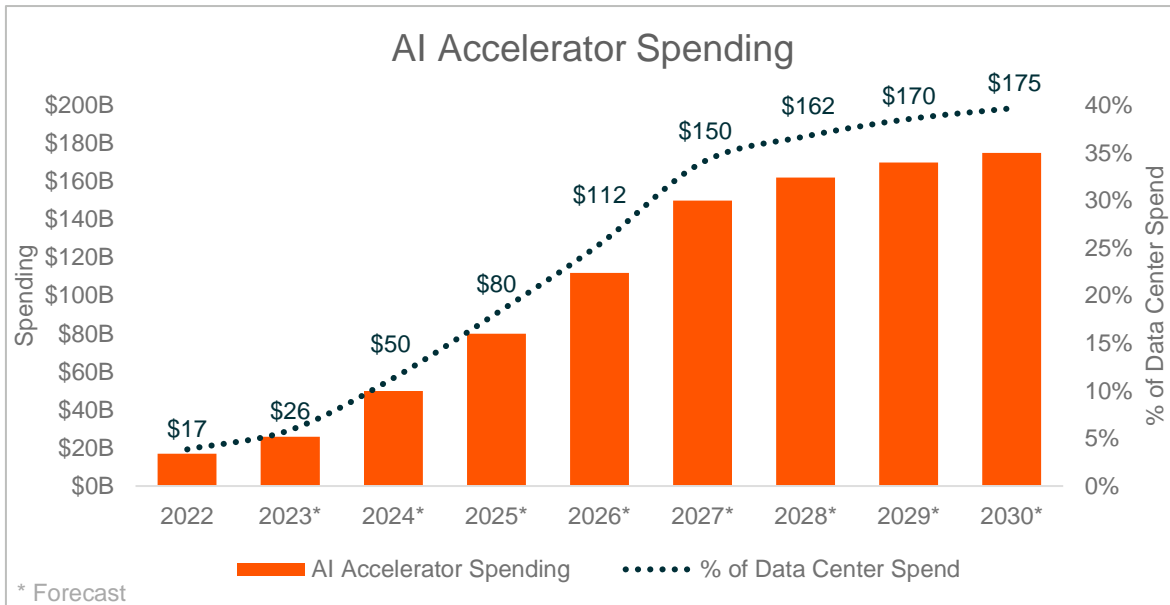
Sources: The Next Platform, 2021; Nvidia, n.d.; Intel, n.d.; Qualcomm, n.d.; Advanced Micro Devices (AMD), n.d.; Marvell, n.d.

The AI Chipset Market Could Be Worth More Than \$200 Billion by the End of the Decade

The graphics processing unit (GPU) market is projected to exceed \$247 billion by 2028, and the broader AI accelerator market is expected to approach \$162 billion.^{1,2}

AI accelerators are specialized hardware components designed to perform the complex computations required by AI and machine learning (ML) algorithms more efficiently than general-purpose central processing units (CPUs). In addition to GPUs, other accelerators include field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and Tensor Processing Units (TPUs).

Nvidia currently owns a more than 70% share in datacenter acceleration, but vendors like AMD are making strides.³ AMD is moving fast to build a foothold and meet surging AI demand, including by bringing its new MI300 accelerator chip to the market.



Sources: Text: 1. Precedence Research, 2023; 2 Bloomberg, 2023; 3. Visual Capitalist, 2023; Charts: Left: Precedence Research, 2023; Bloomberg, 2023; Statista, 2022; Right: FactSet, 2023

Open-Source Models Allow for Robust AI Innovation Outside Big Tech's Control

Andrew Carr

The open-source community is gaining momentum with industry giants such as Meta Platforms releasing models. This community also excels in curating small datasets that the public can use to fine-tune these models.



	Alphabet	Amazon	Microsoft/OpenAI	Meta Platforms	Nvidia	Stability AI	Additional Contributors
Text / Language	Bard, BERT, PaLM, GLaM, Chinchilla	AlexaTM, Titan LLM	GPT-4, ChatGPT, MT-NLG	LLaMA, OPT-175B	MT-NLG		Claude, Cohere, Jurassic-1, Dolly, BLOOM, Alpaca
Code	AlphaCode	Code Whisperer	Copilot, Codex, CodeBERT	Code LLaMA			Replit, Polycoder, Code T5
Image	Parti, DreamBooth, Imagen		Dall-E 2, Kosmos-2, CLIP, NUWA-Infinity	Dinov2, Make-a-scene	SPADE	Stable Diffusion	Midjourney, Waifu Diffusion
Speech & Music	WaveNet, MusicLM		Whisper, Jukebox			Dance Diffusion	WaveGAN
Video	Imagen Video, Phenaki		NUWA-Infinity	Make-a-video			CogVideo
3D	DreamFusion, 3DiM		Point-E		Get3D, Magic3D		Motion Diffusion Model

■ Proprietary
 ■ Open Source
 ■ Private

Source: Tola Capital, 2023

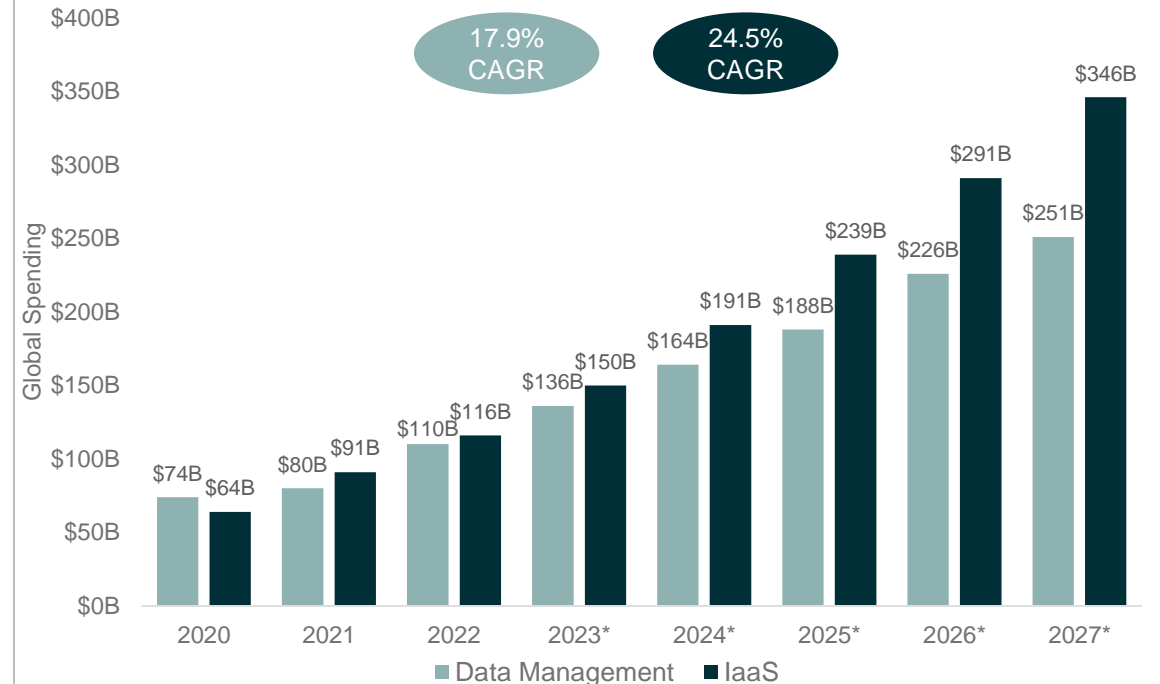
AI Implementation Benefits Cloud Infrastructure Providers and Data Solutions Suppliers

AI services will largely be distributed and consumed through the public cloud. Data management solutions and apps are essential for enterprises looking to extract insights from the explosion of data and enhance their offerings.

Data Explosion Increases Demand for Cloud Resources



Data Management Spend Expected to Grow at 18% CAGR



Sources: Charts: Right: Gartner, 2023; Research and Markets, 2023

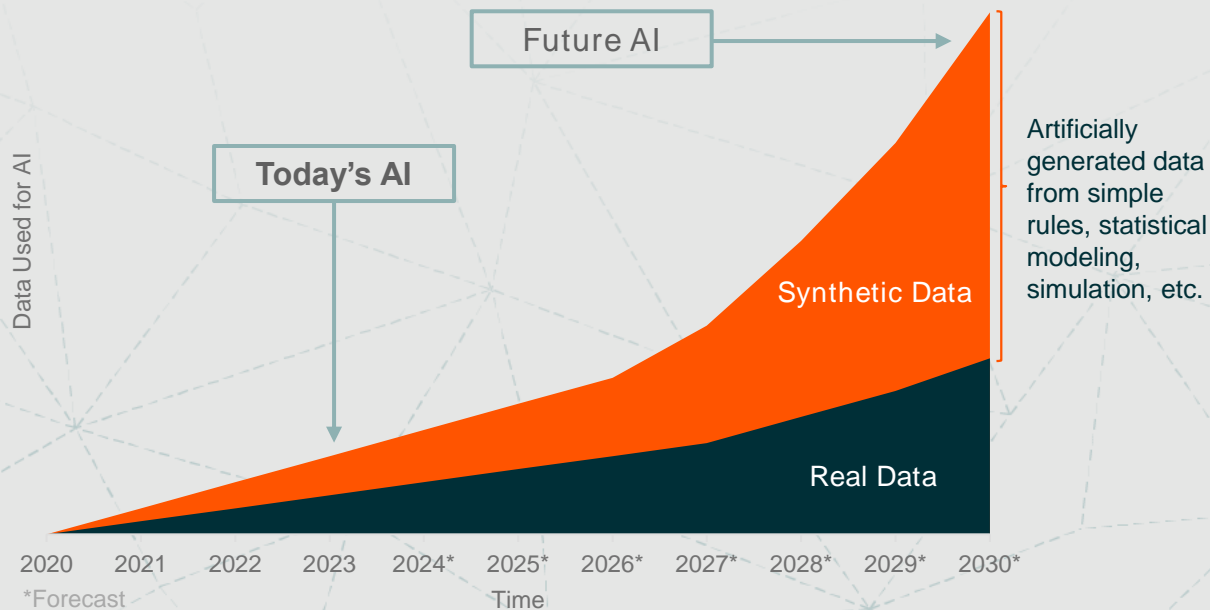
Emerging Model Architectures Benefit from Synthetic Data

Andrew Carr

Trillions of data points go into training the best of these models. What happens when we run out of data? How do we train the next generation of models? Synthetic data is a potential answer.

Synthetic Data: Manufactured, Not Based on Real-World Events

Real Data vs. Synthetic Data in AI Models



Synthetic Data Benefits



Cost Savings

Overcome the data gap and reduce the overall expense of obtaining and annotating data needed to train AI models.



Accuracy

Create highly accurate, generative AI models by training with data including rare, crucial corner cases otherwise impossible to collect.



Privacy

Tackle privacy concerns and reduce bias by creating varied datasets that mirror the real world.



Scalable

Generate data that scales with your use case across manufacturing, automotive, robotics, and more.

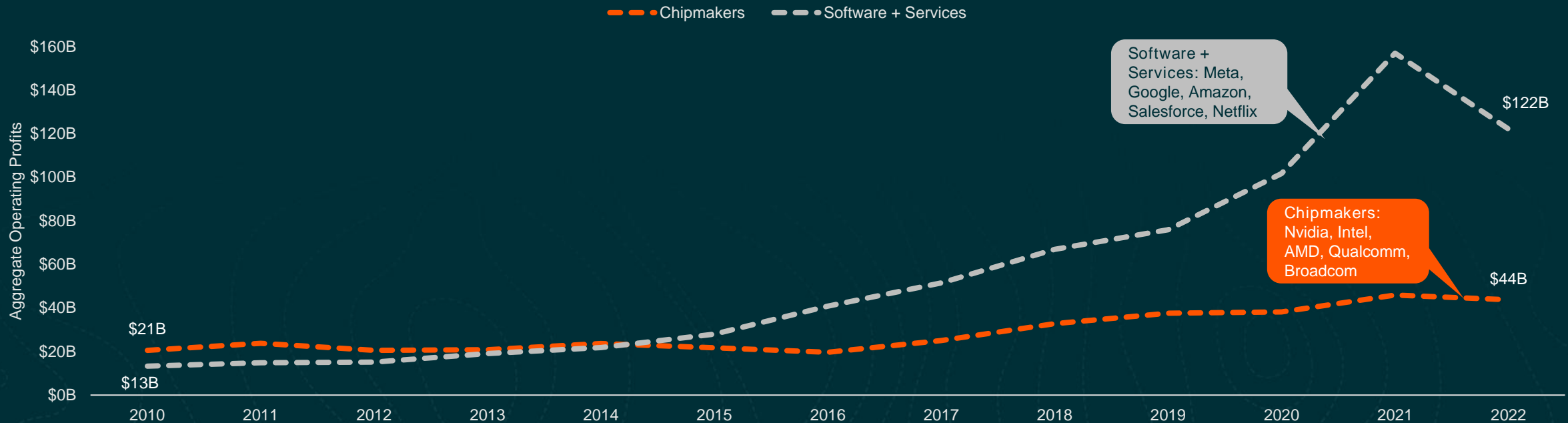
Sources: Charts: Left: Gartner, 2021; Right: Nvidia, n.d.

History Suggests Interface Layer Will Capture Maximum Value from the AI Platform Shift

The interface layer is how consumers experience paradigm shifts. Like Microsoft did for PCs and Apple did for smartphones, the apps that integrate generative AI models into user-facing products can accrue incredible value.

Services Providers and Platforms, Created by a New Tech Cycle, Reap Better Profits Than Chipmakers Powering the Cycle

Software & Services vs. Chipmakers Cohort Operating Profits, 2010-2022



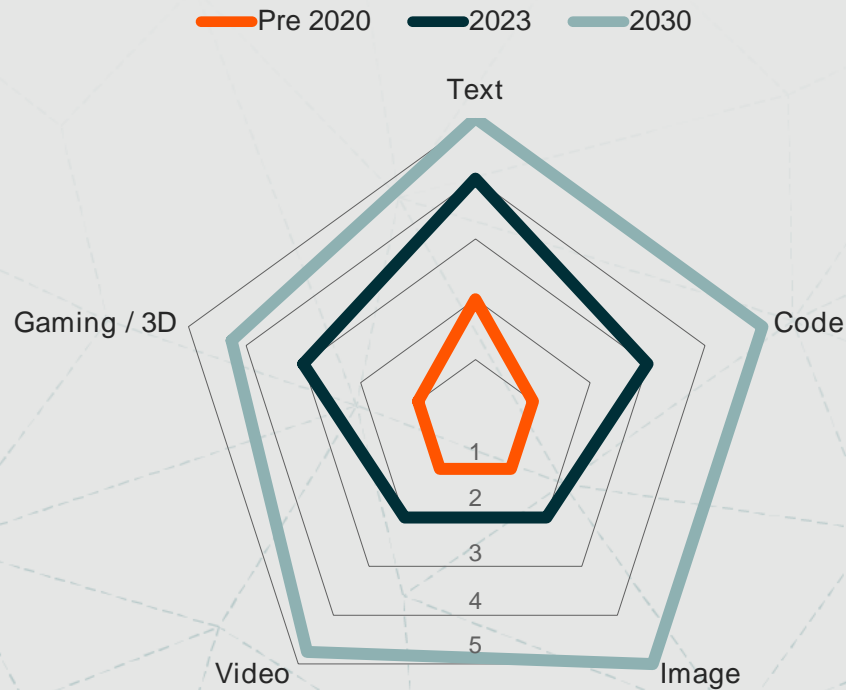
Sources: FactSet, n.d.

Multimodal LLMs Can Bring AI Closer to Widespread Consumer Application

Andrew Carr

Editability and flexibility are keys to advancing LLMs. Multimodal LLMs, which combine text with other data, like images, videos, or animation, can address the limitations of text-only models and unlock new applications and uses.

Generative AI Capabilities by Different Modalities



Note: Scale 1-5, with 5 being most capable

Sources: Charts: Right: The Information, 2023

Leading AI Players Race Towards Multi-Modal LLMs

Google Gemini

Google's inhouse AI group, DeepMind, will launch Gemini in 2024. Gemini is a multimodal LLM that enables users to generate content based on various inputs, write software code, summarize content, as well as draft emails and song lyrics.

As the impact of AI broadens and new use cases emerge, large data-rich tech players, like Google, intend on being the engine of creativity while creating new business models by supplying multi-modal systems.

OpenAI GPT-Vision and Gobi

OpenAI is developing a new multi-modal AI model called Gobi, which will learn from the company's GPT-based system and integrate multi-modal capabilities.

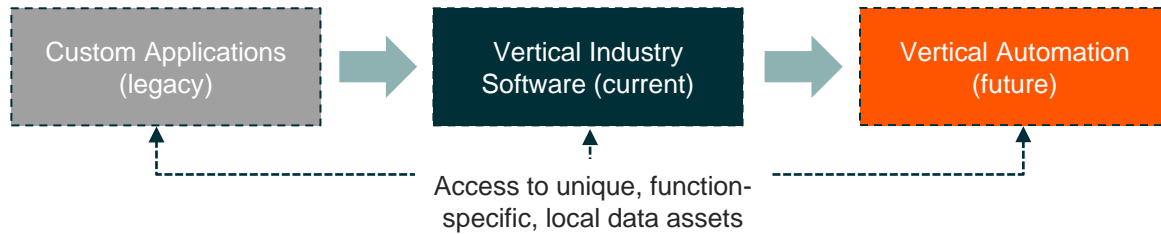
Open AI has also recently launched GPT-Vision, a multimodal feature that equips GPT-4 with image comprehension abilities, broadening the range of applications it offers its users.

This enhancement enables new image-based applications for GPT-4, such as generating text that matches images.

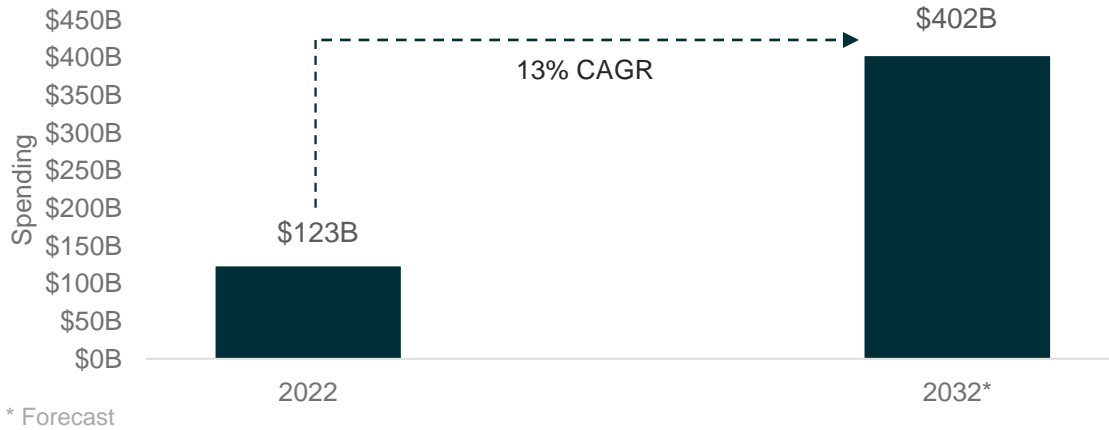
New AI-Embedded SaaS Applications Will Continue to Emerge Through the Decade

Vertical automation is the future. SaaS providers are in a unique position to leverage data assets at their disposal to train foundational models and bring them to market to automate industry-specific systems.

Software Moving from Custom-Built to Verticalized Intelligence



Vertical Software Market Spend



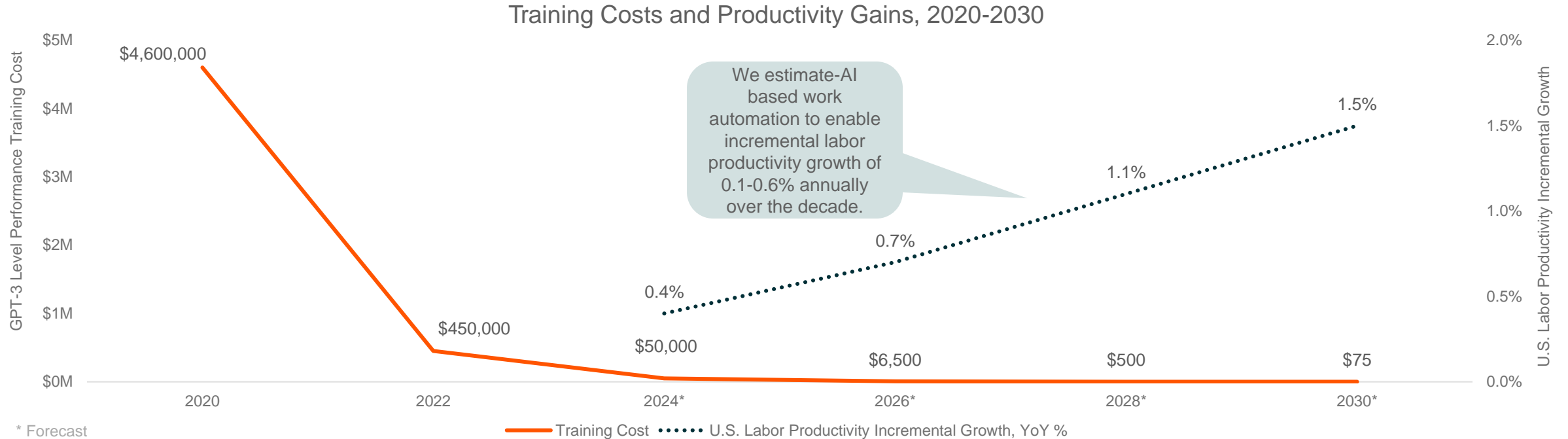
Platform	Tool	Function
Salesforce	Einstein GPT	Auto-generates sales, marketing, content, targeting, messaging, and personalization across channels.
Adobe	Firefly	Generates images, fill, text effects, and recolor from text prompts. Can also create content and edit video with text prompts.
Meta	AI Sandbox	Tools that enable businesses to create AI-based ads and better predict performance.
Microsoft	365 Copilot	Generates tasks, word-processing documents, presentations, spreadsheets, emails, and Microsoft office updates via text prompts.
Google	Workspace Bard	Generates drafts, replies, and proofs in Gmail and Google Docs; images, audio and video in Slides; and notes/audio in Meet.
Canva	Magic Write	Generates drafts, outlines, lists, and captions from text prompts.
HubSpot	ChatSpot	Conversation bot that automates all customer relationship management tasks.
Grammarly	GrammarlyGo	Generates writing and revisions relevant to tone, clarity, length, and tasks via text prompts across various forums.

Sources: Charts: Left: Future Market Insights Inc., 2022; Right: Quesenberry, 2023

AI to Emerge as a Co-Pilot to Human Intelligence

AI is already dramatically increasing knowledge workers' productivity. As adoption intensifies, AI hardware, software, and training costs are expected to decline, promoting even greater adoption and productivity.

Cost of Training a GPT-3 Level LLM Declined by About 90% from 2020-2022, Which Could Reignite Productivity Growth

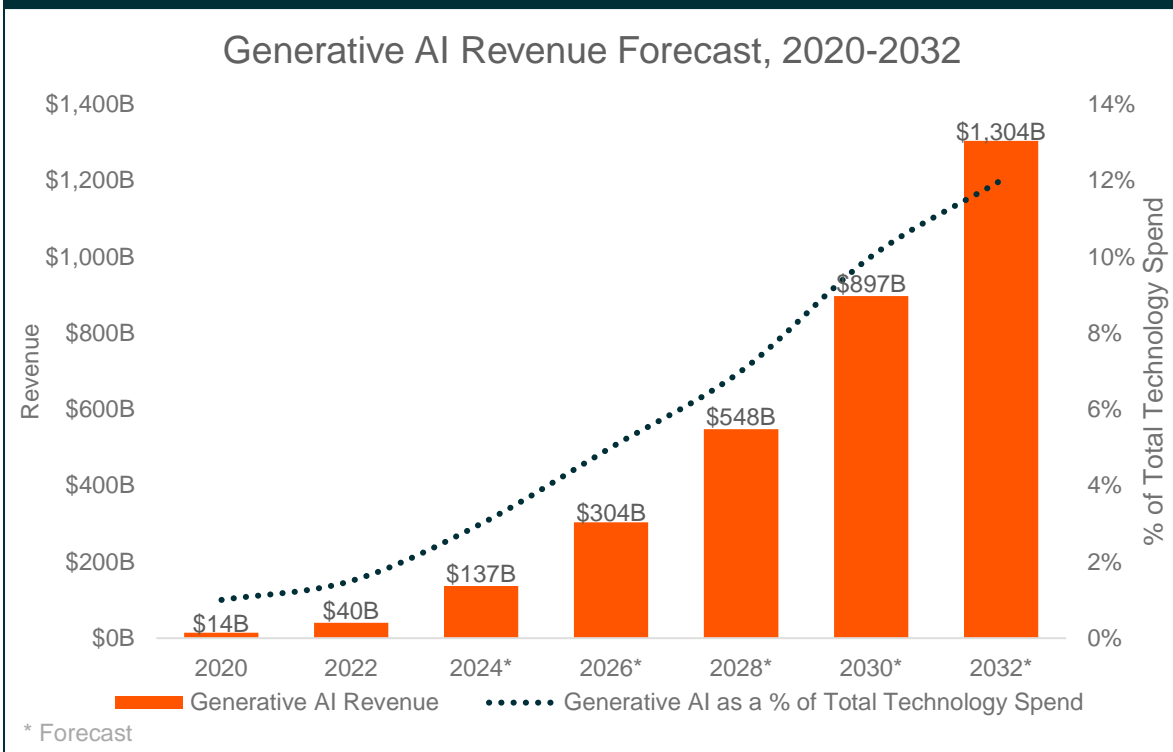


Note: U.S. Productivity Growth measures the incremental YoY boost to labor productivity, measured as output per hour worked, of non-farm business employees, delivered by increased use of automation in work. Sources: McKinsey & Company, 2023; MosaicML, 2022; Lambda, 2020; U.S. Bureau of Labor Statistics, 2023

Generative AI-Based Technology Could Account for \$1.3 Trillion in Spending By 2032¹

Generative AI growth will be largely driven by training infrastructure in the near term before gradually shifting to specialized software and services over the longer term.

Gen AI to Comprise ~10% of Tech Spending by 2030



Generative AI Revenue Projections (\$M)	2022	2027*	2032*	CAGR
Hardware				
Devices (Inference)	\$37,973	\$223,615	\$641,737	33%
Computer Vision AI Products	\$4,128	\$82,965	\$168,233	45%
Conversational AI Products	\$1,032	\$22,124	\$60,564	50%
Generative AI Infrastructure (Training)	\$3,096	\$60,841	\$107,669	43%
Data Center/Infrastructure (Training)	\$33,845	\$140,650	\$473,505	30%
AI Server + Storage	\$31,588	\$82,735	\$226,459	22%
Generative AI Infrastructure as a Service	\$2,256	\$57,915	\$247,046	60%
Software				
Specialized Generative AI Assistants	\$1,493	\$58,826	\$279,899	69%
Coding, DevOps, and Gen AI Workflows	\$447	\$20,864	\$89,035	70%
Coding, DevOps, and Gen AI Workflows	\$213	\$12,617	\$50,430	73%
Gen AI Workload Infrastructure Software	\$439	\$13,468	\$71,465	66%
Gen AI Drug Discovery Software	\$14	\$4,042	\$28,343	113%
Gen AI Based Cybersecurity Spending	\$9	\$3,165	\$13,946	109%
Gen AI Education Spending	\$370	\$4,669	\$26,500	53%
Other Software Spending	\$368	\$116,904	\$381,915	100%
Total	\$39,834	\$399,345	\$1,303,551	42%

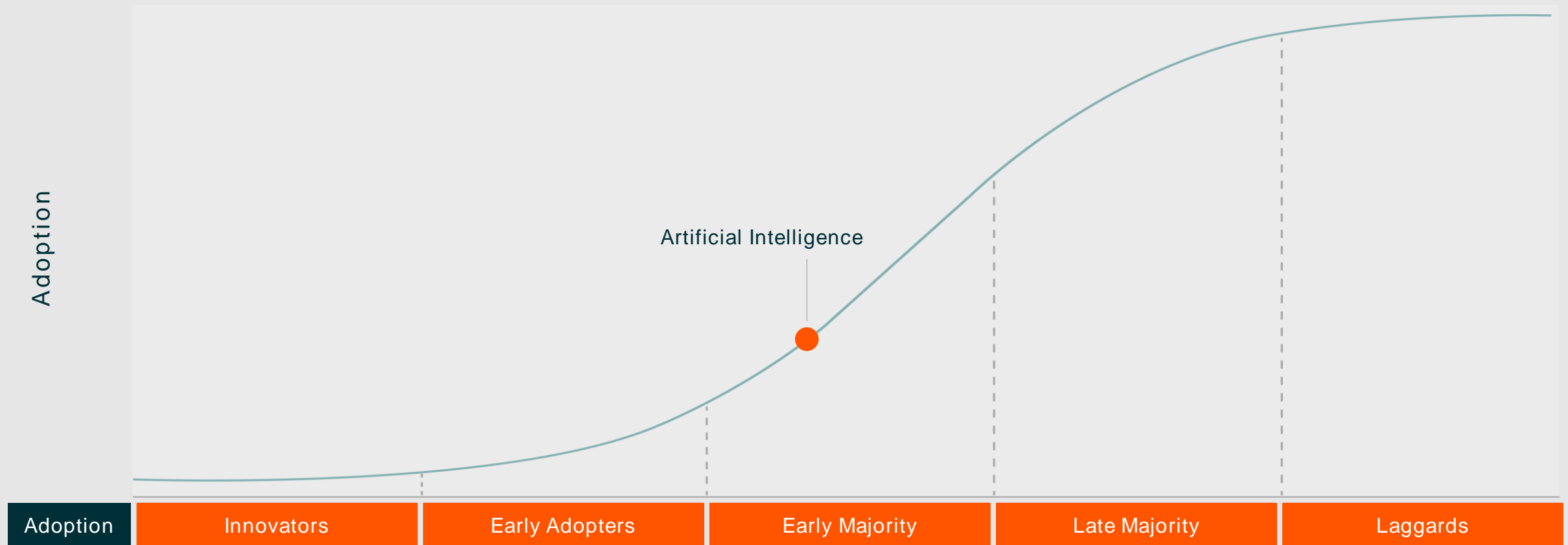
* Forecast

Notes: CAGR = 2022-2032E; Other Software Spending includes Gen AI Gaming spend, Gen AI Ad spend, Gen AI IT spend, Gen AI Business Service spend.

Sources: Text: 1. Bloomberg, 2023; Charts: Bloomberg, 2023

Artificial Intelligence: S-Shaped Curve of Adoption

Generative AI generated revenues of roughly \$40 billion in 2022. That figure is expected to top \$1.3 trillion by 2032, representing a 40%+ compound annual growth rate (CAGR).¹



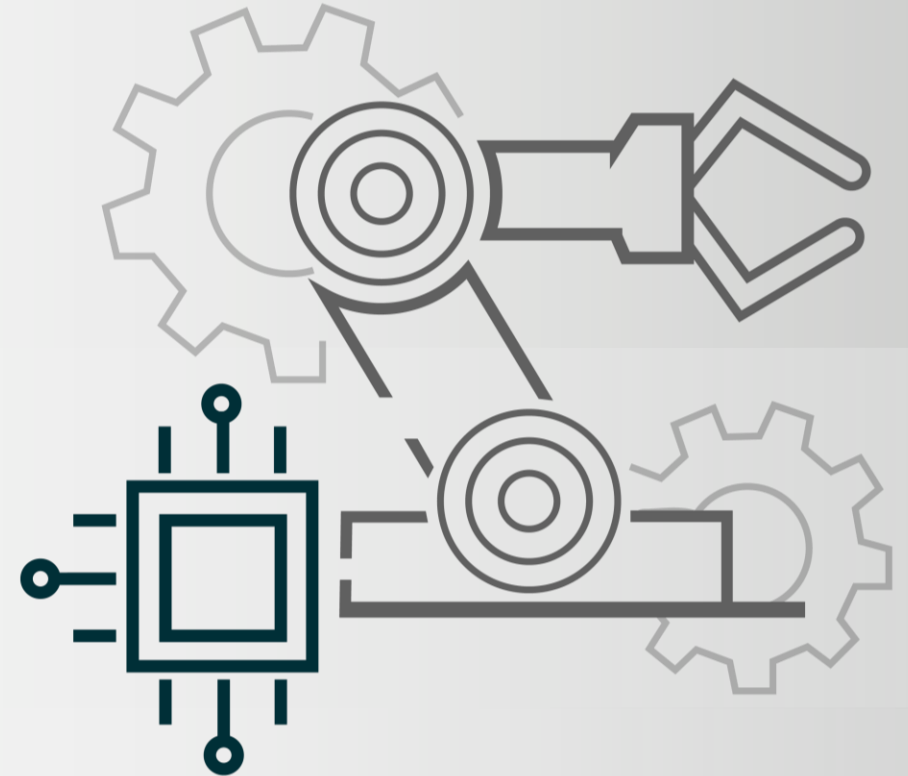
Note: For illustrative purposes only.
Sources: Text: 1 Bloomberg, 2023

Paradigm-Shifting Technologies

Robotics

The Rise of Smart Machines

Industrial robotic installations are at record highs and we anticipate that robots in the service industry, particularly those used in delivery and healthcare, will continue to expand their market share due to advancements in technologies like generative artificial intelligence (AI). Concurrently, the reshoring trend in manufacturing and industrial operations necessitates substantial investments in infrastructure and technology. Robotics systems will be instrumental in these transitions, being poised to enhance quality, lower costs, and enable businesses to maintain global competitiveness.

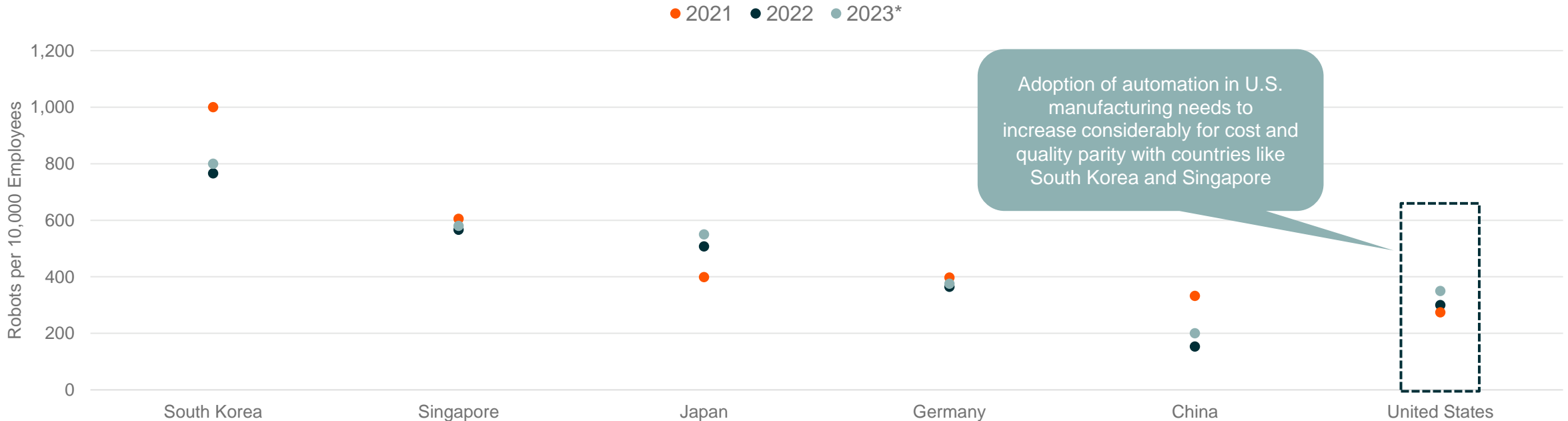


Reshoring of Manufacturing Is Not Possible Without Adoption of Automation

As automation becomes more widely available, offshoring manufacturing operations overseas may no longer be more affordable. Automation will play a key role in allowing U.S. businesses to stay competitive on the global stage.

Top Five Markets with the Highest Robot Densities in 2022: South Korea, Singapore, Japan, Germany, and the United States ¹

Robots per 10,000 Employees in Manufacturing



* Forecast.

Note: U.S. numbers for 2022 are Global X ETFs estimates based on sources below

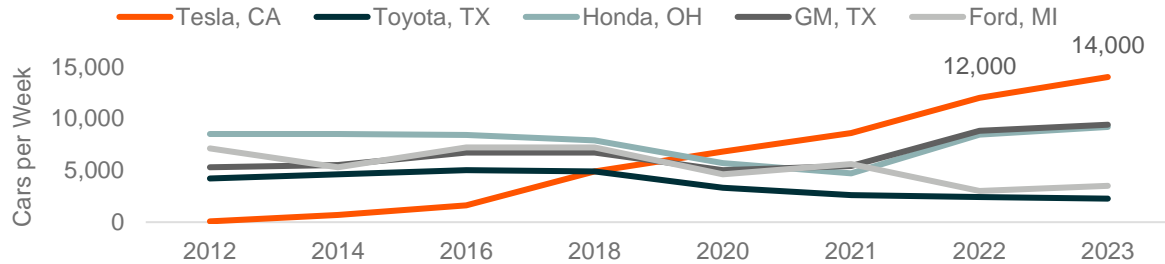
Sources: Text: 1. RobotIQ, 2023; Chart: International Federation of Robotics, 2022; RobotIQ, 2023

Tesla Case Study: Robotic-Heavy Auto Manufacturers Outperform Traditional OEMs in Efficiency

By strategically investing in robotics and AI over human capital, manufacturers can achieve significant productivity gains. Tesla’s implementation of these technologies enabled it to increase output while curtailing labor hours.

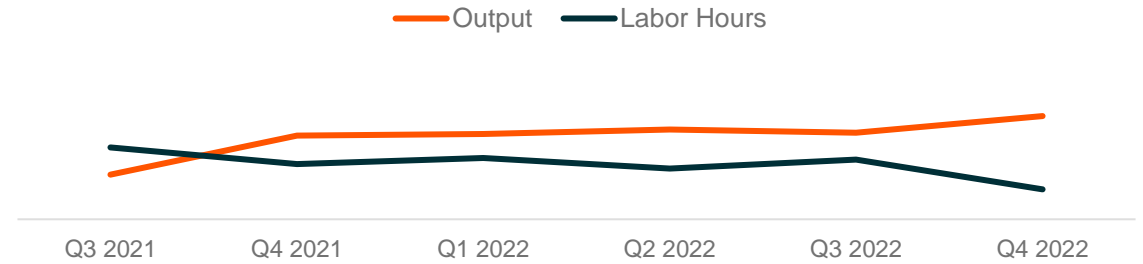
Tesla’s Fremont, CA Factory Led EV Auto Production in 2022

Average Weekly Output by Year and Factory

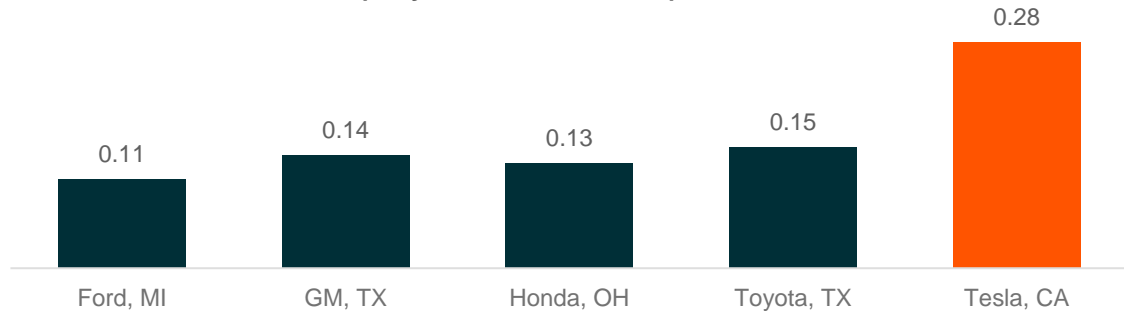


Tesla’s Labor Hours Drop as Its Production Facilities Mature

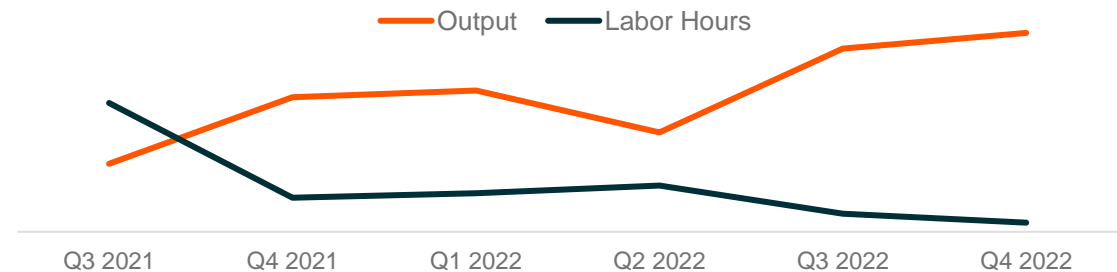
Tesla Fremont



Robot to Employee Ratio for Top U.S. Automakers



Tesla Shanghai



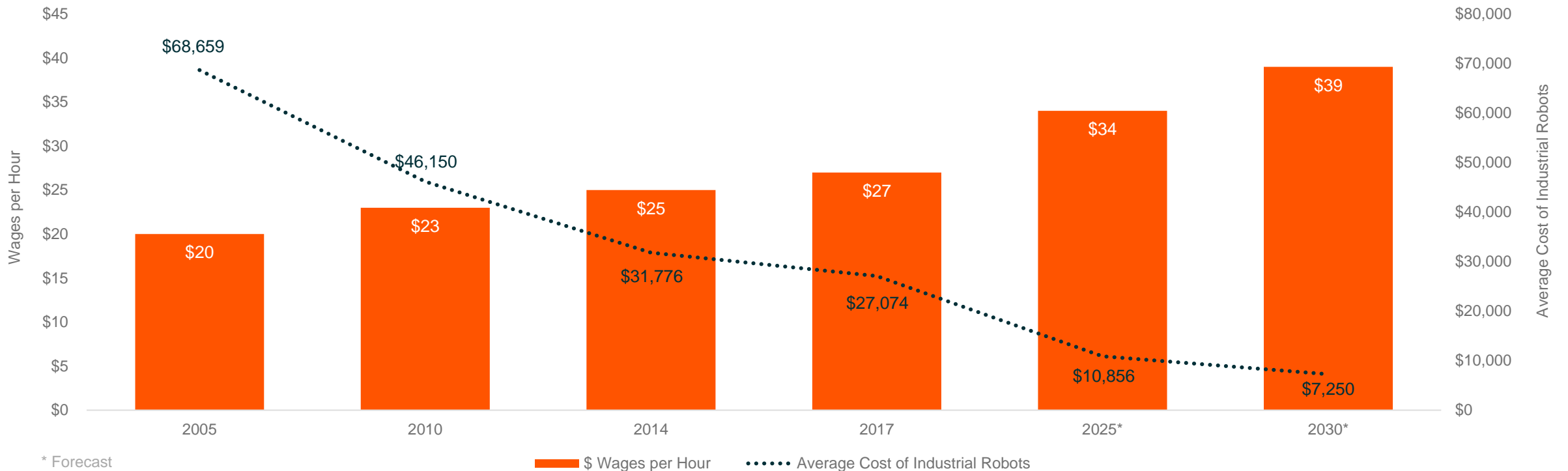
Note: OEM = Original Equipment Manufacturer; EV = Electric Vehicles; 2023 data in Average Weekly Output by Year and Factory is a Global X ETFs estimate

Sources: Charts: Left Top and Bottom: The Washington Post, 2016; Bloomberg, 2022; Toyota, 2020; Manufacturing Digital Magazine, 2020; Wired, 2013; Tesmanian, 2022; Right Top and Bottom: Tesla, 2023

Lower Costs and Higher Precision Drive Adoption of Robotic Systems Across Industries

As industrial robots become more affordable and technologically sophisticated, their adoption will increase across various industries, especially as companies look for ways to improve efficiency and productivity.

Manufacturing Wages vs. Average Cost of Industrial Robots

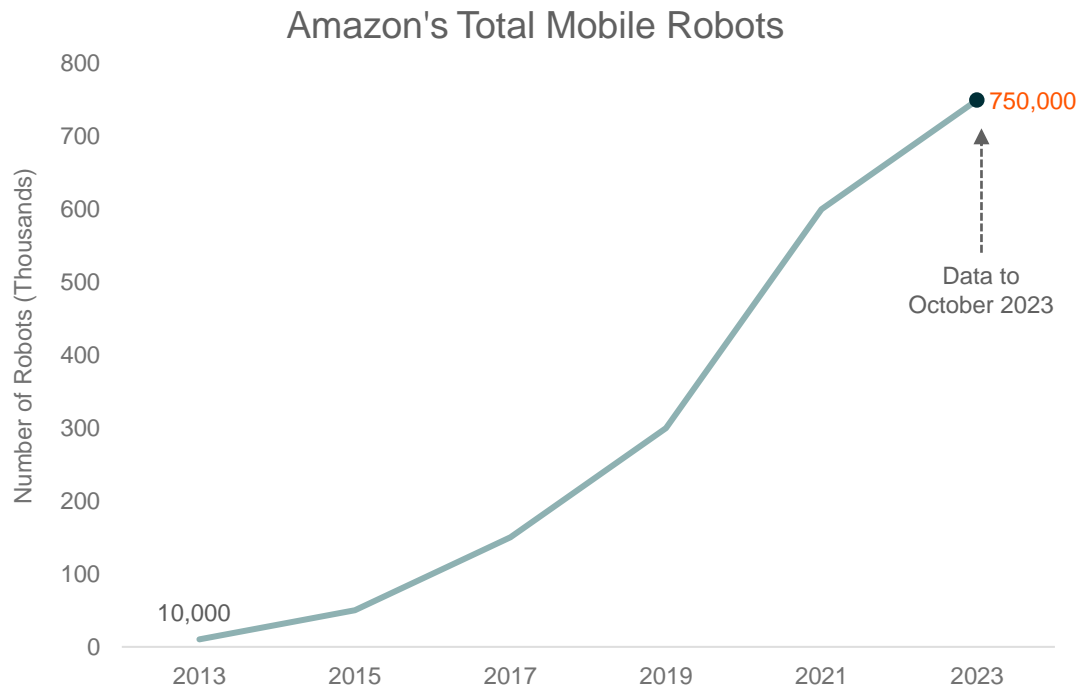


Sources: U.S. Bureau of Labor Statistics, 2023; Munich Personal RePEc Archive, 2021

Novel Patents and Innovations Generating Cross-Industry Adoption

Robotics and AI innovation is being prioritized across diversified key segments spanning e-commerce, healthcare, and agriculture, further evidenced by patent activity.¹

Amazon Rapidly Increased Production of the Robots It Uses in Its Warehouses



Field Testing

Proteus & Cardinal

Amazon is testing the joint operation of its Proteus and Cardinal robotics systems. The Cardinal system loads packages bound for the same zip code into designated carts. Proteus robots then bring the carts to delivery trucks, smoothly navigating the outbound dock area while working alongside human staff.



Sparrow

Sparrow selects and categorizes numerous customer orders, effectively testing its ability to manage highly repetitive tasks. Recent progress in computer vision, machine learning, and AI facilitates achievements that were not possible just a short time ago.



Containerized Storage

Amazon's new Containerized Storage System uses robotics and software to ensure employee safety and efficiency. It determines the right container, its location, and guides its retrieval and pick-up by employees.

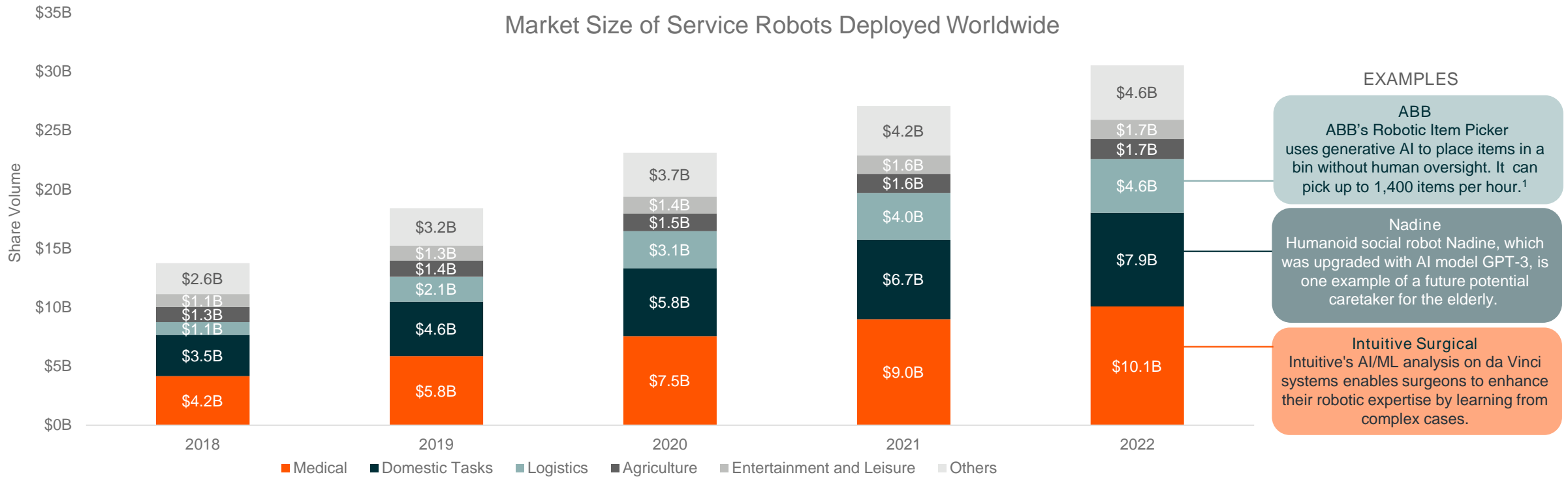


Sources: Text: 1. GlobalData, 2022; Chart: Wired, 2023

Service Industry Robotics Positioned to Receive a Boost from Generative AI

AI can revolutionize the robotics industry through personalization, with generative AI being key. Synthetic scenarios can facilitate reinforcement learning in simulations, allowing robots to acquire novel behaviors.

Progress in AI, Advancements in Systems Engineering, and High Labor Costs Are Boosting the Service Robotics Market



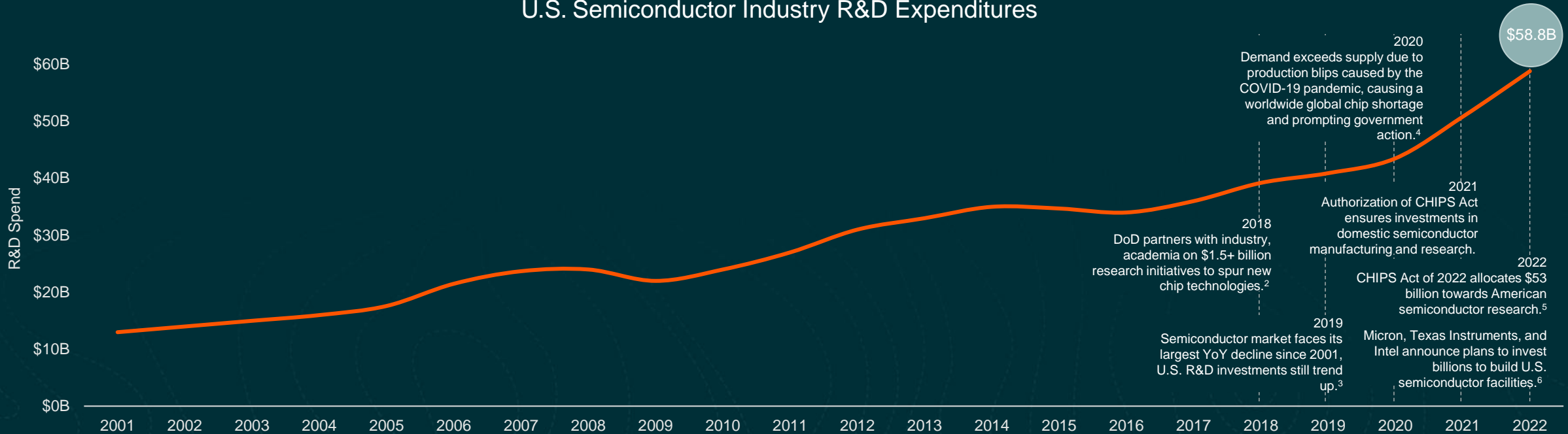
Sources: Text: 1. ABB, 2023; Chart: IFR Pressroom, 2022

U.S. Chip Manufacturing Programs Are Tailwinds for Automation

Over 50 projects totaling \$210 billion in semiconductor manufacturing investment commitments have been announced across 20 states since May 2020.¹

R&D Spending from U.S. Semiconductor Companies Remains High, Irrespective of Fluctuations in Sales Trends

U.S. Semiconductor Industry R&D Expenditures



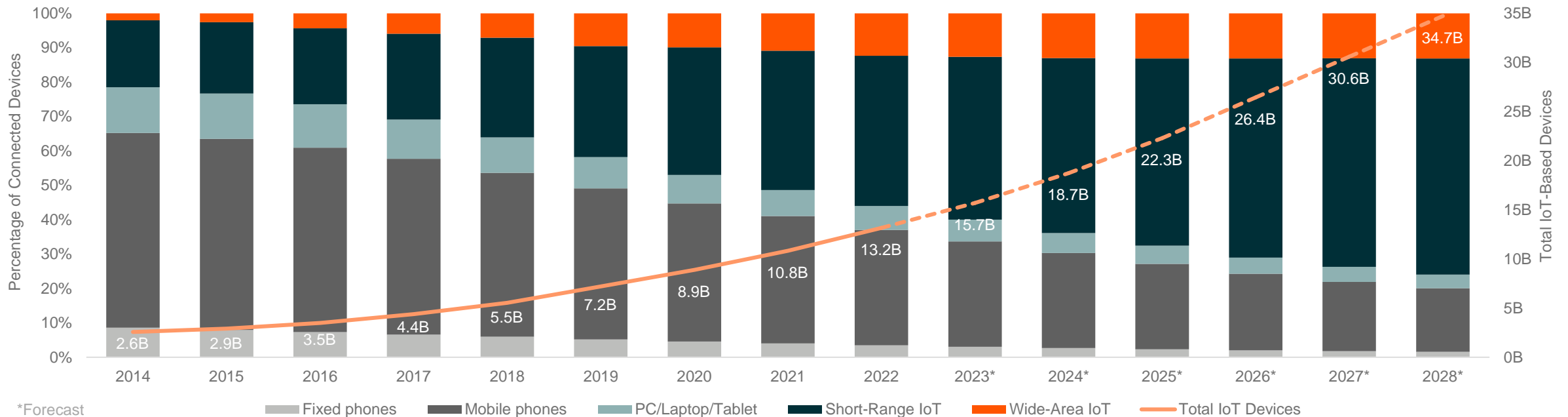
Sources: Text: 1. Semiconductor Industry Association, 2023; 2. Semiconductor Industry Association, 2021; 3. Electronic Specifier, 2019; 4. Semiconductor Industry Association, 2021; 5. The White House, 2022; 6. Tom's Hardware, 2022; Chart: Semiconductor Industry Association, 2023

Automation and Digitization of Operational Technology on Track to Boost IoT Adoption

In the rapidly evolving landscape of technology and connectivity, the proliferation of Internet of Things (IoT) devices is poised to reach unprecedented heights.

Global IoT Devices Are Expected to Top 15.7 Billion in 2023 and More Than Double from There by 2028

Global Connected Device Mix and IoT Installed Base



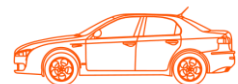
Note: Connected devices classified within IoT include items such as wearables, machines, sensors, connected cars, and more. These devices are further classified into Short-Range IoT and Wide-Area IoT based on connectivity range.




Sources: Ericsson, n.d.

Autonomous Vehicles (AVs) Are Expanding Their Commercial Footprints

While AVs are not available for purchase yet, driverless commercial vehicles are operational. Robo-taxis are witnessing a phased, geo-fenced launch nationwide, while major investments continue to fund autonomous trucking.




Robo-Taxi Offerings Already Hitting the Road



Company	Fully Driverless Offering Release*	Where is it Available?
 Google's Waymo ¹	October 2020	Metro Phoenix, San Francisco, and ramping up in LA and Austin
 AutoX ²	January 2021	Silicon Valley, Shenzhen, Shanghai, Guangzhou, and Beijing
 Baidu's Apollo Go ³	May 2021	Beijing, Wuhan, Chongqing, Shanghai, and Shenzhen
 GM's Cruise ⁴	November 2021	San Francisco, Austin, Phoenix, and Houston

Fully Driverless Truck Deliveries on the Way



Company	Expected Commercial Launch*	Where Could it be Available?
 Kodiak Robotics ⁵	2024	Texas, Oklahoma, and other Southern States
 Aurora ⁶	2024	Texas
 TuSimple ⁷	2025	Arizona

Note: Fully driverless offerings already released and expected commercial launches are only in selected cities. For example, Cruise and Waymo both currently operate in San Francisco and Phoenix, and both companies have ambitious expansion plans with test sites in Southern California, Texas, Nashville, Miami, and beyond.

Sources: Text: 1. White, 2020; 2. Crowe, 2021; 3. Baidu, Inc., 2021; 4. Bellan, 2021; 5. Taube, 2023; 6. Tilton, 2023; 7. TuSimple, 2023

Autonomous Trucks: Plug-and-Play Technology to Accelerate Adoption

Don Burnette

AVs use advanced sensor technologies such as LiDAR, radar, and cameras, along with powerful computing systems driven by AI. Kodiak's latest SensorPods replace a truck's mirrors with a compact package of these technologies.

Kodiak's Trucks Use Eight Cameras, as well as Four Radar and LiDAR Units

Cameras:

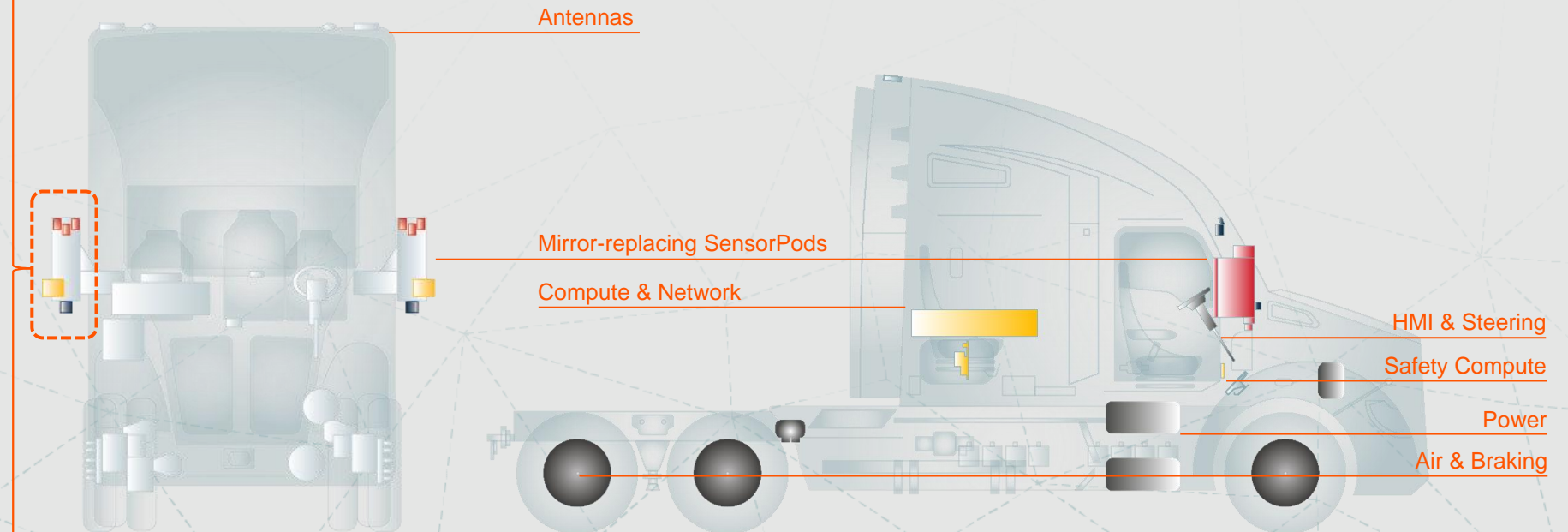
1. Cost-effective and widely available.
2. High-resolution imaging for detailed visual perception.
3. Efficient in identifying and interpreting traffic signs, signals, and road markings.

LiDAR (Light Detection and Ranging):

1. Precise 3D mapping and spatial awareness.
2. Effective in low-light conditions and at night.
3. Accurate depth perception and object recognition.

Radar:

1. Excellent in detecting the speed and distance of objects.
2. Works well in adverse weather conditions.
3. Robust in identifying and tracking moving objects.



Autonomous Trucks' Market Opportunity

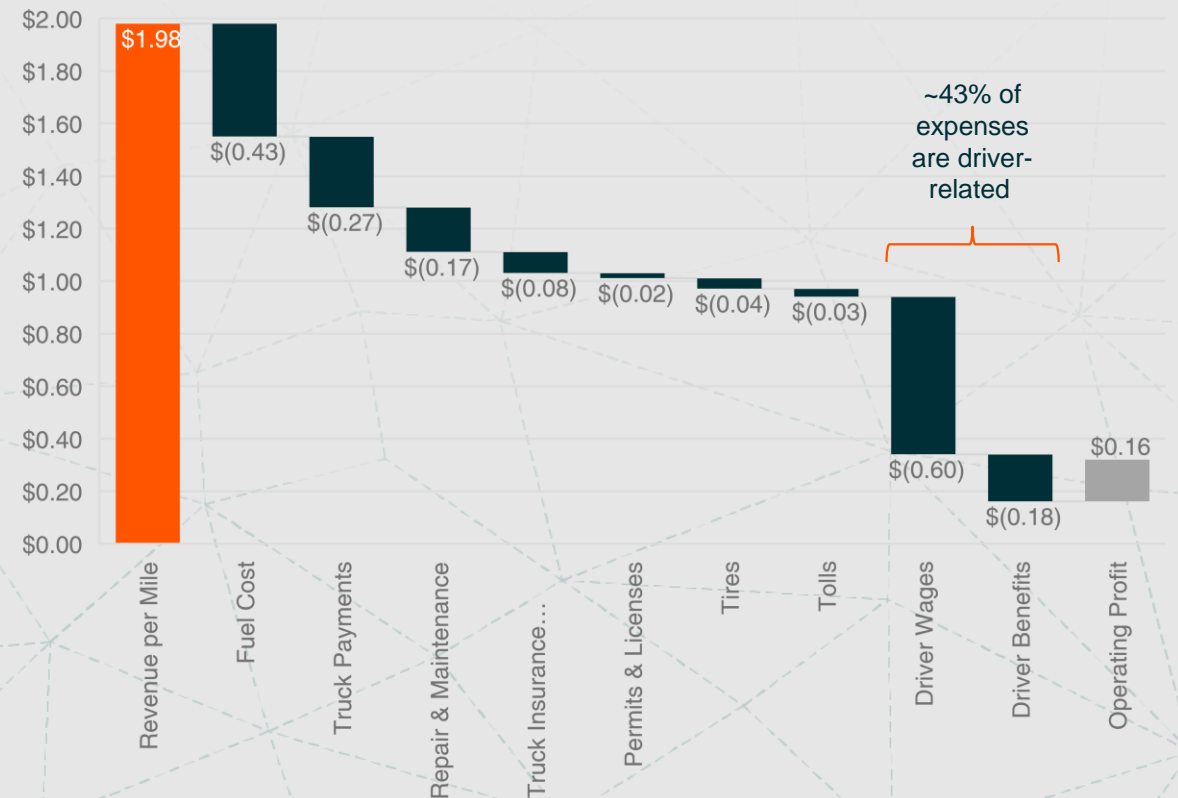
Don Burnette

The global economy relies on trucks. For example, in the United States, trucks accounts for 4% of GDP.¹ In addition, AVs have the potential to increase truck utilization, revenue, and margins, while effectively addressing driver shortages.

Global Trucking Total Addressable Market



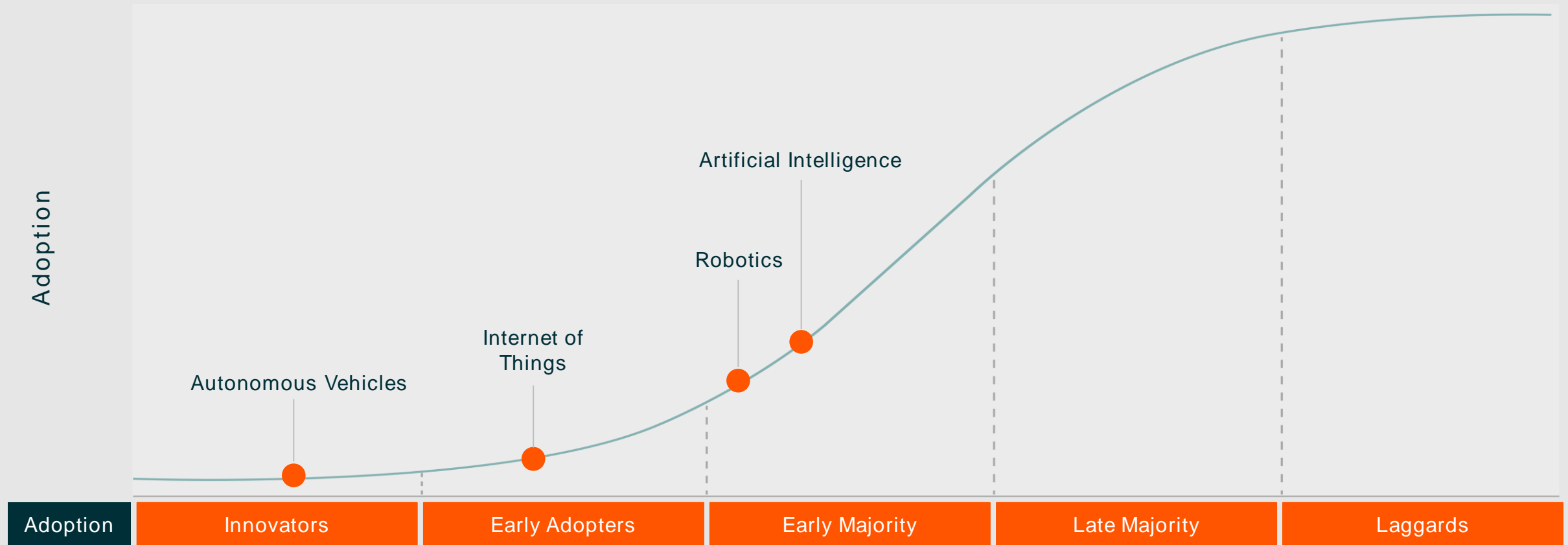
Truckload Carrier's Revenue and Expenses per Mile



Sources: Text: American Trucking Associations, 2023; Charts: Right: J.P. Morgan, 2021; Left: Williams & Murray, 2020

Robotics: S-Shaped Curve of Adoption

The global robotics market is expected to expand to about \$250 billion by 2030, a 22.8% compound annual growth rate (CAGR).¹



Note: For illustrative purposes only.

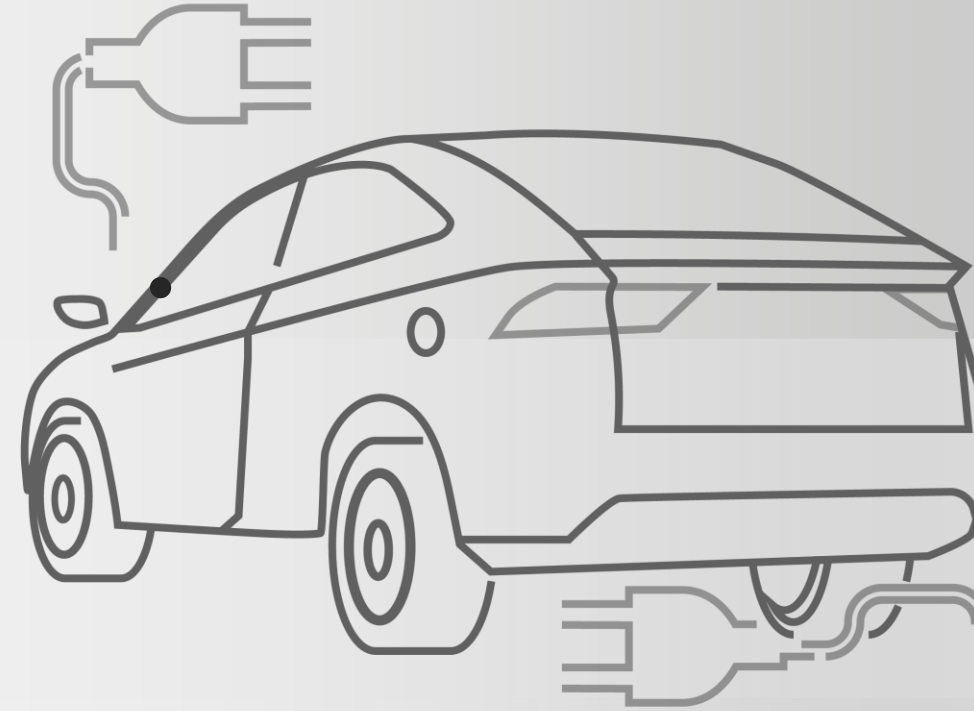
Sources: Text: 1.Market Research Future, 2023

Earth's Evolution

An Electric Future

Greener Transportation & Battery Tech Innovations

Electric vehicles (EVs) are the world's most effective tool to chip away at emissions from the road. Fortunately, a paradigm shift in the automotive industry is already underway as legislators, automakers, and consumers align toward this shift to electrified mobility options. The continued adoption of EVs also presents important ramifications for supply chains, from materials sourcing to battery recycling.



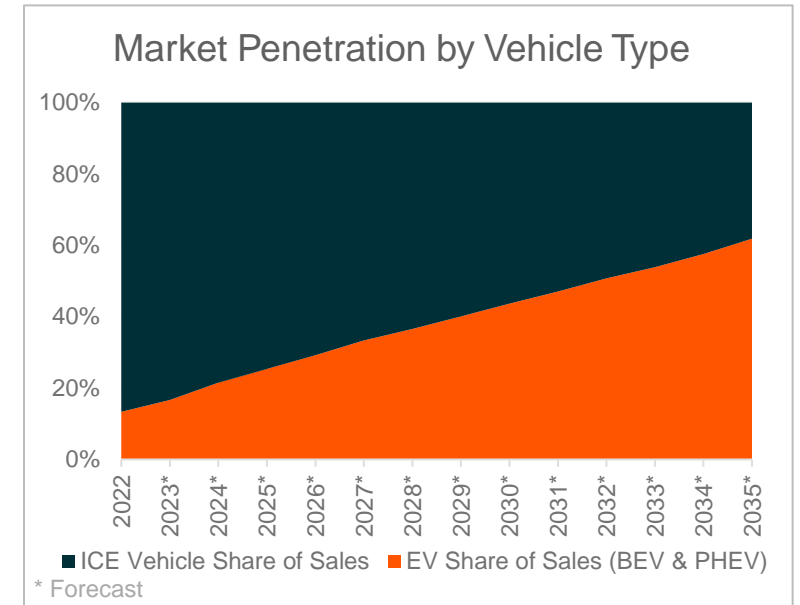
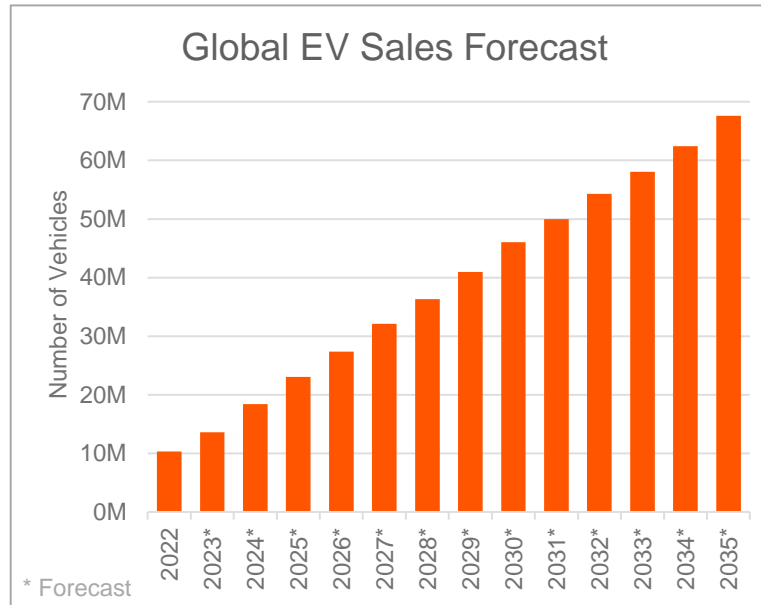
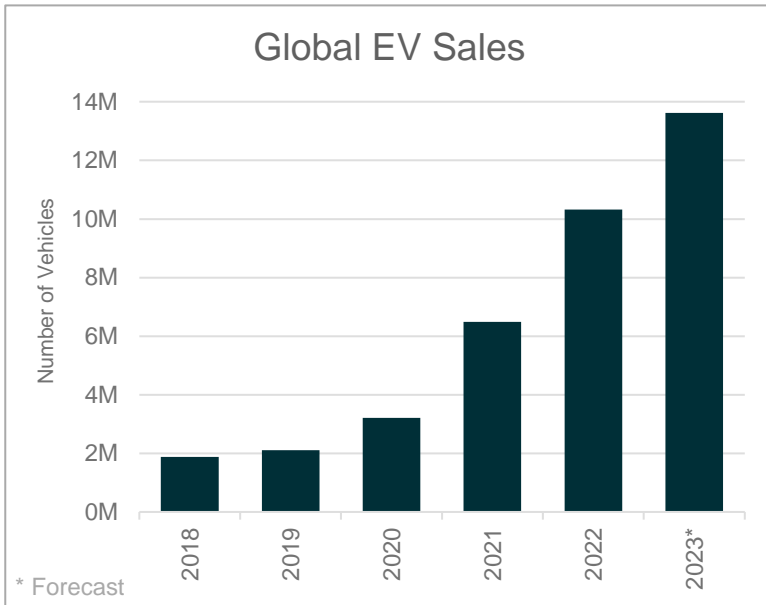
The Electric Vehicle (EV) Revolution Is Reaching an Inflection Point

Factors such as accommodative government policy, technological improvement, traditional automaker commitments, and increasing buy-in from consumers are combining to support rapidly increasing rates of adoption for EVs.

A true turning point for the EV industry came in 2021 when global sales doubled year over year. Global EV sales increased another 58% between 2021 and 2022.¹

Starting from a base of about 10 million units in 2022, global EV sales could grow at a CAGR of 15.5% to approach 70 million units by 2035.²

Market share for EVs in light-duty vehicle segment could grow from 13% in 2022 to more than 60% in 2035.³ EV sales could cross the 50% threshold as soon as 2032.⁴

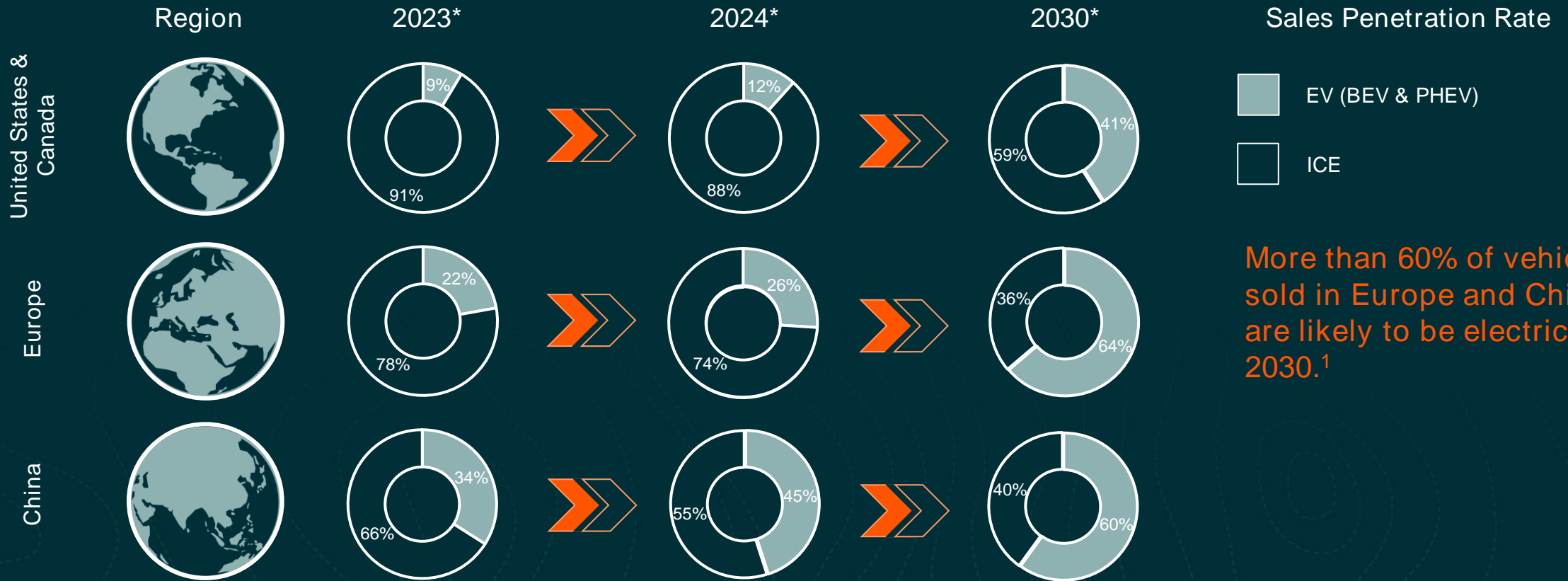


Note: Battery Electric Vehicle or pure electric (BEV), Plug-in Hybrid Electric Vehicle (PHEV)

Sources: Text: 1. Rho Motion, 2023; 2. Ibid.; 3. Ibid.; 4. Ibid.; Charts: Rho Motion, 2023

Fleet Electrification Is a Global Trend

Adoption of electric vehicles has sharply increased across all classes in recent years. Despite an uncertain macro backdrop and contraction in the broader automobile industry, EV penetration is expected to increase in 2023.



More than 60% of vehicles sold in Europe and China are likely to be electric by 2030.¹

*Forecast.

Notes: Internal Combustion Engine Vehicle (ICE). Data includes BEVs, PHEVs, and all classes of EVs.

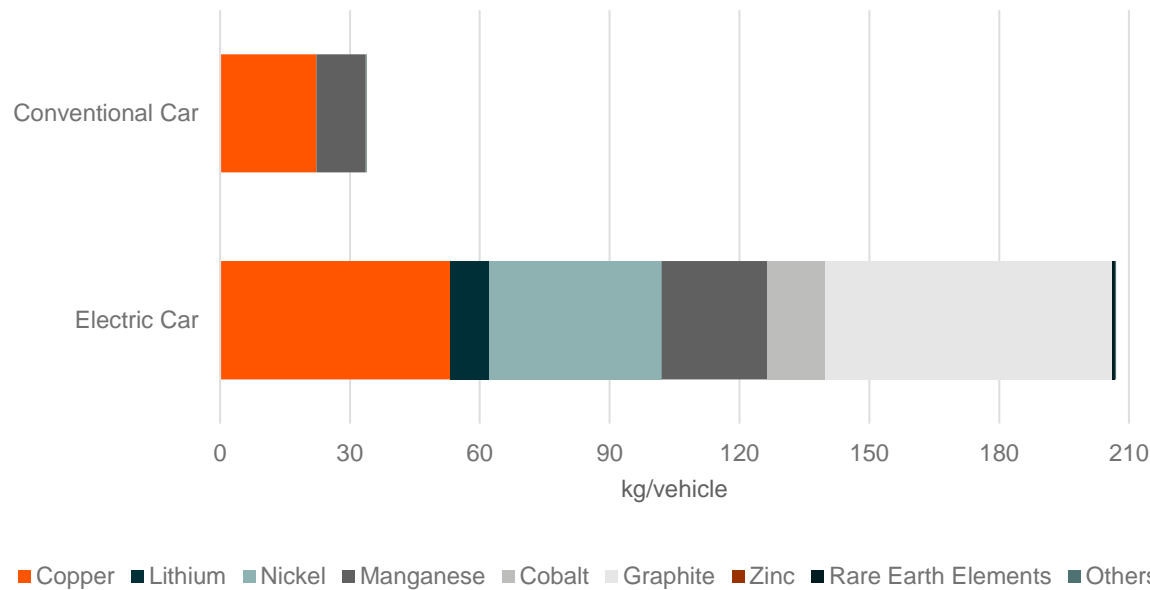
Sources: Text: 1.Rho Motion, 2023; Charts: Rho Motion, 2023

The Transition to EVs Could Magnify Demand for Disruptive Materials

An EV requires six times more disruptive materials than a traditional ICE vehicle.¹ As a result, EVs are expected to become a significant driver of demand for several minerals, including graphite and lithium.

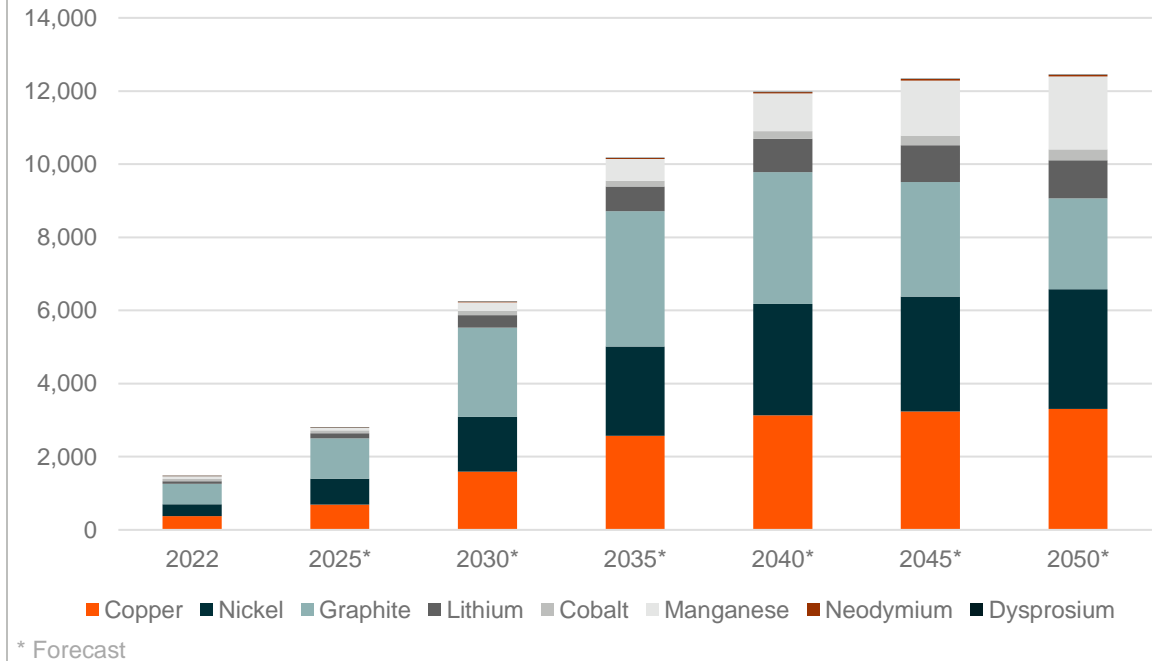
EVs Require More Minerals Than Conventional Cars²

Mineral Use in EVs vs. Traditional ICE Vehicles



Mineral Demand from EVs Could Be 4x Higher by 2030³

Mineral Demand from EVs

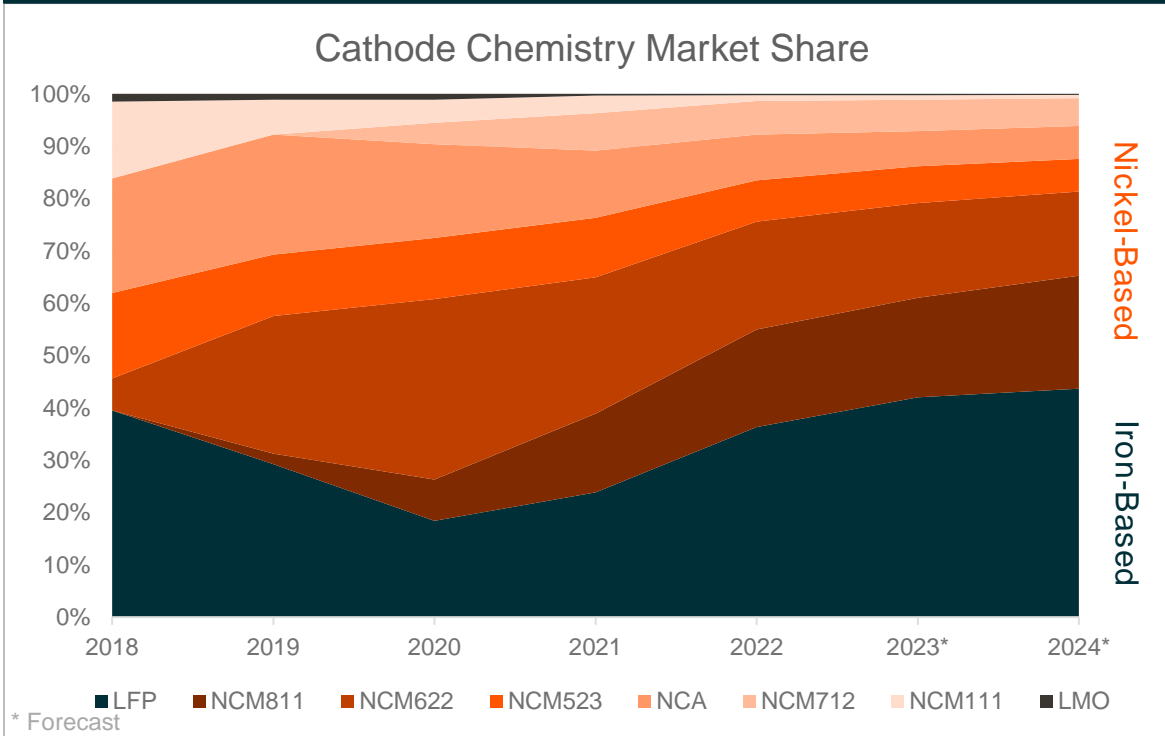


Sources: Text: 1. International Energy Agency (IEA), 2021; 2. Ibid; 3. IEA, 2023; Charts: Left: IEA, 2021; Right: IEA, 2023

Lithium-Ion Batteries Will Power the EV Revolution

Lithium-ion chemistries vary widely, and battery makers continue to experiment with different combinations. Lithium is a shared input across the two most common cathode architectures, lithium iron phosphate (LFP) and nickel-based.

LFPs and Nickel-Based Cathodes Dominate the EV Market



Note: Lithium nickel cobalt aluminum oxides (NCA), lithium-ion manganese oxide (LMO)

Sources: Charts: Left: Rho Motion, 2023; Right: Gaines, Richa, & Spangenberg, 2018

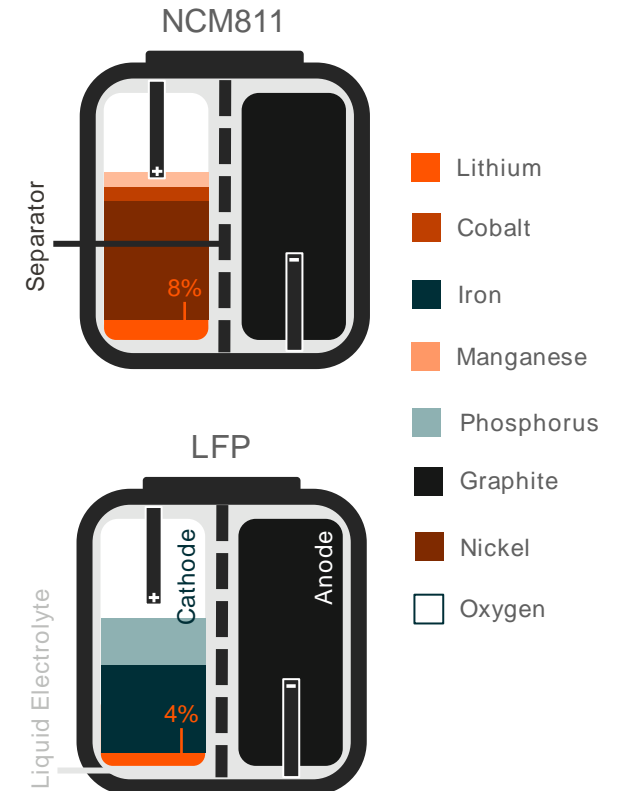
Nickel-Based (NCMs & NCAs)

Nickel-based batteries support higher range and acceleration at a premium. Various iterations of nickel, cobalt, manganese (NCM) batteries are on the market, with NCM811 being the most advanced.

Iron-Based Phosphates (LFPs)

LFPs are a class of legacy battery tech that has reclaimed market share in recent years due to lower costs and longer lifespans. Charging station buildout has made lower-range tech more viable.

Note: Not an exhaustive list of materials and elemental inputs. Lithium content expressed as a percent weight of cathode.



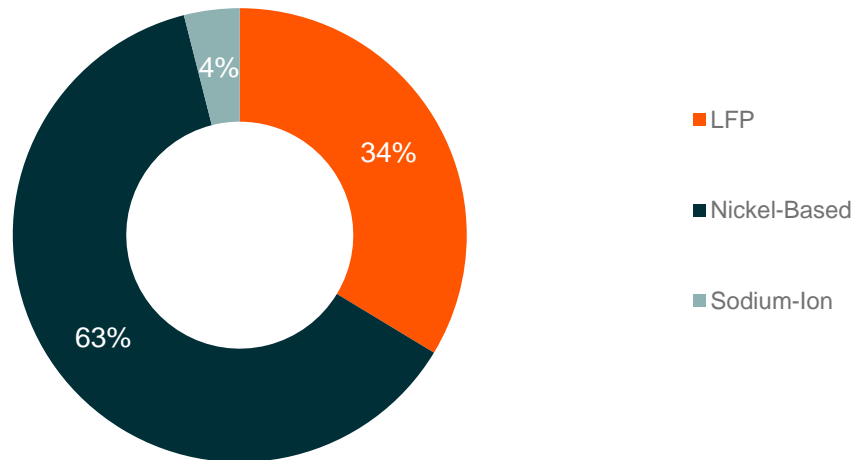
Sodium-Ion Could Have a Niche Role in Future Battery Mixes

Sodium-ion (Na-ion) batteries grabbed headlines in 2023 as a potential low-cost substitute to lithium-ion. The chemistry can help electrify various segments, but likely as a niche complement to lithium-based architectures.

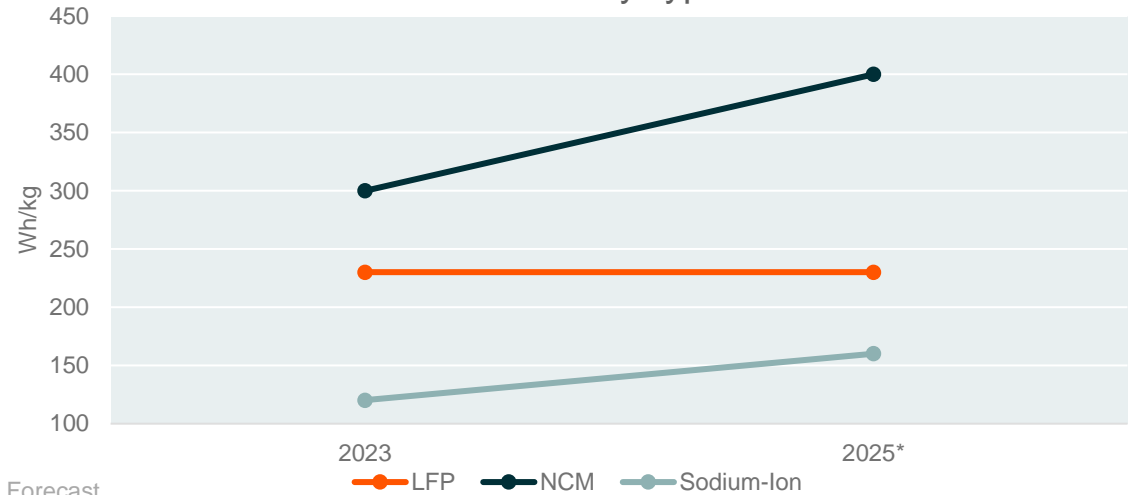
Forecasts place Na-ion manufacturing capacity at around 150 gigawatt-hours by the end of 2030.¹ In contrast, global lithium-ion production is expected to pass 1 terawatt-hours in 2023, more than six times the entire Na-ion pipeline through the end of 2030.²

Na-ion could eventually result in substantial cost savings, but it sacrifices energy density. Energy density, which determines the range and power available to an EV, is likely to limit Na-ion adoption for energy storage, electric equipment, and lower-end EVs.

2040 Cathode Market Share Forecast



Approximate Maximum Gravimetric Energy Density Across Battery Types



Sources: Text: 1. Benchmark Mineral Intelligence, 2023-May; 2. Benchmark Mineral Intelligence, 2023-Feb; Charts: Left: Rho Motion, 2023-Sep; Right: Electrive, 2022; InsideEVs. 2022; Rho Motion, 2023-Jun

Lithium Is Key to Current and Next-Generation Battery Tech

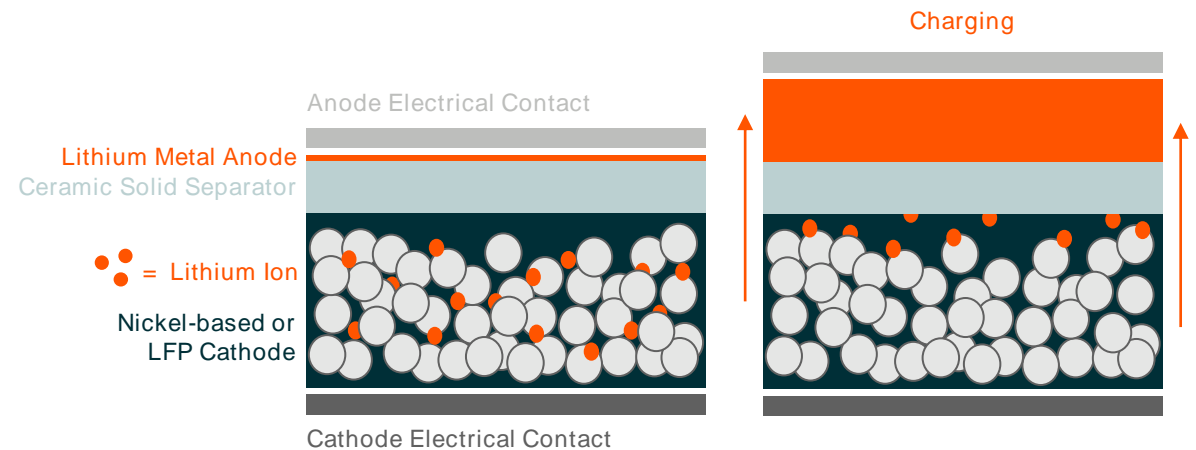
The race is on to develop solid-state battery technology, the often-heralded next generation of EV battery technology. Nearly every solid-state prototype leverages legacy cathode technology and expands usage of lithium to the anode.

Solid-state battery tech could bring more range and faster charging at a lower cost. Broad commercialization is likely years away, although several key developers are already working on semi-solid-state prototypes (see table).

QuantumScape is developing a battery that may support a 400-mile range and 15-minute charge.¹ The design is “anodeless,” where lithium deposits during charging. Other solid-state designs have permanent anodes, often a blend of lithium metal and graphite.

Company	Cathode Type	Anode Inputs	Time Frame
QuantumScape	NCM, LFP	Lithium, Copper	Production prototypes by 2025
Samsung SDI	NCM, NCA	Lithium, Steel	Commercial production by 2027
Ganfeng	NCM, LFP, LCO	Lithium, Graphite	In production as of May 2023
SES	NCM	Lithium, Copper	Expected in vehicles by 2025
Solid Power	NCM	Lithium, Silicon, Copper	Expected in vehicles by 2028
ProLogium	NCM811	Lithium, Silicon, Graphite, Copper	Commercial production by 2026

QuantumScape Proposed Solid-State Battery Design



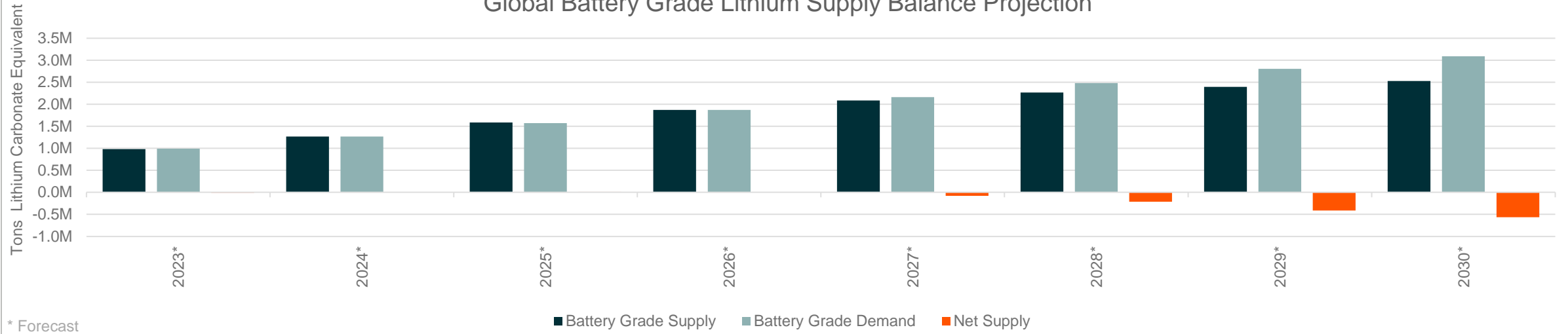
Sources: Text: 1. QuantumScape, n.d.; Charts: Left: CNBC, 2022; CnEVPost, 2023; Green Car Congress, 2023; Rho Motion, 2023; Tech Brew, 2021; TechCrunch, 2022; Yonhap News Agency, 2023; Right: QuantumScape, 2021

Elevated Lithium Pricing Could Be Here to Stay

The inelastic nature of lithium supply combined with growth in EV demand supports structurally high lithium prices. Even as more mining capacity comes online, we expect lithium pricing to remain elevated.

Tight Lithium Markets Are Likely to Persist Through the End of the Decade, Potentially Supporting Elevated Pricing

Global Battery Grade Lithium Supply Balance Projection



Approximate Production Ramp Timelines for Components of the Lithium Supply Chain



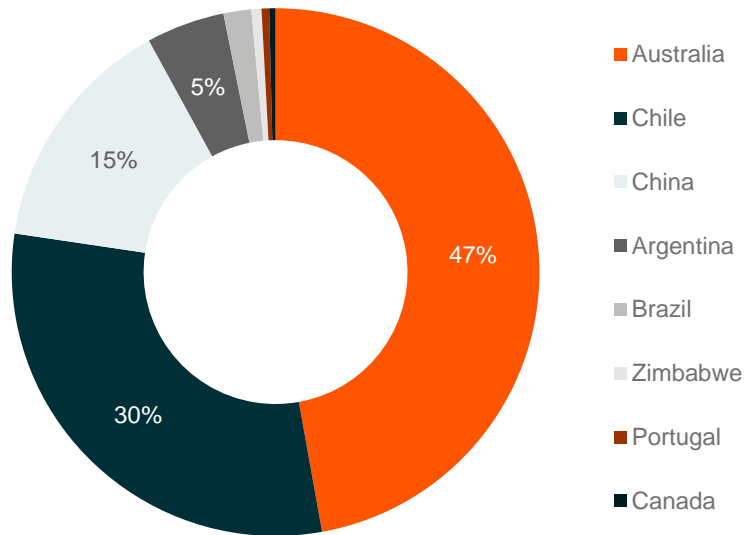
Sources: Charts: Top: AMG Critical Materials, 2023; Benchmark Mineral Intelligence, 2023; Bottom: Benchmark Mineral Intelligence, 2023.

Lithium Production Does Not Align with Resource Distribution

Lithium is an abundant resource found all over the world. However, lithium production is concentrated in only a handful of countries. This concentration is part of the challenge and opportunity in bringing lithium to market.

Australia and Chile Lead in Lithium Production While the “Lithium Triangle” Contains More Than Half of Known Resources

Lithium Production by Country

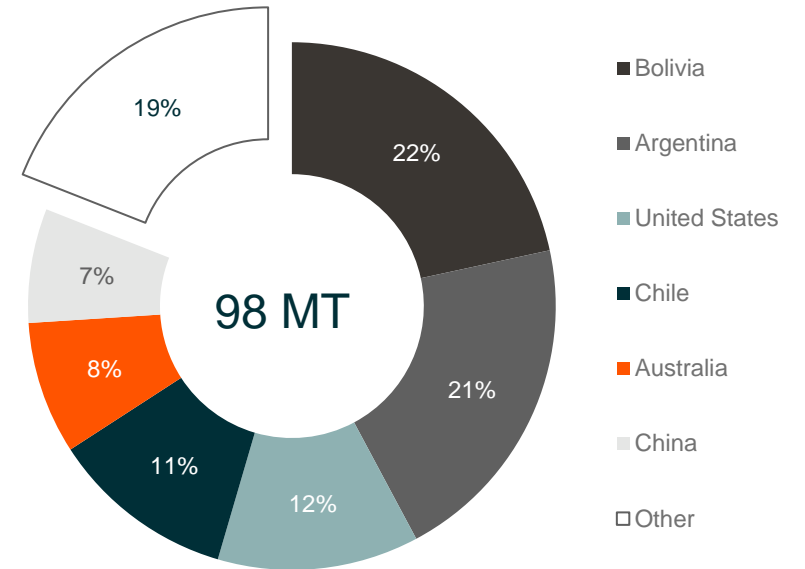


Hard rock and brine are the two main types of lithium deposits. Hard rock deposits can be found in Australia and Canada and are extracted in a process akin to traditional mining.

Brine deposits are metallic solutions that are most abundant in the “Lithium Triangle” of Argentina, Bolivia, and Chile. Brine deposits are pumped to the surface where evaporation gradually yields a lithium concentrate.

Lithium brine resource viability varies. Bolivia has the largest reserves, but also lower evaporation rates and more rainfall than Chile. Regulations also determine if a resource is developed.

Identified Lithium Resources

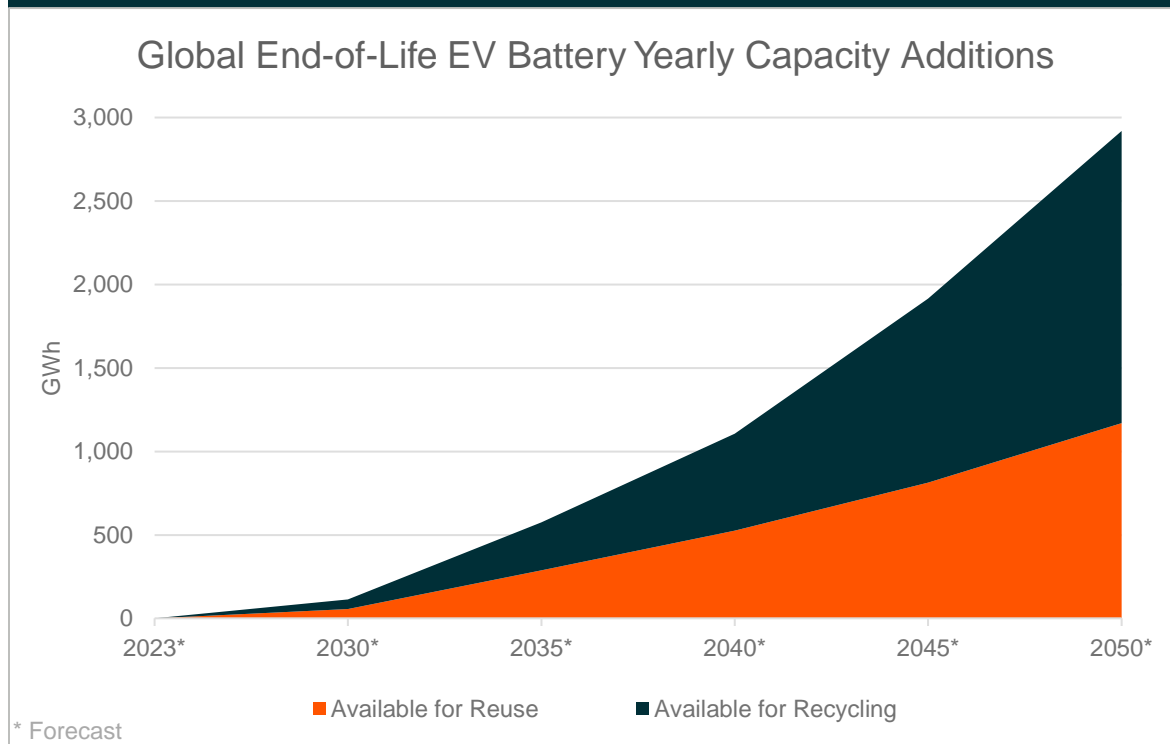


Source: U.S. Geological Survey, 2023.

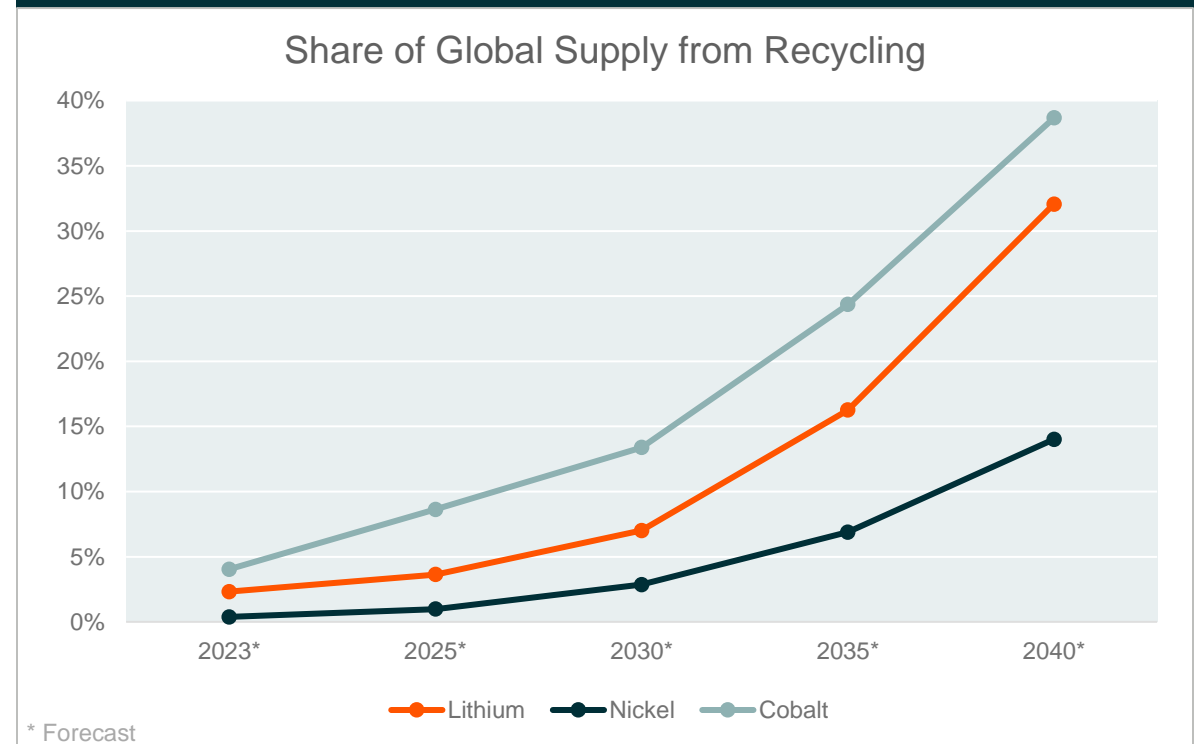
Circular Battery Economics Could Secure Supplies for Key Materials

Limited EV battery recycling capacity exists today, but this is set to change in the coming decades as vehicles start to age out of use. Recycling efforts are likely to help bridge the gap between raw material supply and battery demand.

Spent EV Battery Capacity Is Likely to Grow Substantially



Recycling Could Help Supply Key Battery Inputs



Sources: Charts: Left: International Council on Clean Transportation, 2023; Right: Benchmark Mineral Intelligence, 2022.

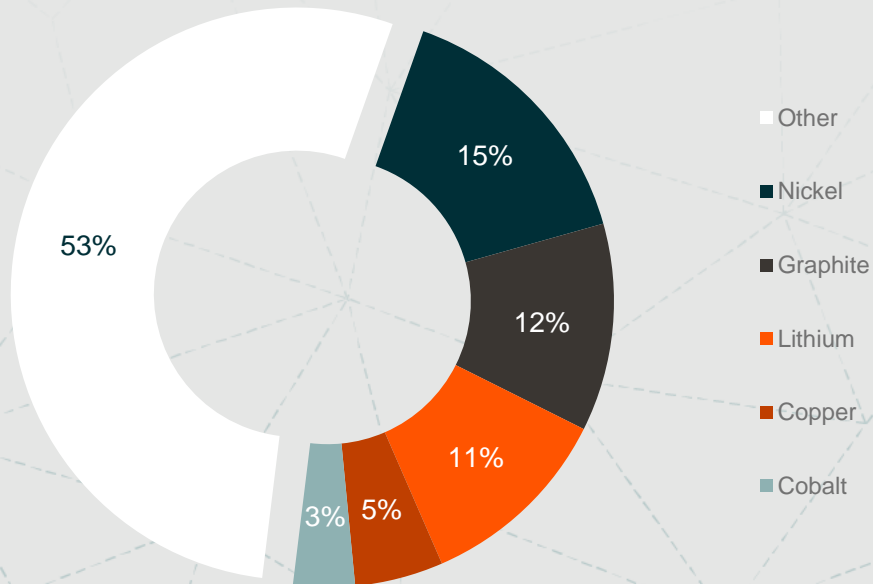
Batteries Contain Recoverable Value

Mike O’Kronley

EV batteries contain valuable metals such as lithium and nickel. Elevated lithium prices in recent years improved the value proposition for battery recycling and could contribute to industry growth alongside EV adoption.

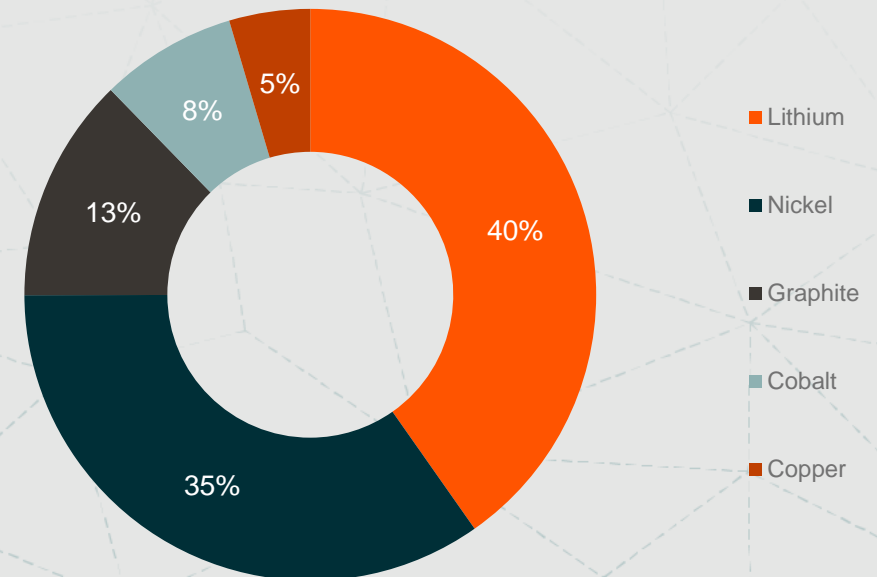
Nearly Half the Weight of a Battery Pack Is Valuable Material

Average 100 KWh Battery Pack Weight Breakdown



Lithium and Nickel Represent the Majority of Recoverable Value

Average 100 KWh Battery Pack Value Breakdown



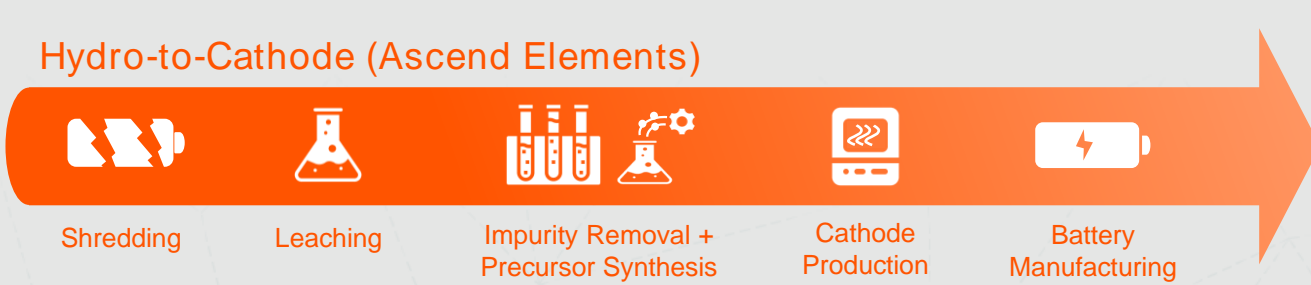
Sources: Charts: O’Kronley, 2023

Processes Exist to Recycle EV Batteries

Mike O’Kronley

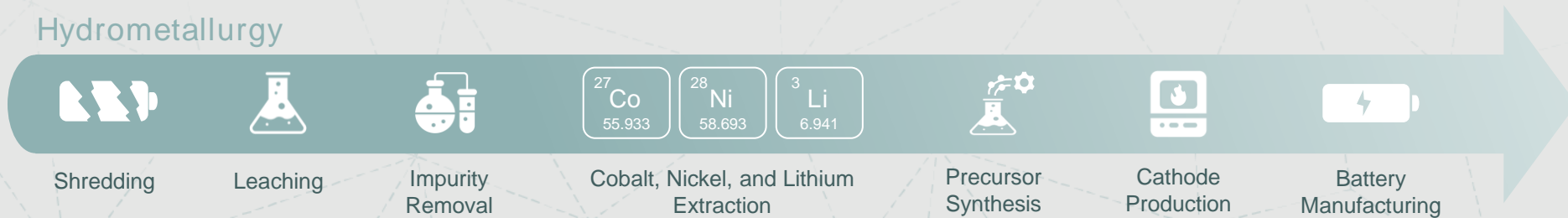
Better recycling economics and greater spent battery volumes are drawing automakers, battery producers, and startups to the space. Several techniques are already in use and we expect major innovation as capacity expands.

Hydro-to-Cathode (Ascend Elements)



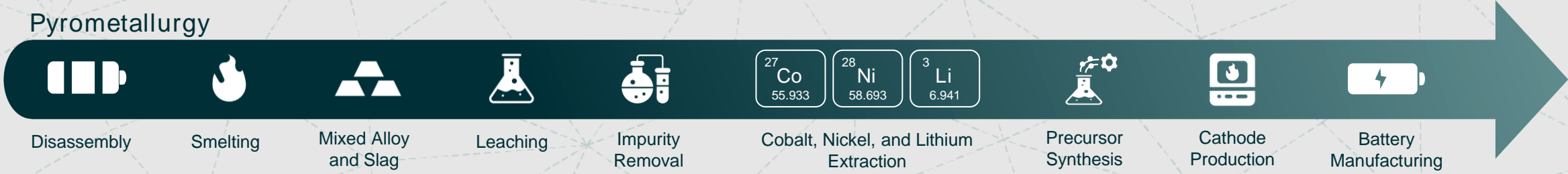
Ascend Elements’ Hydro-to-Cathode technology improves upon traditional hydrometallurgy techniques and aims to produce a customizable cathode input. This technology contrasts with traditional recycling techniques that produce usable metal content by refining black mass.

Hydrometallurgy



Hydrometallurgy uses aqueous solutions and pyrometallurgy uses high temperatures to extract metals from batteries.

Pyrometallurgy



Direct Lithium Extraction Could Usher in a New Era of Lithium Mining

Direct lithium extraction (DLE) pulls lithium directly from metallic brines without the need for evaporation. If developed at scale, this technology could provide a host of environmental and operational benefits.

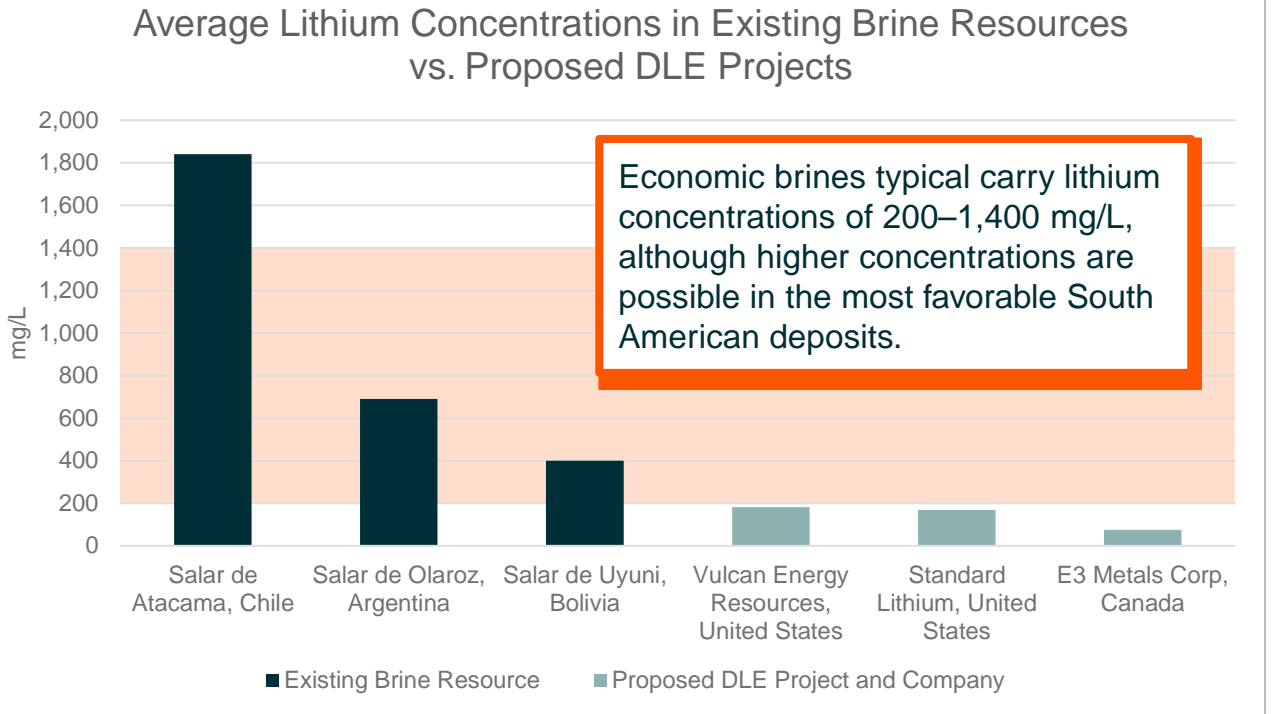
Potential DLE Benefits

Reduced Ecological Footprint: Full DLE systems could dramatically reduce land, energy, and water use. Current evaporation techniques use as much as 200 cubic meters of water to produce 1 tonne of lithium carbonate equivalent.¹ Some pilot projects produced lithium extract using about 1% the water required for brine fields.²

Improved Lithium Concentrations: A brine resource's viability is partially dictated by the lithium concentration, which naturally varies by region. DLE pilot projects achieved lithium yields of 70–90%, and as high as 99%, compared to a typical recovery rate of 50% for traditional evaporation projects.^{3,4}

Accelerated Extraction Timelines: Currently, an evaporation pond normally takes 18–24 months to produce commercial products, depending on weather conditions.⁵ Pilot tests of DLE condensed this process into a matter of days.

DLE Could Enable Projects with Lower Lithium Concentrations



Sources: Text: 1. CleanTech Lithium, n.d.; 2. Ibid; 3. Green Car Congress, 2023; 4. National Renewable Energy Laboratory, 2021; 5. Washington Post, 2023; Charts: Chemical Geology, 2020; National Renewable Energy Laboratory, 2021; PorterGeo Database, n.d.; U.S. Geological Survey, 2013

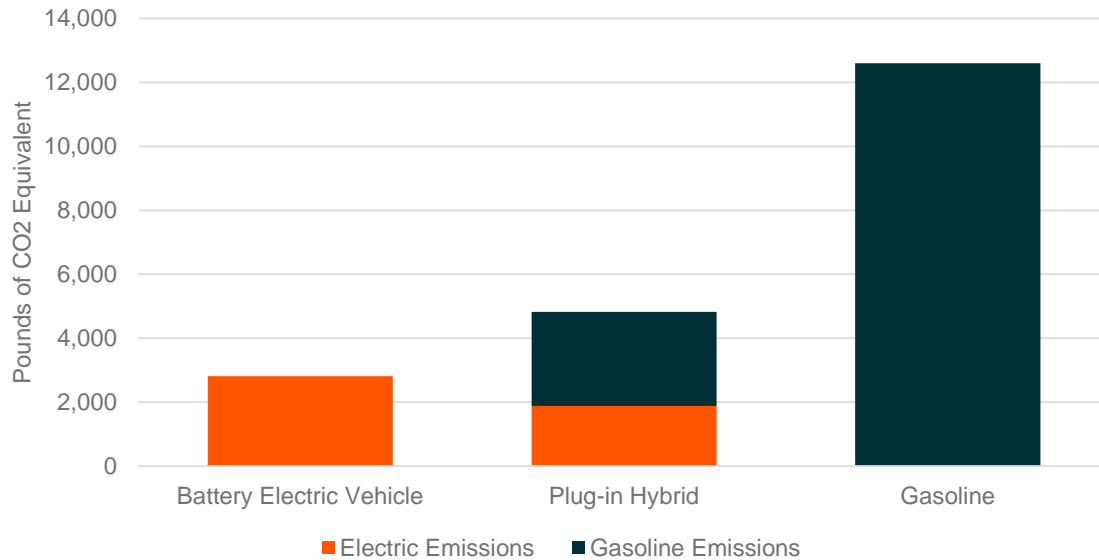
EVs Produce Fewer Lifetime Emissions Than Gasoline-Powered Vehicles

Even with higher mineral demand, EVs can produce fewer lifetime greenhouse gas emissions than comparable ICE vehicles.¹ Cleaner power grids as well as improved production and recycling methods could yield further emissions cuts.

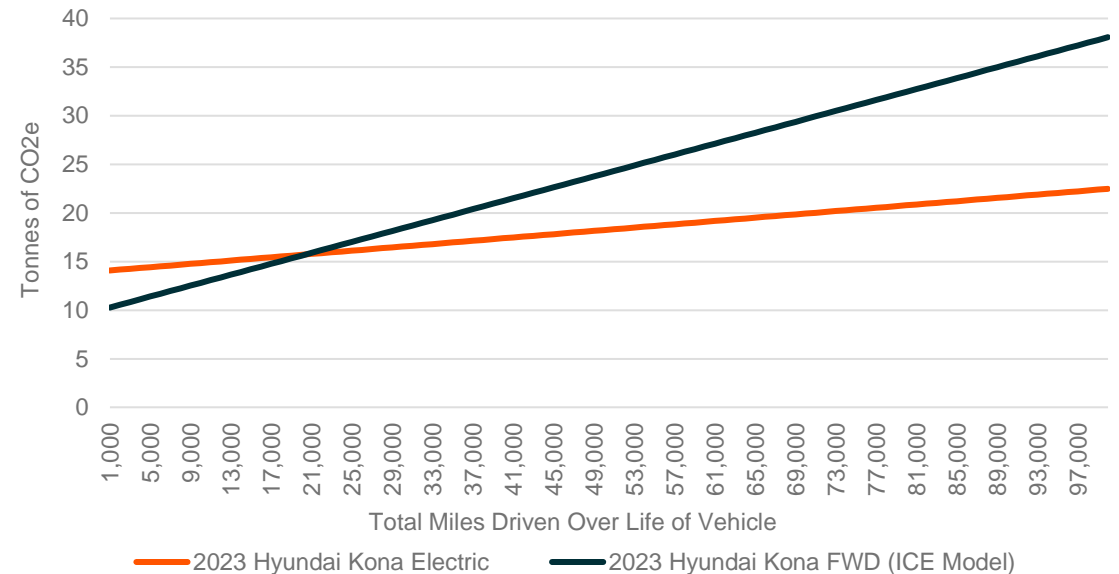
Manufacturing an EV often produces more carbon emissions than a similarly-sized ICE vehicle due to energy-intensive raw materials and manufacturing processes.² However, EVs produce significantly lower average annual emissions, even on fossil fuel-dominant energy grids like the United States.³

Considering emissions produced during manufacturing and while in use, the Hyundai Kona Electric is estimated to break even with the most efficient Kona ICE model at around 20,500 miles, even on the United States' power grid. At 100,000 miles, the EV produces an estimated 41% fewer lifetime emissions.

Average U.S. Annual Emissions per Vehicle



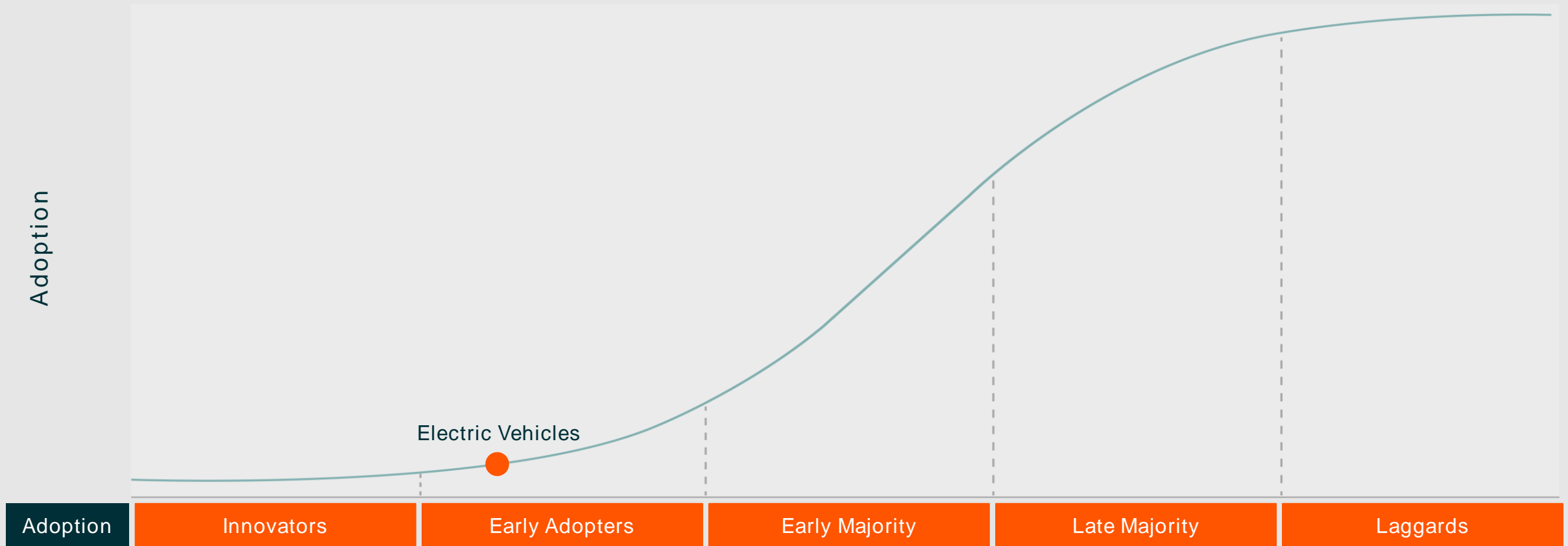
Estimated Total Emissions for 2023 Hyundai Kona, ICE vs. EV Models



Sources: Text: 1. Office of Energy Efficiency & Renewable Energy, n.d.; 2. Visual Capitalist, 2023; Charts: Left: Office of Energy Efficiency & Renewable Energy, n.d.; Right: Dominion Energy, n.d.; Visual Capitalist, 2023.

An Electric Future: S-Shaped Curve of Adoption

EVs are the primary pathway for decarbonizing the mobility segment. EVs are forecast to account for 43% of global vehicle sales by 2030, up from 16% in 2023.¹



Note: For illustrative purposes only.

Source: Text: 1. Rho Motion, September 2023.

Earth's Evolution

CleanTech & Beyond

The Push for Net Zero Emissions

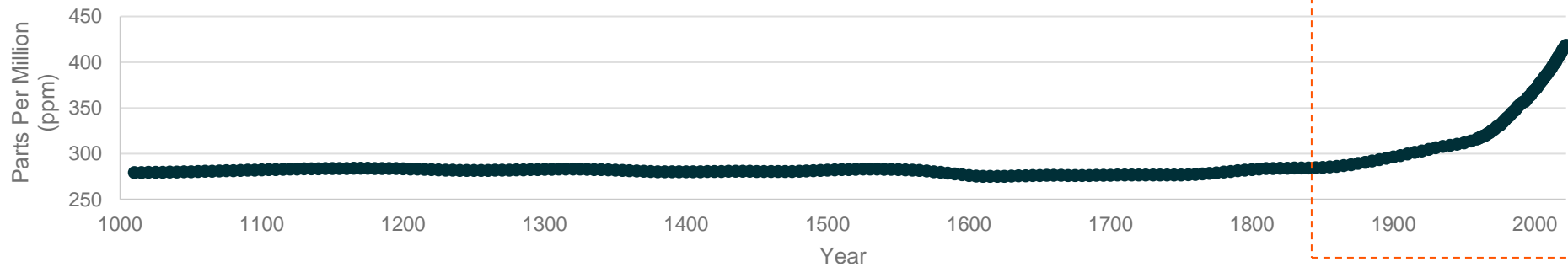
The average temperature of the Earth is rising, resulting in a range of negative environmental and societal impacts. While there is still time to limit the effects of climate change, it requires rapid, deep, and sustained greenhouse gas emissions reductions. Fortunately, technology-driven solutions already exist that can push the world closer towards net zero emissions, including renewable energy, energy storage, low-carbon hydrogen, carbon capture utilization and storage, as well as plant-based meat.



Earth's Global Surface Temperature Has Increased More Than 1°C Due to Human Activities¹

The rapid rise in human-produced greenhouse gas emissions is causing unprecedented changes to the Earth's climate. Since 1970, the global surface temperature has increased at a faster rate than any other 50-year period in 2000+ years.²

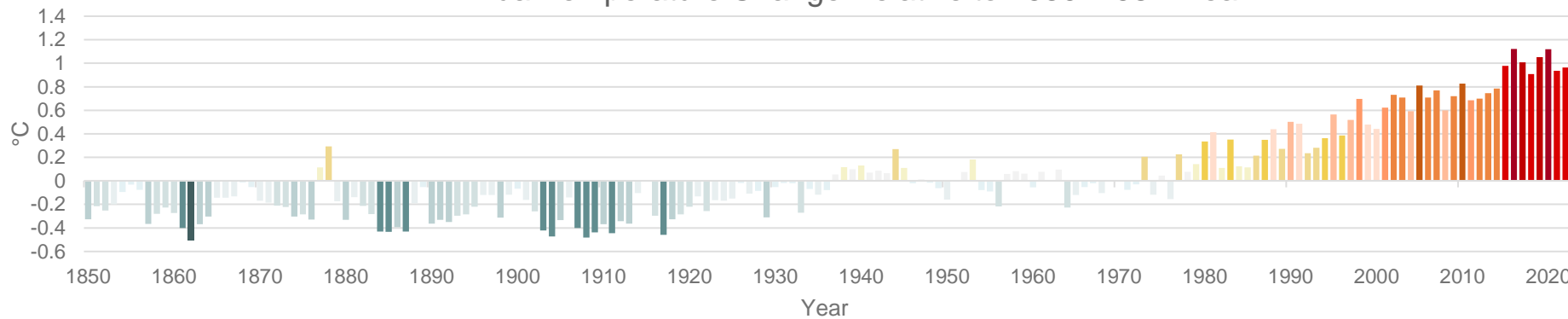
Atmospheric CO₂ Concentration



+50%

increase in the atmospheric CO₂ concentration from the 1750–1800 average to 2022. Concentrations increased from an average of 279ppm to nearly 419ppm.^{3,4}

Annual Temperature Change Relative to 1950–1981 Mean



1.1°C

increase in global surface temperature from the pre-industrial period of 1850–1900 to 2010–2020. Only +/-0.1°C could be from natural drivers like solar activity.⁵

Sources: Text: 1. Intergovernmental Panel on Climate Change (IPCC), 2023; 2. Carbon Brief, 2023; 3. Etheridge, et al, 1998; 4. National Oceanic and Atmospheric Association (NOAA), n.d.; 5. IPCC, March 2023; Charts: Top: Etheridge, et al, 1998; NOAA, n.d.; Bottom: Berkley Earth, n.d.

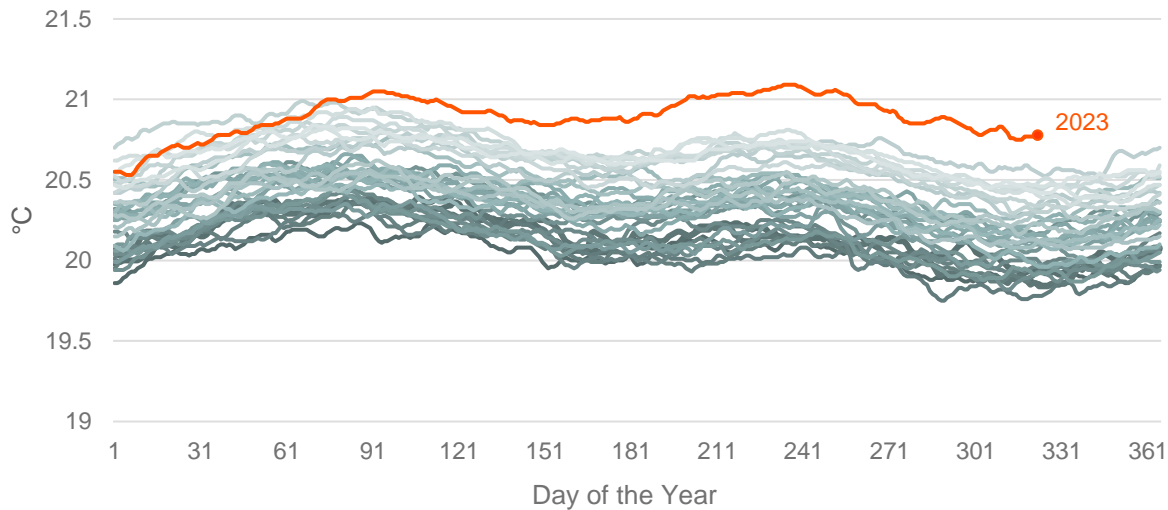
Current Levels of Warming Already Having Negative Effects

Notable shifts in the physical environment are evident at current levels of temperature change. 2023 is on track to be the warmest year ever recorded as the effects of a strong El Niño event are being compounded by climate change.¹

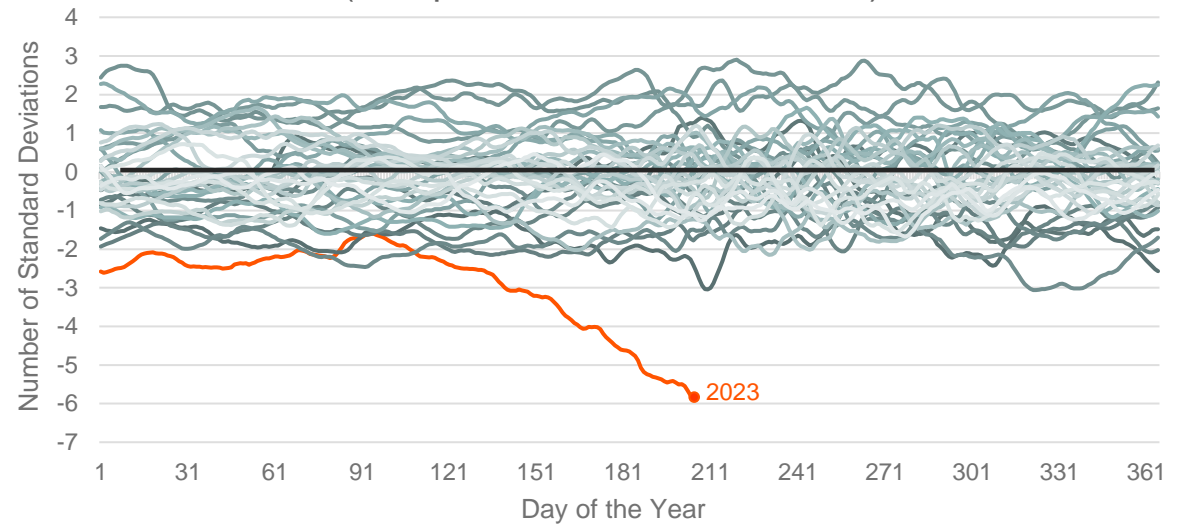
Record-breaking sea surface temperatures (SST) have been recorded around the world in 2023. In July, the Mediterranean Sea hit a record 28.7°C and the North Atlantic was at a record 24.9°C. Waters off Florida’s coast reached a significant 38.3°C.²

In 2023, Antarctic sea ice reached its lowest levels since official records began over 40 years ago.³ In July, sea ice extent represented a nearly six-sigma event, which equates to a once-in-7.5-million-year event.⁴ Given the Arctic’s natural state, scientists believe that human-induced climate change is the cause.⁵

Daily Average Sea Surface Temperature Between 60°N & 60°S, 1989–2023



Daily Standard Deviation for Antarctic Sea Ice Extent, 1989–2023 (Compared to 1991–2020 Mean)



Sources: Text: 1. Carbon Brief, 2023; 2. Phys.org, 2023-Jul; 3. National Aeronautics and Space Administration (NASA) Earth Observatory, 2023; 4. Phys.org, 2023-Aug; 5. Ibid.; Charts: Left: Climate Reanalyzer, n.d.; NOAA, n.d.; Right: Vishop, n.d.

Concerns About Climate Change Rise with More Extreme Weather Events

Climate change is affecting the strength and likelihood of extreme weather events, including drought conditions in the Western United States and extreme heat events globally – impacting levels of concern over climate change.

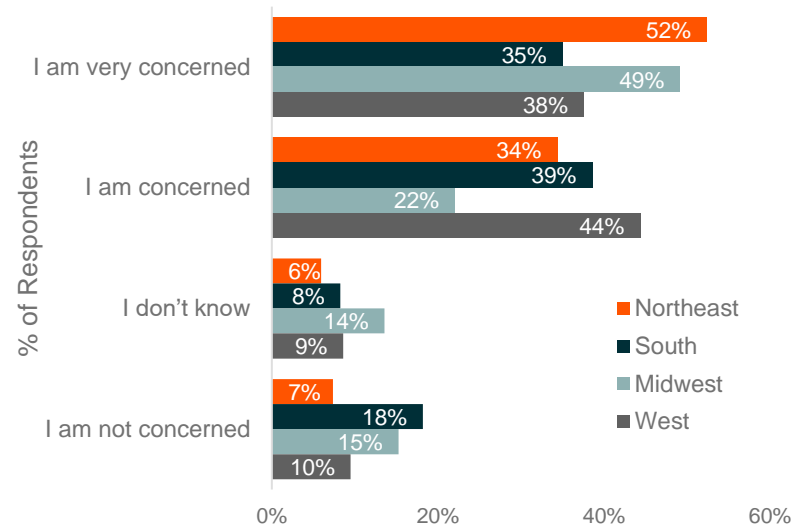
Climate change has been linked to magnifying the intensity and/or likelihood of many recent extreme weather events throughout the world.¹

- Western Mediterranean heat wave in April 2023: Occurrence at least 100x more likely due to climate change.²
- **Argentina’s record heat wave in December 2022:** Occurrence at least 60x more likely due to climate change.³
- **West Africa’s severe rainfall and flooding in 2022:** Occurrence at least 80x more likely due to climate change.⁴
- Northern Hemisphere droughts in 2022 (United States, Europe, China): Occurrence at least 20x more likely due to climate change.⁵

In the United States, 81% of respondents to a recent Global X ETFs survey are concerned about climate change, with the Northeast and West regions showing the highest levels.⁶

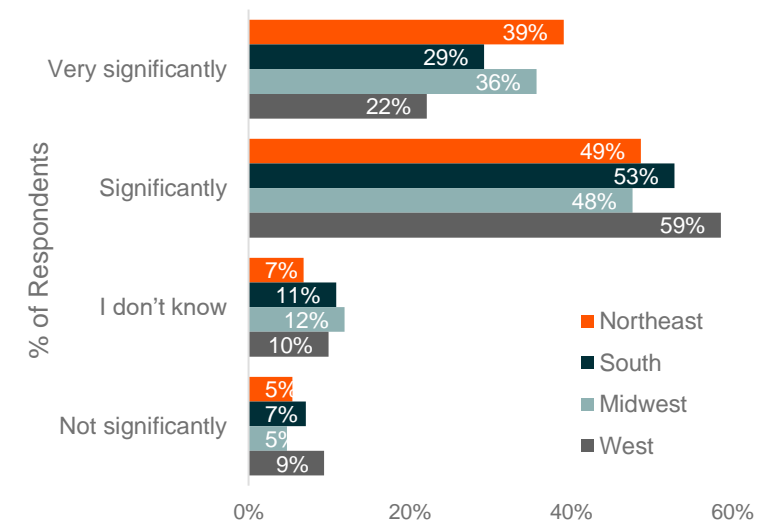
Among those concerned about climate change, recent extreme weather events played a significant role in increased levels of concern.

Q: How concerned are you about climate change?



Note: Number of respondents = 1,065.

Q: How has your level of concern been impacted by new extreme weather events?








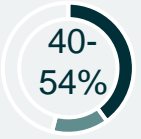

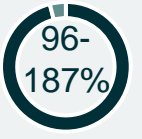


Note: Number of respondents = 856. Only answered by individuals who responded “I am very concerned” or “I am concerned” to the previous question.

Sources: Text: 1. Carbon Brief, 2022-Aug; 2. Carbon Brief, 2023-May; 3. Carbon Brief, 2022-Dec; 4. Carbon Brief, 2022-Nov; 5. Carbon Brief, 2022-Oct; 6. De, 2023; Charts: De, 2023

Every Fraction of Warming Can Rapidly Escalate the Impacts on People and Ecosystems

Global consensus is that the world must limit warming to 1.5–2°C to avoid the worst impacts. However, the world is on track for as much as 3°C by 2100.¹ The difference in potential impacts at these levels is sizeable.

Projections Show Heightened Risks for Extreme Weather, Sea Level Rise, and Biodiversity Loss as Temperatures Rise

Level of Warming	1.5°C	2.0°C	3.0°C	Level of Warming	1.5°C	2.0°C	3.0°C
Floods Percent increase in global population exposed to flooding	 24%	 30%	Data not available	Biodiversity Loss Maximum percent of terrestrial species at high risk of extinction	 14%	 18%	 29%
Fires Percent increase in burnt area across Mediterranean Europe	 40-54%	 62-87%	 96-187%	Coral Reefs Projected further percent decline in coral reefs	 70-90%	 99%	Data not available
Extreme Heat Increase in number of days per year with max temperature of 35°C+	45 to 58 Days	52 to 68 Days	66 to 87 Days	Drought Dryland pop. exposed to water/heat stress as well as desertification	0.95B People	1.15B People	1.29B People
Food Security Costs for adaptation and residual damage to major crops globally	\$63B	\$80B	\$128B	Sea Level Rise Global mean sea level rise by 2100 (meters)	0.28m to 0.55m	0.33m to 0.61m	0.44m to 0.76m

Sources: Text: 1. IPCC, 2023. Charts: IPCC, 2023; World Resources Institute, 2023

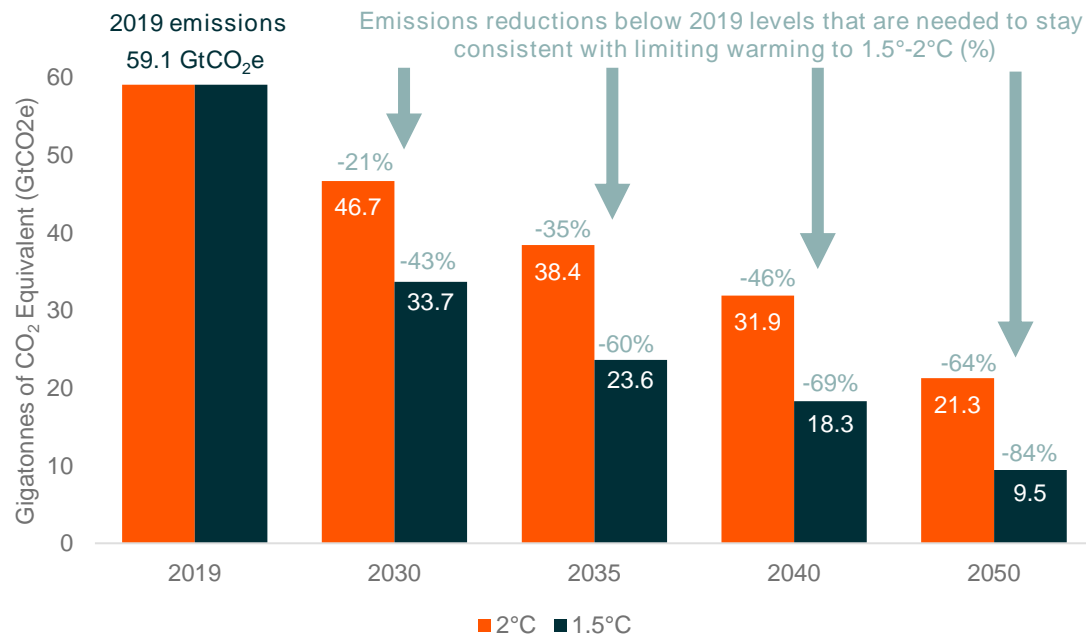
Deep, Rapid, and Sustained Emissions Cuts Can Limit Warming, but More Investment Needed

Global investment across all energy transition technologies must total an estimated \$150 trillion from 2023–2050 to limit warming to 1.5°C, or about \$5 trillion annually.¹ CleanTech investment is projected to reach \$1.7 trillion in 2023.²

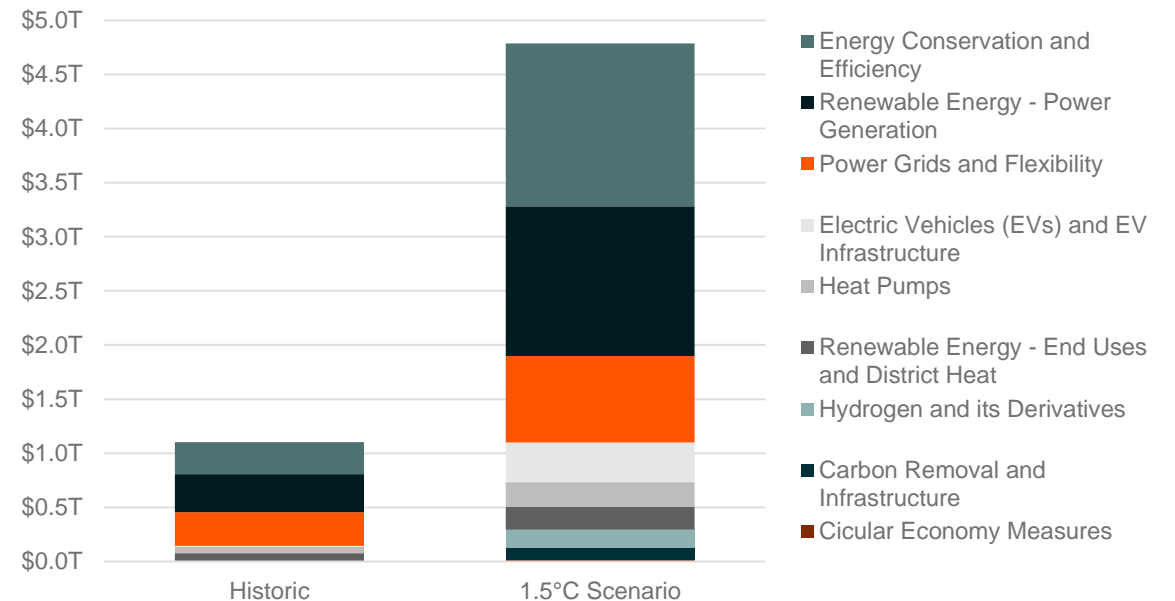
Rapid Decline in Emissions Is Needed to Limit Warming

CleanTech Investment Needs to Accelerate to Stay on Track

Projected CO2 Emissions in 1.5°C and 2°C Mitigation Pathways



Annual Historic and Projected CleanTech Investments



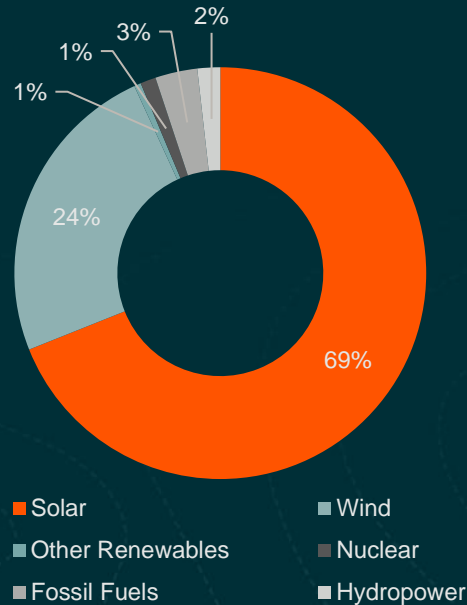
Sources: Text: 1. International Renewable Energy Agency (IRENA), 2023; 2. International Energy Agency (IEA), 2023; Charts: Left: IPCC, 2023; Right: IRENA, 2023

Widespread Adoption of Renewables Can Decarbonize the Power Sector

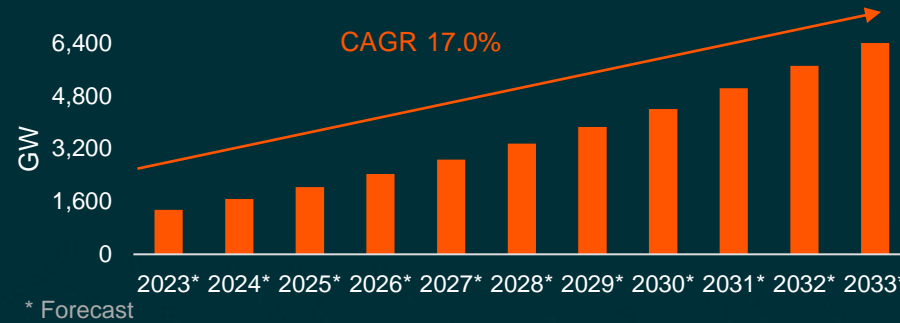
The global clean energy transition is well underway. Non-hydropower renewable electricity generation is forecast to increase 3.2x between 2023 and 2033.¹ By 2033, non-hydro renewables could account for 38% of generation.²

Global Non-Hydropower Renewable Capacity Is Forecast to Increase from 2,508 Gigawatts (GW) in 2023 to 9,475 GW in 2033.³

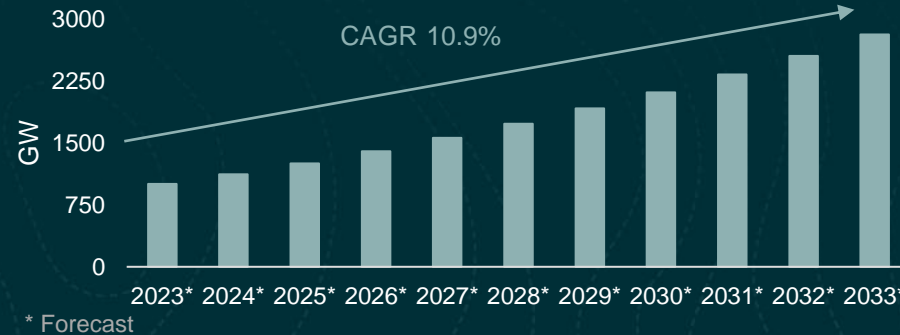
Share of Forecasted Net Capacity Additions from 2023–2033 (%)



Global Solar Power Capacity



Global Wind Power Capacity



Key Drivers of Renewables Growth

- **Favorable Policy Environments:** Over 150 countries have economy-wide net zero emissions targets, with governments using measures such as tax credits and project tenders to encourage renewables growth.⁴ The U.S. Inflation Reduction Act (IRA) and the European Union’s RePowerEU plan are prime examples of policies that can boost growth.
- **Corporate Sustainability Efforts:** Many corporations are becoming increasingly interested in using renewable energy to reduce operational emissions.
- **Technology Improvements:** Advancements in wind and solar power components, such as solar modules and wind turbines, can improve system performance and efficiency while further cutting costs.
- **Increased Cost Competitiveness:** Onshore wind and solar photovoltaic (PV) power costs declined 68% and 88%, respectively, between 2010 and 2021.⁵ While costs have been elevated in recent years, tech advancements and addressing supply issues can yield further price declines.

Sources: Text: 1. Global X forecast based on information derived from several sources – see Appendix: CleanTech & Beyond: Sources; 2. Ibid; 3. Ibid; 4. Net Zero Tracker, n.d.; 5. IRENA, 2022.

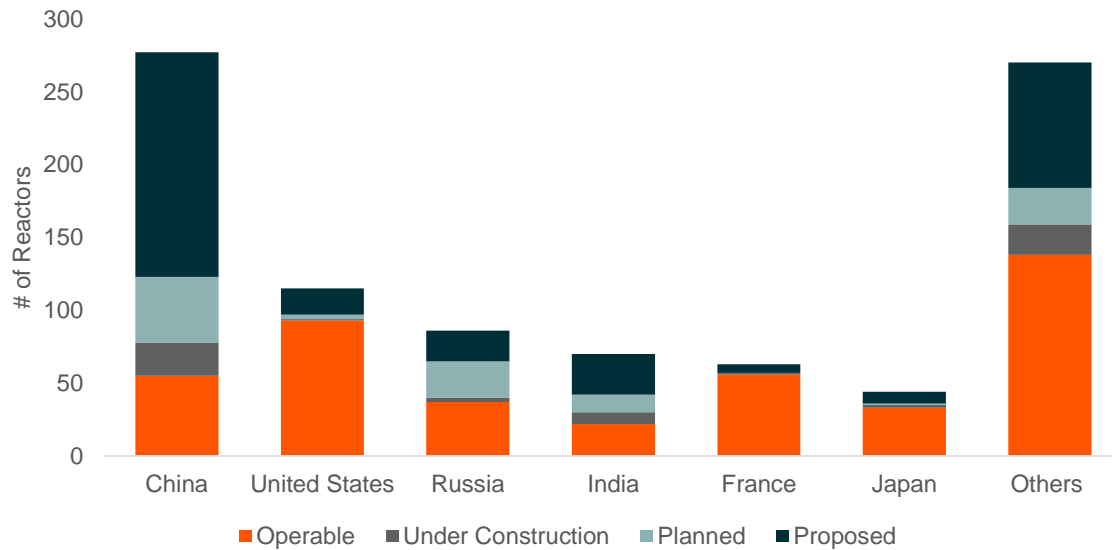
Many Governments Continue to Support Nuclear Power for a Clean Energy Future

Nuclear energy is one of the cleanest, most reliable ways to make electricity, as plants can operate at full capacity 90% of the time.¹ Nuclear power can help governments improve energy security and mitigate climate change.

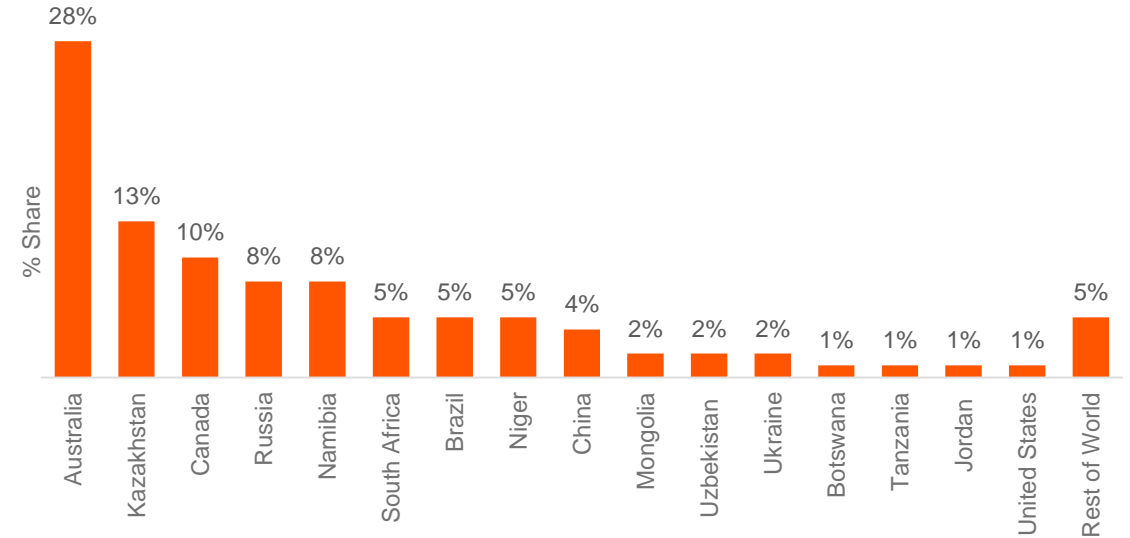
Next-generation small modular reactor (SMR) technologies offer a safer, more modular, and less expensive alternative to traditional nuclear power plants.² The recent nuclear fusion breakthrough is a decades-long scientific accomplishment that has the potential to advance clean power.³

Given nuclear power's benefits for energy security and decarbonization, as well as the industry's growth potential, exploration expenditures for uranium grew by a significant 60% year-over-year in 2022.⁴ For example, the U.S. Department of Energy started to support a strategic domestic uranium reserve.

Nuclear Reactors Under Development, by Stage and Country



Uranium Reserves Worldwide



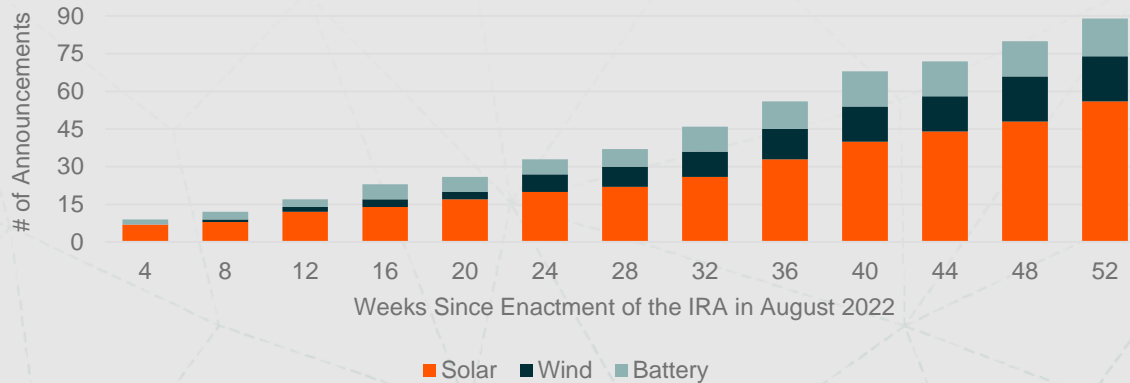
Sources: Text: 1. Energy Industry Association (EIA), 2022; 2. International Atomic Energy Agency, 2023; 3. Reuters, 2023; 4. IEA, 2023; Charts: Left: World Nuclear Association, 2023a; Right: World Nuclear Association, 2023b

Policy Highlight: The IRA Has Spurred Significant Clean Energy Investment

Katherine Hamilton

Over \$270 billion in investments across the wind, solar, and battery value chains is attributable to the Inflation Reduction Act (IRA). In the IRA's first year, 80+ new or expanded clean energy production facilities were announced.

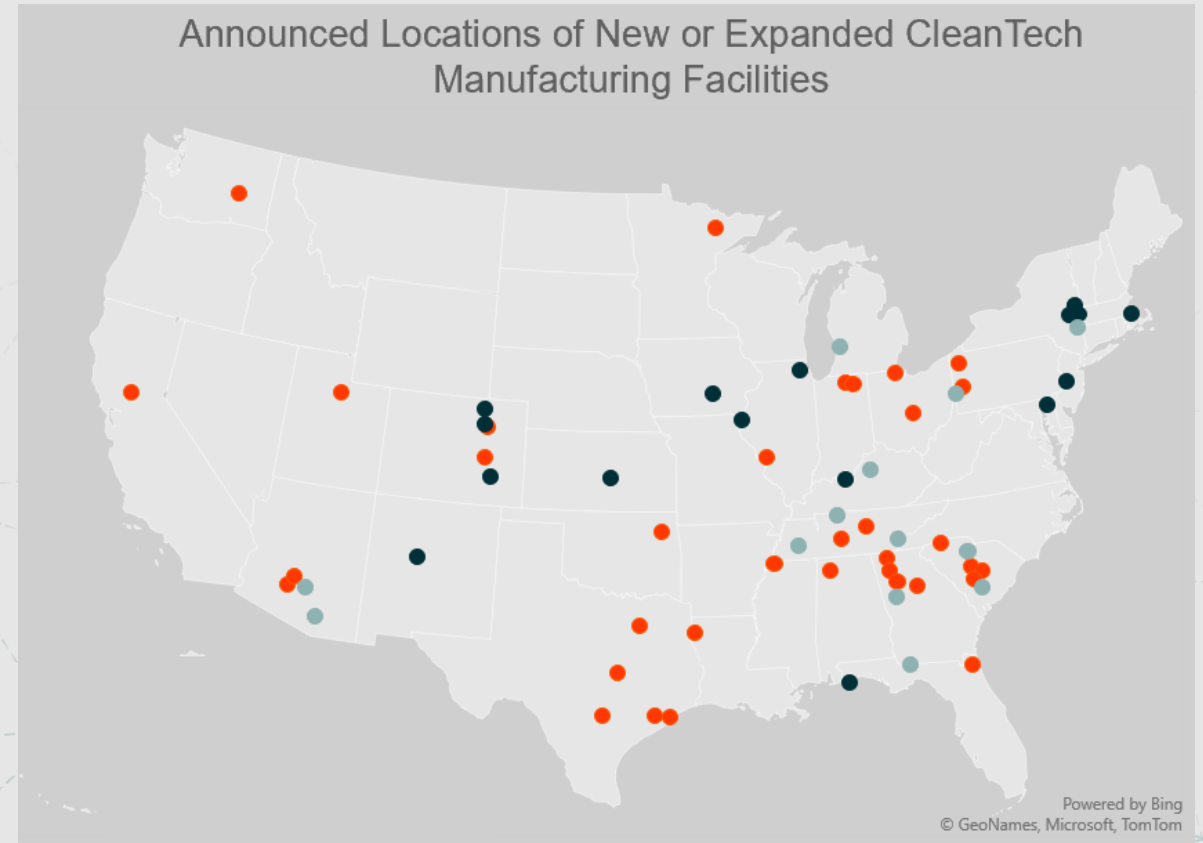
New or Expanded Facility Announcements Since the IRA's Enactment



U.S. Renewables Supply Chain Led by Solar

The supply chain is crucial to the deployment of renewables, especially given the domestic content mandate built into tax credits and ongoing tariff discussions in the U.S. solar industry. Solar companies announced 50+ new or expanded manufacturing facilities in the IRA's first year. Combined, these facilities could add more than 70GW of solar power equipment manufacturing capacity. Canadian Solar, Enphase, First Solar, Meyer Burger, Jinko Solar, JA Solar, and Polar Racking are among the companies that made announcements.

Announced Locations of New or Expanded CleanTech Manufacturing Facilities



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Sources: Text and Charts: American Clean Power, n.d.

Policy Highlight: IRA Can Speed Up Solar’s Reach in Underserved Communities Katherine Hamilton

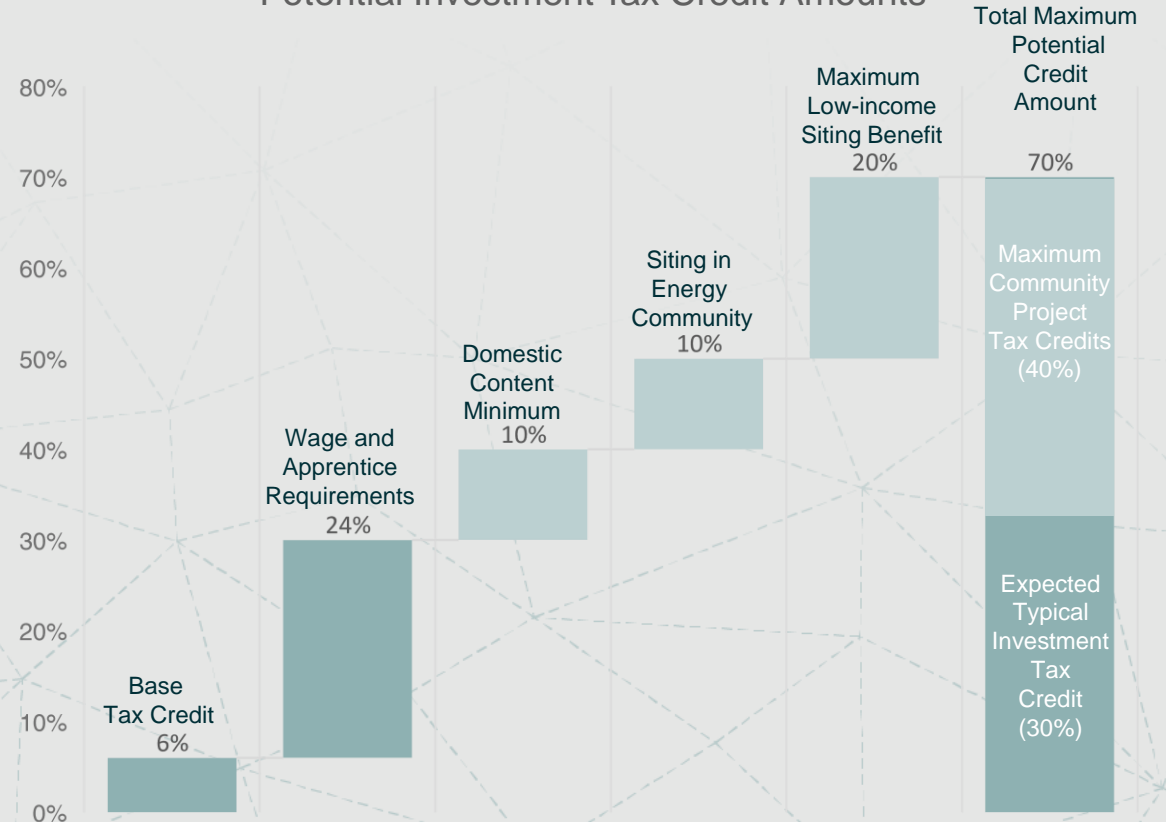
Developers that build in underserved communities can potentially benefit from a tax credit of up to 70%.¹ These measures, combined with solar’s scalability and cost advantages, are likely to lead to robust solar power growth.

The IRA Takes an Inclusive Approach to the Clean Energy Transition

By ensuring that a wider range of communities can benefit, the IRA greatly expands the potential growth opportunities for the U.S. solar power sector. The stacking of economic incentives aims to help renewables reach areas in most need of well-paying jobs, economic growth, and clean air. With these tax credits, it can become more cost-effective to build solar in communities that have previously not had much access.

Highlighted Tax Credit Incentive	Requirements for Credit	Maximum Credit %
Wage and Apprenticeship Requirements Credit	Developers pay laborers prevailing wages and employ apprentices for a set number of hours, as determined by the U.S. Department of Labor. ²	24%
Domestic Content Credit	Developers surpass required amount of domestically produced project components of steel or iron. ³	10%
Siting in Energy Community Credit	Project is built in an Energy Community, which can be defined as an area that has disproportionately suffered from the impact of fossil fuels. ⁴	10%
Siting in Low-Income Community Credit	Project is under 5MW in total size and built in designated low-income community. ⁵	Up to 20%

Potential Investment Tax Credit Amounts



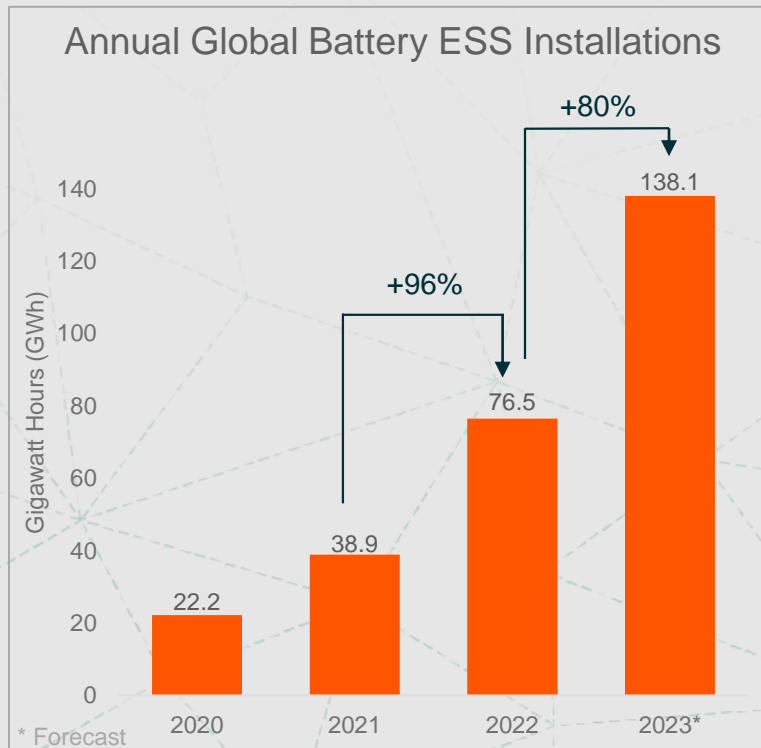
Sources: Text: 1. Center for American Progress (CAP), 2023; 2. Internal Revenue Service (IRS), n.d.; 3. Bond, Davis, Rodgers, & Saccomanno, 2023; 4. U.S. Department of the Treasury, 2023; 5. U.S. Department of Energy (DOE), n.d.; Charts: CAP, 2023.

Rapid Growth in Energy Storage Is a Positive Sign for the Energy Transition

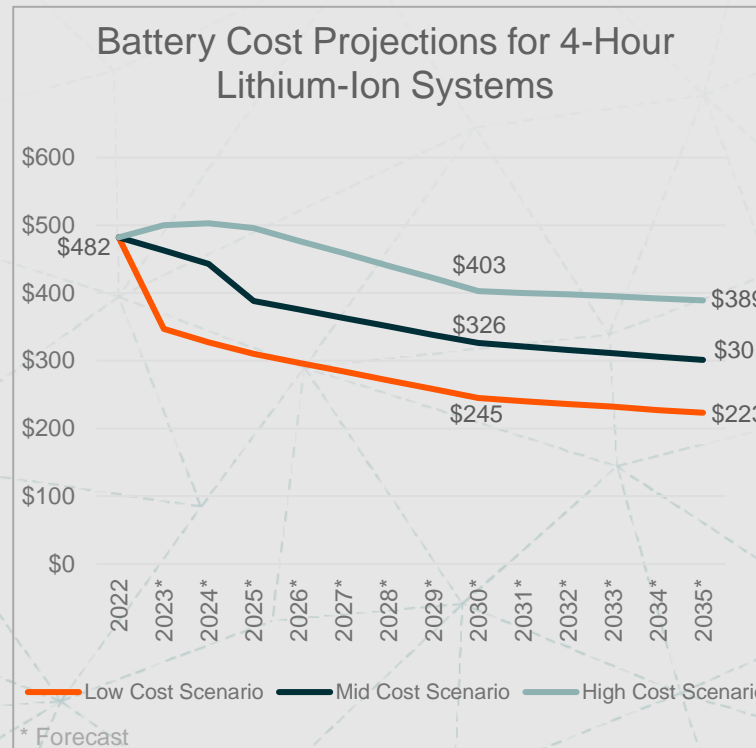
Katherine Hamilton

The expected growth in energy storage systems (ESS) speaks volumes about the world's ability to integrate renewable energy and balance greener power grids. Supportive policies are likely to make ESS more cost-effective over time.

Strong ESS Growth Forecast for 2023



ESS Costs Expected to Decline Rapidly



Policies Support Positive ESS Outlooks

Policy Highlights

- United States:** The IRA creates a standalone tax credit for energy storage systems.¹ Additionally, the Infrastructure Investment and Jobs Act includes potential financing support for long-duration storage technologies and ESS manufacturing facilities.²
- China:** Policies that require renewables projects to be paired with ESS could help energy storage capacity grow to over 50GW by 2025.³
- European Union:** In March 2023, the European Commission published an analysis that outlines best practices and financing frameworks that can help boost ESS deployment in the region.⁴
- India:** In August 2023, India's government published its National Electricity Plan, which targets 74GW/411GWh of energy storage by 2032.⁵ The government is planning to expand measures to encourage ESS growth over the coming years.

Sources: Text: 1. Energy Storage News, 2023-Jan; 2. DOE, n.d.; 3. South China Morning Post, 2023; 4. European Commission, 2023; 5. Energy Storage News, 2023-Sept; Charts: Left: Rho Motion, 2023; Right: National Renewable Energy Laboratory (NREL), 2023.

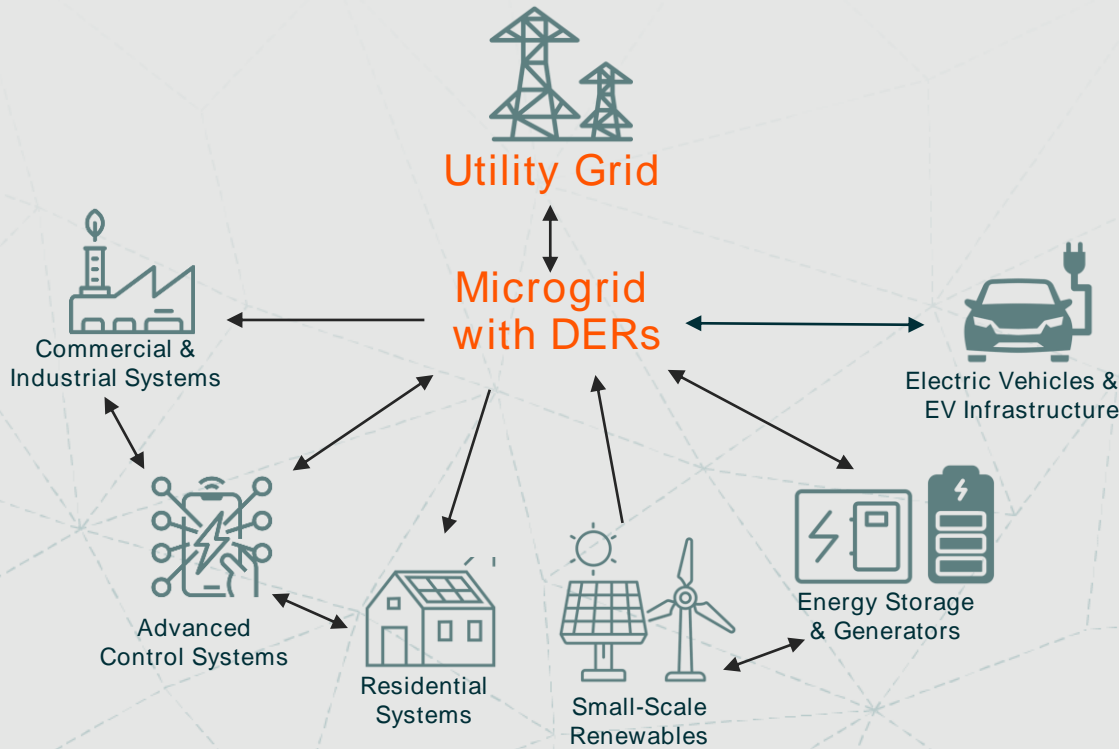
Distributed Energy Resources (DERs) Can Further Increase Grid Resilience

Katherine Hamilton

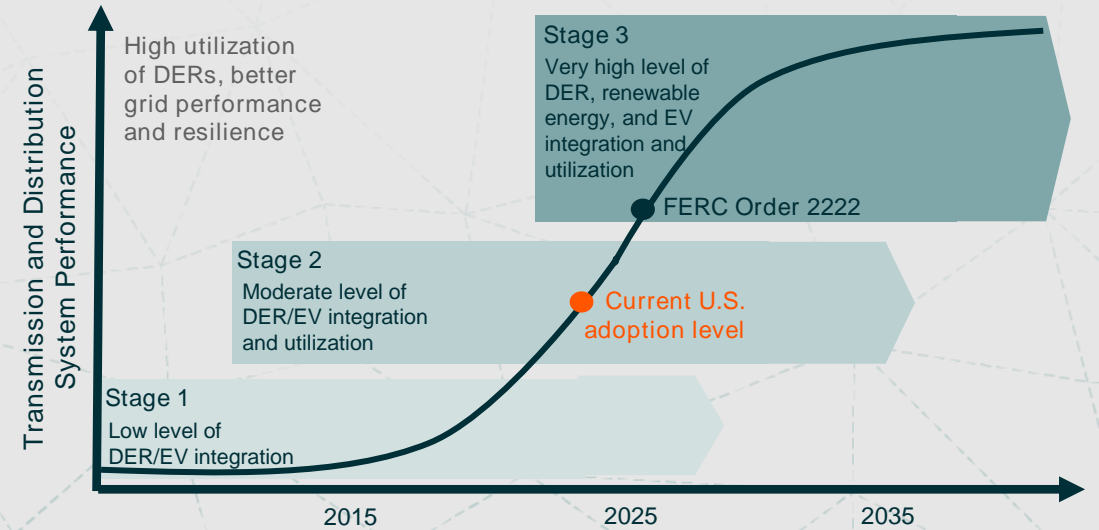
DERs - such as microgrids with residential solar power systems, electric vehicle (EVs), heat pumps, and energy storage - are crucial to balancing power systems and ensuring that grids can absorb 100% clean energy.

DERs Included in Microgrids Can Boost Capacity on Utility Grids

Grids Expected to Become More Reliable with Uptake of DERs



Status of DER Integration in the United States



Order 2222: The U.S. Federal Energy Regulatory Commission (FERC) calls for the integration of DERs into wholesale energy markets by 2025.¹ This order poses challenges, but it can also boost grid capacity and provide other benefits.

Sources: Text: 1. PCI Energy Solutions, 2023.; Charts: Left: VectorMine, n.d.; Right: Berkley Lab, 2023-Apr 25; Berkley Lab, 2023-Apr 13

Nascent Yet Growing Technologies Can Reach the Hardest-to-Abate Sectors

Katherine Hamilton

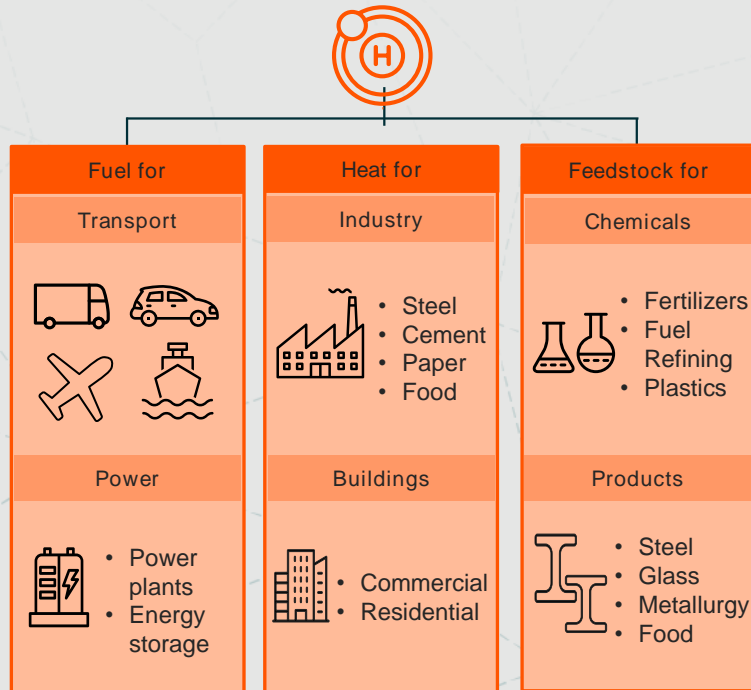
We envision a fully decarbonized world with solutions such as low-carbon hydrogen and carbon capture giving industries like steel, cement, and petrochemicals clear pathways to decarbonize.

Hydrogen (H) Can Clean Up Many Sectors

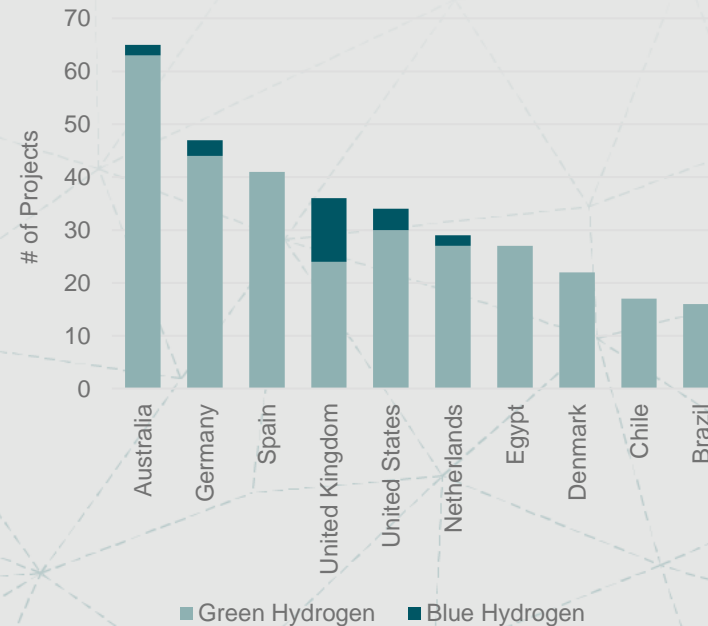
500+ Clean H Projects Are in Development

Policies Encourage a New Global Industry

Hydrogen Use Cases



Low-Carbon Hydrogen Project Pipeline, Top 10 Countries



Policy Highlights

- **Australia:** Helped by its \$2 billion Hydrogen Headstart Program, which will provide financial support to large-scale projects, Australia aims to be a major global exporter of clean hydrogen by 2030.¹
- **United States:** The IRA includes a Clean Hydrogen Production Tax Credit that is expected to bring low-carbon hydrogen prices closer to cost parity with traditional grey hydrogen.² This credit can create political will and incentivize the production and use of low-carbon hydrogen.
- **European Union:** Among the European Union's many hydrogen-related objectives, the region aims to produce 10 million tonnes and import 10 million tonnes of low-carbon hydrogen by 2030.³
- **Chile:** The Chilean government intends to provide \$1 billion for green hydrogen projects to help the country become a top exporter and produce the lowest-cost hydrogen over the next decade.⁴

Sources: Text: 1. Australian Government, n.d.; 2. Atlantic Council, 2022; 3. European Commission, n.d.; 4. HydrogenInsight, 2023; Charts: Left: Bloomberg, 2019; Right: Fitch Solutions, 2023

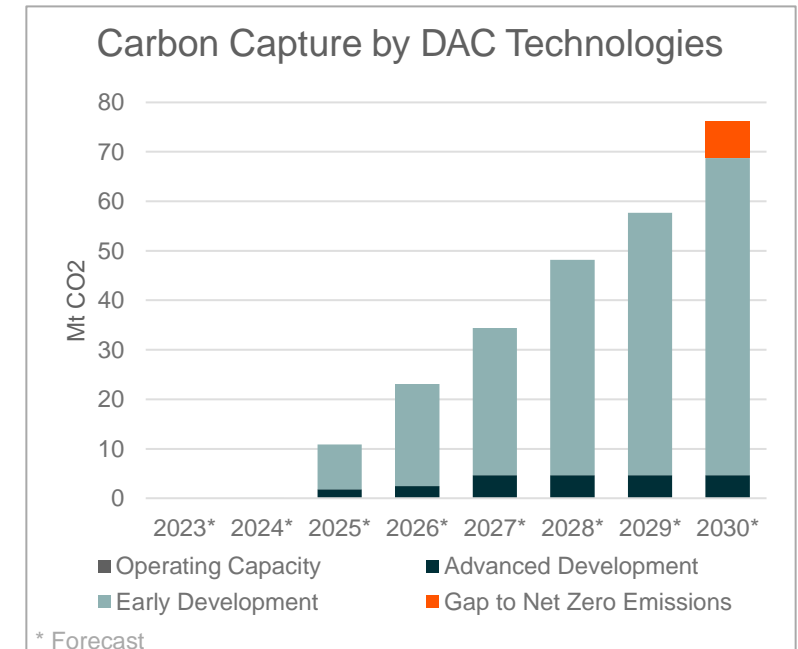
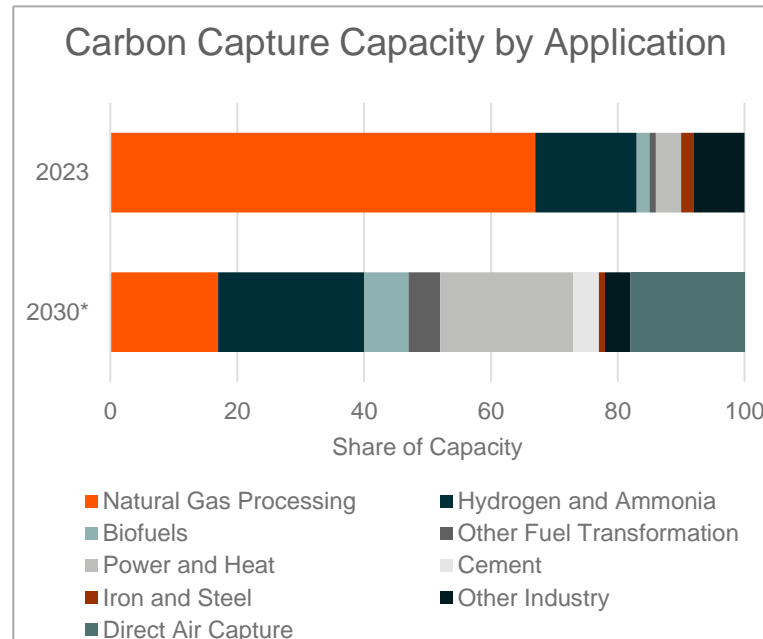
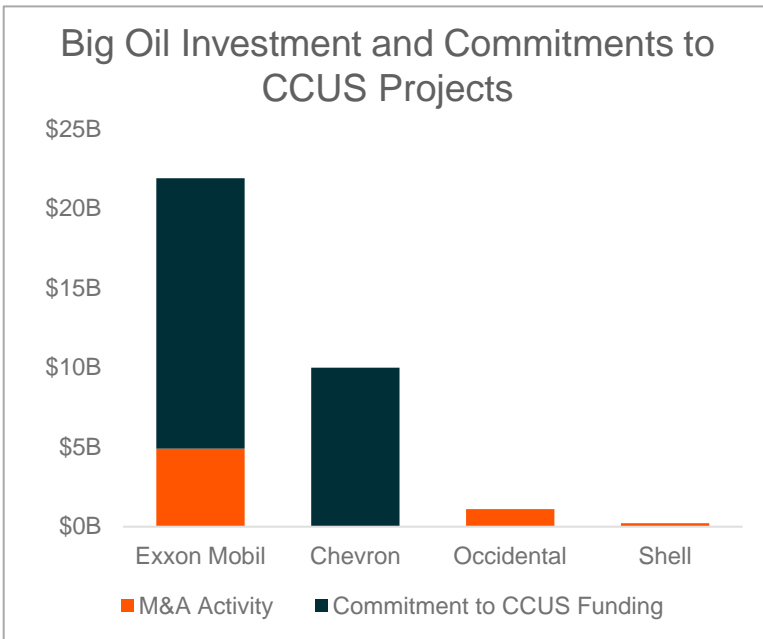
Carbon Capture Technologies Playing a Key Role in Net Zero Pursuit

Favorable policies are incentivizing companies to invest in carbon capture technologies, such as carbon capture, utilization, and storage (CCUS) and direct air capture (DAC) systems.

Oil and gas companies are investing in CCUS systems as well as related mergers and acquisitions, given their synergies. In July 2023, Exxon Mobil acquired carbon solutions provider Denbury Inc. for \$4.9 billion.¹ Chevron has committed \$10 billion for CCUS.²

Nearly 70% of today's operating carbon capture systems are used for natural gas processing.³ By 2030, these systems are expected to be used in applications for power and heat, direct air capture, as well as hydrogen and ammonia production.

While CCUS systems are placed at specific sites like smokestacks, DAC systems pull carbon directly from the atmosphere. 130+ facilities are in development, which could remove 70 MTCO₂/year by 2030.⁴ This carbon can then be stored or used as feedstock.

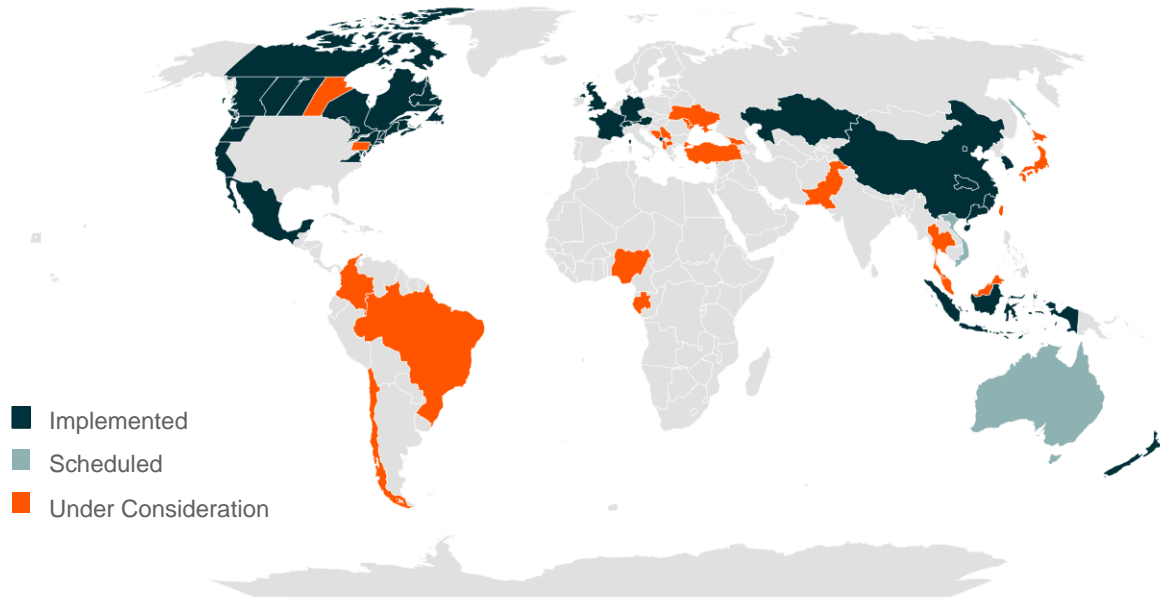


Sources: Text: 1. Exxon, 2022; 2. Chevron, 2022; 3. IEA, 2023; 4. Ibid.; Charts: Left: Exxon Mobil, 2022; Reuters, 2023-Jul; Chevron, 2022; Reuters, 2023-Aug; Shell, 2022; Middle: IEA, 2023b; Right: IEA, 2023a

Regional and National Emissions Trading Schemes (ETS) Continue to Expand Globally

Carbon allowance ETS are another decarbonization tactic, and they could create additional growth opportunities for CCUS. New ETS are increasingly prevalent, and price activity for existing schemes is at record highs.

Status of Global Compliance Carbon Markets



Notable ETS Developments Over the Past Year

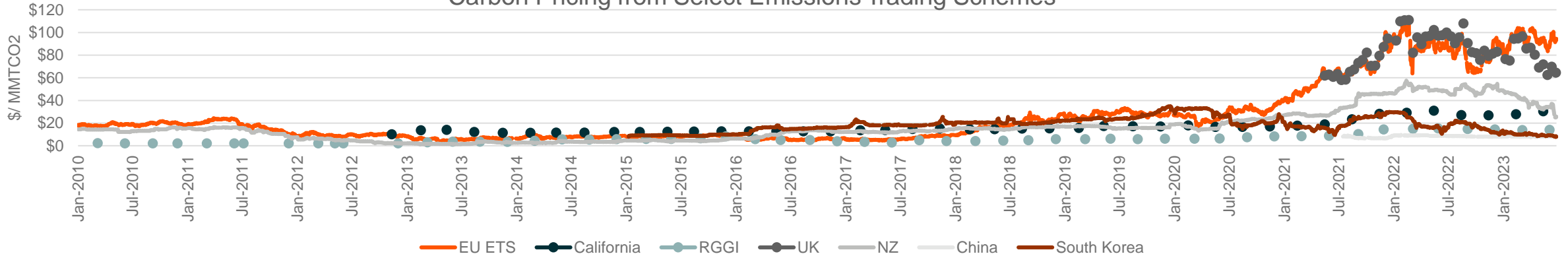
- European Union:** In April 2023, the EU ETS increased its ambition as part of the European Union's Fit for 55 in 2030 package. The program now targets reducing carbon emissions from ETS sectors by 62% by 2030 compared to 2005 levels. It also phases out free allowances to companies from 2026 until 2034 and creates a second ETS for additional sectors, including road transport and buildings.¹
- China:** China's relatively new ETS still only covers the power sector. By 2025, China's ETS is expected to expand to seven more carbon-intensive industries, such as building materials, domestic aviation, and petrochemicals.²
- United Kingdom:** The UK ETS Authority published results of its consultations on reforms and proposed a new cap of 936 million allowances from 2021–2030, more than a 30% reduction from the prior 1.3 billion allowances. The supply cut is a bullish indicator for UK Allowances (UKA) prices.³
- California:** The California Air Resources Board (CARB) approved the 2022 Scoping Plan, which targets a 48% reduction in the state's emissions compared to 1990 levels. The state's prior target was 40%.⁴

Sources: Text: 1. European Parliament, 2023; 2. S&P Global, 2023; 3. Reuters, 2023; 4. California Air Resources Board (CARB), 2022; Charts: Carbon Pricing Dashboard by the World Bank, 2022

Higher Prices for Carbon Allowances Can Help Reduce Polluting Activities

Increased political net zero ambitions, constricted supply, and the lack of cost-effective carbon abatement technologies continue to drive positive price movements for carbon allowances. Companies that reduce emissions stand to benefit.

Carbon Pricing from Select Emissions Trading Schemes



Global ETS Timeline



Sources: Text: 1. United Nations Framework Convention on Climate Change (UNFCC), n.d.b; 2. European Commission, n.d.; 3. Center for Climate and Energy Solutions (CCES), n.d.a; 4. Motu, 2016; 5. CCES, n.d.b; 6. UNFCC, n.d.a; 7. Asia Society Policy Institute, n.d.; 8. Reuters, 2023; 9. Forbes, 2022; 10. European Parliament, 2023; 11. CARB, 2022; 12. Reuters, 2023; 13. International Carbon Action Partnership (ICAP), 2023; Charts: ICAP, 2023

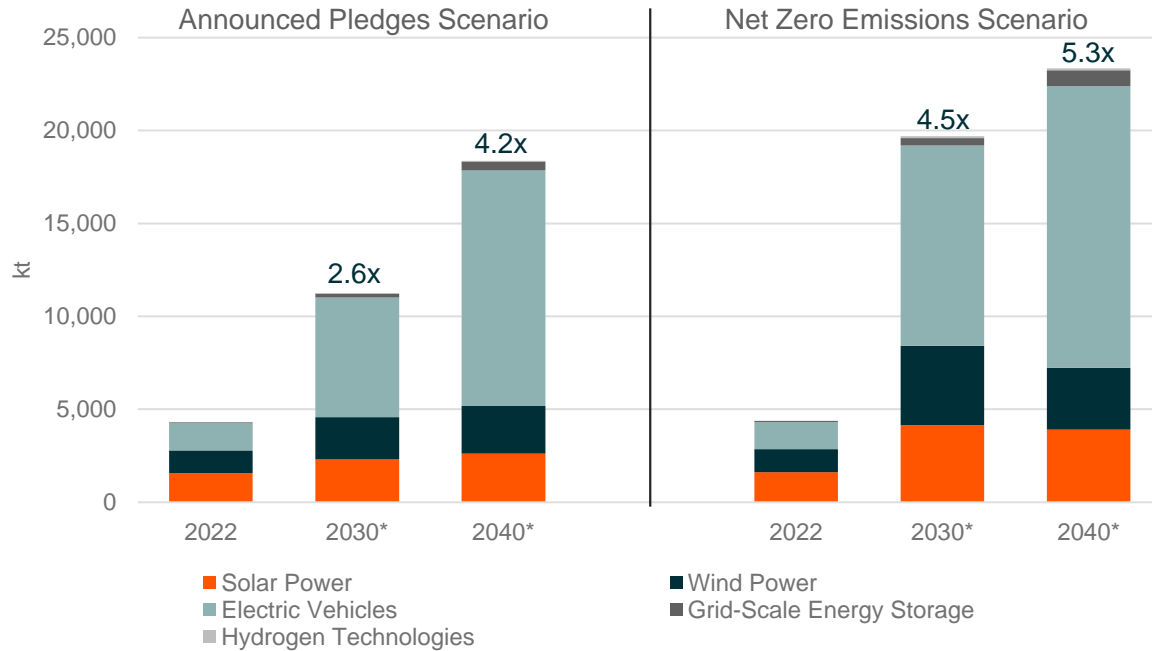
Significant Opportunities Are Forming for Materials at the Center of the Clean Energy Transition

Companies involved in the mining and processing of minerals such as lithium, nickel, graphite, copper, manganese, and rare earth elements (REEs) are well positioned in the clean energy transition.

Mineral Demand Could Be 2x to 5x Higher by 2040¹

Supply Shortage Risks Exist for In-Demand Minerals

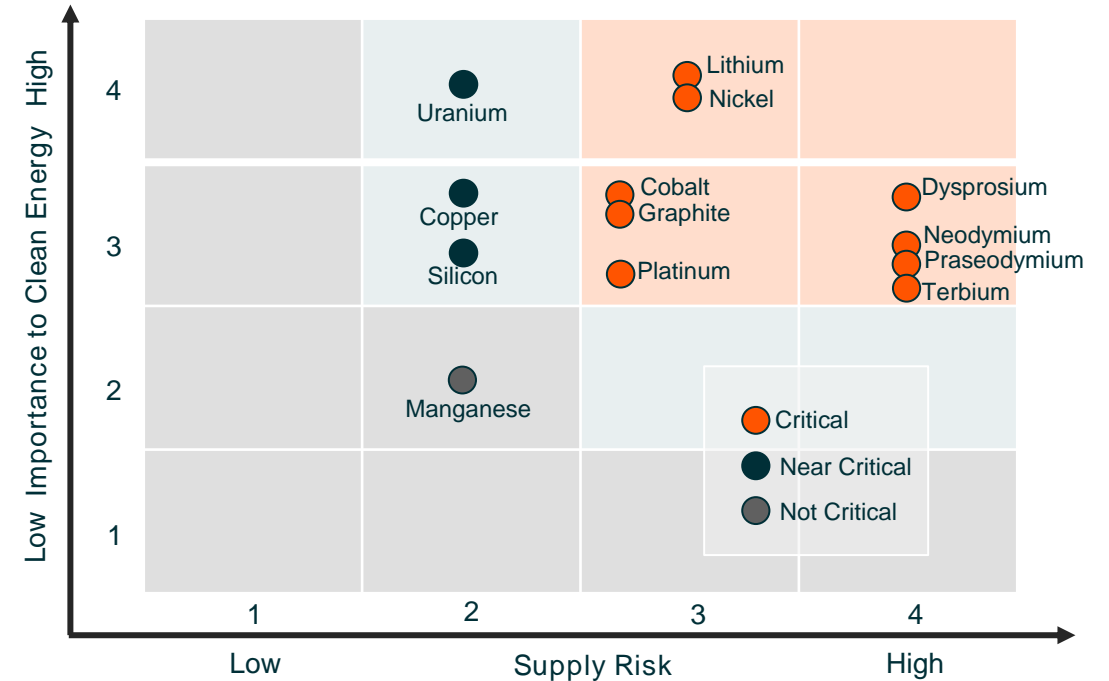
Mineral Demand by Clean Energy Technology



* Forecast

Sources: Text: 1. IEA, 2023. Charts: Left: IEA, 2023; Right: DOE, 2023

Medium-Term Mineral Criticality Matrix (2025–2035)

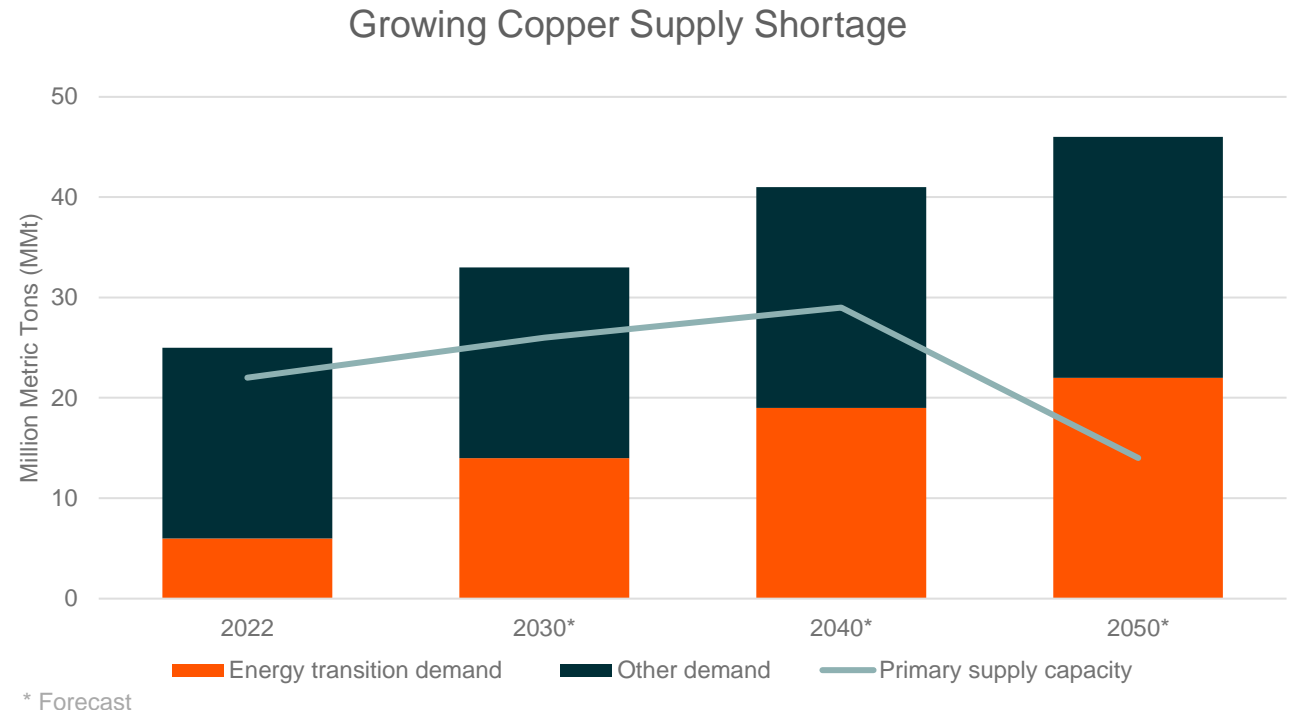


Copper Industry Critical to the Energy Transition, but Supply Risks Loom

Copper's conductive properties make it essential to such clean technologies as renewable energy systems and electric vehicles. This conductivity is forecast to result in significant demand for the eternal metal and strain supply.

Primary Copper Supply Could Fall Further Behind Demand Over the Coming Decades as the Energy Transition Gains Traction

- By 2050, copper consumption is forecast to increase to 46 million metric tonnes, up from 26 million in 2022. Power grids and transport will likely be the biggest consumers as part of the energy transition.¹
- Wind power systems are among the applications that will require more copper. By mid-century, offshore wind farms are expected to use 2.9 tonnes of copper per kilowatt, up from 2.5 tonnes currently.²
- In 2022, the primary copper supply was 4 million tonnes short. If current reserves are not replaced by new geological discoveries and initiatives, this gap is forecast to rise eightfold to 32 million tonnes by 2050.³
- Because opening new mines is difficult, industry consolidation is a growing trend. Copper continues to be one of the main targets of M&A transactions.
- Increases in investment and exploration spending is attributable to strong cash flows and the momentum behind energy transitions.⁴



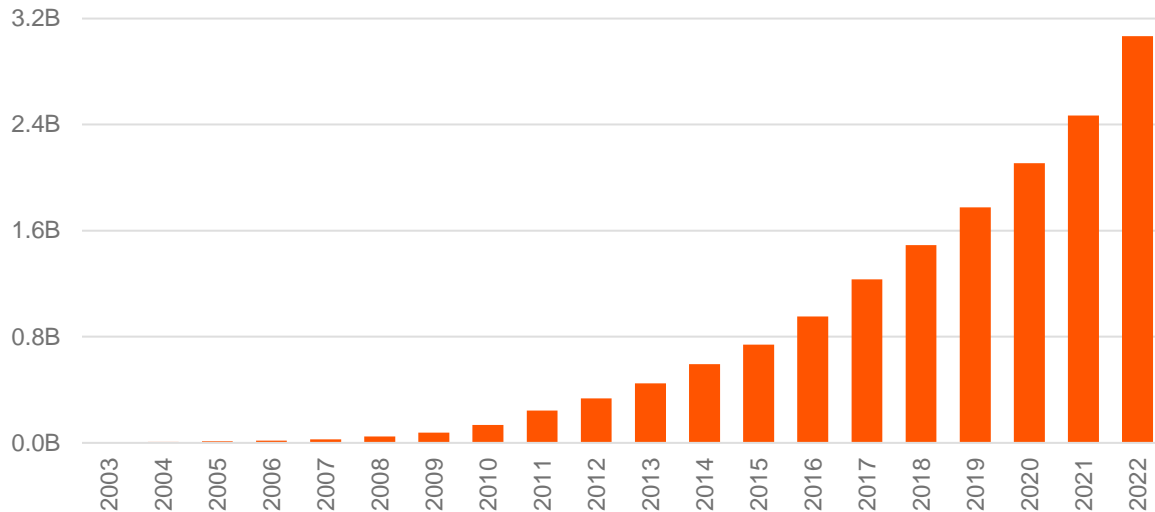
Sources: Text: 1. BloombergNEF, 2023; 2. Ibid.; 3. Ibid.; 4. IEA, 2023; Charts: BloombergNEF, 2023

Recycling Can Improve Renewables' Circularity and Reduce Supply Risks

Aging solar and wind power systems may create tens of millions of tons of waste by the 2040s. Improved recycling measures can help minimize environmental impacts and boost supplies of key minerals, such as silicon and copper.

Solar panels generally last 25–30 years.¹ Few solar systems have reached their end-of-life (EOL), but more will in coming years. Total waste from EOL solar panels could exceed 61 million tons by 2045.² Panels contain key metals, such as copper and silicon.

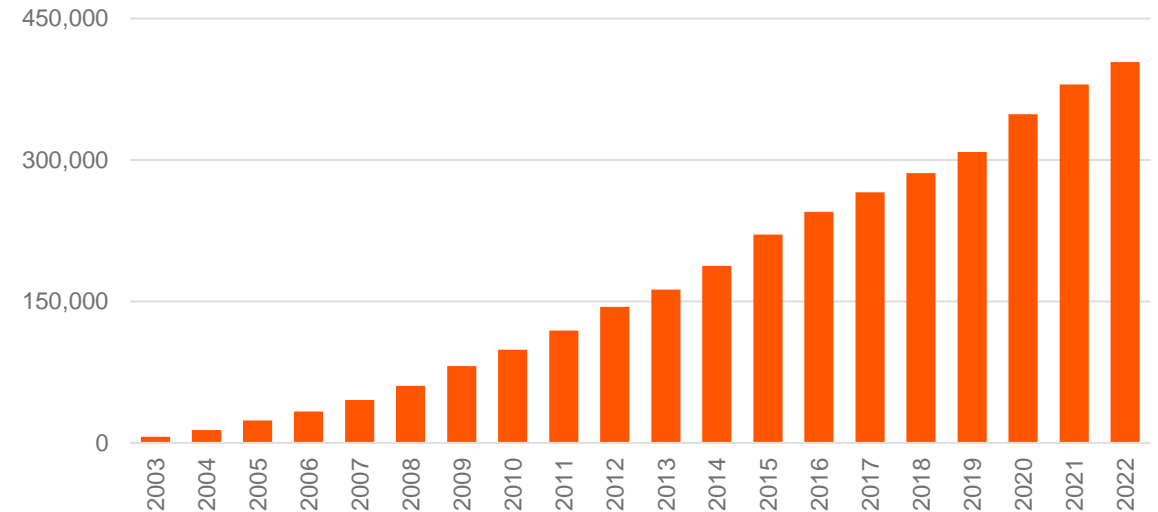
Estimated Cumulative Number of Solar Panels Installed Globally



Note: Numbers are estimates

Wind turbines typically last 20–25 years.³ Waste from EOL wind turbine blades could total more than 14 million tons by the early 2040s.⁴ However, in February 2023, leading wind turbine producer Vestas announced a chemical recycling technique that could be a potential breakthrough for the industry.⁵

Estimated Cumulative Number of Wind Turbines Installed Globally



Note: Numbers are estimates

Sources: Text: 1. Forbes Home, 2023; 2. Global X ETFs analysis of: EIA, n.d.; Energy Sage, 2023; Greentech Media, 2019; NSK Global, n.d.; Solar Energy World, 2023; DOE, 2023; 4. Global X ETFs analysis of: EIA, n.d.; Energy Sage, 2023; Greentech Media, 2019; NSK Global, n.d.; Solar Energy World, 2023; DOE, 2023; 5. Energy Monitor, 2023; Charts: Left: EIA, n.d.; Energy Sage, 2023; Greentech Media, 2019; NSK Global, n.d.; Solar Energy World, 2023; DOE, 2023; Right: EIA, n.d.; Energy Sage, 2023; Greentech Media, 2019; NSK Global, n.d.; Solar Energy World, 2023; DOE, 2023

Shifting Food Consumption Habits Can Yield Significant Climate Benefits

Peter McGuinness

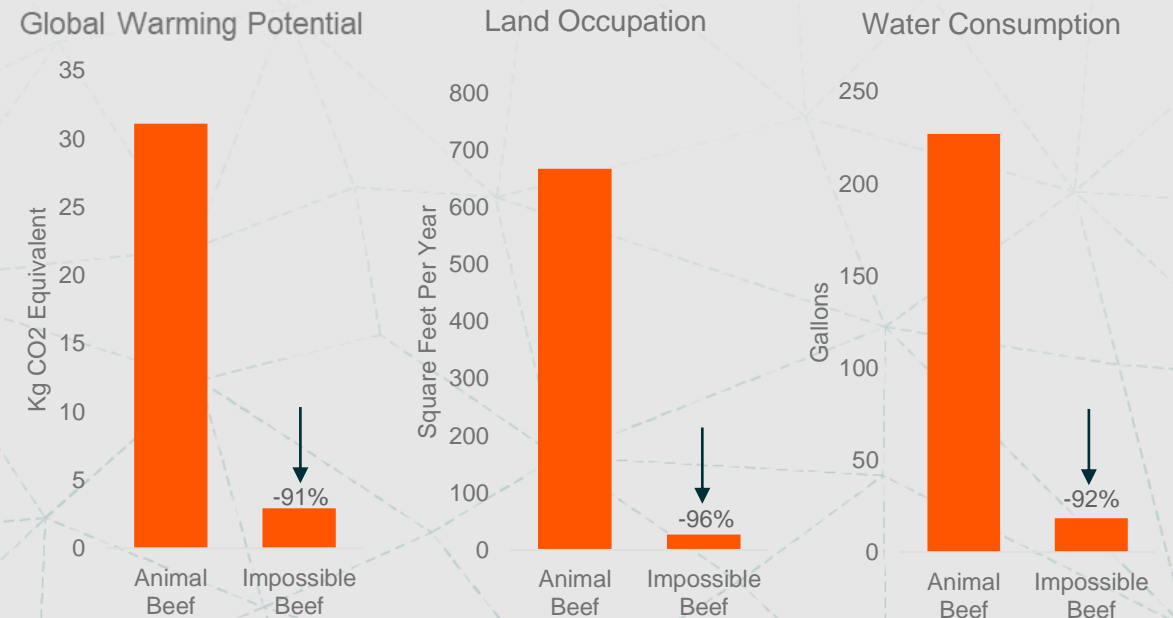
Increased consumption of plant-based meat over beef, chicken, sausage, and pork from animals can substantially lower water usage, reduce land use, and reduce greenhouse gas emissions produced within the food chain.

Plant-Based Foods Can Provide Several Environmental Benefits

Compared to meat from animals, 10 lbs of...	Avoids the GHG emissions equivalent to approximately ...	Saves the land footprint equivalent to a habitat the size of approximately ...	Saves water use that is equivalent to approximately ...
Impossible Beef	281.7 lbs of CO2	2,906 square feet	946.6 gallons
Impossible Sausage	52.2 lbs of CO2	119.6 square feet	520 gallons
Impossible Pork	56.1 lbs of CO2	190.4 sq ft	532 gallons
Impossible Chicken	12.4 lbs of CO2	120.5 square feet	143.7 gallons

Plant-Based Alternatives to Beef Are Produced More Efficiently

Resource Comparison, Impossible vs. Beef Burger



Note: Calculations based on 1kg of food

Source: Charts: Left: Impossible Foods & WSP, 2022 (ISO compliant); Impossible Foods, n.d.; Right: Impossible Foods & WSP, 2022 (ISO compliant).

Nascent Plant-Based Segment Can Capture Greater Market Share

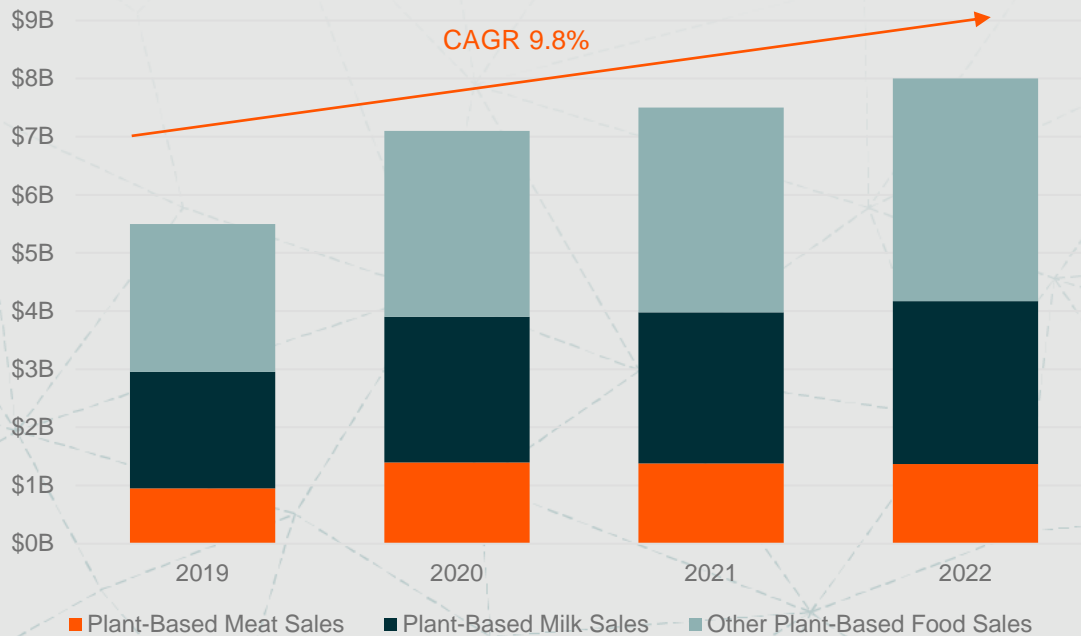
Peter McGuinness

Plant-based foods are becoming more accessible and affordable as companies diversify and scale products. They have a growing opportunity to capture greater market share in segments like the \$1 trillion+ global meat industry.

Plant-Based Milks and Meat Are Top Sales Categories in the U.S.

Plant-Based Meat Sales Remain Promising Amid Headwinds

Total U.S. Plant-Based Foods Market



17.5%

U.S. household penetration rate of plant-based meat products in 2022.

62.5%

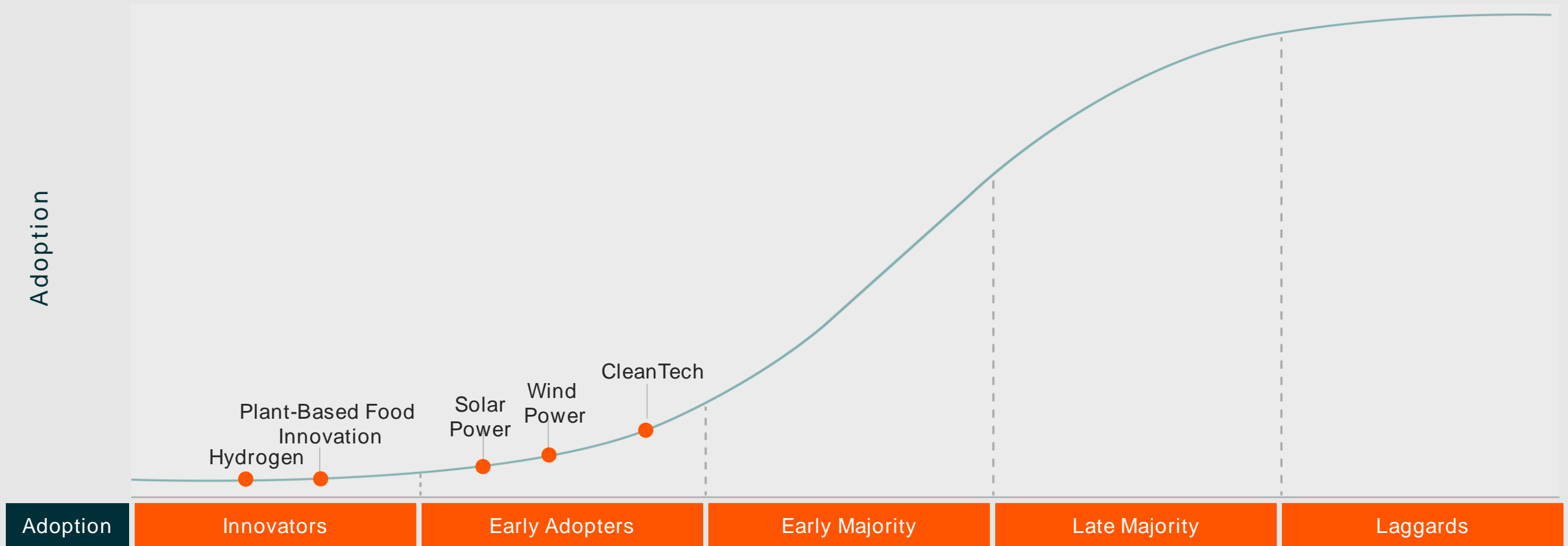
repeat purchasing rate of U.S. plant-based meat consumers in 2022.

- Plant-based meats have been around for less than a decade. While U.S. household awareness of plant-based meats is low at under 20%, the segment is in a hyper growth stage, and the repeat purchasing rate is highly positive. These dynamics give Impossible Foods and other companies in the industry significant room for growth.
- Continuous product innovation, education, and consumer adoption could lead plant-based meats to follow a similar market-share trajectory as plant-based milks. Today, plant-based milks account for 15% of total U.S. milk sales.
- Global sales of plant-based meats increased 8% YoY to \$6.1 billion in 2022, despite inflation leading to higher food prices and more price-conscious consumer spending habits in key markets, such as the United States.

Source: Text and Charts: Plant-Based Foods Association, 2023.

CleanTech & Beyond: S-Shaped Curve of Adoption

Technologies such as renewable energy are essential for mitigating climate change. Through 2050, an estimated \$150 trillion in CleanTech investments is needed to limit warming to 1.5°C.¹



Note: For illustrative purposes only.

Sources: Text: 1. IRENA, 2023

Paradigm-Shifting Technologies

Cloud Computing

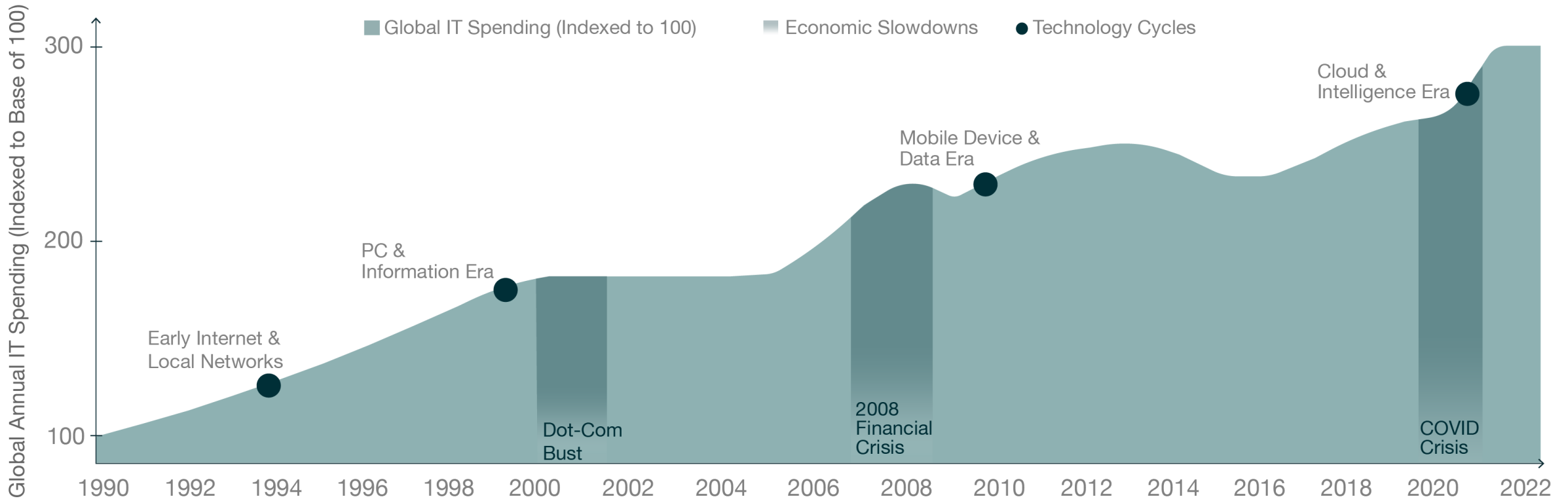
Navigating New Realms

Cloud computing is central to modern information technology (IT), and now the default way to build, deploy, and manage computing resources. In the last 24 months, IT's transition to the cloud entered an optimization phase as macroeconomic conditions shifted. However, we still expect the cloud market to grow through this decade, driven by the broad data explosion and the adoption of emerging technologies like artificial intelligence (AI). Cybersecurity challenges will also present opportunities for growth.



Emerging Platforms and Shifting Economic Conditions Spurred Computing's Evolution

Computing evolved through multiple cycles, going from a decentralized on-premise model to a much more efficient centralized hyperscale model over the past 30 years, driving a jump tripling IT spending.

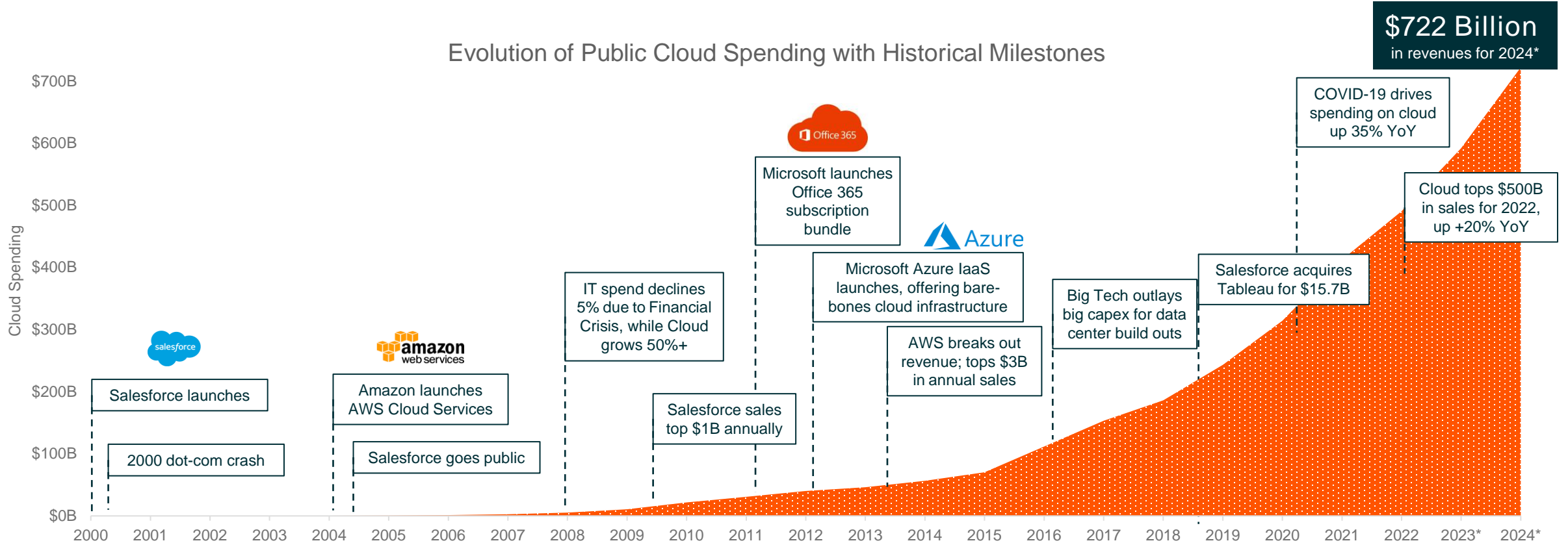


Sources: Gartner, 2022; Gartner, 2023; Weatherly Asset Management, 2022

Modern Computing Continues to Evolve with Cloud and Hyperscaling at Its Core

Cloud achieved parabolic scale due to the data explosion, need for ubiquitous access to information, and resultant productivity gains. Cloud revenue in 2025 could equal the cumulative revenue of the 20 years before COVID-19.

Evolution of Public Cloud Spending with Historical Milestones



* Forecast

Sources: Gartner, 2023; International Data Corporation (IDC), 2023; Weatherly Asset Management, 2022

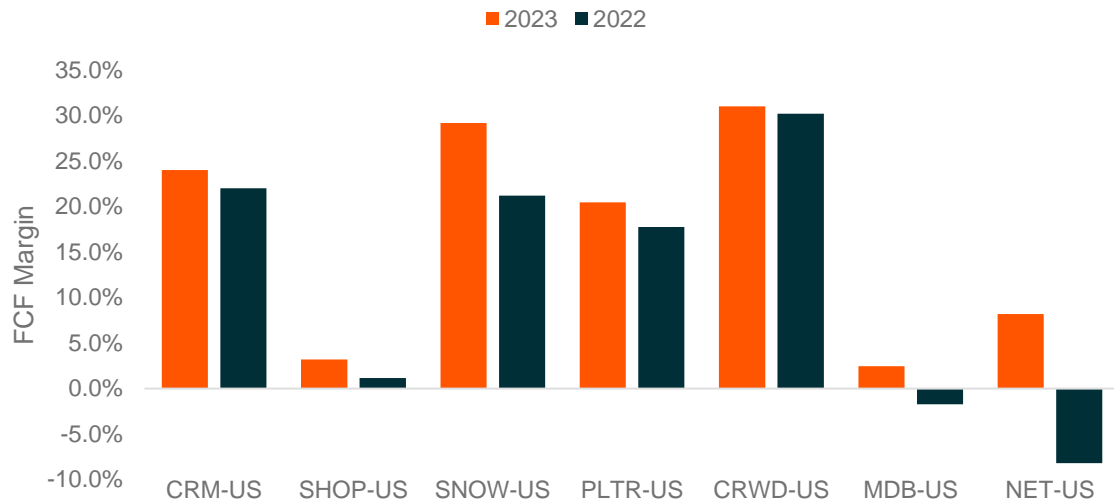
Cloud Computing Entered an Optimization Phase in 2022–2023

Rising interest rates and an IT slowdown forced cloud giants to be resourceful and improve fundamentals. Bottom-line efficiency achieved in the recent past will help deliver an outsized boost to profitability in 2024 and beyond.

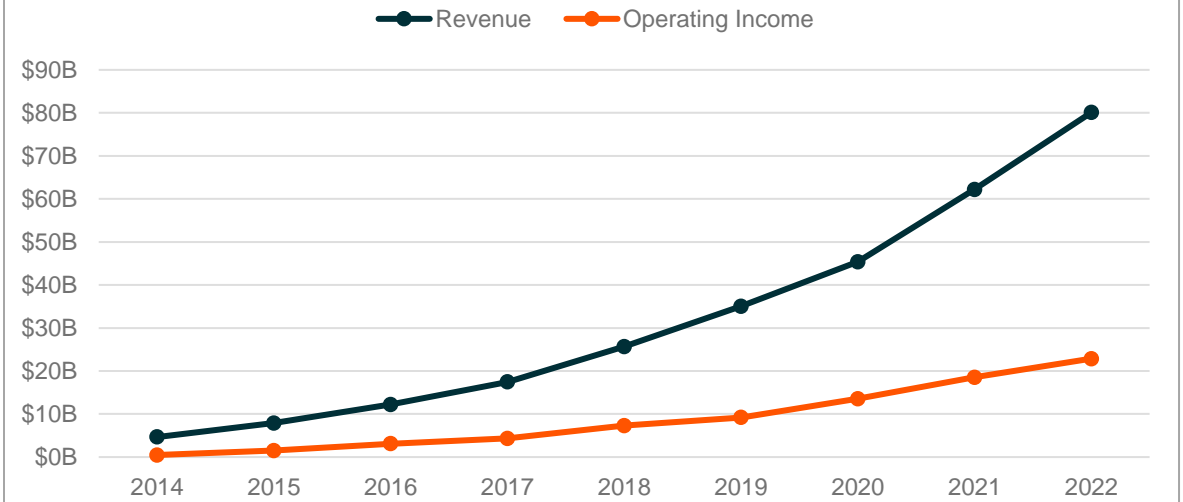
As cost of capital increased over the past 24 months, cloud computing companies focused on improving bottom-line performance. SaaS companies improved free cash flows (FCFs), with an average of 350bp improvement in the last 12 months.¹

Hyperscalers' margin structures indicate that the businesses can produce steady margins and profits at scale. Market leader Amazon Web Services totaled over \$80 billion in operating profits over the past 10 years.²

Top Public SaaS Companies Show FCF Improvements



Amazon Shows Consistency in Revenue and Profits



Note: Left Chart: 2023 = August 31, 2022 – August 31, 2023; 2022 = August 31, 2021 – August 31, 2022

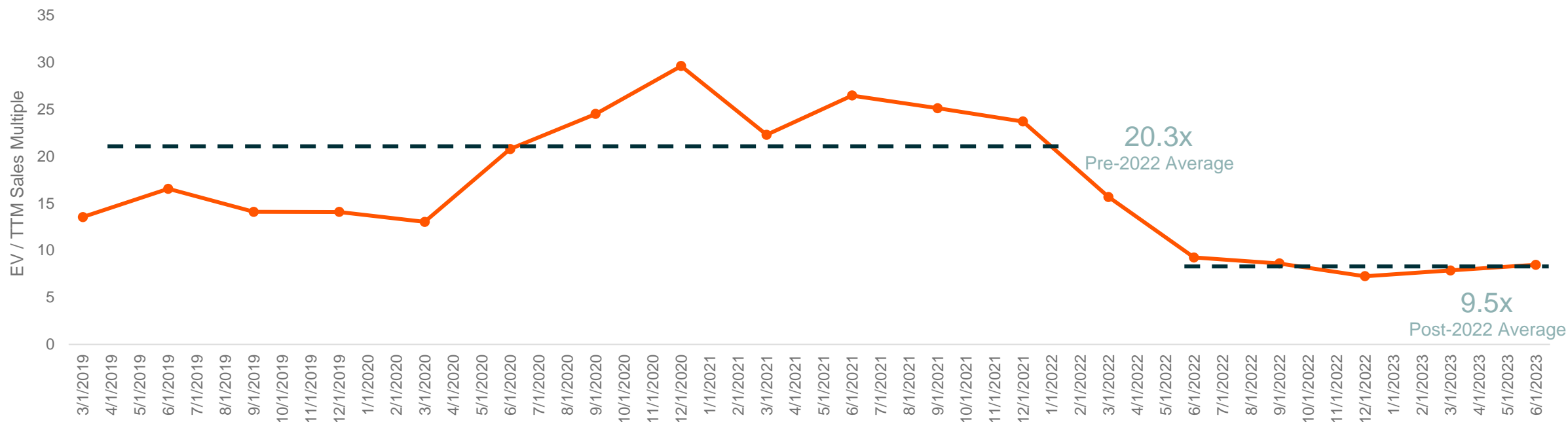
Sources: Text: 1. Factset Research Systems, n.d.; 2. Amazon Investor Relations, 2023; Charts: Left: FactSet Research Systems, 2023; Right: Amazon Investor Relations, 2023; FactSet Research Systems, 2023

Higher Interest Rates Pushed Cloud Computing Valuation Multiples to Historic Lows

Rising interest rates disfavored high-growth software stocks, despite cloud adoption humming along through 2022. Lower multiples present an interesting entry point, as fundamental improvements continue unabated.

Rising Rates Dropped Multiples for Cloud Computing Companies to Historic Lows, Despite Fundamental Improvements

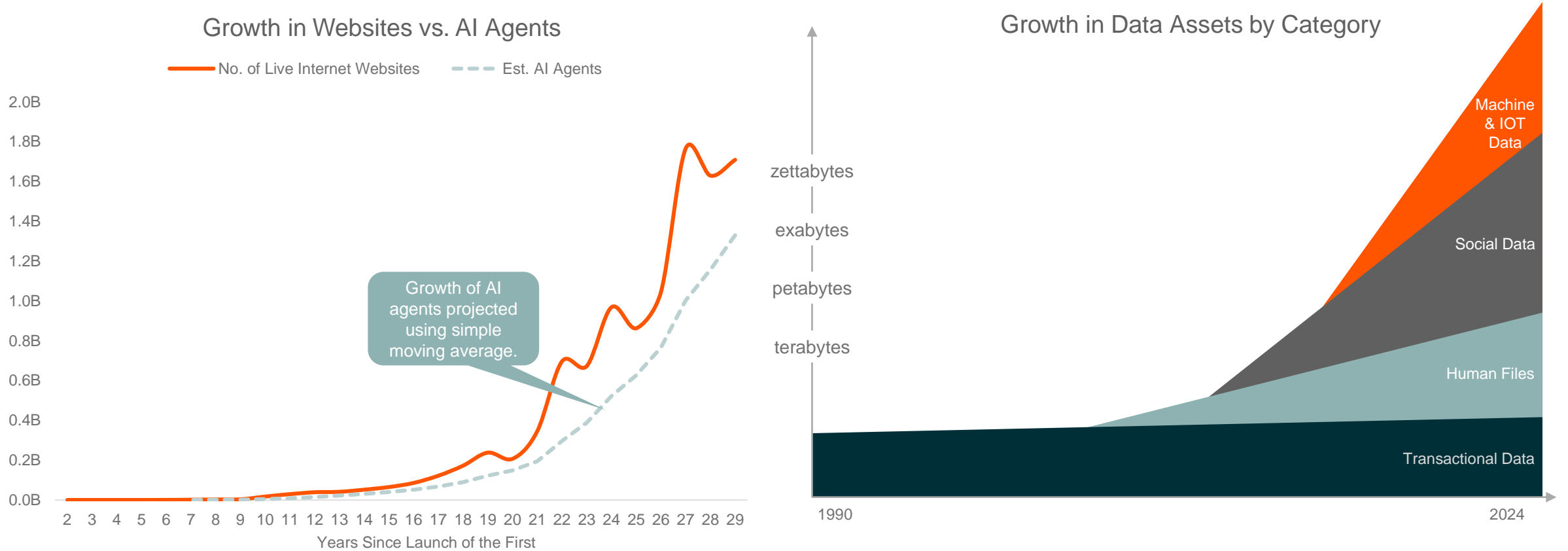
Enterprise Value (EV) to Trailing-Twelve-Months (TTM) Sales Ratio for Cloud Computing SaaS Stocks



Sources: Meritech Capital, n.d.

More Cloud Resources Needed as Data Continues to Explode

The proliferation of AI is likely to shift data creation dynamics, perhaps permanently. By 2030, AI could drive more than half of all online data creation.¹

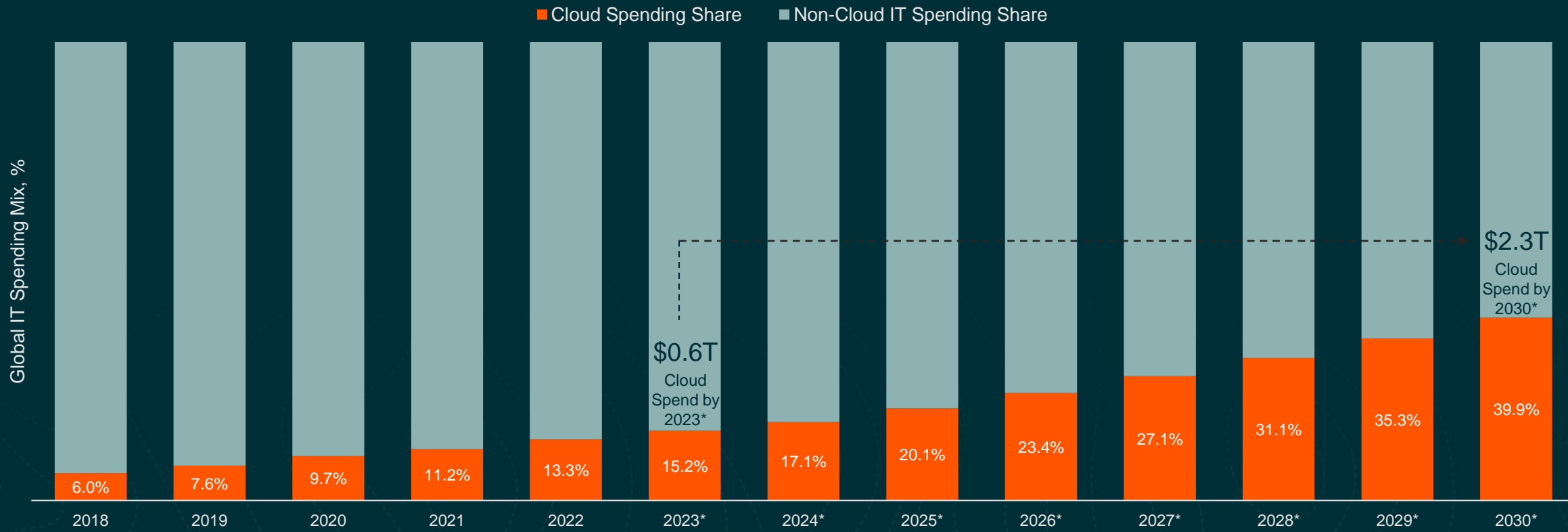


Note: For left chart, Est. AI Agents trajectory is projected using 5-year moving average.

Sources: Text: 1. Gartner, 2021; Charts: Left: Internet Live Stats, n.d.; Gartner, 2021; Right: Exploding Topics, 2023; TechJury, 2023

Investments in AI Primed to Accelerate On-Premise to Cloud Transition

In the current economic climate where cost savings are highly valued, the flexibility and turnkey nature of the cloud model is increasingly important. Spending on AI-related technology is likely to boost cloud's share of IT spend.



* Forecast

Sources: Gartner, 2022; Gartner, 2023

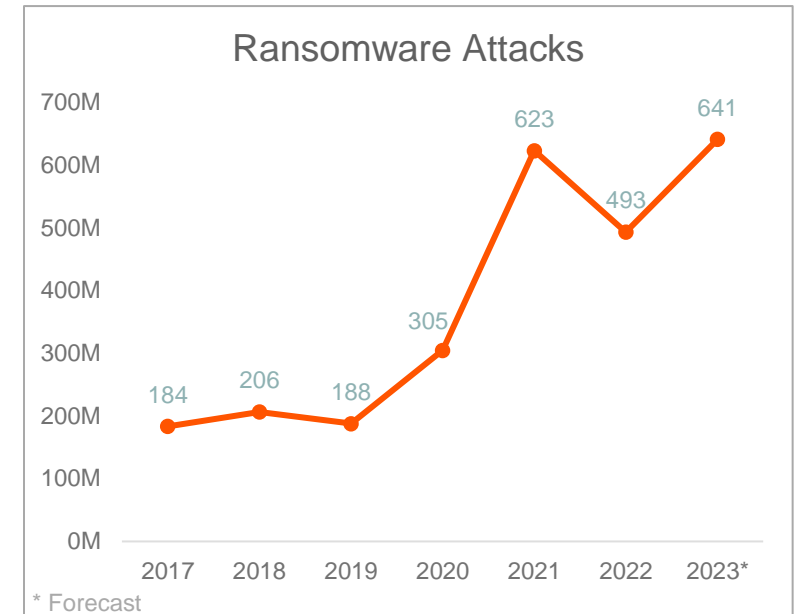
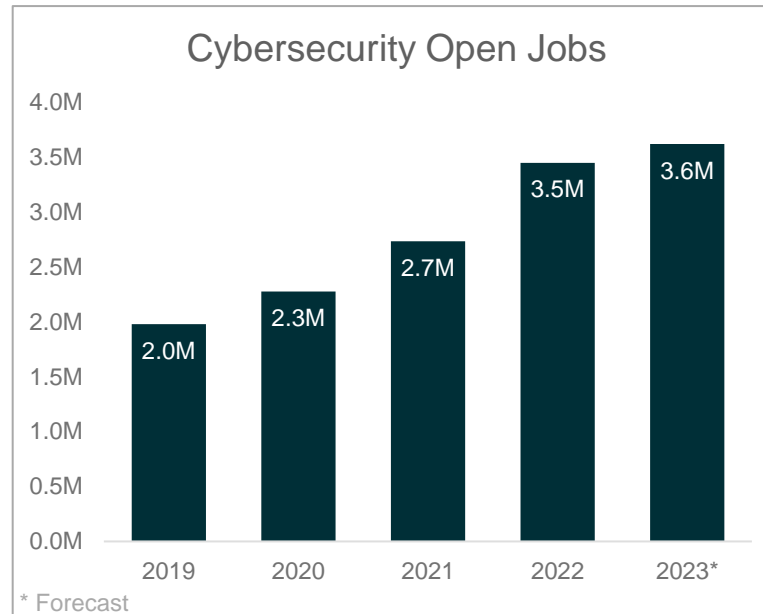
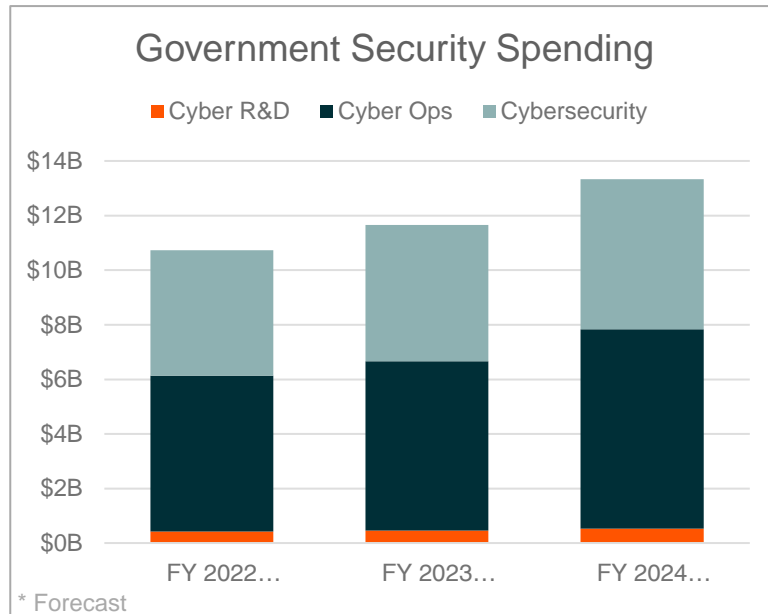
Mounting Cybersecurity Challenges Benefit Cloud-Native Solution Providers

Security teams continue to struggle with rising cyber threats and inefficient operations. Industry demands standardization, and spending on security software will continue to favor cloud-native solutions.

Government priority: Cybersecurity now attracts billions of dollars in spending at the national, state, and local levels. Stricter regulations is also a major focus.

Cyber skill gap: There are 3.6 million unfilled cybersecurity jobs worldwide.¹ This skill deficit affects incident response times and increases vulnerability.

Growing attacks: Ransomware attacks increased 37% in 2023.² Loosely digitized during the pandemic, healthcare and education institutions were primary targets.

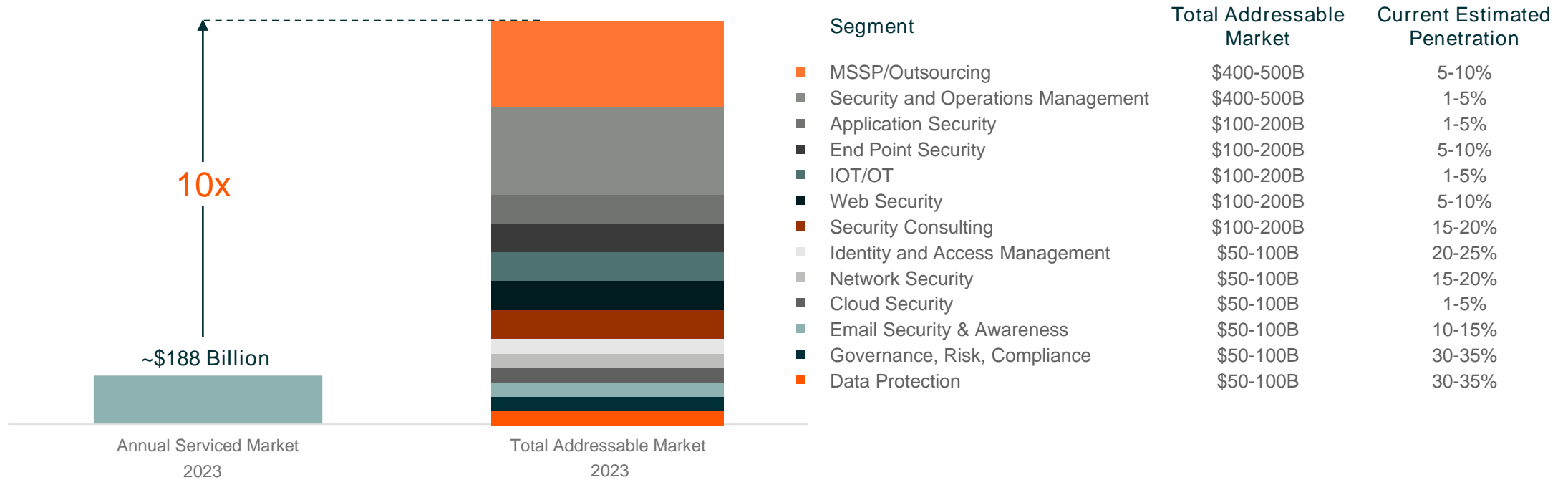


Sources: Text: 1. Cybersecurity Ventures, 2023; 2. Zscaler, Threatlabz Industry Report on Ransomware, 2023; Charts: Left: Security Intelligence, 2023; Middle: Cybersecurity Ventures, 2023; Left: Zscaler, 2023

Industry Fragmentation Favors Cloud-Native Solutions and Large Security Vendors

Cybersecurity markets display extreme fragmentation with nearly 50% of all security spending going to custom and inefficient security services.¹ This dynamic creates opportunities for leading cloud platforms.

Cybersecurity Total Addressable Market Projected to Be Nearly 10x the Total Current Spending on Cybersecurity Solutions

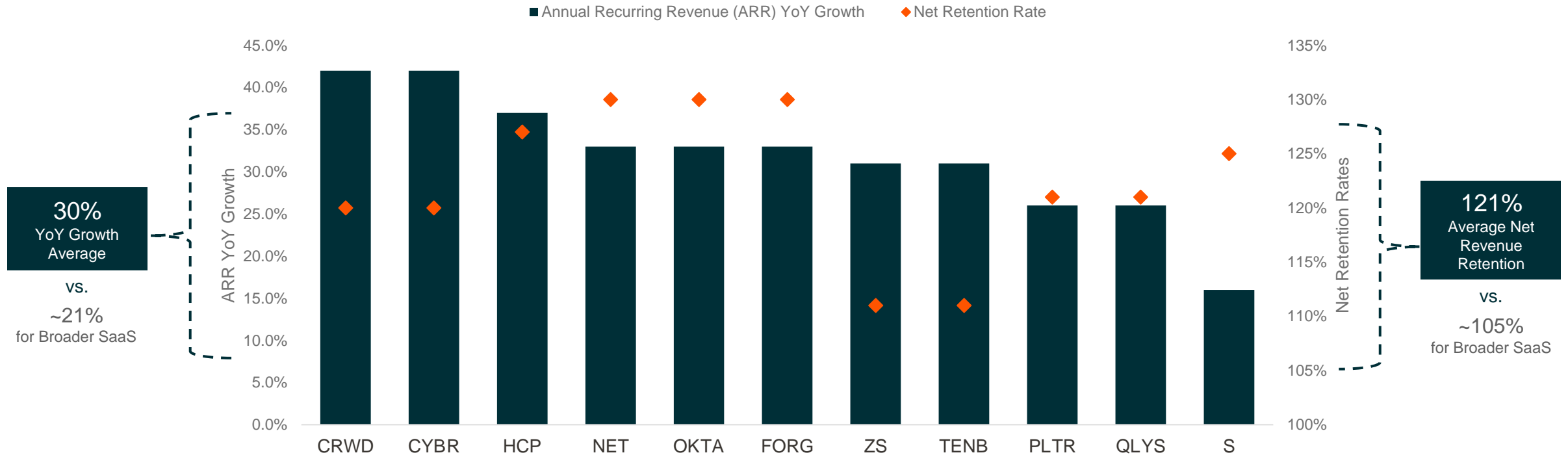


Source: Text: 1. Mckinsey Research, 2022; Charts: Mckinsey Research, 2022

Cybersecurity Is Stickier and Offers a Better Growth Profile Than Broader Cloud Software

The critical nature of software coupled with consumption-based business models results in strong recurring growth for cybersecurity companies, beating broader cloud software standards.

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



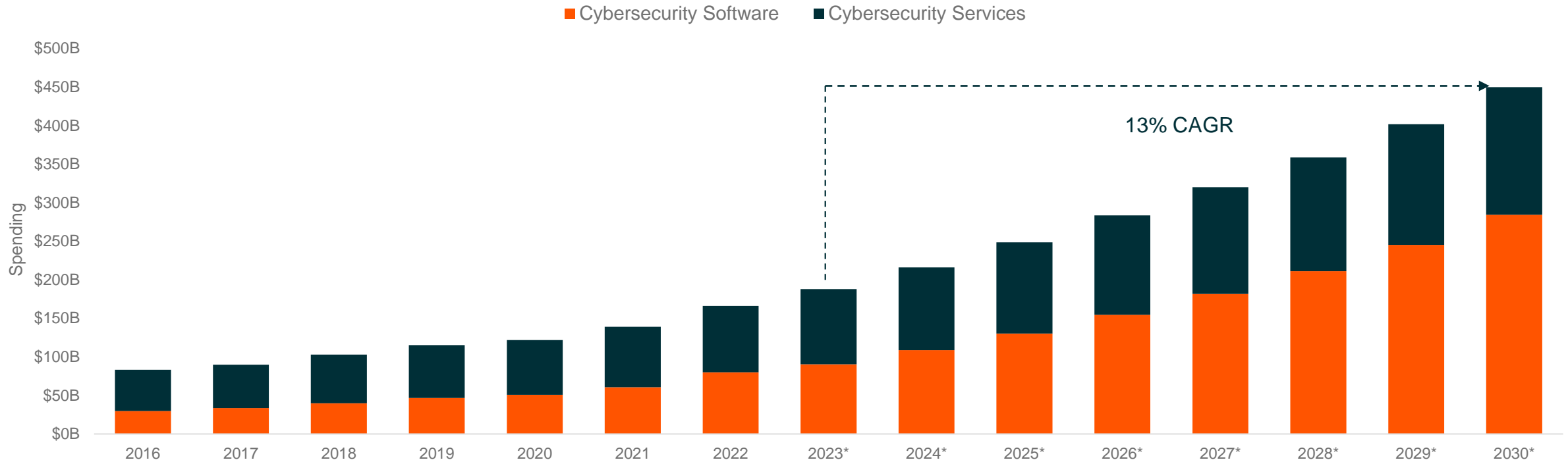
Note: Broader SaaS indicates non-security cloud companies in Meritech Capital Cloud Applications Database. CRWD = CrowdStrike, CYBR = CyberArk, HCP = Hashi Corp, FORG = ForgeRock, NET = Cloudflare, OKTA = Okta, ZS = Scaler, TENB = Tenable Holdings, PLTR = Palantir, QLYS = Qualys, S = Sentinel One.

Sources: Meritech Capital, n.d.

Software Solutions Forecast to Help Cybersecurity Spending Grow 2.5x to \$450 Billion by 2030¹

Cloud-native security solutions allow a broad range of enterprises to phase out custom security solutions and adopt best-of-breed software.

Cloud Software Spending for Cybersecurity Expected to Outpace Spending for Security Services

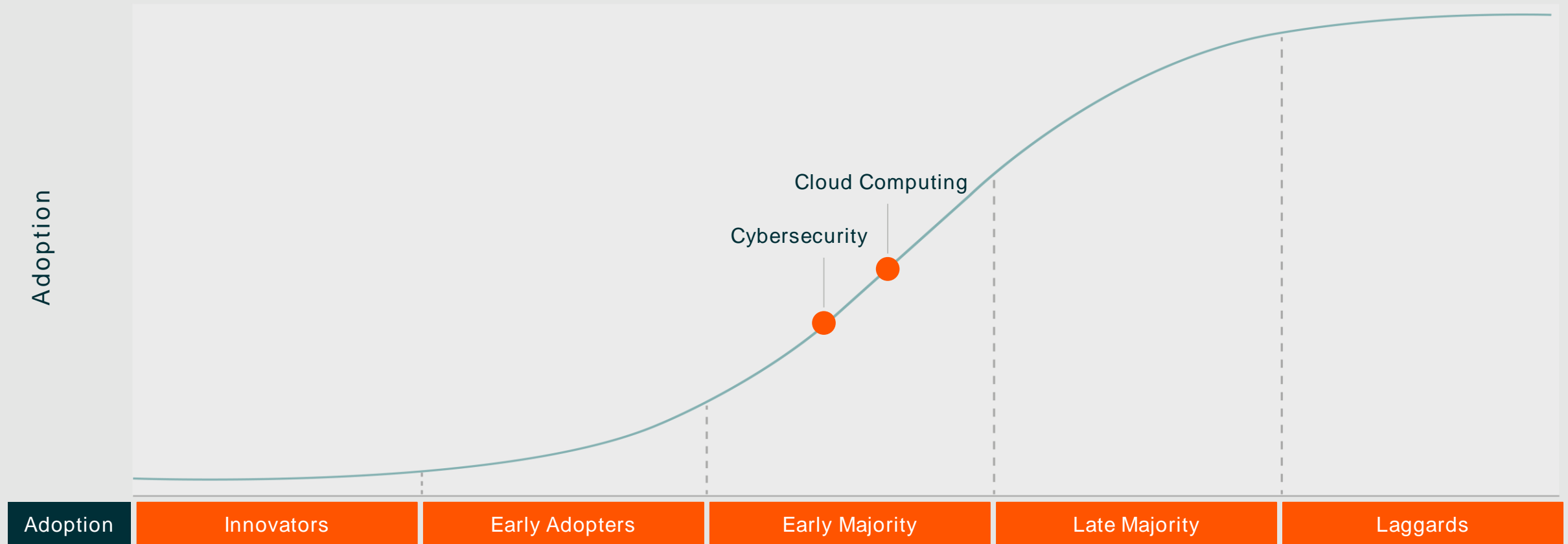


* Forecast

Source: Text: 1. Global X Estimate with data from Gartner 2023, Gartner Forecasts Global Security and Risk Management Spending to Grow 14% in 2024; 2. Gartner, 2022; Chart Source: Gartner, (2023, Sep 28). Gartner Forecasts Global Security and Risk Management Spending to Grow 14% in 2024

Cloud Computing: S-Shaped Curve of Adoption

Cloud computing is expected to generate revenues of \$600 billion in 2023, up 21% YoY.¹



Note: For illustrative purposes only.

Sources: Text: 1 Gartner, 2023

Medical Breakthroughs

Digitizing Medicine

AI, Surgical Robots & More

The only thing more complex than human biology may be the systems used to facilitate patient care. Friction and inefficiencies abound. Against this backdrop, digital health is primed as a solution. By leveraging digital health technologies, such as artificial intelligence (AI) and wearable sensors, we expect improved patient outcomes and greater access to life-saving genomic treatments. With healthcare spending now an estimated 11% of global GDP, we believe there are considerable opportunities in the digital health space to render longstanding inefficiencies in healthcare a thing of the past.¹

Sources: Text: 1. World Health Organization (WHO), 2022



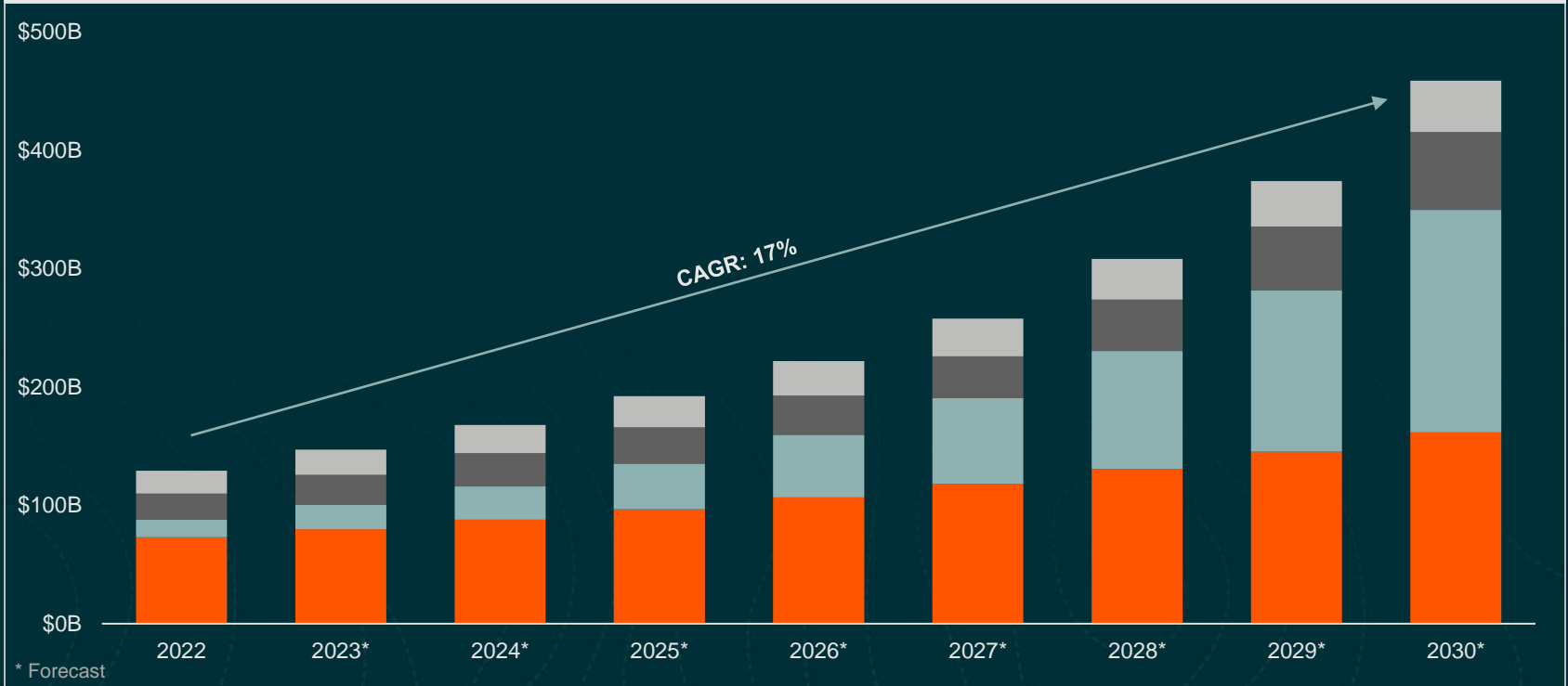
Digital Health: Growing Market Driven by Inefficiencies in Patient Care

The digital health market is still in its infancy, and we expect continued industry consolidation as well as interoperability of digital health segments to help increase ease of use and accelerate patient and physician adoption.

A New Technological Toolkit

- **Administrative Digitization:** Software to streamline and automate medical processes. 10% CAGR
- **Healthcare Analytics:** Platforms for statistical and computational analysis of medical data. 37% CAGR
- **Telemedicine:** Healthcare that remotely connects patients with medical professionals. 15% CAGR
- **Wearable Sensors:** Devices that automatically transmit data to patients and their physicians. 11% CAGR

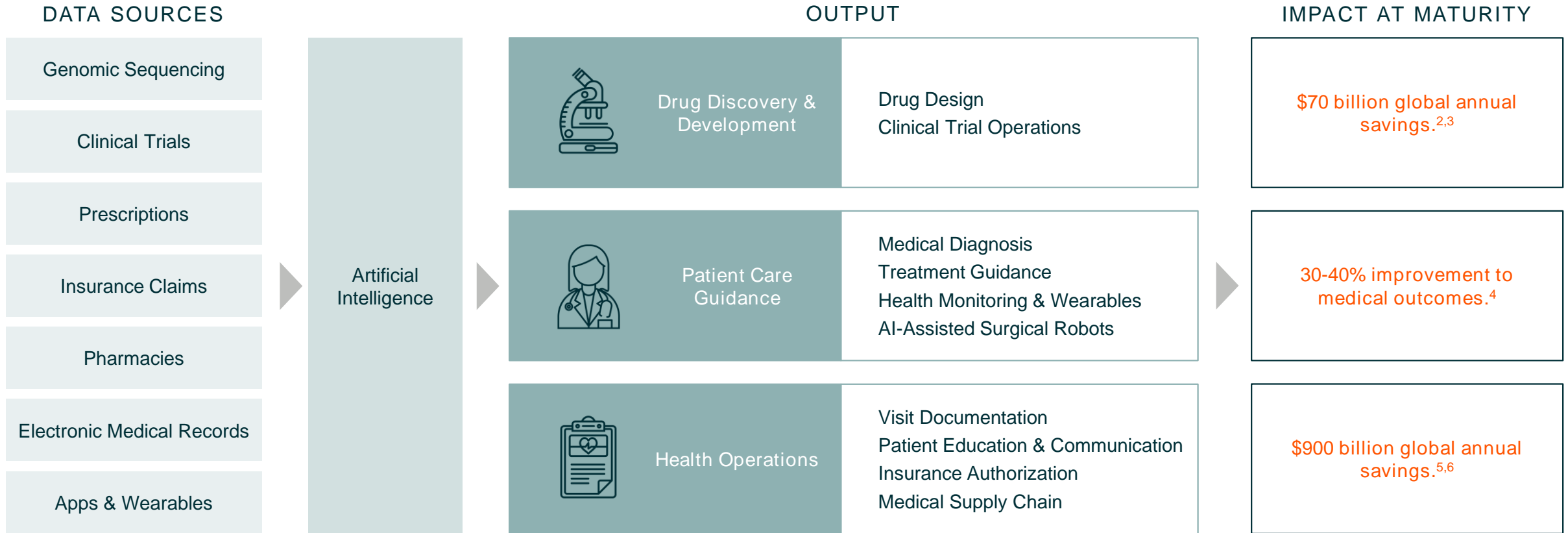
Digital Health Market Opportunity: Ample Room to Grow



Sources: Data Bridge Market Research, 2023; Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Insight Partners, 2023; Precedence Research, 2022-Aug; Precedence Research, 2022-Oct; Precedence Research, 2023; Statista Market Insights, 2023

AI in Healthcare Promises to Enhance the Industry's Reach

AI has the potential to save the United States as much as 10% of annual healthcare spending.¹






Sources: Text: 1. National Bureau of Economic Research, 2023; 2. Evaluate Pharma, 2022; 3. Morgan Stanley, 2022; 4. Frost & Sullivan, 2016; 5. National Bureau of Economic Research, 2023; 6. WHO, n.d.




AI in Healthcare Operations: The Missing Link to Transformative Digitization

Healthcare has made great strides in digitizing operations, but it lacks automation. AI can streamline processes, like data input, into electronic databases and help the industry glean more insights from the data it generates.

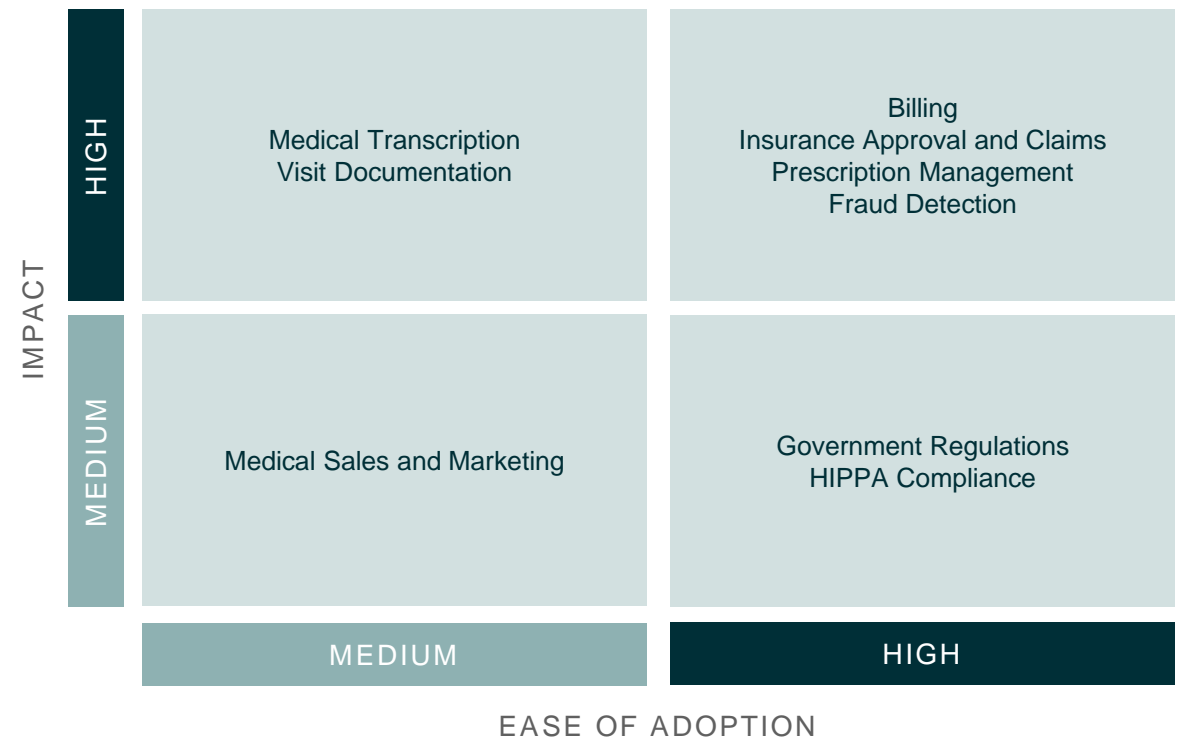
Healthcare Needs Automation

-  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.
-  A recent study revealed that doctors spend 73% of their time on administrative tasks and only 27% of their time actually with patients.²
-  Unsurprisingly, 78% of physicians report burnout and fatigue related to health IT systems.³

AI Brings Cost Savings Potential to the Healthcare Ecosystem

-  Private insurance firms could save 7–9% of costs, resulting in \$80–110 billion annual savings.⁴
-  Physician groups could save 3–8% of costs, resulting in \$20–60 billion savings.⁵
-  Hospitals could save 4–11% of costs, resulting in \$60–120 billion annual savings.⁶

AI Implementation in Healthcare Operations

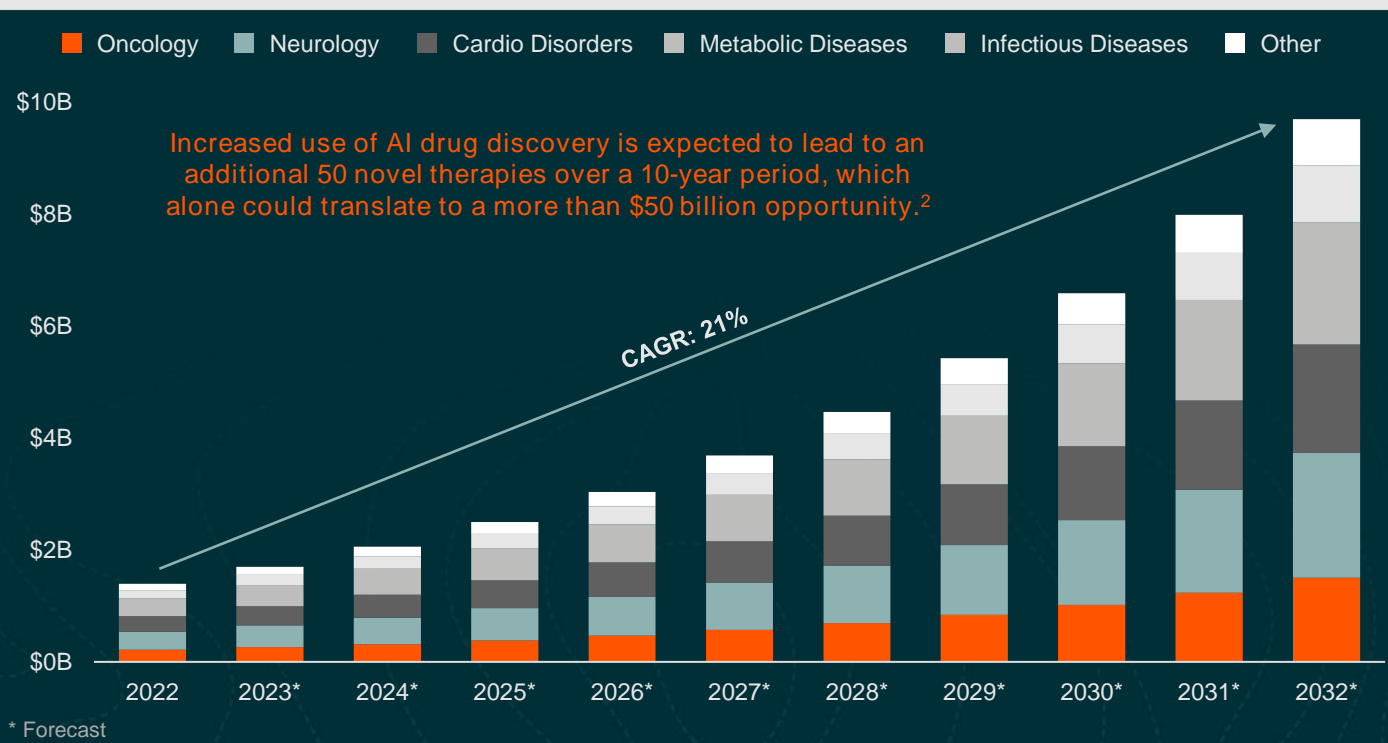


Sources: Text: 1. Doximity, 2023; 2. Gist Healthcare, 2018; 3. Doximity, 2023; 4. National Bureau of Economic Research, 2023; 5. Ibid; 6. Ibid.

AI in Drug Discovery: Supercharging Decades of Computer-Aided Drug Design

Computer simulation software has been used to develop investigational drugs since the 1990s.¹ Today's AI-enabled models propose a new standard for drug discovery that offers improved drug efficacy and decreased costs.

AI Drug Discovery Software Market: The Tip of the Iceberg






AI Improves Unit Economics for Drug Development

Despite technological advancements, developing a new medicine still takes 10–15 years and cost an average of \$1.3 billion.^{3, 4} Complicating matters, 90% of investigational drugs fail when tested in humans due to having no effect or too many side effects.⁵

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.^{6, 7}

Benefits to AI-Enabled Drug Discovery

-  Better Molecule Construction: AI software predicts the 3D structure of target proteins, drug-protein interactions, and activity in new therapies.
-  Maximized Investigational Efforts: AI software helps design multi-target drug molecules and predict drug repurposing to maximize a treatment's reach.
-  Enhanced Patient Identification: AI software predicts toxicity and efficacy of the treatment via genomic profiling.

Sources: Text: 1. National Institute of Health 2009; 2. Morgan Stanley, 2022; 3. PhRMA 2021; 4. Journal of the American Medical Association, 2020; 5. National Institute of Health, 2019; 6. Morgan Stanley, 2022; 7. Margaretta Colangelo, 2019; Chart: Grand View Research, 2022; Precedence Research, 2022

AI in Drug Development: Modernizing In-Human Clinical Trials

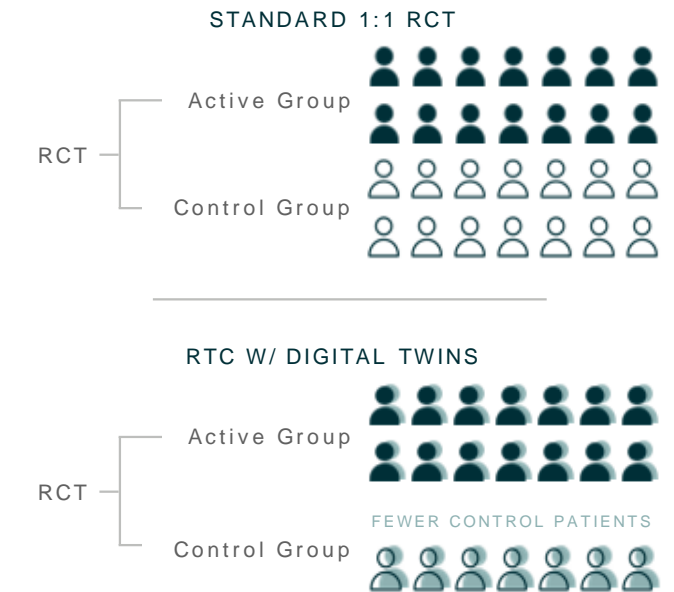
Clinical trials are notoriously difficult to design and operate. AI offers a scalable solution for some of the biggest stumbling blocks in the drug development process while reducing operating costs.

Where Current Trial Protocols Go Wrong and How AI Can Help

	Impact	AI's Solution
Poor Design	The causes of a negative trial outcome can be difficult to discern. Unknown flaws in trial design or trial execution can mask the true efficacy of a drug and next steps for researchers.	AI can identify patterns that humans can't, helping determine if, for example, a drug is only a good fit for a specific subset of patients. Digital twins can also help identify potential flaws in a trial's design.
Ineffective Recruitment	An estimated 86% of trials miss their enrollment deadlines, due in part to 85% of patients being unaware that they could participate. ¹ Nearly a third of phase III trials fail due to enrollment difficulties. ²	AI can proactively identify patients best suited for clinical trials, while digital twins can simulate dosing regimens and patient progressions, reducing the number of participating patients.
Insufficient Data	A rubric is used to evaluate drug efficacy, but many trials rely on surrogate endpoints, including most cancer trials. ³ In these cases, the trial measures drug effectiveness by using a specific data point that might result in clinical improvement, though does not guarantee it.	AI-powered wearables can help measure drug efficacy and monitor patients during clinical trials. Increased integration with electronic patient-recorded data and telemedicine are expected to make AI models more powerful.

The Digital Twin Advantage

Researchers can monitor patients in real-time while simulating clinical outcomes in a randomized clinical trials (RCT).



Sources: Text: 1. Clinpal, n.d.; 2. Ibid; 3. Clinical Trials Arena, 2021

Surgical Robots: Harnessing Innovative Hardware and Applying AI to Improve Patient Outcomes

Robot-assisted surgeries have a growing track record of success with patients. Key benefits include shorter hospital stays, smaller surgical scars, lower risk of infection, and less pain during recovery.¹

Surgical Robots: Ripe for Growth as Adoption Spikes

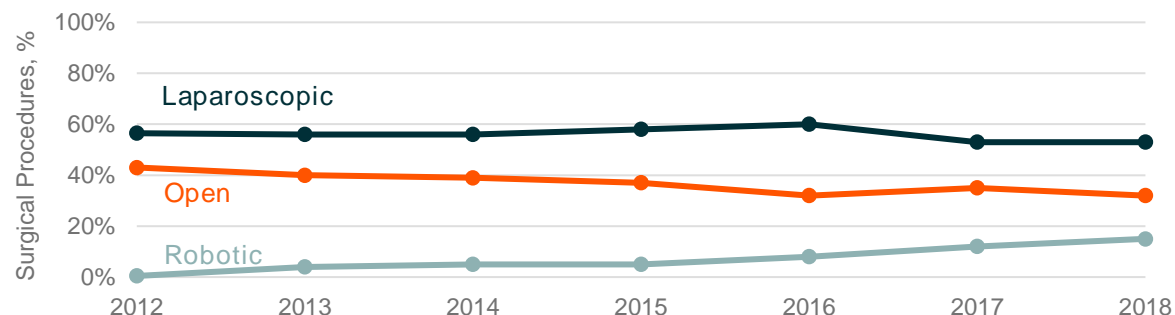


< 5% of Surgeries Are Robot-Assisted – That’s Changing²

- Surgical robots have been around for over 20 years, but with new technology they now help with more complex surgeries, including general, orthopedic, and spinal procedures.
- An estimated 78% of U.S. surgeons are interested in embracing surgical robots due to their improved capabilities.³
- New sales models, such as equipment leasing contracts, are expected to help accelerate adoption and stabilize revenue for robotic surgery firms.

Case Study: Surgical Robot Adoption Trends

A hospital study shows less-invasive procedures rise following surgical robot purchase.



Sources: Text: 1. Cleveland Clinic, n.d.; 2. Medtronic, 2023; 3. Bain & Company, 2023. Charts: Left: Markets and Markets, 2023; Right: Journal of the American Medical Association, 2020

Surgical Robots: An Evolving Category with a Growing Product Lineup

We expect firms to focus on adapting their existing robotic software and hardware to service a greater proportion of procedures in the general surgery category rather than develop vertical-specific robots.

	General Surgery	Orthopedic Surgery	Spinal Surgery	Lung Biopsy
Intuitive Surgical	da Vinci			Ion
Asensus Surgical	Senhance			
Medtronic	Hugo*		Mazor	
Johnson & Johnson	Ottava	Velys		Monarch
Stryker		Mako		
Zimmer Biomet		Rosa		
Globus Medical			ExcelsiusGPS	
Vicarious Surgical	Beta 2			

Notes: Medtronic's Hugo is commercially available in Europe, Canada, and Japan. A Launch in the United States is expected in 2024.¹ Legend: Commercially Available, In Development

General surgery is the most mature category, with Intuitive Surgical a leading player. **Over 13 million procedures have been performed with Intuitive's da Vinci platform**, which has over 8,000 placements globally.² Launches in the next few years from Medtronic and Johnson & Johnson, as well as a next-generation da Vinci platform, are expected to increase robotic surgery adoption.³ Newer entrants, like Vicarious Surgical, want to raise the bar via augmented intelligence and more cost-effective manufacturing, which could lead to platforms with **capital costs 5–10 times lower** than existing robots.⁴

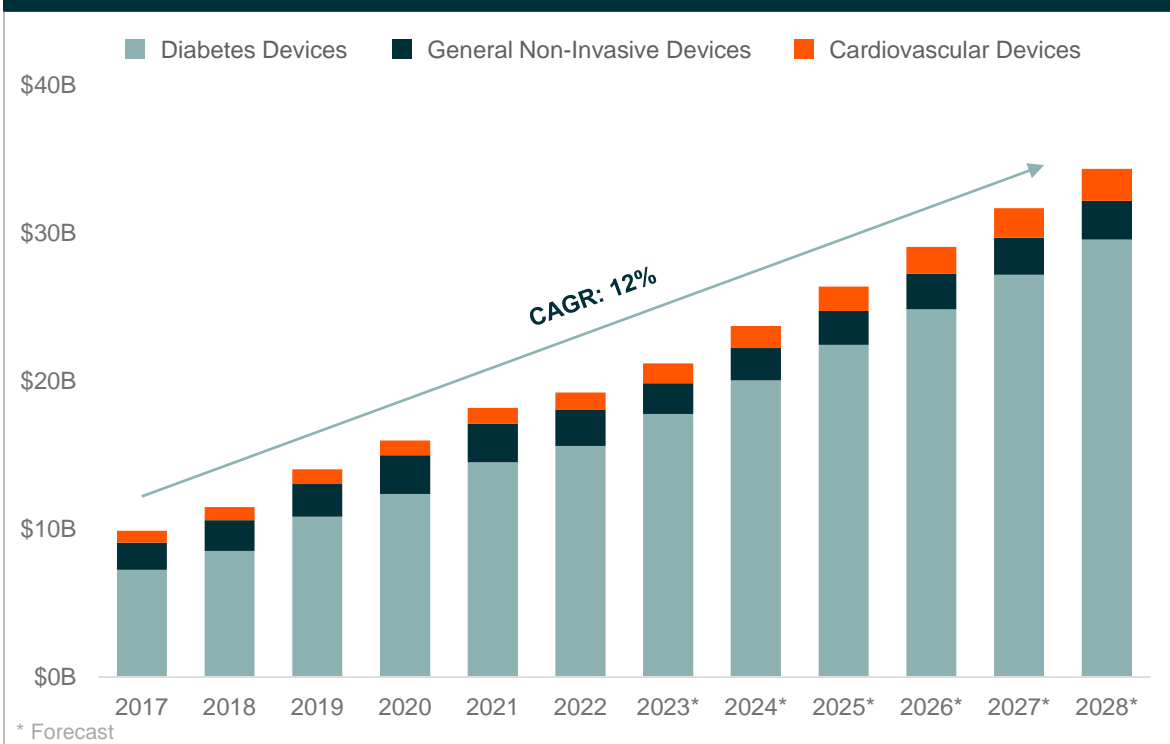
Recent developments in lung biopsy also point to increased conversion between diagnostic and surgical intervention, helping to engrain surgical robotics across the healthcare continuum.

Sources: Text: 1. Fierce Biotech, 2022; 2. Intuitive Surgical, 2023; 3. Intuitive Surgical, 2023; 4. Medtech Drive, 2021; Chart: Intuitive Surgical, 2023; Asensus Surgical, n.d.; Medtronic, n.d.a.; Medtronic, n.d.b.; Johnson & Johnson, n.d.; Stryker, n.d.; Zimmer Biomet, n.d.; Globus Medical, n.d.; Vicarious Surgical, 2022

Wearable Technology: Diabetes Devices Created the Blueprint for Other Health Categories

Given significant success in diabetic monitoring, the wearables industry now looks to bring this type of technology to other health categories, notably cardiovascular care.

Monitoring Wearable Devices: Only Getting Started



Cardiovascular Monitoring: Growing Patient Demand

Innovation in cardiovascular diagnosis and monitoring has accelerated in recent years given the large patient population. Nearly half of U.S. adults, for example, have some type of cardiovascular disease.¹ To address this population, new devices have come to market for:

- **Arrhythmia Diagnosis and Monitoring**
 - An estimated 11 million individuals in the United States have arrhythmias, and an average of 160,000 deaths each year are associated with atrial fibrillation (Afib).²
 - Wearables like iRhythm Technologies' ZIO can detect 99% of arrhythmias via small, patches.³ Incumbent devices only detect 47% of arrhythmias, on average.⁴
- **Blood Pressure Monitoring**
 - In the United States, approximately 120 million individuals have hypertension, yet only 1 in 4 adults with high blood pressure have their condition under control.⁵ Caring for patients with hypertension costs the United States about \$131 billion each year.⁶
 - Continuous blood pressure (BP) monitors can measure BP levels as often as every 15 minutes, providing vital information for physicians to develop treatment plans.

As the cardiovascular device segment continues to mature, we expect increased consolidation of monitoring capabilities in a single device, which should help accelerate adoption and drive reimbursement coverage.

Sources: Text: 1. American Heart Association, 2019; 2. iRhythm Technologies, 2023; 3. American Journal of Cardiology, 2013.; 4. Ibid; 5. Centers for Disease Control and Prevention, 2023; 6. Ibid. Chart: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c

Wearable Technology: Neurology Devices Are the Next Frontier

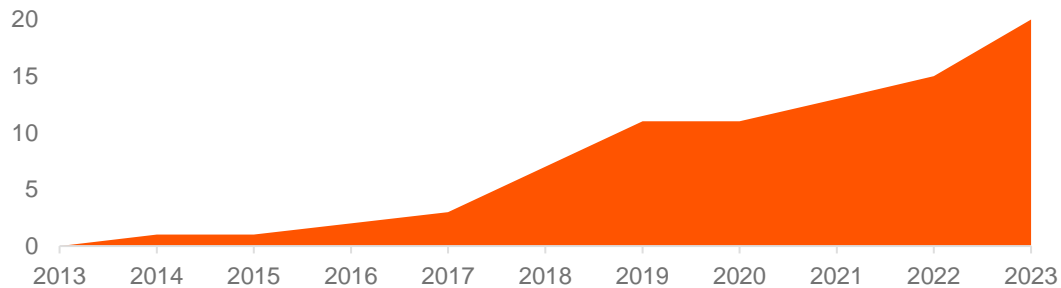
Leveraging adoption of diabetes and cardiovascular devices, we expect neurological wearables to drive the next wave of technological innovation in the healthcare industry.

Wearable Technology Bridges Gaps in Current Neurological Care

Neurological disorders are notoriously difficult to diagnose, monitor, and treat. Wearable sensors can have broad reaching potential across many conditions.

- **Sleep:** Wearable sleep trackers can help diagnose and monitor sleep disorders, like sleep apnea and insomnia, in the comfort of a patient’s home.
- **Head Trauma:** Sensors can detect impacts and measure the force and direction of injuries, helping determine severity of the trauma and inform patient care.
- **Epilepsy:** Monitors can help identify seizure triggers, track the effectiveness of medication, as well as warn patients and loved ones of impending seizures.

Cumulative FDA Approvals of Neurology AI-Enabled Devices



Note: 2023 Approvals as of October 19, 2023.

Sources: Charts Left: Food and Drug Administration, 2022; Right: De, 2023

Wearables Particularly Useful for Age-Related Diseases

We view self-sustaining monitoring and therapeutic systems as the future of patient care, though it is particularly beneficial for elderly patients. In a recent Global X ETFs survey, we found that individuals are even more likely to encourage elderly loved ones to utilize wearable technology where available.

Would you utilize a wearable sensor for a chronic illness, if appropriate?



% of Respondents

Would you encourage an elderly loved one to utilize a wearable sensor that could automatically transmit health vitals to their physician and alert emergency services, if needed?

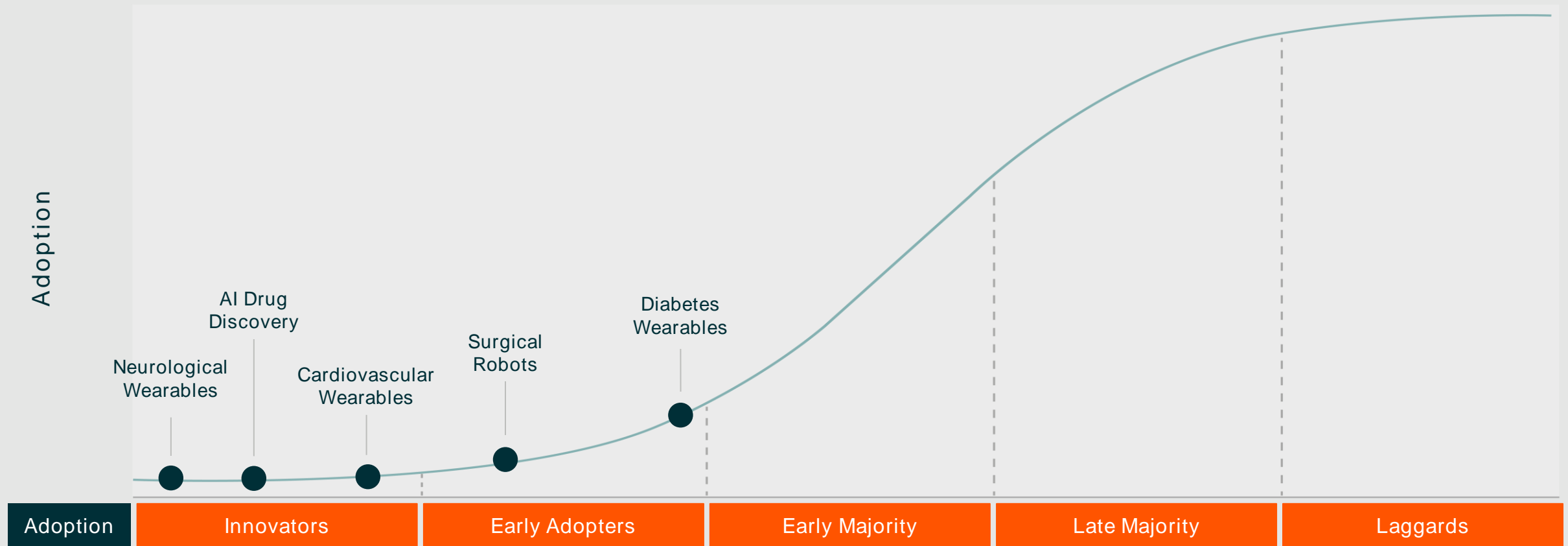


% of Respondents

Note: Number of respondents = 1,032.

Digitizing Medicine: S-Shaped Adoption Curve

We expect the digital health industry to reach \$459 billion by 2030, representing 17% compound annual growth.¹



Note: For illustrative purposes only.

Sources: Text: 1, Data Bridge Market Research, 2023; Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Insight Partners, 2023; Precedence Research, 2022-Aug; Precedence Research, 2022-Oct; Precedence Research, 2023; Statista Market Insights, 2023

Medical Breakthroughs

Therapeutics



Shaping Personalized Medicine

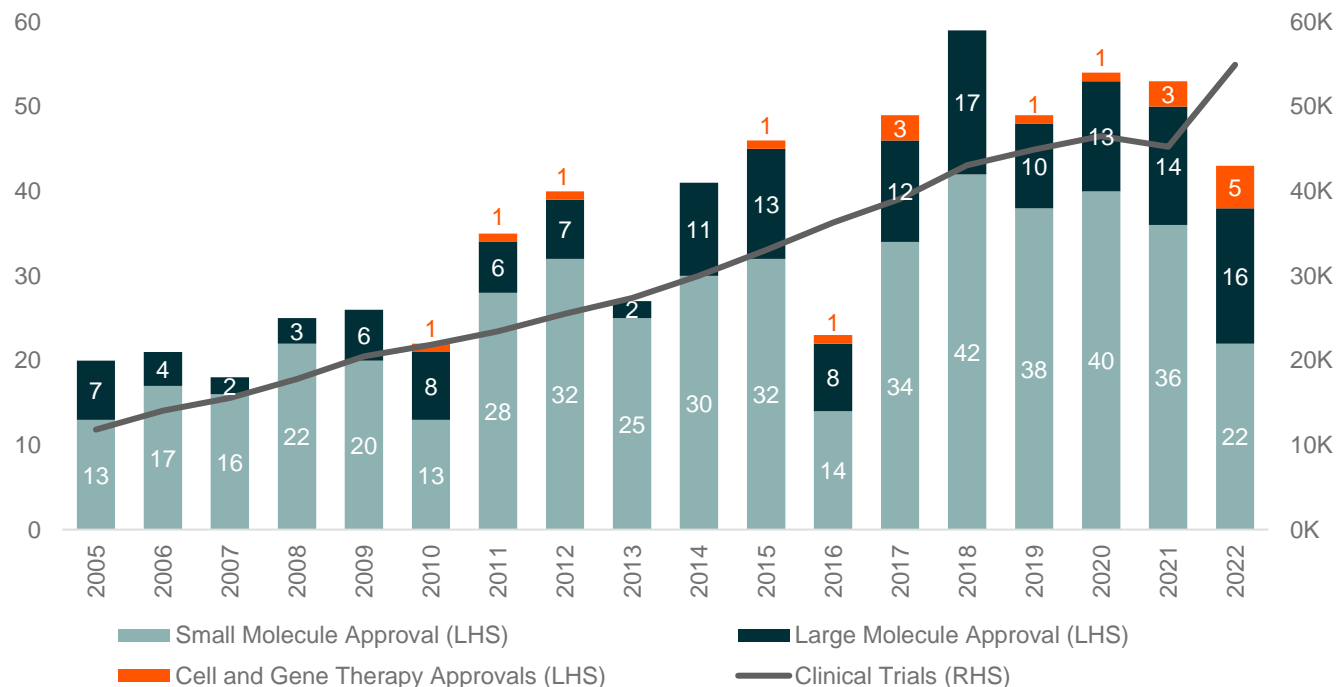
Genomic technologies have opened the door for a new era of drug discovery. Such advancements are revolutionizing disease management and illness prevention, resulting in superior patient outcomes. Newer genomic treatments, like gene therapies and genomic editing, offer near-cures for highly cumbersome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



Therapeutic Development: A New Era of Drug Discovery Is Underway

Validation and adoption of genomic technologies have accelerated development of highly targeted treatments and regulatory approvals. New drug categories, such as cell and gene therapies, seek to further improve drug efficacy.

Increasingly Complex Treatments Offer New Efficacy Standards



Small Molecule Drugs consist of small, simple chemical structures and are usually administered orally.



Large Molecule Drugs (aka Biologics) are made from living cells, tissues, and viruses. They are administered via injections or infusions.



Cell and Gene Therapies rely on living cells and genetic alterations to repair, replace, or restore damaged tissue and treat illnesses. This is a relatively new treatment category and is traditionally administered via infusions.

Historically, the medical community has been limited in how it can address diseases. With an increased understanding of illnesses and new therapeutic technologies, the medical community now has additional opportunities for improved treatments across virtually all disease categories.

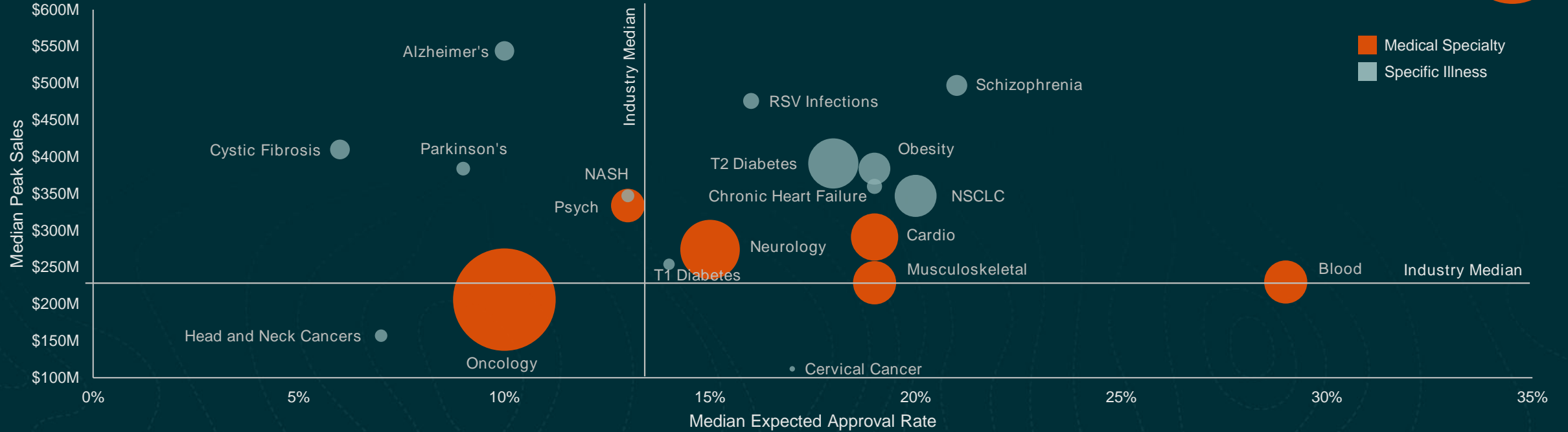
Sources: Food and Drug Administration, n.d.a; Food and Drug Administration, n.d.b; World Health Organization, 2023

Therapeutic Innovation Evident Across a Wide Spectrum of Illnesses

The prioritization of therapeutic development is influenced by unmet medical need, size of the patient population affected, historical success in treating the illness, and the competitive landscape.

Higher Risk, Higher Return	Lower Risk, Higher Return
Higher Risk, Lower Return	Lower Risk, Lower Return

Size of Bubble: Market size, based on estimated worldwide 2028 sales.

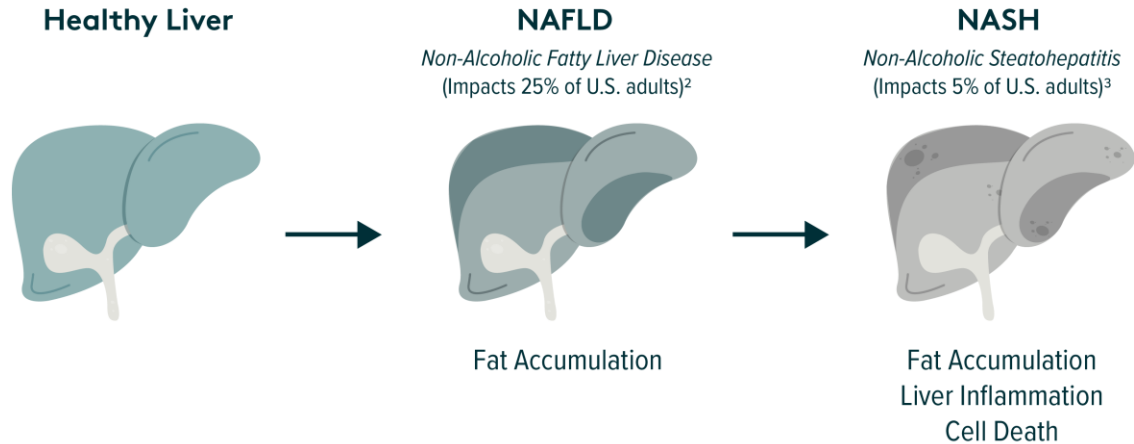


Source: Evaluate Pharma, n.d.

Case Study: Non-Alcoholic Fatty Liver Disease (NAFLD)

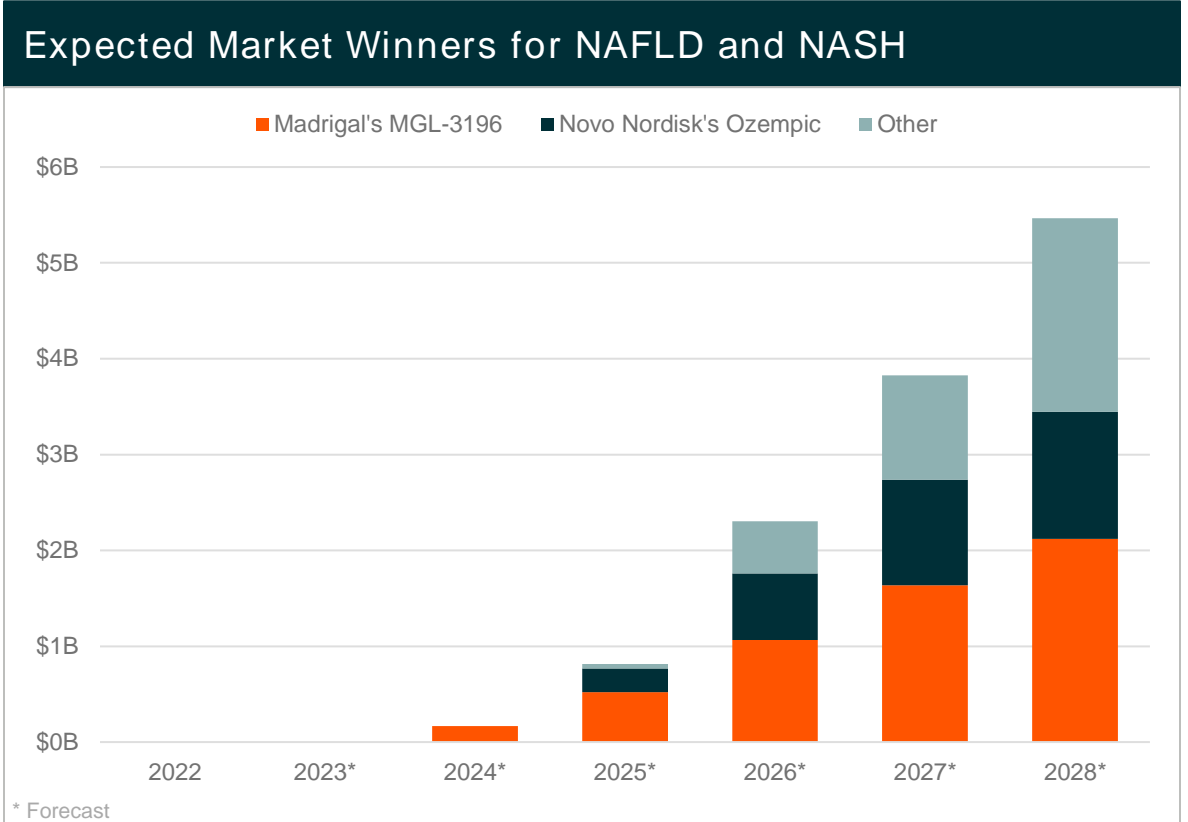
NAFLD is a high-risk, high-return category for therapeutic development given the lack of available treatments and scale of affected patients. The annual cost of managing NAFLD in the United States is \$103 billion.¹

NAFLD: Growing Market for Diabetes Drug Treatments



NAFLD and NASH currently have no approved treatments. As cases continue to largely go untreated, NASH prevalence is projected to increase 63% between 2015 and 2030.⁴

Given overlap in risk factors between diabetes and liver disease, diabetic treatment Ozempic is expected to be the second highest grossing treatment for NAFLD and NASH by 2028.^{5,6} Up to 75% of people who are overweight and 90% of individuals with extreme obesity have NAFLD.⁷



Note: NAFLD is also recently referred to as metabolic dysfunction-associated steatotic liver disease (MASLD). NASH is also recently referred to as metabolic dysfunction-associated steatohepatitis (MASH).

Sources: Text: 1. National Institute of Health, 2016; 2. American Liver Foundation, 2023-Aug; 3. Ibid; 4. American Liver Foundation, 2023-Sep; 5. Evaluate Pharma, n.d.b; 6. Evaluate Pharma, n.d.a; 7. National Institute of Health, 2019. Chart: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b

Preventative Healthcare: Treating Obesity, a Starting Point for Better Health

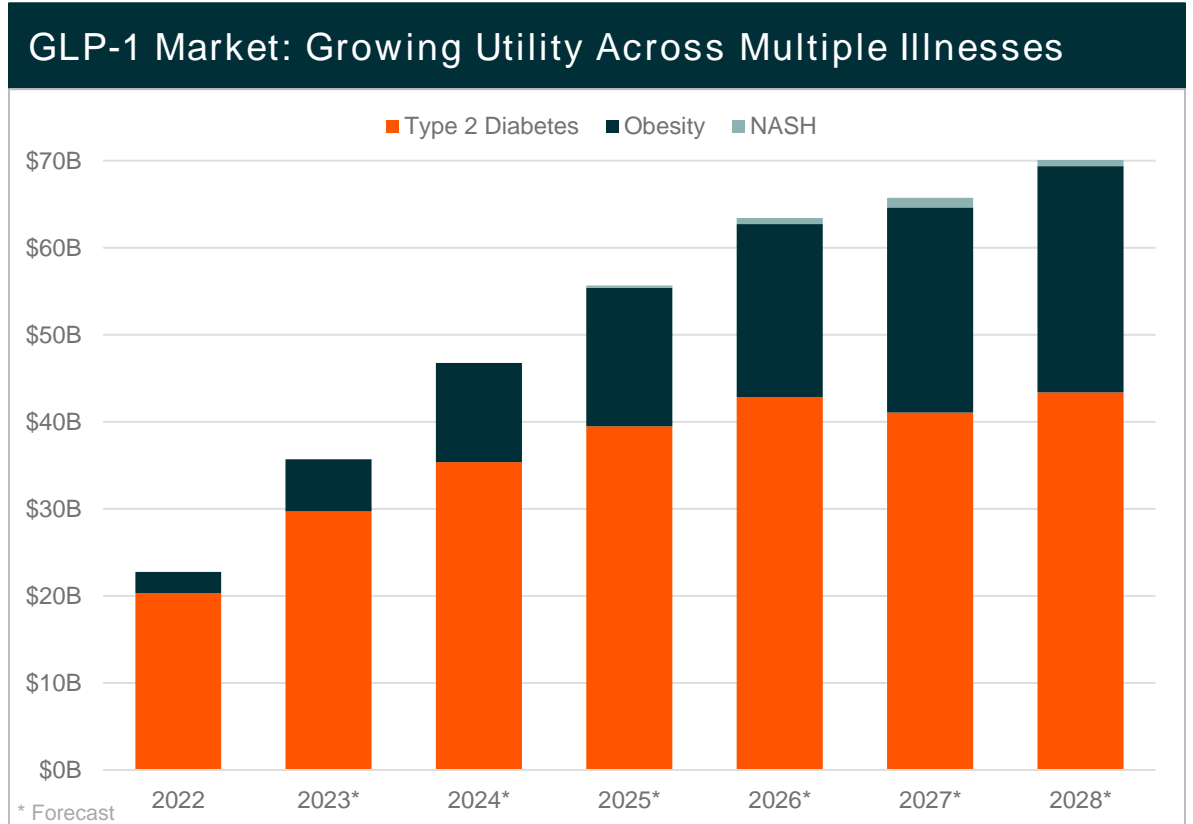
FDA-approved diabetes drugs have become household names for their success in achieving weight loss in obese patients. Now the healthcare industry seeks to replicate success in cardiac and metabolic illnesses.

Obesity Is a Primary Risk Factor in Multiple Diseases

The obesity market is expected to be worth over \$100 billion by the end of the decade, up from \$2.8 billion today.^{1,2} Global obesity rates have nearly tripled since 1975, increasing prevalence rates for related disorders.³

	Increased Risk	Annual Cost in United States
Type 2 Diabetes (T2D)	Obesity accounts for 80–85% of the risk of developing T2D. ⁴	\$380 billion ⁵
Cardiovascular Disease	Obesity accounts for up to 78% of hypertension cases. ⁶	\$320 billion ⁷
Liver Disorders	Up to 90% of obese individuals have NAFLD. ⁸	\$103 billion ⁹

Glucagon-like peptide-1 (GLP-1) treatments, like Ozempic and Mounjaro, were developed for type 2 diabetes. As they also show the ability to curb hunger, their potential use for obesity and obesity-driven illnesses is a promising development. Patients undergoing GLP-1 treatments have experienced weight loss of up to 22.5% of their body weight, rivaling weight loss from gastric bypass and sleeve gastrectomy surgeries.¹⁰



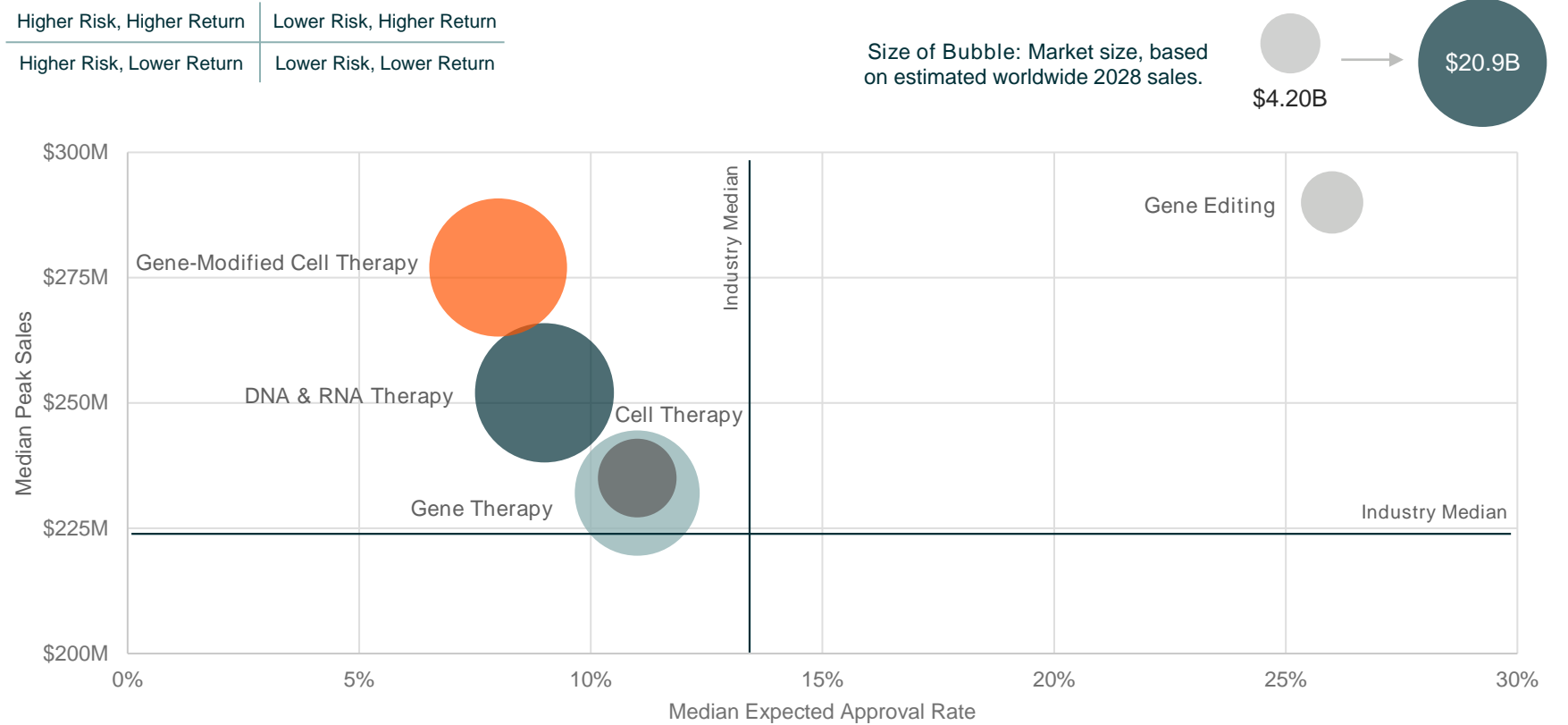
Sources: Text: 1. Barron's, 2023; 2. Evaluate Pharma, n.d.; 3. World Health Organization, 2021; 4. Diabetes U.K., 2022; 5. International Diabetes Federation, 2021; 6. National Institute of Health, 2020; 7. American Heart Association, 2021; 8. National Institute of Health, 2019; 9. National Institute of Health, 2016; 10. Eli Lilly, 2022; Chart: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b

An Arsenal of Investigational Technologies to Combat Illnesses

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

Novel Technologies Give Hope

- Gene Editing: Editing parts of the genome by removing, adding, or altering sections of DNA.
- Cell Therapy: Transplanting healthy human cells to replace or repair damaged tissue and/or cells.
- Gene Therapy: Replacing a defective or missing gene in a patient's cells with a healthy version of that gene.
- DNA & RNA Therapy: Providing instructions to the body's RNA for making proteins or turning genes on and off.
- Gene-Modified Cell Therapy: Transplanting genetically modified cells to fight disease.

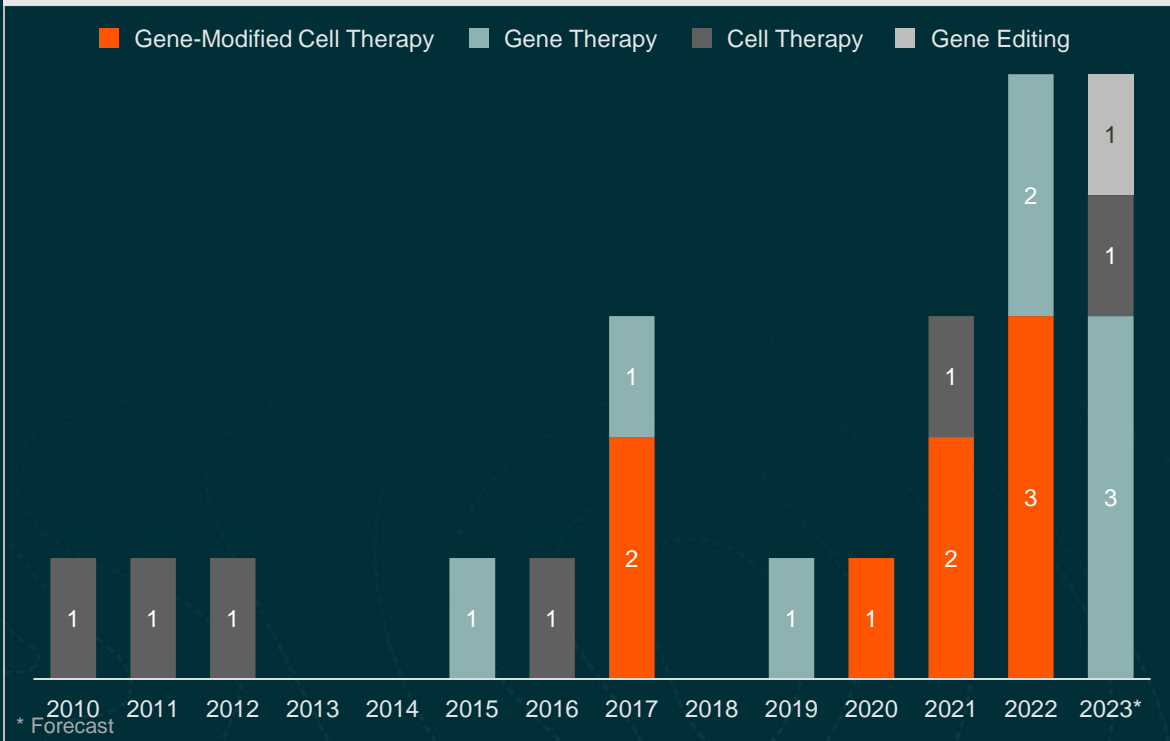


Source: Evaluate Pharma, 2023

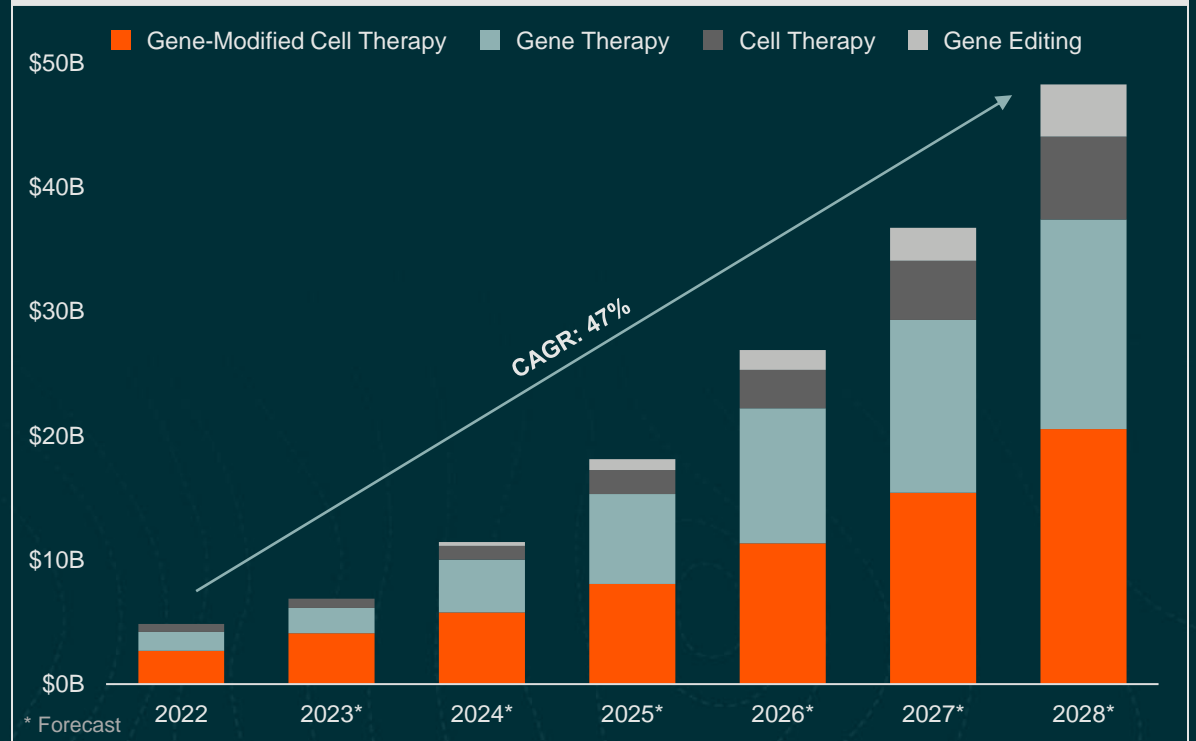
Genomic Medicines: Gaining Momentum

We believe 2023 will mark a breakout year in the genomic medicines space and the beginning of the gene editing market, which is expected to be worth nearly \$4.2 billion by 2028.¹

Approvals Ramping Up: Confirming Genomic



Genomic Medicines: Validation of Sector Driving Growth



Sources: Text: 1. Evaluate Pharma, n.d.; Charts: Left: Food and Drug Administration, n.d.; Right: Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Evaluate Pharma, n.d.d

Genomic Medicines: Price to Value Analysis

New therapeutic categories offer one-time treatment alternatives for cumbersome illnesses, changing drug pricing strategies. Though treatments seem more expensive at face value, new methods offer a longer-term economic benefit.

Therapy	Indication	E.U. Approval	E.U. Pricing	U.S. Approval	U.S. Pricing
Bluebird's Zynteglo	Thalassemia	Jun 2019	Withdrawn	Aug 2022	\$2,800,000
Novartis' Zolgensma	SMA	May 2020	€1,900,000	May 2019	\$2,125,000
Bluebird's Skysona	Cerebral ALD	Jul 2021	Withdrawn	Sep 2022	\$3,000,000
BioMarin's Roctavian	Hemophilia A	Aug 2022	€1,500,000	Jun 2023	\$2,500,000

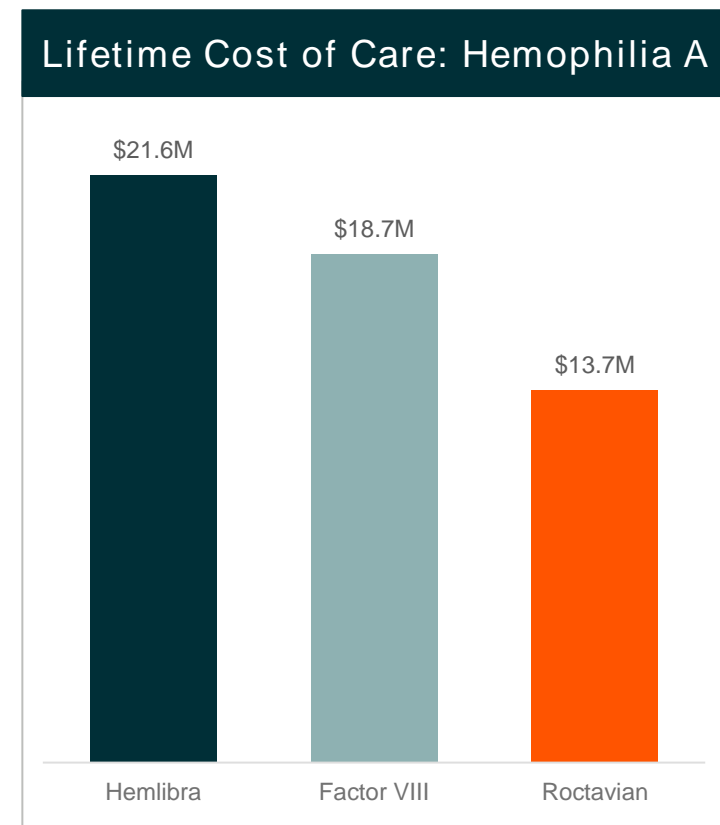
Note: SMA = Spinal Muscular Atrophy; ALD = Adrenoleukodystrophy

Are the High Prices Justified?

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

- **Gene Therapy Advantage:** Roctavian is a one-time gene therapy that reduces bleeding rates by 85%.¹ Though the dose cost is significantly higher, the infrequency of administration compared to alternative treatments awards Roctavian significant lifetime cost-of-care savings up to \$7.9 million.²
- **Shortfalls of Traditional Treatment:** Hemlibra is a once weekly injection that can result in up to \$482,000 in annual costs.³ In contrast, Factor VIII, administered via an infusion as frequently as every day, results in an estimated \$265,000 annual cost.⁴

Given the curative intent of gene therapies, a different pricing framework is needed. For example, some firms created outcome-based policies. Bluebird will offer up to an 80% refund of the price of its thalassemia gene therapy, Zynteglo, if the patient does not see a sustained response up to 2 years after administration.⁵

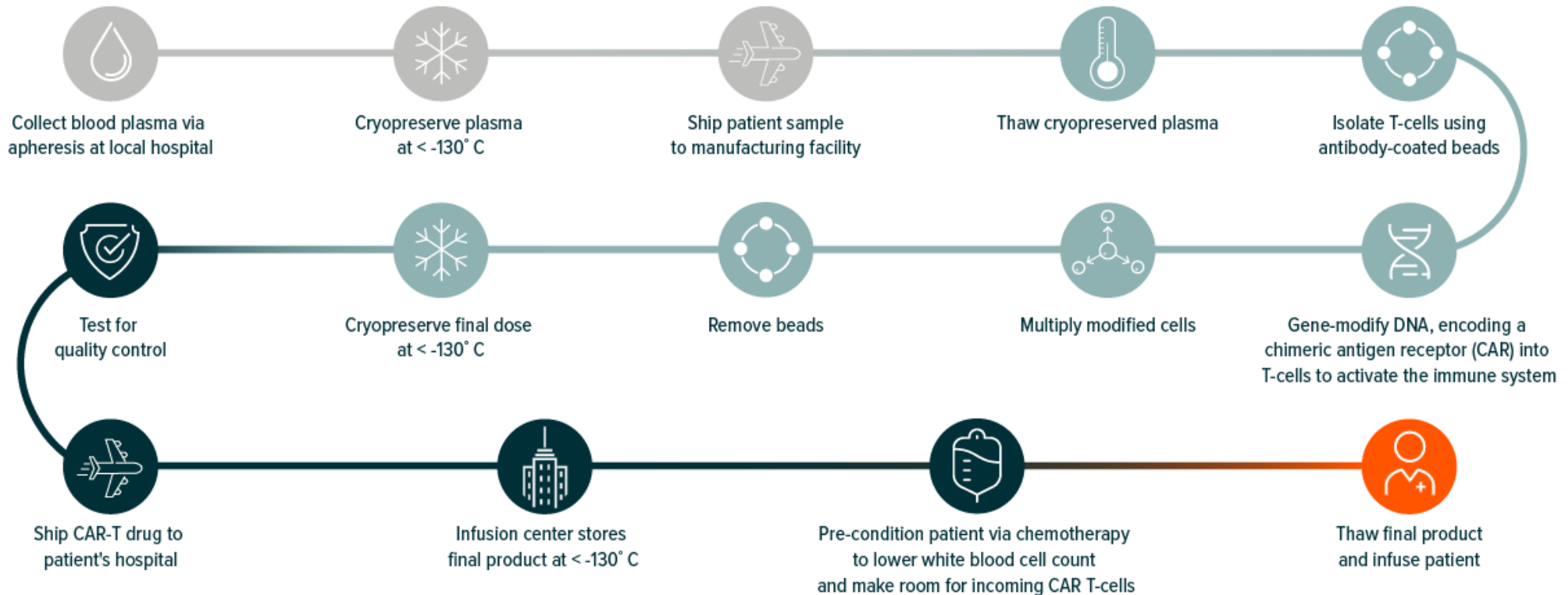


Sources: Text: 1. European Medicines Agency, 2022; 2. National Institute of Health, 2021-May; 3. Fierce Healthcare, 2018; 4. National Institute of Health, 2021-Mar; 5. Bloomberg Intelligence, 2023; Charts: Left: Bloomberg Intelligence, 2023; Right: National Institute of Health, 2021

Genomic Medicines: High Prices Driven by Cumbersome Manufacturing Guidelines

Manufacturing genomic medicines is incredibly complex. 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}

Manufacturing Process for CAR-T Gene-Modified Cell Therapy



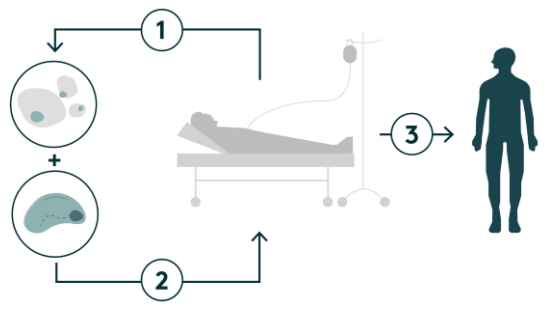
Sources: Text: 1. University of Pittsburgh Medical Center, n.d.; 2. Bluebird Bio, 2023; 3. Genetic Engineering & Biotechnology News, 2023

Wide-Scale Availability of Cell and Gene Therapies Depends on Manufacturing Improvements

Investigational methods like allogeneic manufacturing seek to improve manufacturing costs, turnaround times, and supply, which can help drive changes in reimbursement coverage and develop industry best practices.

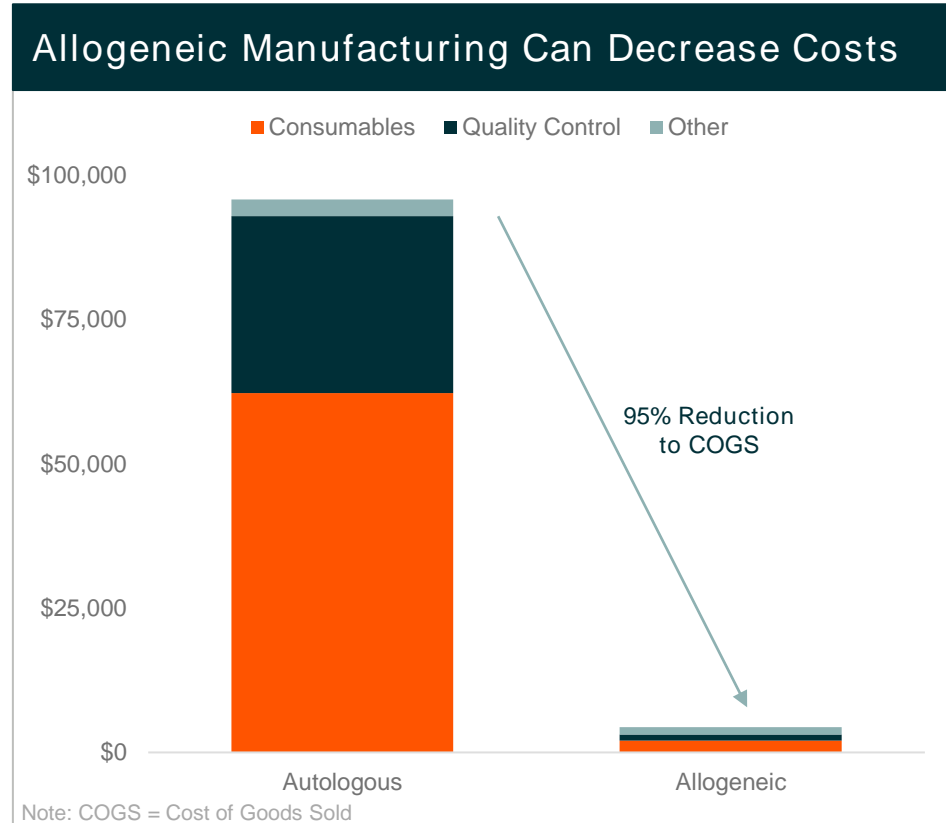
Autologous Manufacturing:

The patient's own cells are extracted, edited, and then returned to the patient to combat an illness.



Allogeneic Manufacturing:

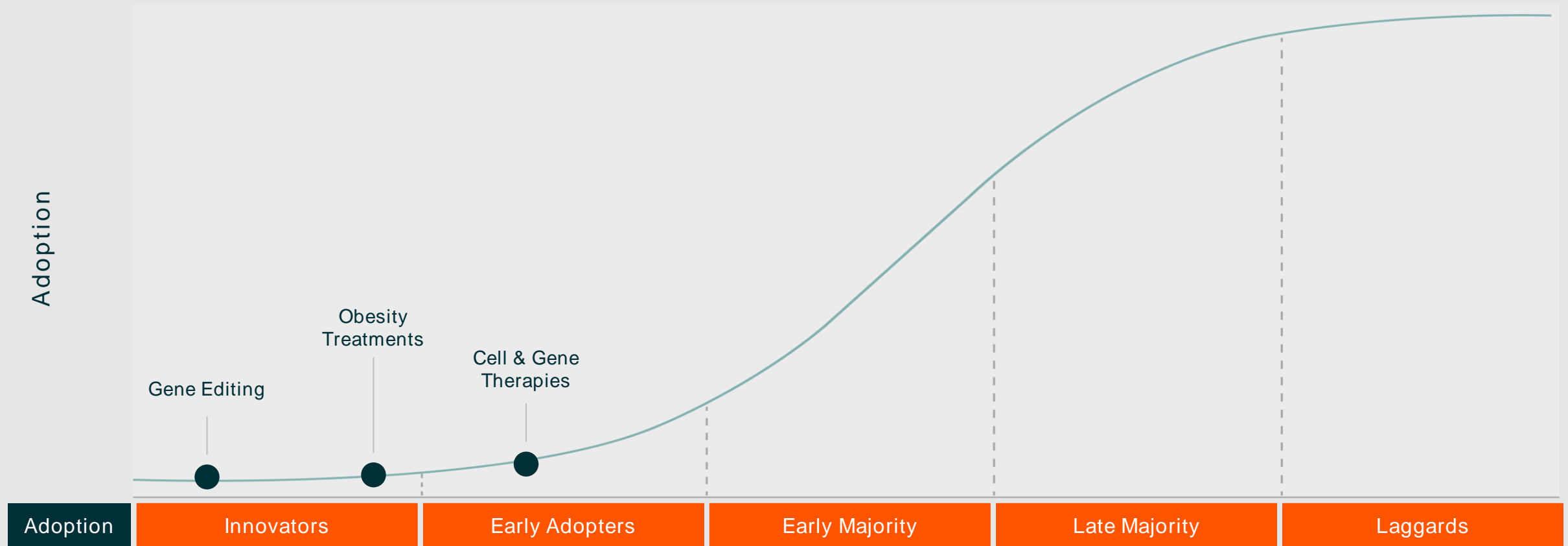
Donated cells are edited and delivered to the patient to combat an illness. This method is more scalable and cost effective.



Source: International Society for Cell & Gene Therapy, 2019

Therapeutics: S-Shaped Curve of Adoption

We expect genomic medicines to comprise 6% of the \$1.24 trillion pharmaceutical market in 2028, up from 1% of the \$895 billion market in 2022.¹



Note: For illustrative purposes only.

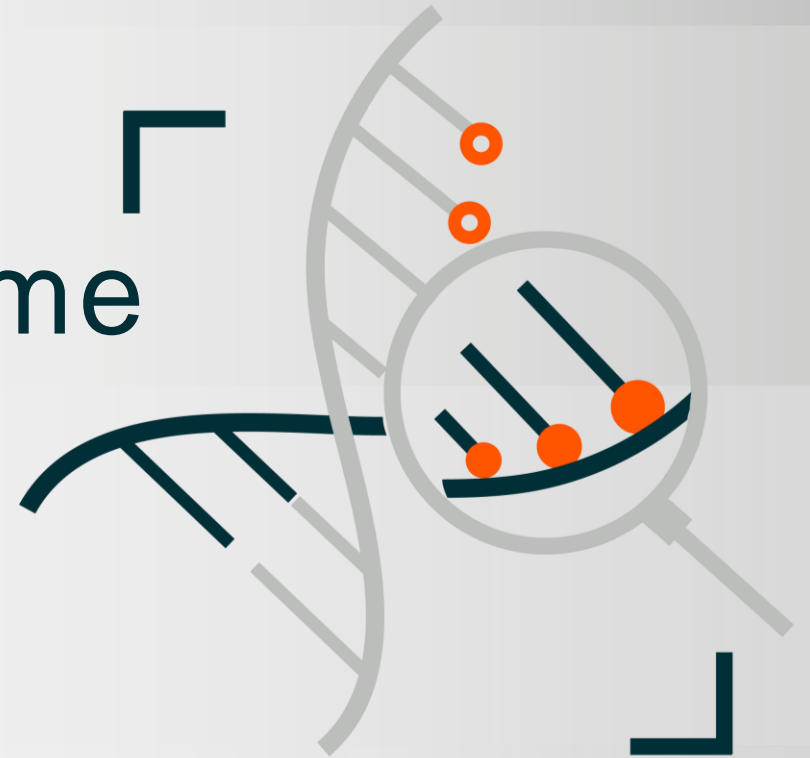
Sources: Text: 1. Evaluate Pharma, n.d.a; Evaluate Pharma, n.d.b; Evaluate Pharma, n.d.c; Evaluate Pharma, n.d.d; Evaluate Pharma, n.d.e; Evaluate Pharma, n.d.f

Medical Breakthroughs

Decoding the Human Genome

Secrets of Our Genetic Blueprint

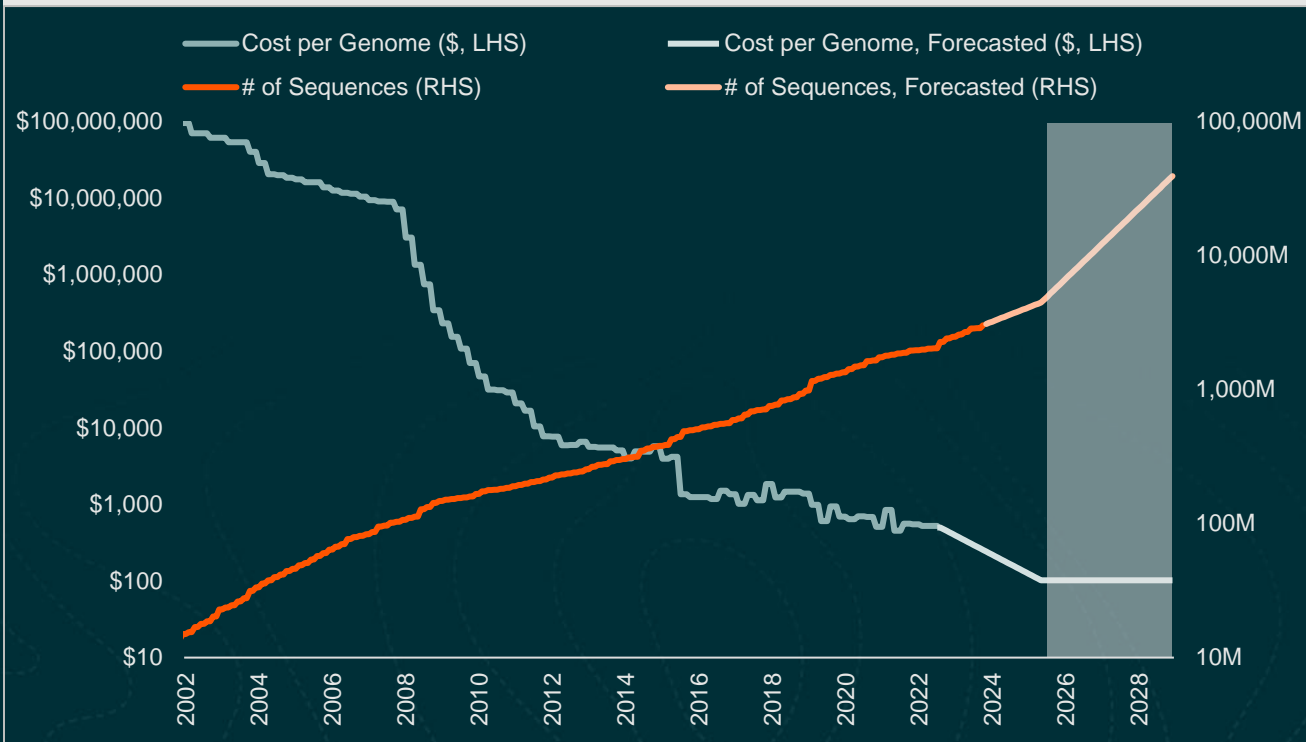
Technological advancements have provided a stronger understanding of human biology than ever before, though questions remain regarding predispositions and links to illnesses. A new class of technological applications, however, provides a comprehensive toolkit for genomic diagnostics and life saving treatments. This allows for a clearer picture of how to improve human health and quality of life.



Reaching the Inflection Point for Genomic Adoption

Genomic sequencing technology has been used since the 1990s, though its potential for accessibility, diagnostics, and new customized treatments is just beginning to be tapped.

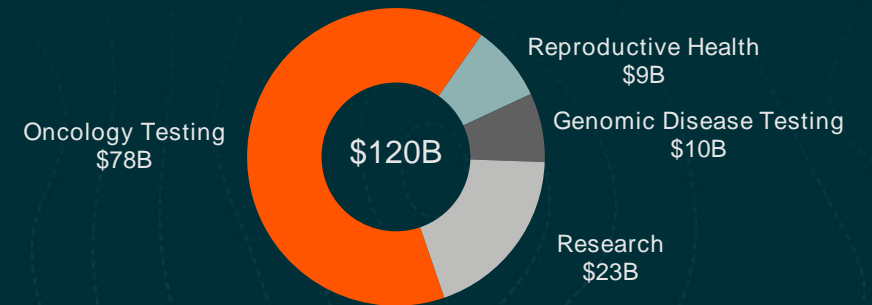
Sequencing Adoption to Accelerate as Cost Continues to Decline



The Sequencing Industry Is Poised for Rapid Expansion

- For genomic sequencing to reach its full potential, it requires tens of millions of individuals' sequencing to enable a comprehensive and unbiased study of the human genome. To date, 0.07% of the world's population has had their genome sequenced.¹
- At \$100 per genome sequence, the adoption of genomic technology is expected to accelerate, unlocking the industry's promise.² At a constant rate of decline, the milestone price of \$100 per genome is expected by 2025.³
- Currently, the sequencing industry is only 7% penetrated, a figure expected to reach 14% by 2027.⁴

Genomic Sequencing Addressable Market, 2027



Sources: Text: 1. Illumina, 2023; 2. Nature, 2020; 3. Global X ETFs analysis of: National Human Genome Research Institute, n.d.; National Institute of Health, n.d.; 4. Illumina, 2023; Charts: Left: National Human Genome Research Institute, n.d.; National Institute of Health, n.d.; Right: Illumina, 2023

Genomics: Expanding Field Now Encompassing Multiple Technologies

Dr. Kieren Patel

Multi-omic analyses allow for an increasingly precise understanding of human biology, enabling improved diagnostic and therapeutic options.

Each –omic technology is a piece of the puzzle, contributing key information about biological and disease mechanisms.

	Genomics	Epigenomics	Transcriptomics	Proteomics
Study Of	<u>DNA</u> : Contains a person’s unique genetic code and supplies the genetic instructions for life.	<u>Modifications</u> : Information not stored in the genome that can have a global impact on how DNA is (mis)regulated.	<u>RNA</u> : Carries forward DNA information to make proteins.	<u>Proteins</u> : Do most of the work in cells. Are required for the structure, function, and regulation of tissues and organs.
Informs	What could happen.	What is directionally happening.	What is directionally happening.	What is happening right now.
Market Size	\$120 Billion ¹	\$39 Billion ²	\$20 Billion ³	\$75 Billion ⁴
By the Numbers	20,000 Genes ⁵	100,000 Epigenomic Events ⁶	100,000 Transcriptions ⁷	1,000,000 Proteoforms ⁸
Primarily Used To Analyze	<u>Whole Genome</u> : Analyzes the whole genome to discover novel genomic variants and identify previously unknown variants for future studies. <u>Whole Exosome</u> : Analyzes structures released by cells that are critical for cell-to-cell communication.	<u>Chromosome Profiling</u> : Analyzes “hot spots” where transcription activity is high and related cell functions. <u>Methylated DNA Markers</u> : Analyzes modifications to DNA that regulate transcription and correlate with disease.	<u>Single-Cell Whole Transcriptome</u> : Analyzes all transcripts in a cell to discover cell types, behaviors, and cell-cell interactions. <u>Gene Expression Panels</u> : Identifies which genes are active or inactive and impact on transcription processes.	<u>Mass Spectrometry</u> : Can detect and measure specific proteins, including post translational modifications. <u>High/Low Plex Protein Detection</u> : Can detect and measure the levels of multiple proteins simultaneously.
Useful For	Non-Invasive Prenatal Testing [NIPT] Tumor and Liquid Cancer Biopsies	Cancer Liquid Biopsy Biological Age Assessments	Immune Cell Profiling Reflex Pathways in Cancer Cells	Immunohistochemistry (IHC) Drug Discovery

Sources: Text: 1. Illumina, 2023; 2. Grand View Research, 2022a; 3. Grand View Research, 2022b; 4. The Analytical, Life Science & Diagnostics Association, 2021; 5. National Institute of Health, n.d.; 6. Nature, 2021; 7. National Institute of Health, n.d.; 8. Ibid.

Multi-omics Technologies: Converging Product Lineup Facilitating Growth

Dr. Kieren Patel

Ongoing efforts to improve data integration and system interoperability will play a key role in the multi-omic industry’s growth prospects.

	Genomics	Transcriptomics	Proteomics
Thermo Fisher Scientific	Short-Read Sequencing	RNA Sequencing, Gene Expression Sequencing	Mass Spectrometry
Danaher Corporation			Mass Spectrometry, Immunoassays, Antibodies
NanoString Technologies		Spatial Biology	
Agilent Technologies			Mass Spectrometry
BGI Genomics	Short-Read Sequencing	RNA Sequencing	Mass Spectrometry
Illumina	Short-Read Sequencing, Long-Read Sequencing	RNA Sequencing	
Bio-Techne			Immunoassays, Antibodies
10X Genomics		Gene Expression Sequencing	Spatial Biology
Olink Holding			High-Plex
Oxford Nanopore	Long-Read Sequencing	RNA Sequencing, Gene Expression Sequencing	
Pacific Biosciences	Short-Read Sequencing, Long-Read Sequencing	RNA Sequencing	

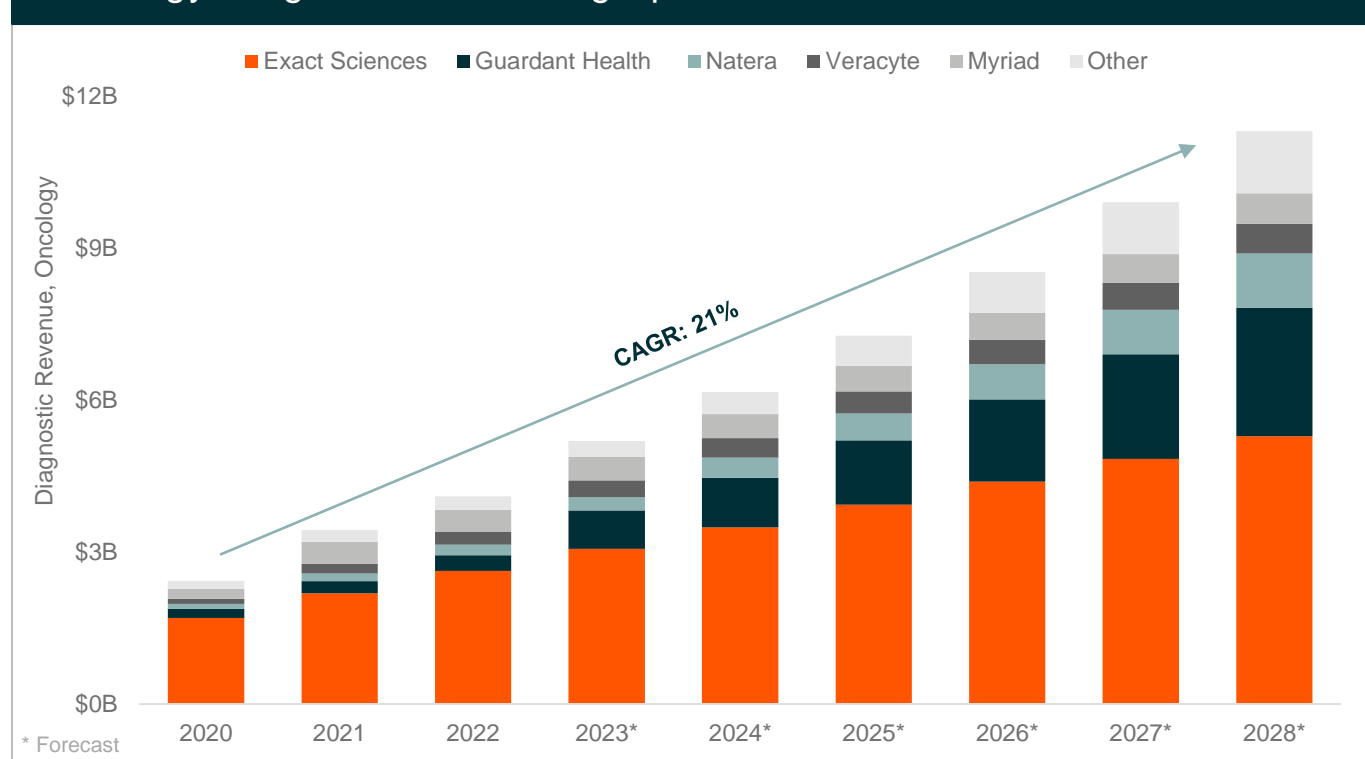
Note: Firms sorted by market capitalization as of November 15, 2023.

Sources: Thermo Fisher Scientifics, n.d.; Danaher Corporation, n.d.; NanoString, n.d.; Agilent Technologies, n.d.; BGI Genomics, n.d.; Illumina, n.d.; Bio-Techne, n.d.; Qiagen, n.d.; 10X Genomics, n.d.; Olink Holding, n.d.; Oxford Nanopore, n.d.; Pacific Biosciences, n.d.

New Diagnostic Opportunities Prompted by Multi-omic Capabilities

Multi-omic technologies have greatly enhanced physicians' diagnostic capabilities and now inform every step of patient care routine health checks to recurrence monitoring.

Oncology Diagnostics: Gaining Speed



Increasing Utility of Diagnostic Tests

The role of diagnostic aids has increased in importance, given that they now inform physicians across the entire care continuum.

- **Health Check:** Routine test for presence of disease-specific biomarkers in asymptomatic individuals.
- **Diagnostic Aid:** Informs diagnosis in suspected cases, such as patients with underlying symptoms.
- **Therapy Guidance:** Helps identify if a patient has a specific biomarker that is targeted by a commercially available drug. Helps predict response, and thus determines if the patient should receive the treatment.
- **Intervention Outcome:** Measures presence of the illness during treatments. Helps determine patient response to treatment.
- **Recurrence Monitoring:** Measures presence of illness during remission to monitor any potential recurrence of the disease.

Oncology Sector Has Validated Diagnostic Promise

The most mature segment is the oncology testing sector with a \$78 billion market opportunity.¹

Sources: Text: 1. Illumina, 2023; Chart: Evaluate Pharma, n.d.

New Diagnostic Opportunities: Neurological Disorders Present Highest Unmet Need

Neurological disorders are notoriously difficult to diagnose, though new blood-based and plasma-based tests offer a more accurate and cost-effective alternative to traditional methods.

Therapeutic Innovation Emphasizes Need for Improved Diagnostics



The Alzheimer’s space has been gaining attention following the Food and Drug Administration’s approval of Eisai’s Leqembi and the expected approval of Eli Lilly’s Donanemab by year-end.¹ Spurred by exciting developments like these, the Alzheimer’s treatment category is expected to grow to \$11.7 billion by 2028 from \$747 million in 2022.²



The adoption of these novel treatments, however, relies on clinicians being able to identify which patients are most suitable for treatment. This problem has spurred innovation to improve the diagnostic capabilities to identify and categorize Alzheimer’s patients.

Non-Invasive Multi-omic Tests Offer a Solution



Diagnosing Alzheimer’s traditionally relies on expensive PET scans or measuring biomarkers in spinal fluid, collected via a lumbar puncture. These methods can be difficult in practice and struggle to identify early stages of the disease. Capacity issues are also notable, with only about 2,000 PET centers in the United States.³



New blood-based and plasma-based alternatives offer a more scalable, less invasive, alternative with the goal of identifying Alzheimer’s presence even before a patient is symptomatic. These alternatives can serve an \$8 billion market.⁴

	PET Scan	CSF Test	Blood or Plasma-Based Tests
Definition	Positron emission tomograph (PET) scans show how organs and tissues are working.	Cerebrospinal fluid (CSF) carries waste out of the brain, potentially including proteins that point to Alzheimer’s.	DNA and protein material in the blood can point to Alzheimer’s.
Average Cost	\$5,000 ⁵	\$1,000 ⁶	\$400 ⁷
Capacity	Low	Medium	High
Precision	Medium	High	Medium

Sources: Text: 1. STAT News, 2023; 2. Evaluate Pharma, n.d.; 3. STAT News, 2023; 4. Quanterix, 2023; 5. University of California, 2023; 6. Ibid; 7. Scientific American, 2023

Pharmaceutical & Diagnostic Conversion Accelerating Genomic Adoption

Dr. Kieren Patel

Growing efforts from pharmaceutical firms to partner with or acquire diagnostics firms will help drive adoption of genomic technologies and further refine diagnostic capabilities.

Genomic Profiling Increasingly Informs Therapeutic Intervention

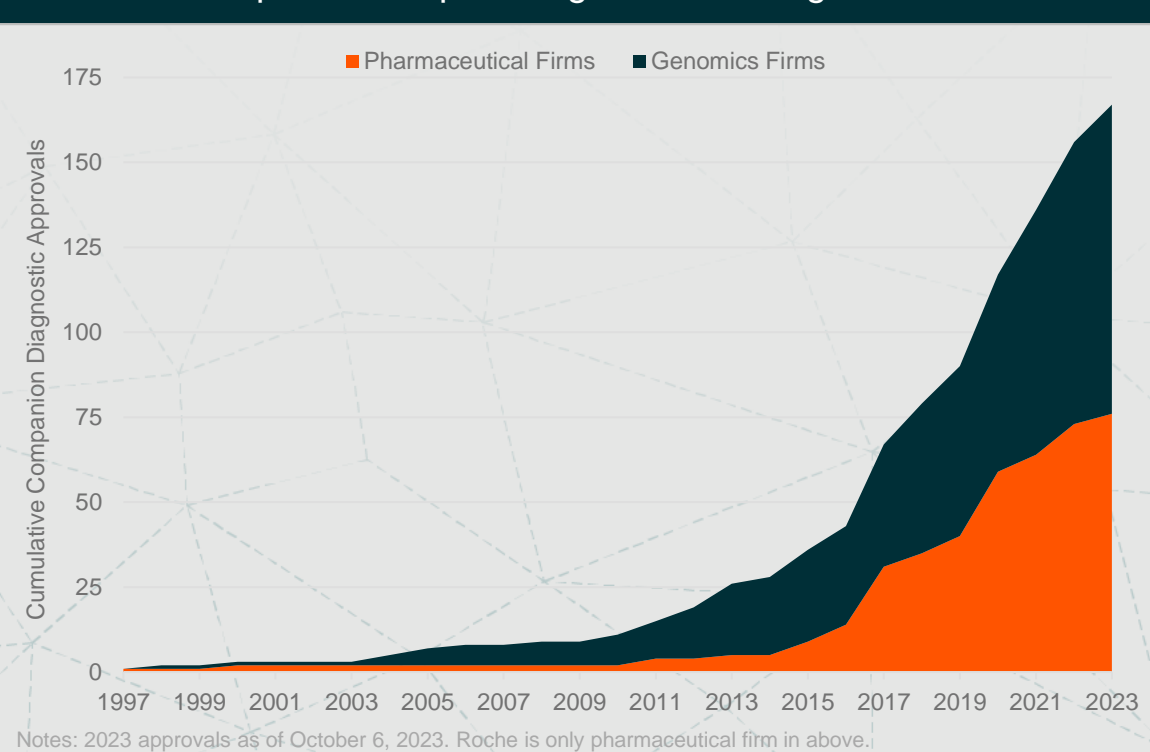
- Companion diagnostics (CDx) tests are used to help match patients to a specific therapy or drug by identifying possible driving factors for the illness. These tests look for possible gene changes or biomarkers in the patient's sample that commercially available drugs target. The tests can also shed light on potential side effects and measure how well the treatment is working.
- These tests play an increasingly important role in the success of investigational treatments and the widespread adoption of approved therapies. As a result, pharmaceutical and biotechnology firms continue to prioritize partnerships and acquisitions to strengthen diagnostic capabilities.

Successful Diagnostic Factors Inform Therapeutic Intervention

- Prioritizing Scalable Diagnostics:** Diagnostic results should be robust, repeatable, and clear with simple positive/negative readouts. Workflows should be simple enough to be easy and cost effective for doctors to incorporate. This ensures broad adoption and clinician support.
- Emphasis on Actionable Insights:** Excessive reports that are time-consuming and difficult to interpret will have limited adoption, given the room for misinterpretation. Measuring the data that matter allows doctors to tailor patient care accordingly and avoid the noise that adds to the complexity and cost of care.

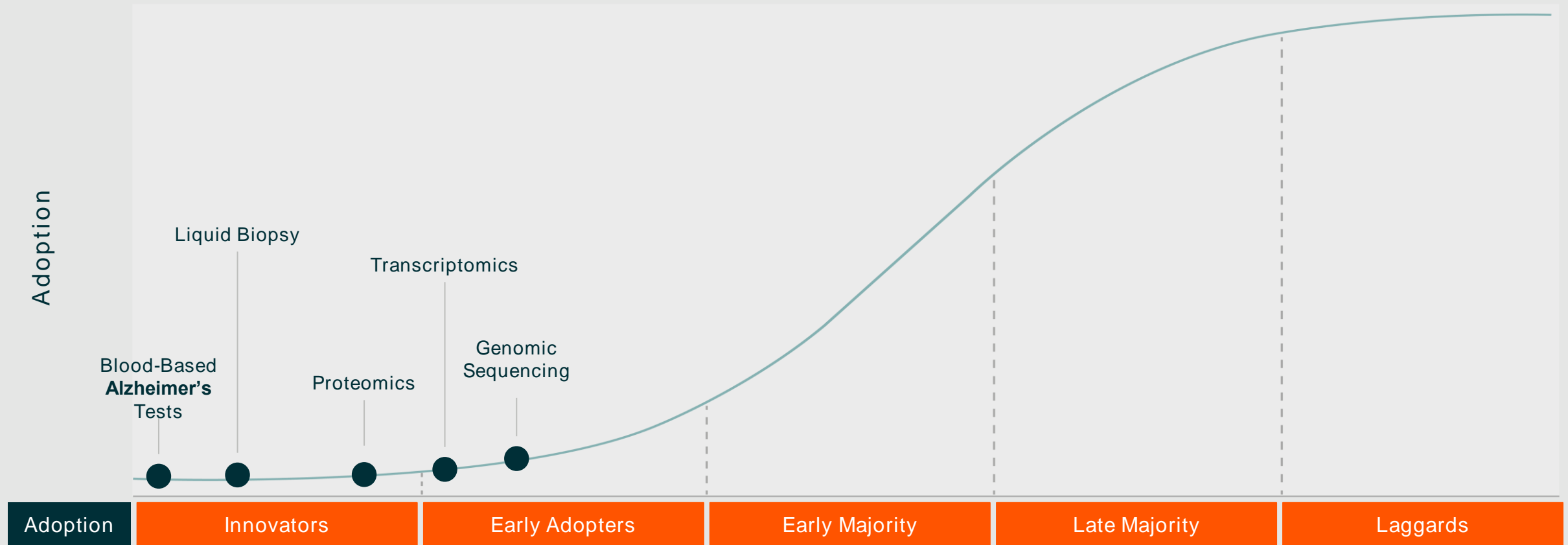
Source: Food and Drug Administration, n.d.

Pharma Companies Expanding Role in Diagnostics



Decoding the Human Genome: S-Shaped Curve of Adoption

We expect \$17 billion in revenue for the global sequencing industry by 2027, doubling the 2023 total.¹



Note: For illustrative purposes only.

Source: Text: 1. Illumina, 2023

Paradigm-Shifting Technologies

Clicks & Commerce

What's Next for the Internet Economy

Consumers are dedicating more time and financial resources to online pursuits. In response, platforms are shifting to align with heightened consumer expectations while progressively monetizing their offerings. The appeal of e-commerce remains strong, but there's a noticeable trend as consumers increasingly return to physical stores, catalyzing the digital transformation of brick-and-mortar establishments. In parallel, the expansion of financial technology persists, and platforms catering to the digitization requirements of banks are experiencing sustainable growth.

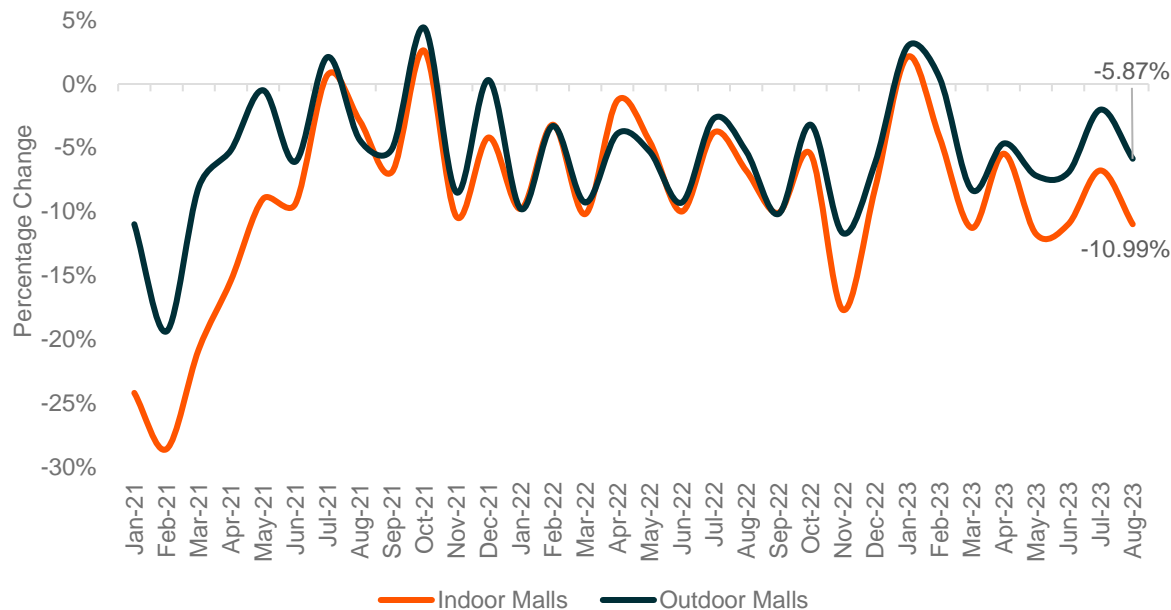


Digitally Equipped Merchants Are Ready for an Omnichannel Future

The brick-and-mortar business remains a critical element for winners in omnichannel. However, a retailer's online presence is an important portal to achieve customer retention in an increasingly digital world.

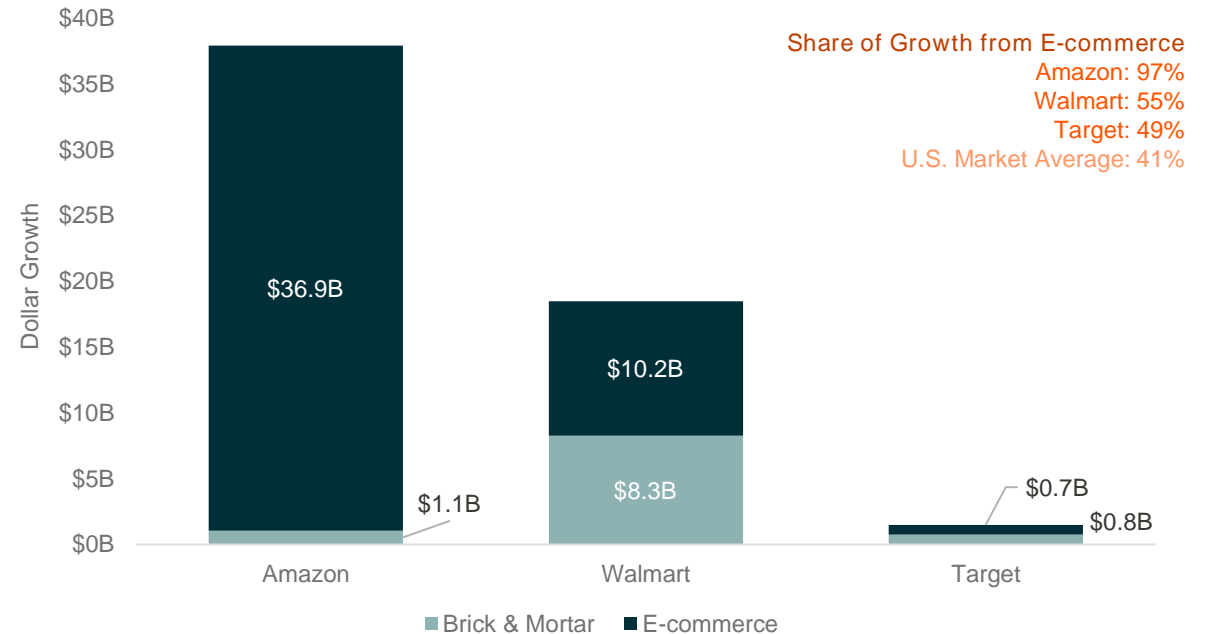
Commercial Foot Traffic Largely Below Pre-COVID Levels

Monthly Foot Traffic in U.S. Malls Relative to 2019



U.S. E-commerce Projected to Take Majority Share

Projected 2023 Revenue Growth of U.S. Retailers



Note: For 2022 and 2023 in LHS chart, Outdoor Malls defined as 'Open-Air Lifestyle Centers.'

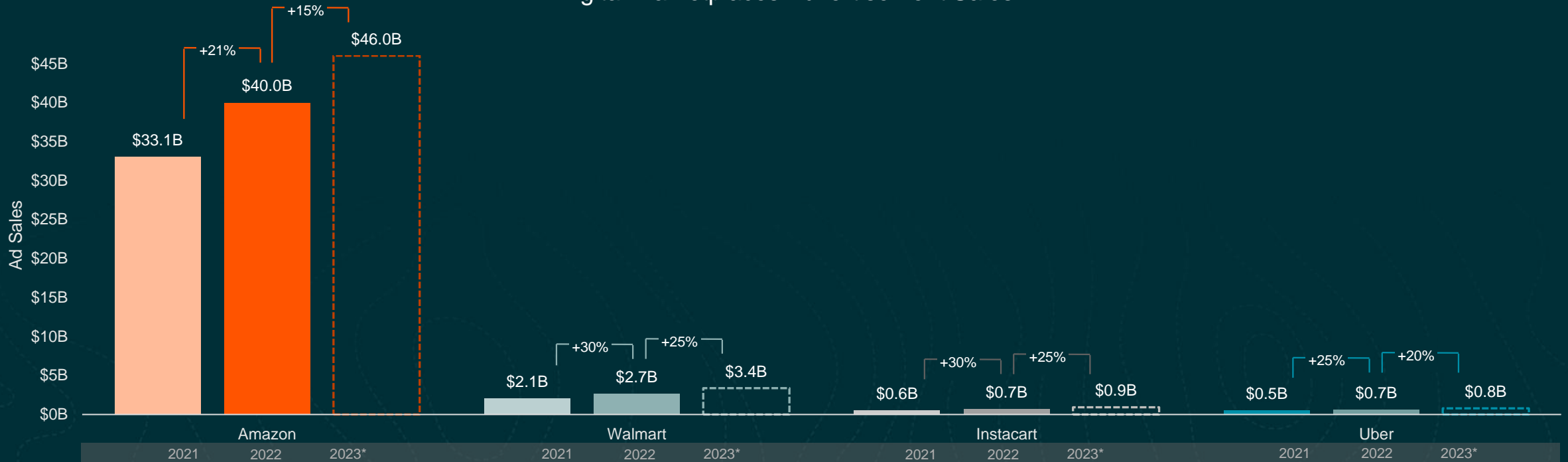
Sources: Charts: Left: Placer.AI, 2023-Sep; Placer.AI, 2023; Right: Stratably, 2023; U.S. Census Bureau, 2023

Digital Retailers and Service Providers Boost Marketplace Profitability Through Advertising

Advertising is a revenue source for top digital marketplace players in e-commerce. Companies like Walmart, Instacart, and Uber embraced ads to capitalize on the benefits of increased sales growth.

Ad Sales Are a Vital Source of Revenue for the Delivery Intermediaries and the Businesses Utilizing Them

Digital Marketplaces Advertisement Sales



* Forecast

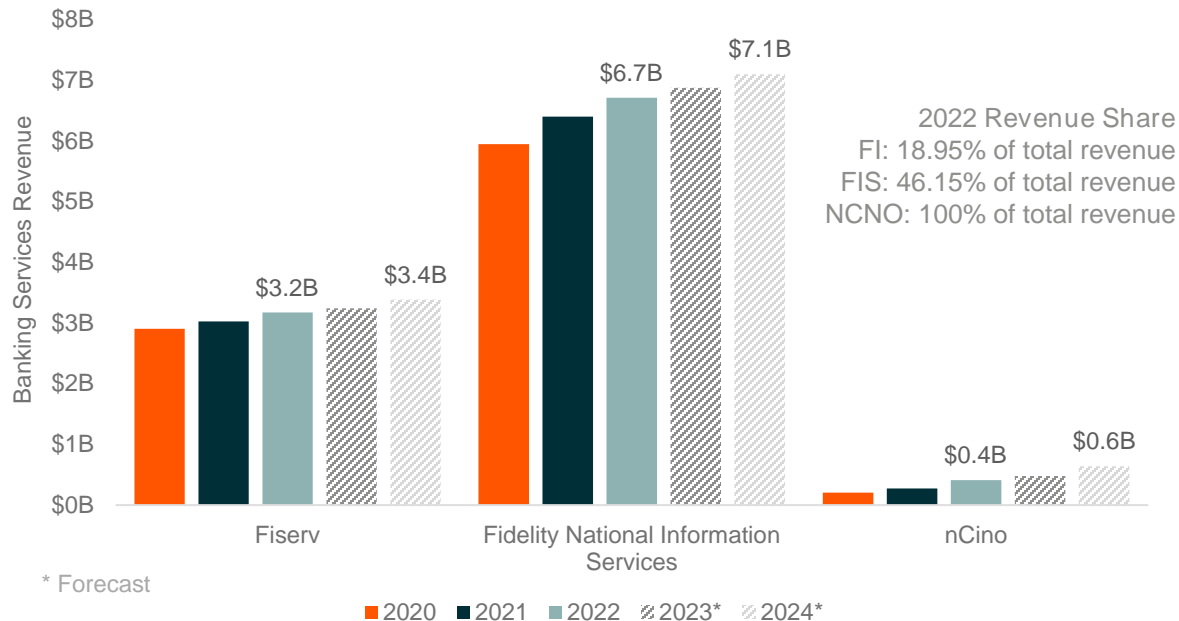
Sources: Amazon, 2022; Amazon, 2023; The Information, 2023; Uber, 2022; Uber, 2023; Walmart, 2022; Walmart, 2023

FinTech Platforms That Help Banks Digitize Their Operations Are Thriving

FinTech infrastructure companies are transforming the industry with application programming interfaces (APIs) that enable banks, and virtually any software company, to offer digital financial products to their customers.

Supplying Infrastructure to Banks Is a Lucrative Business

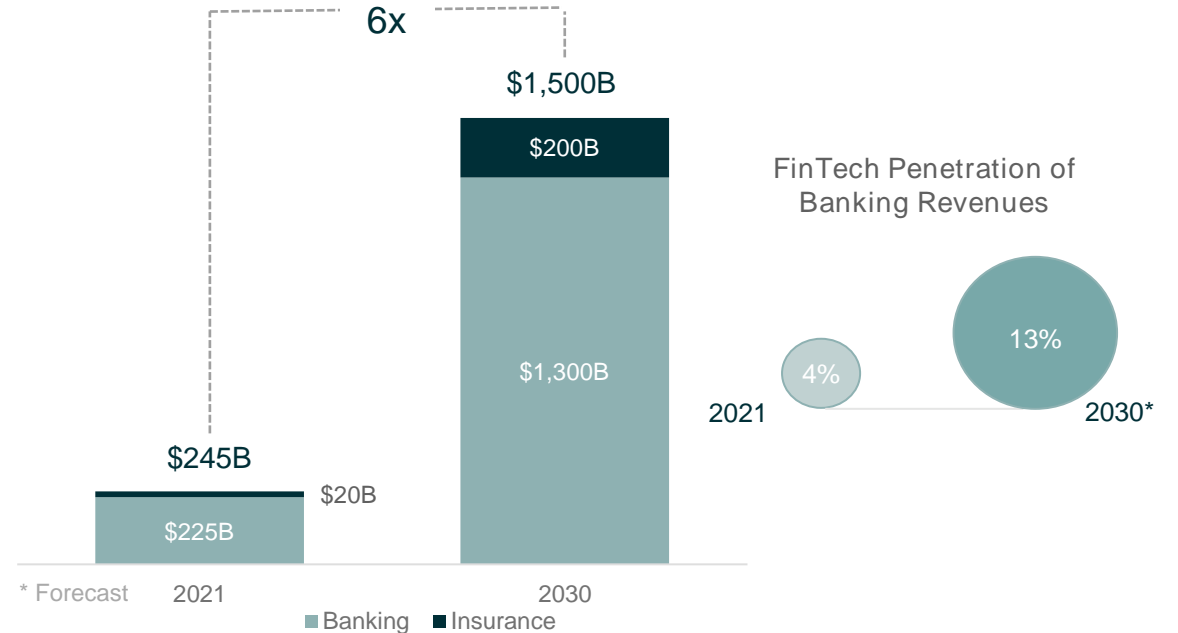
Select FinTechs Revenue Growth from Banking Services



Note: Left Chart, "Banking Services" classified as: Fiserv (FinTech), Fidelity National Information Services (Banking Solutions), nCino (Total). These are based on the category breakdowns provided by FactSet.

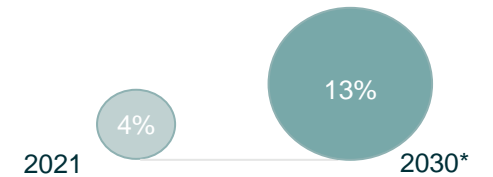
FinTechs Projected to Generate Sizable Banking Revenues

Global FinTech Revenues



Note: Banking FinTech revenues are represented by revenues from lending, deposits, payments, as well as trading and investments.

FinTech Penetration of Banking Revenues



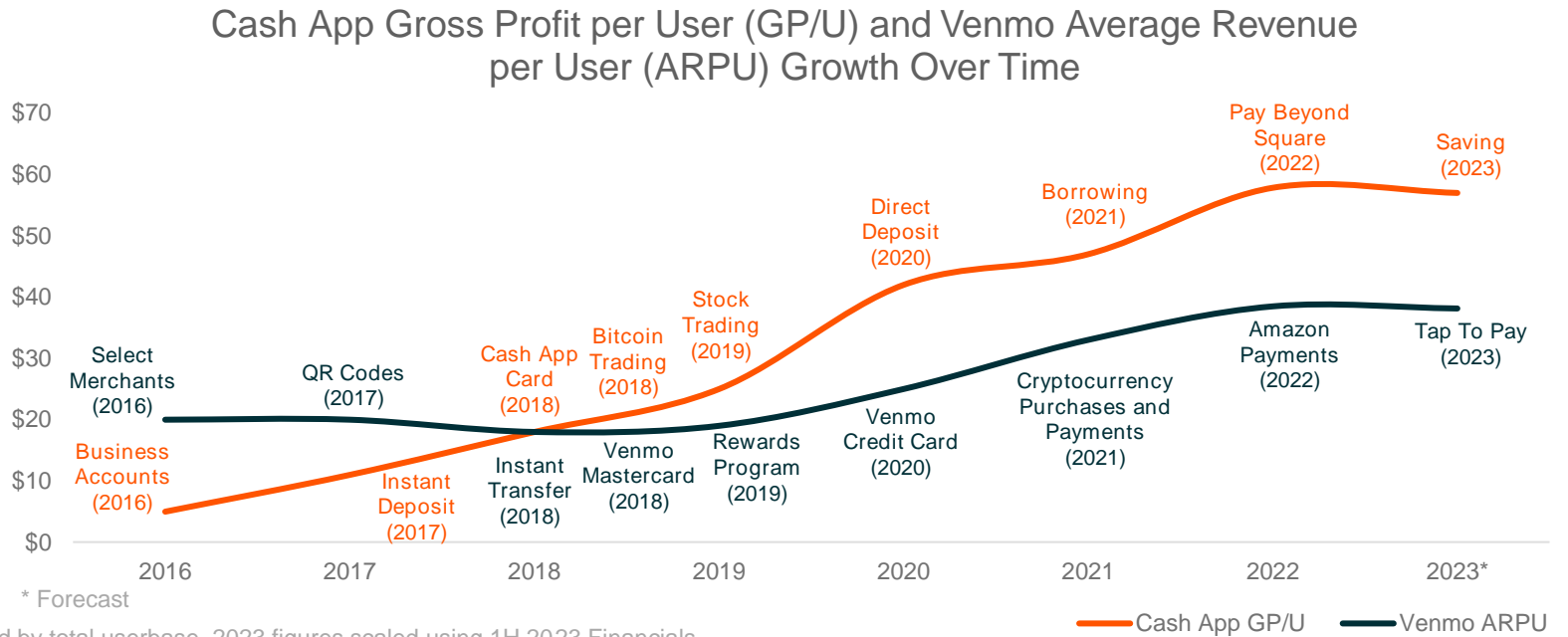
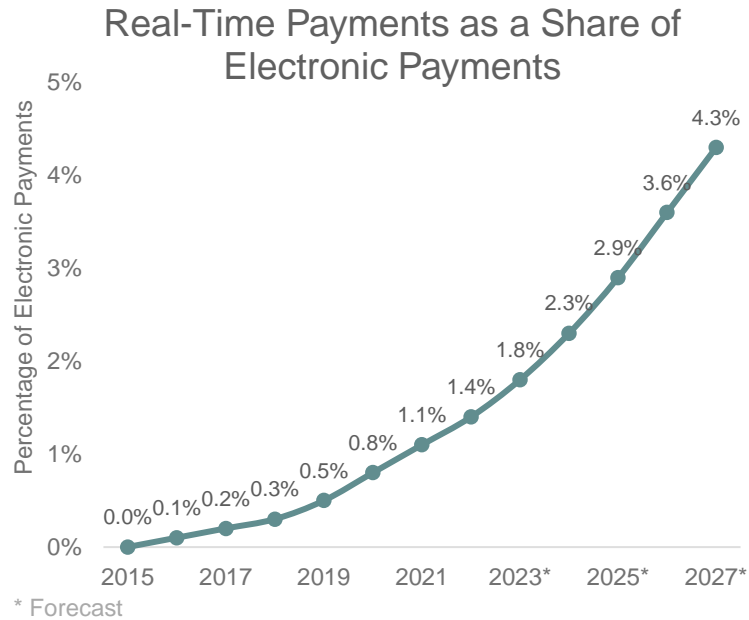
Sources: Left: FactSet Research Systems, n.d.; Right: Boston Consulting Group, 2023

Digital Wallets Are Turning Into Super Apps, Boosting Profitability and Shrinking Costs

There is an uptick in adoption of real-time payments, even relative to increased digitization across the payments industry. Digital wallets like Venmo and Cash App are utilizing this shift to gain on payoff per user.

Real-time payments remain only a fraction of all electronic payments, but they're on an upward trajectory.

Venmo and Cash App's freemium models make them highly scalable. The popular P2P payment platforms' sustainability depends on the power of their network effects, not just their functionality. Value-added services consistently help new users discover utility in these platforms.



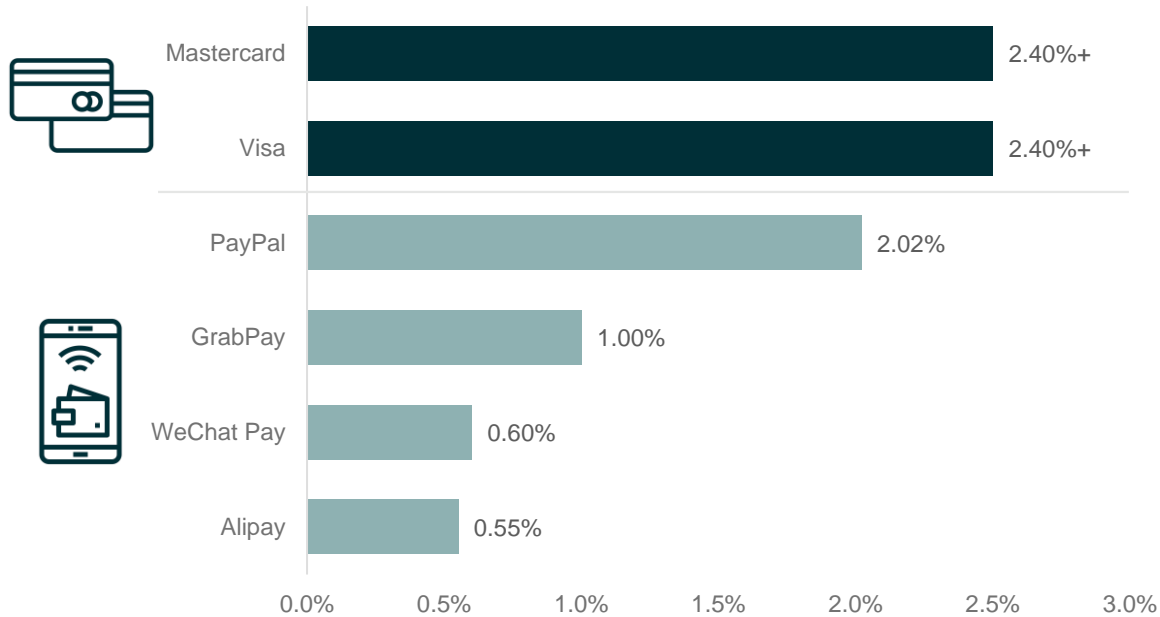
Note: Venmo ARPU calculated using scaled total payment value (TPV) divided by total userbase. 2023 figures scaled using 1H 2023 Financials.

Sources: Charts: Left: ACI Worldwide, 2022; Right: Block Inc., 2023

Global Disruption of Traditional Financial Services Offers Plenty of Opportunity

FinTech industry fundamentals are robust despite the recent challenges and e-wallets continue to gain share, especially in emerging markets.

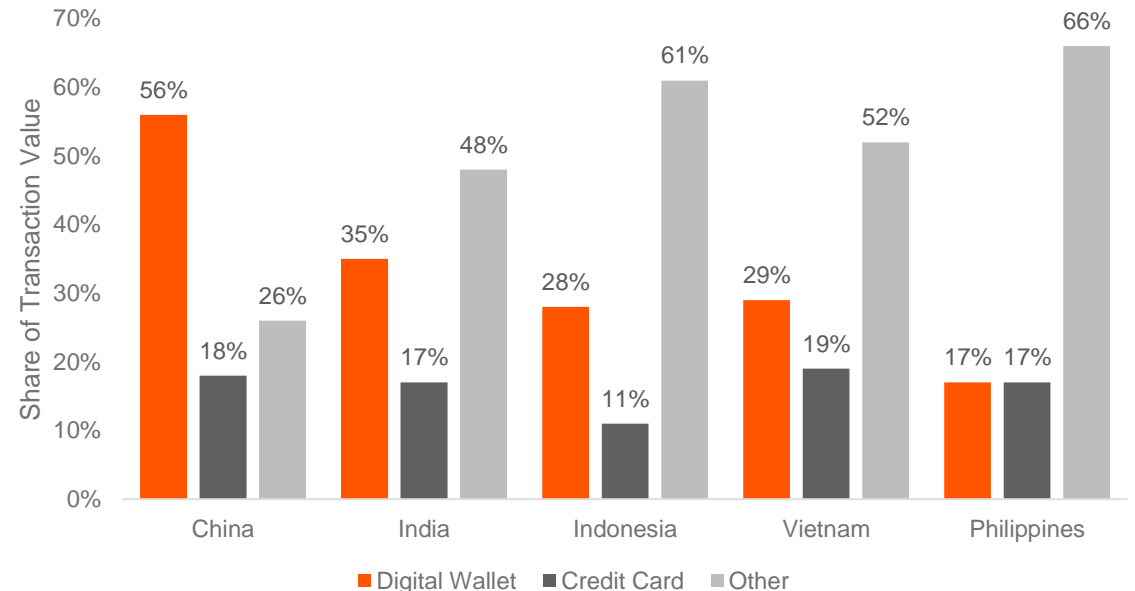
E-Wallet vs. Major Credit Card Merchant Take Rates



Note: Average interchange rates for Visa Card “card present” transactions is 2.10% + \$0.10, while card not present rates are 2.40% + \$0.10. This is aside from the additional assessment fee.¹

Emerging Markets Turn to E-Wallets Over Credit Cards

2022 Point-of-Sale (POS) Payment Methods Estimated Share of Transaction Value

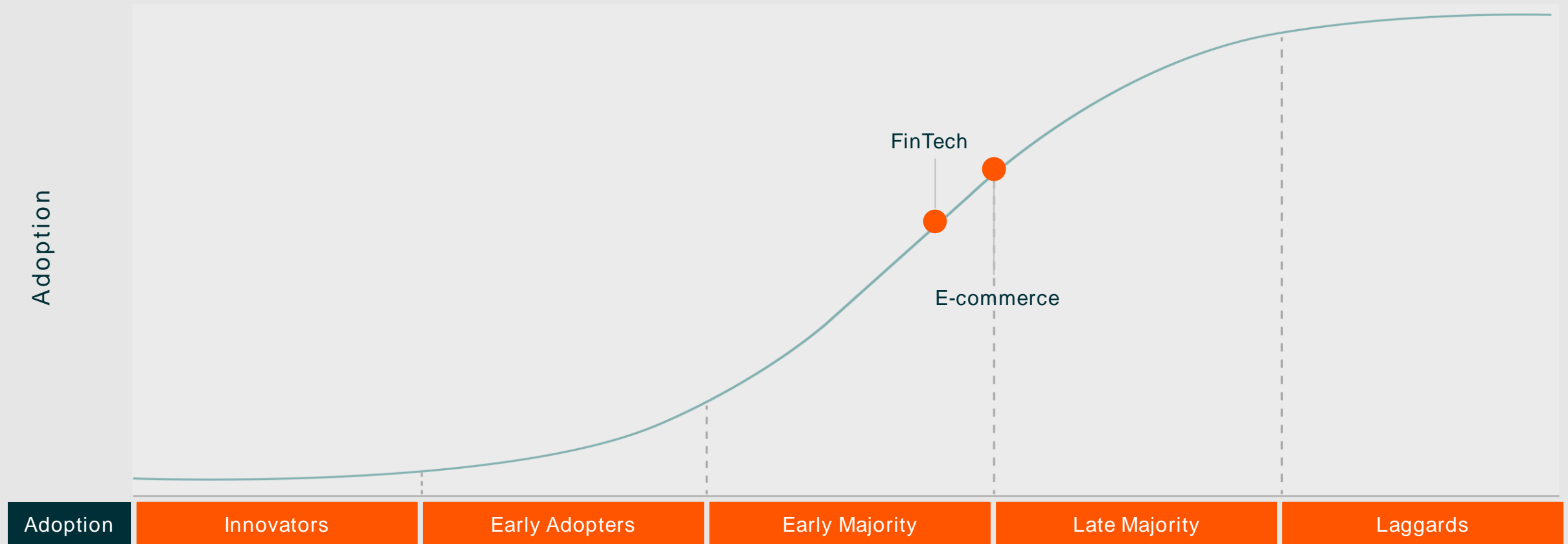


Note: Other includes Debit Card, Cash, POS Financing, and Prepaid Cards.

Sources: Text: 1. FastSpring, 2018; Charts: Left: Oceanpayment, 2021; Shopify, 2021; PayPal, 2023; Right: WorldPay from FIS, 2023

Clicks & Commerce: S-Shaped Curve of Adoption

The future of commerce is omnichannel, with digital financial solutions playing a key role in disrupting legacy players.



Note: For illustrative purposes only.

Crypto & Blockchain Quests

Unlocking Digital Assets

Alternative Currencies & Stores of Value

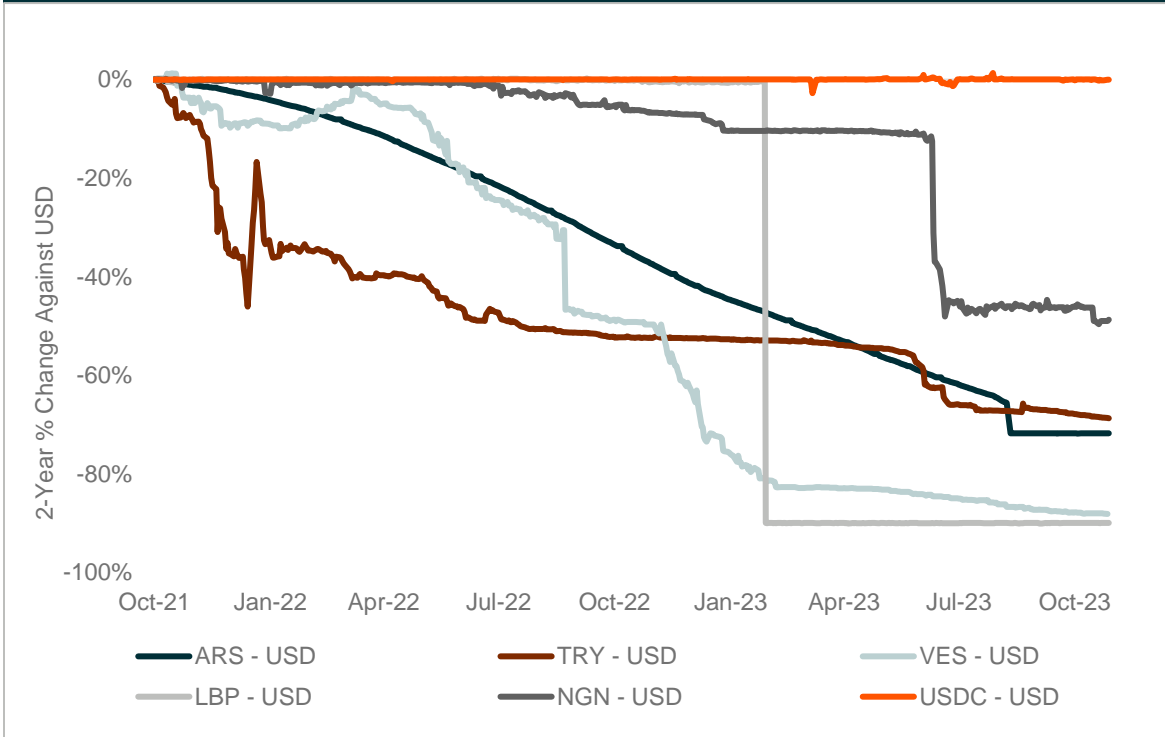
Digital assets, such as stablecoins and bitcoin, represent a transformative shift in the fabric of the global financial system, providing highly efficient means to transact and save, regardless of political and/or economic dynamics. Together, these assets have the potential to foster financial accessibility and inclusion for populations around the world.



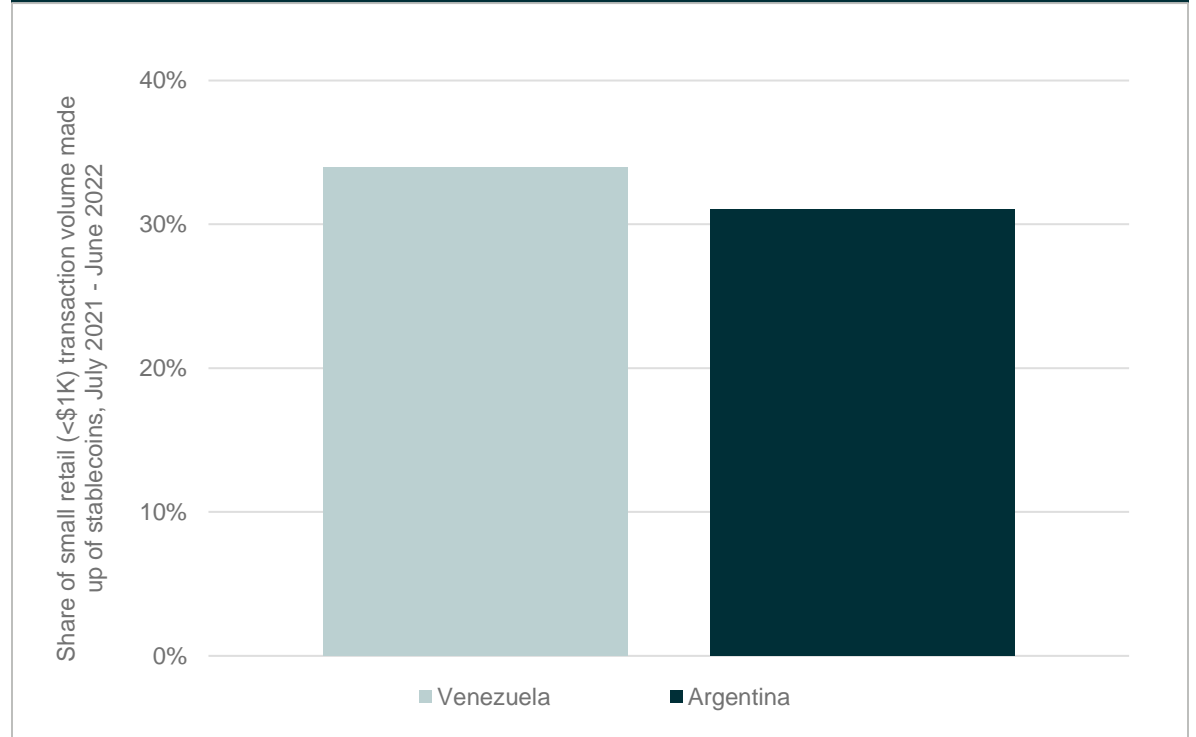
Stablecoins Serve as a Reliable Medium of Exchange in Unstable Economies

Currency debasement and hyperinflation make everyday transactions a challenge. Stablecoins provide an alternative medium of exchange that people around the world can use to transact with greater confidence.

Stablecoin & Hyperinflationary FX Rates Against USD



Stablecoins Are Popular in Unstable Dollarized Economies

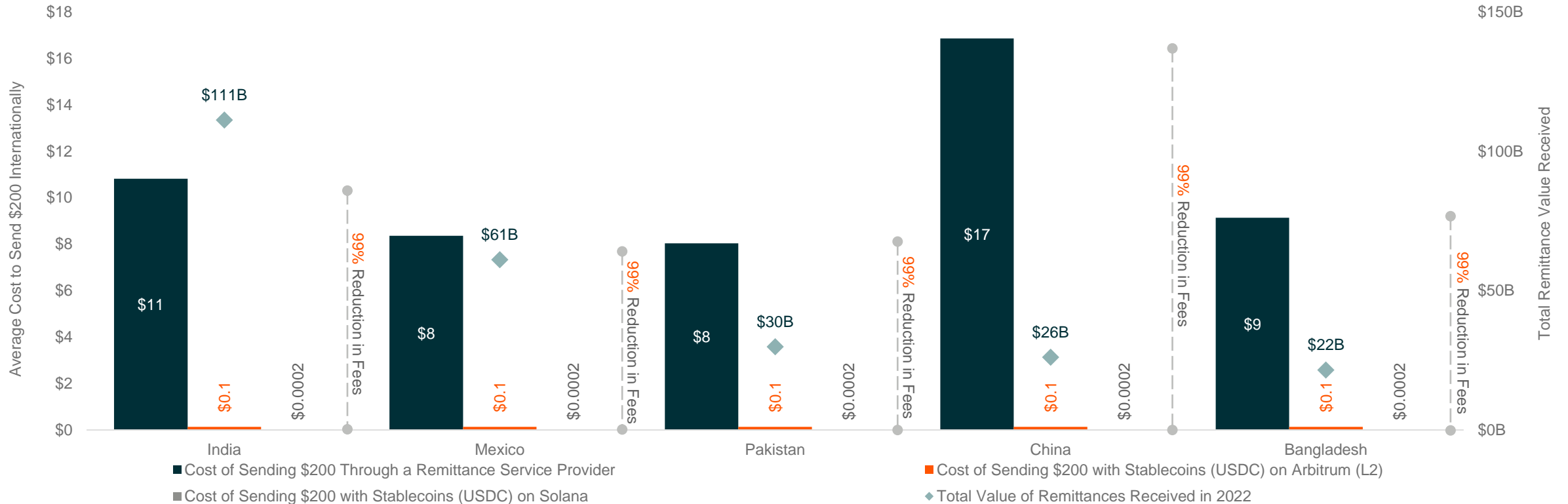


Note: USDC - USD = Circle's USD stablecoin rate, ARS - USD = Argentinian Peso rate, TRY - USD = Turkish Lira rate, VES - USD = Venezuelan Bolivar rate, and NGN - USD = Nigerian Naira rate.

Sources: Charts: Left: TradingView, n.d.; Bloomberg, n.d.; Right: Chainalysis, 2022

Stablecoins Reduce the Cost of Global Remittance Payments by Orders of Magnitude

The price stability, cost effectiveness, and instant transfer capabilities of stablecoins are reducing remittance transaction costs and enabling frictionless cross-border money transfers.

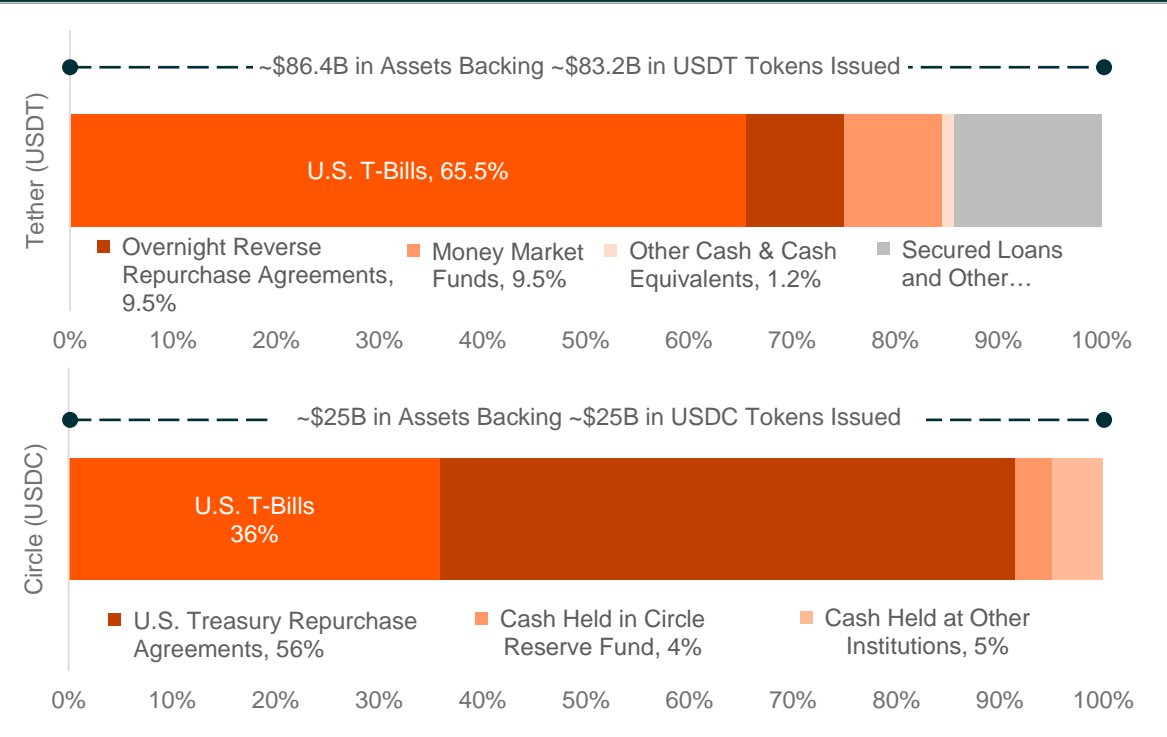


Sources: The World Bank, n.d.a; The World Bank, n.d.b; Arbiscan, n.d.; Solscan, n.d.

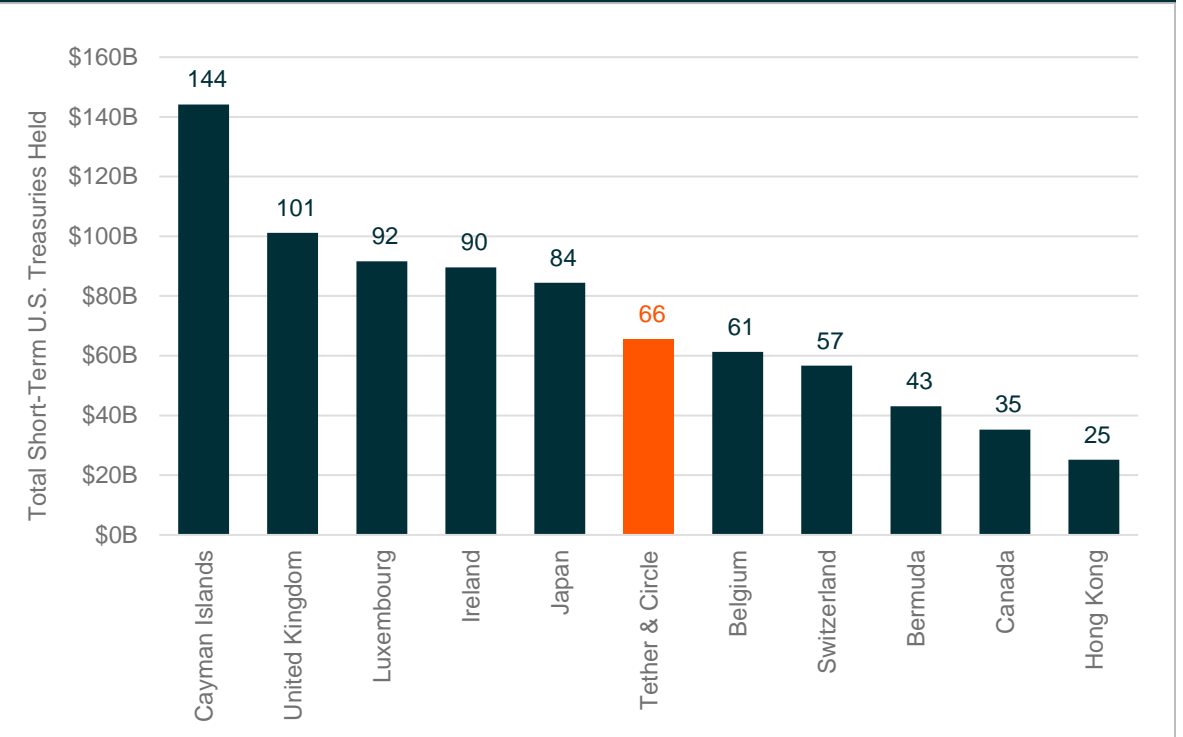
Stablecoins Expand the Global Influence of the U.S. Dollar

The stablecoin market is largely denominated in USD. As global demand for stablecoins continues to grow, the stablecoin industry may soon become one of the largest buyers of U.S. government debt.

Major Stablecoins Are Backed by over \$66B in U.S. T-Bills



Stablecoin Issuers Hold as Many T-Bills as Top Foreign Buyers

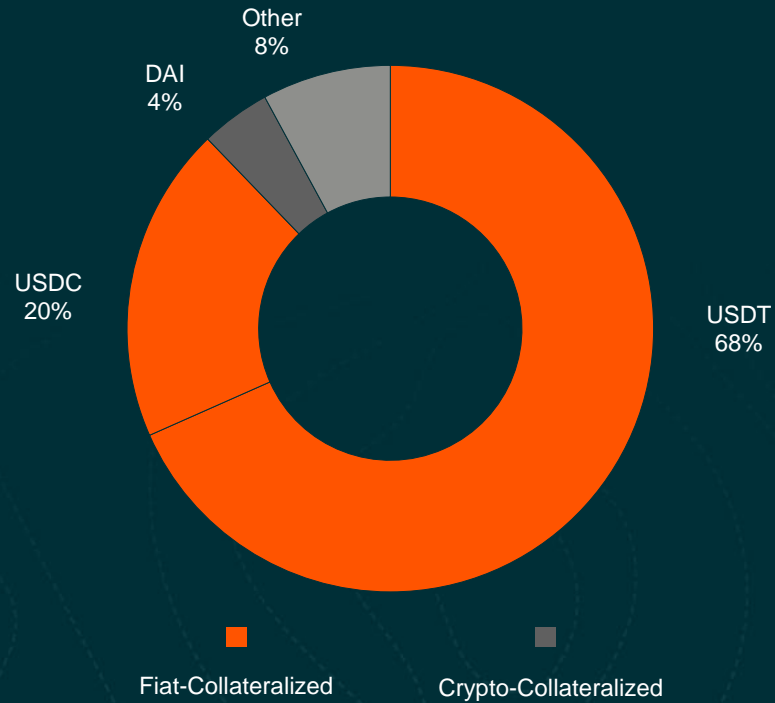


Sources: Charts: Left: Tether Holdings Limited, 2023; Circle Examination Report Audited by Deloitte, 2023; Right: U.S. Department of the Treasury, n.d.

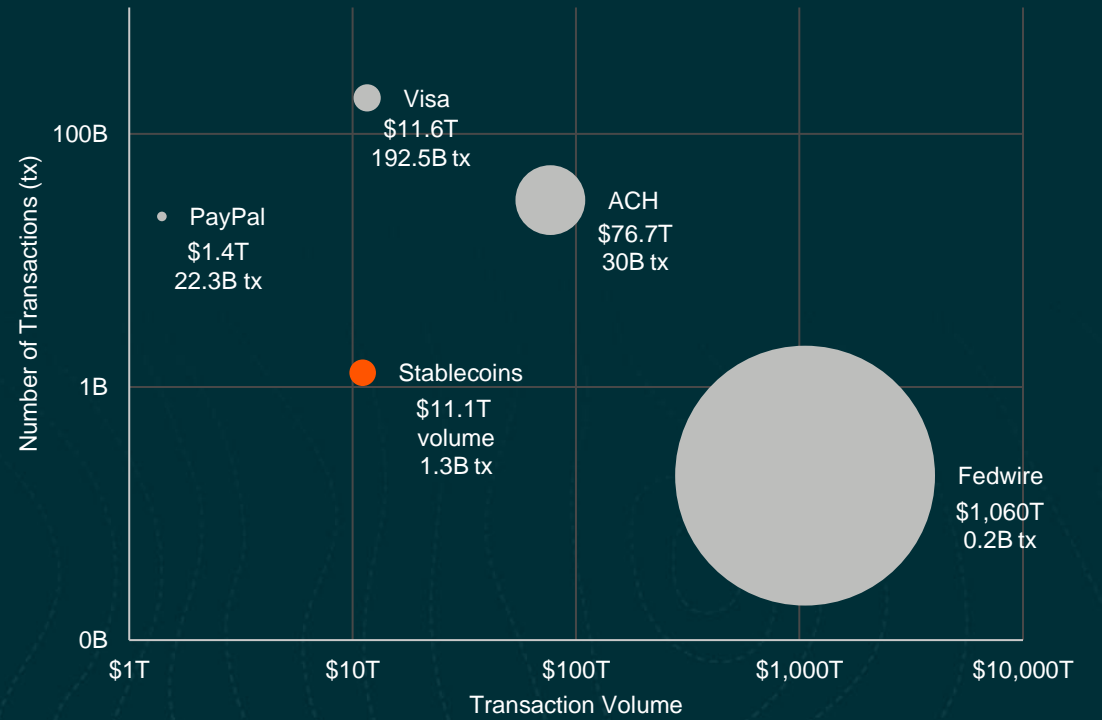
Stablecoins Have Emerged as an Efficient Rail for Global Money Transmission

Already competitive with some of the world’s largest legacy payment systems, stablecoins are set to reshape global finance and cross-border payments by ushering in an era of enhanced financial efficiency and inclusivity.

\$124B of Stablecoins Are in Circulation Today



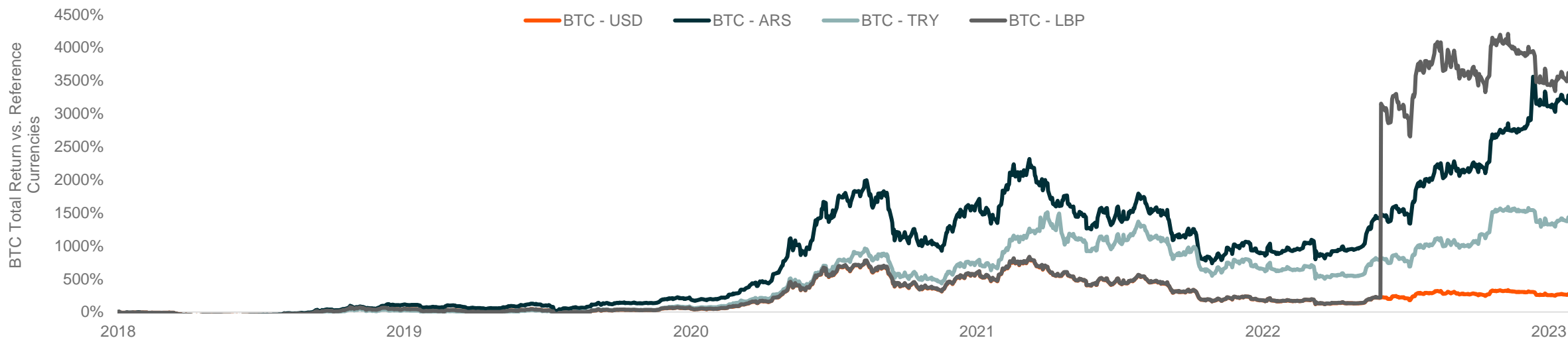
Stablecoins Settled Over \$11T in 2022



Sources: Charts: Left: DeFiLlama, n.d.; Right: Brevan Howard Digital, 2023

Bitcoin Can Be a Long-Term Hedge Against Monetary Instability

Globally accessible, verifiably scarce, and censorship-resistant, bitcoin is a digital store of value that is location-agnostic to national borders and uncorrelated to domestic issues, making it a powerful wealth preservation tool.



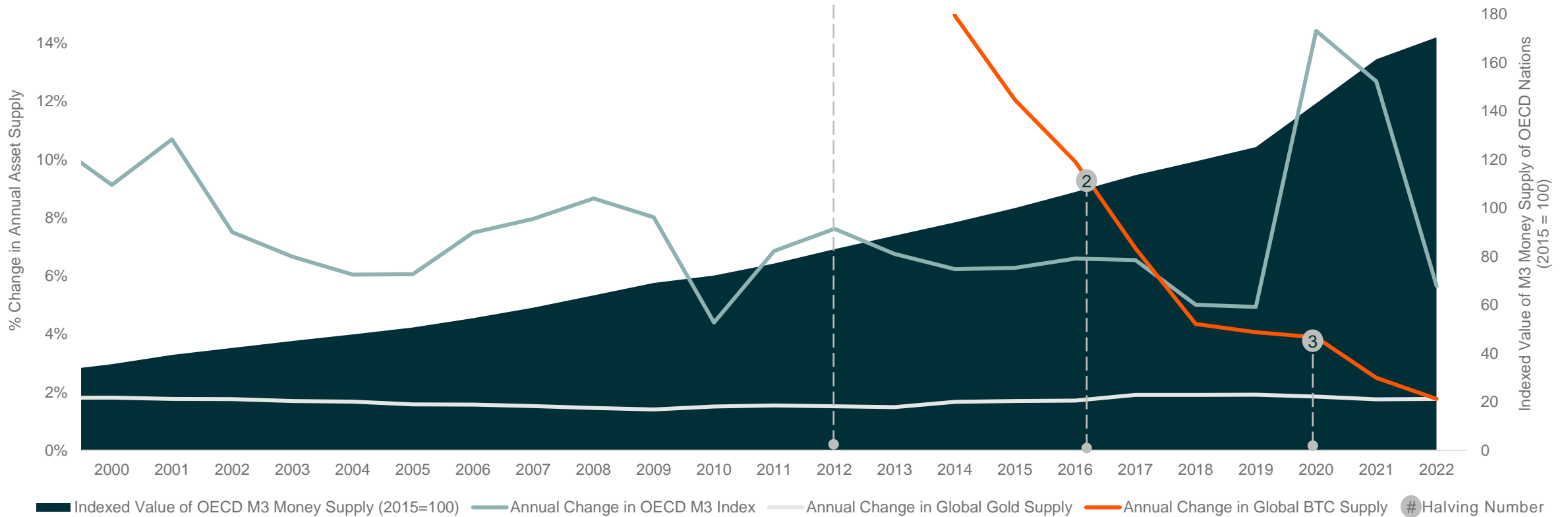
	Argentina	Turkey	Lebanon	United States
Annualized Change in Consumer Prices (September 2018–September 2023)	29.6%	34.0%	99.9%	3.7%
Total Change in Consumer Prices Since (September 2018–September 2023)	266.0%	332.6%	3093.0%	21.9%
BTC Performance (September 2018–September 2023)	3252.2%	1423.2%	3592.7%	268.6%

Notes: The Lebanese economic crisis caused an 80 - 90% devaluation of the Lebanese Pound (LBP) against the USD. Despite an official exchange rate pegged at 1,507.50 LBP - USD since 1997, at least three alternative LBP - USD exchange rates emerged to reflect true market value between 2018 and 2023. In February 2023, the official peg was changed to 15,000 LBP - USD. BTC = Bitcoin, ARS = Argentinian Peso, and TRY = Turkish Lira.

Sources: Bloomberg, n.d.; Bloomberg, n.d.; U.S. Bureau of Labor Statistics. (2023); U.S. Bureau of Labor Statistics. (2018)

Bitcoin's Supply Constraints Provide Scarcity Assurances

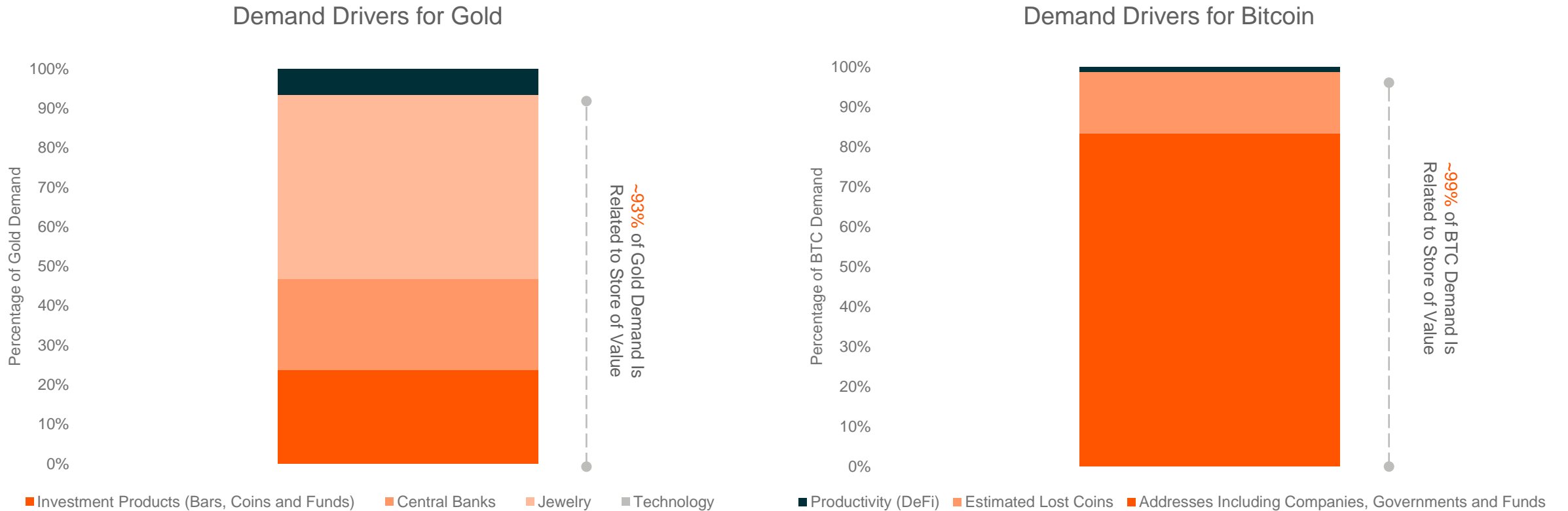
Gold production is limited by mining resources. Bitcoin's supply schedule is defined by the protocol code and protected by consensus. Without these constraints supply can be highly variable, and debasement can accelerate.



Sources: Organization for Economic Cooperation and Development, n.d.; Our World in Data, n.d.; World Gold Council, n.d.; Glassnode, n.d.

Store of Value Is the Primary Demand Driver for Gold and Bitcoin

Gold’s long history as a store of value (SoV) stems from its scarcity, durability, and near-universal aesthetic appeal, underpinning its perceived value. Based on user data, bitcoin demonstrates similar attributes but in a digital format.



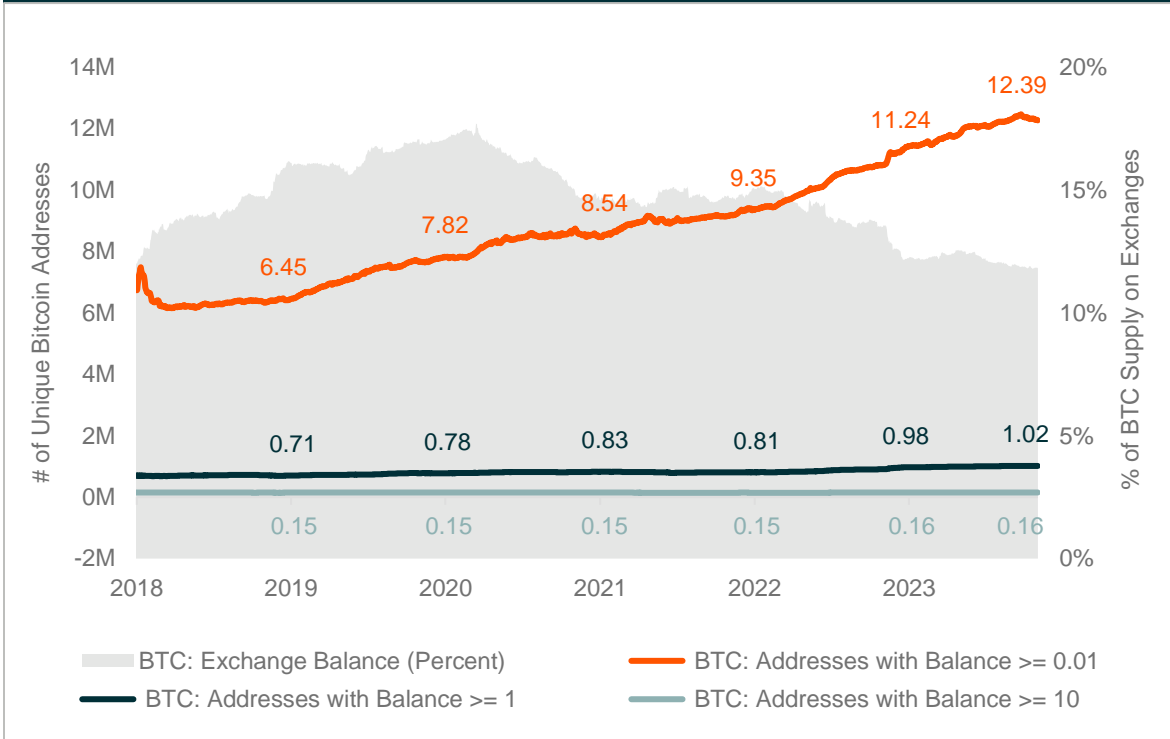
Note: Gold demand values as of 2022

Sources: Charts: Left: World Gold Council, n.d.; Right: Glassnode, n.d.; Bitcoin treasuries.net, n.d.; The Wall Street Journal, 2018; Unchained, 2023

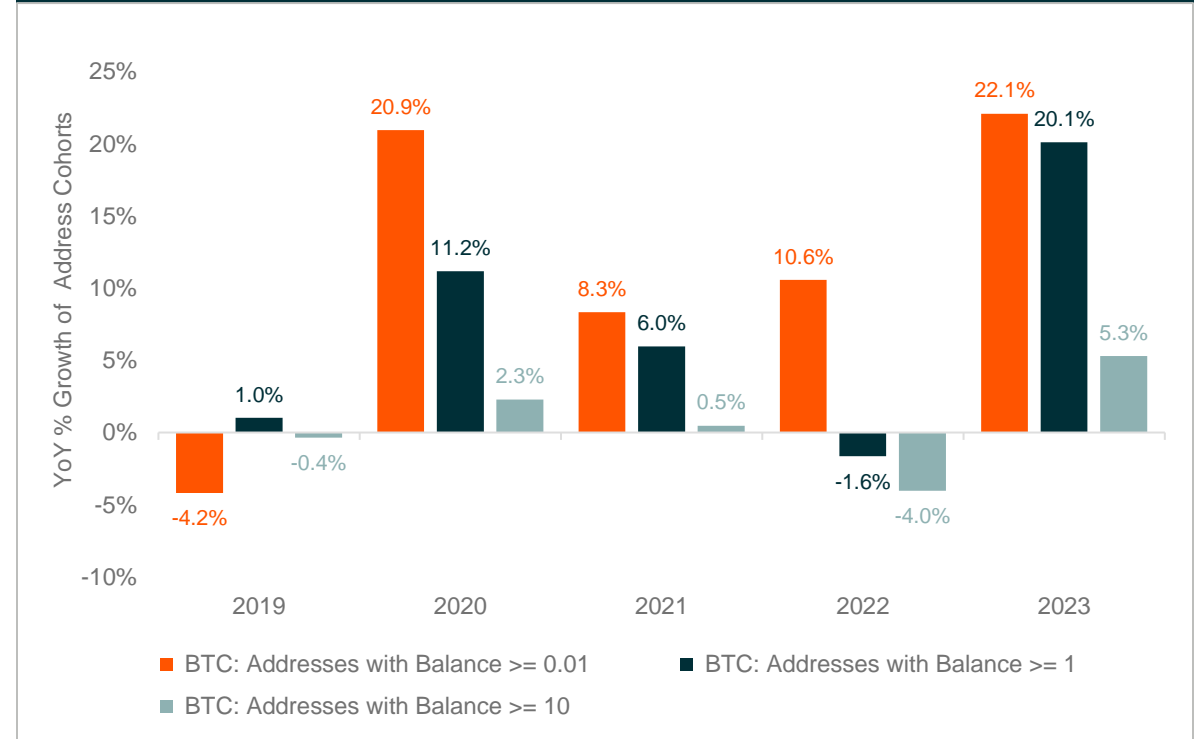
Small and Self-Custodial Account Trends Suggest Growing Appeal of Bitcoin Values

Growth of self-custodial bitcoin wallets suggests that the network’s value proposition is gaining traction. Further, the growth of wallets with smaller balances may indicate increasing adoption among retail consumers.

BTC Flows Off Exchanges Suggests Self-Custody Trend



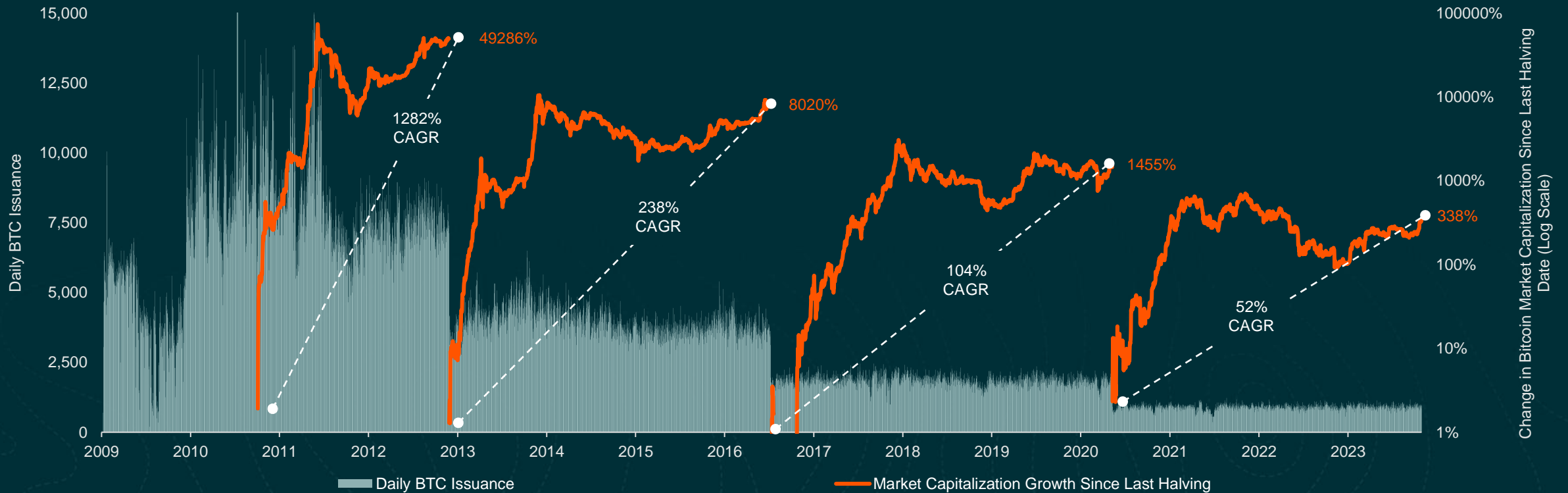
Small Wallet Growth Shows Resilience of Retail Consumers



Sources: Charts: Glassnode, n.d.

The Value of Bitcoin's Scarcity Increases with Each Halving

Every four years, the halving reduces bitcoin's issuance rate by 50%, enforcing its scarcity.¹ Though the timing of these events is predictable, the market only tends to find a new equilibrium market cap after the event occurs.

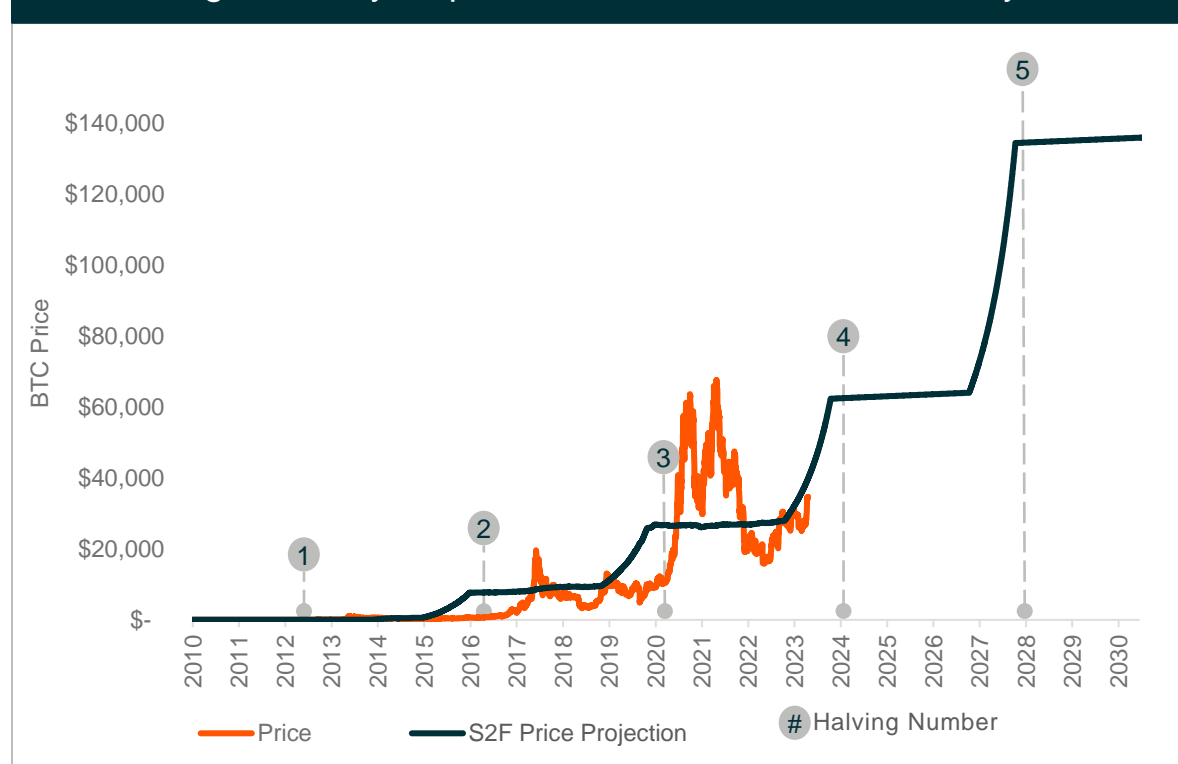


Sources: Text: 1. Conway, 2023; Chart: Glassnode, n.d.

Valuing Bitcoin's Scarcity Using Stock-to-Flow

Stock-to-flow (S2F) models quantify the scarcity value of assets with a limited supply. They provide insights into how scarcity affects value and market dynamics by calculating the ratio of existing supply (stock) to annual production (flow).

Increasing Scarcity Implies BTC Value of \$60,000+ by 2024



Bitcoin S2F Model Outputs

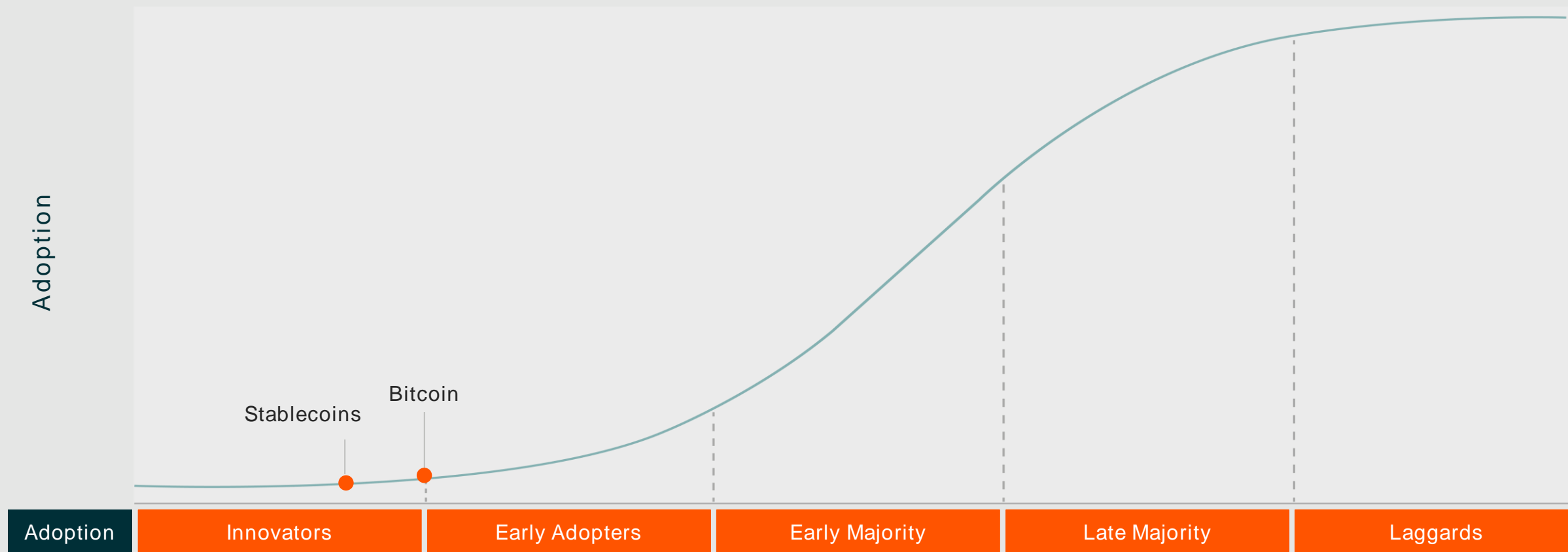
Halving #	BTC Issued Per Block (Pre/Post Halving)	Stock-to-Flow Ratio	Observed BTC Value	Implied Value of BTC Scarcity
1 (November 28, 2012)	50/25 BTC	6.8 Years	\$12	\$0
2 (July 9, 2016)	25/12.5 BTC	22.9 Years	\$677	\$7,655
3 (May 11, 2020)	12.5/6.25 BTC	54.1 Years	\$8,600	\$25,228
4 (Estimated April 2024)	6.25/3.125 BTC	119.5 Years	-	\$62,134
5 (Estimated April 2028)	3.125/1.5625 BTC	247.7 Years	-	\$134,382

Note: The stock-to-flow ratio signals the number of years it takes to replace existing supply at current annual production rates.

Sources: Charts: Glassnode, n.d.

Unlocking Digital Assets: S-Shaped Curve of Adoption

Bitcoin occupies the transition between innovators and early adopters on the adoption curve, while stablecoins are firmly rooted among innovators. Both show strong progress in adoption.



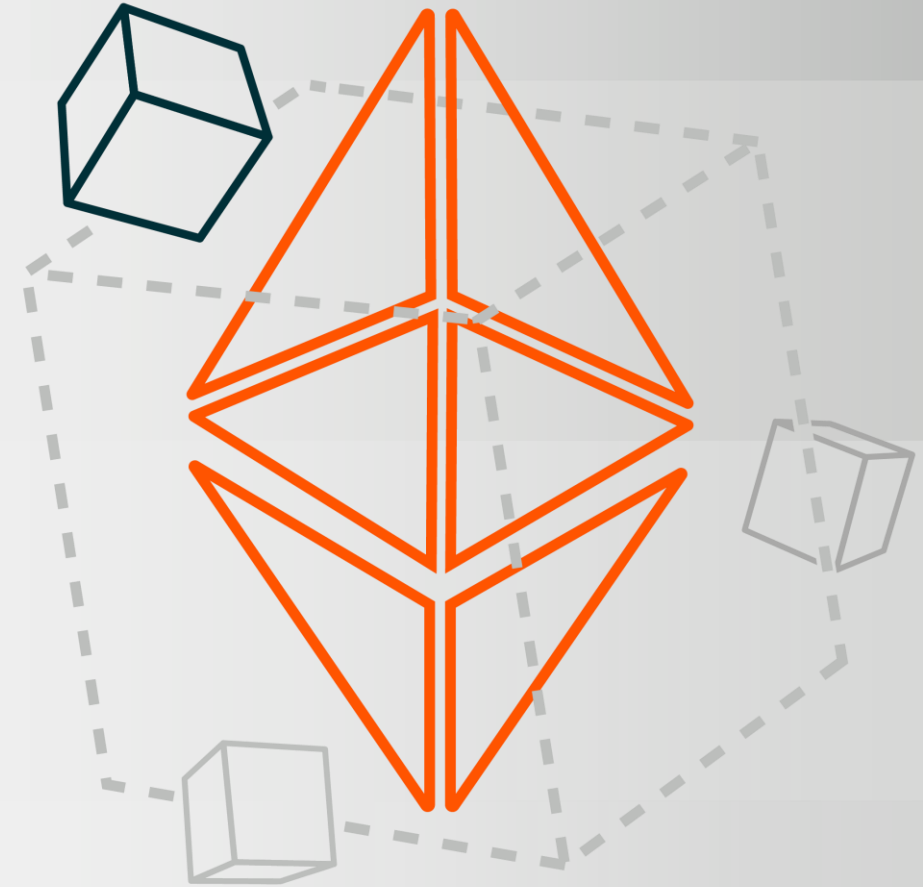
Note: For illustrative purposes only.

Crypto & Blockchain Quests

Ethereum's Blueprint

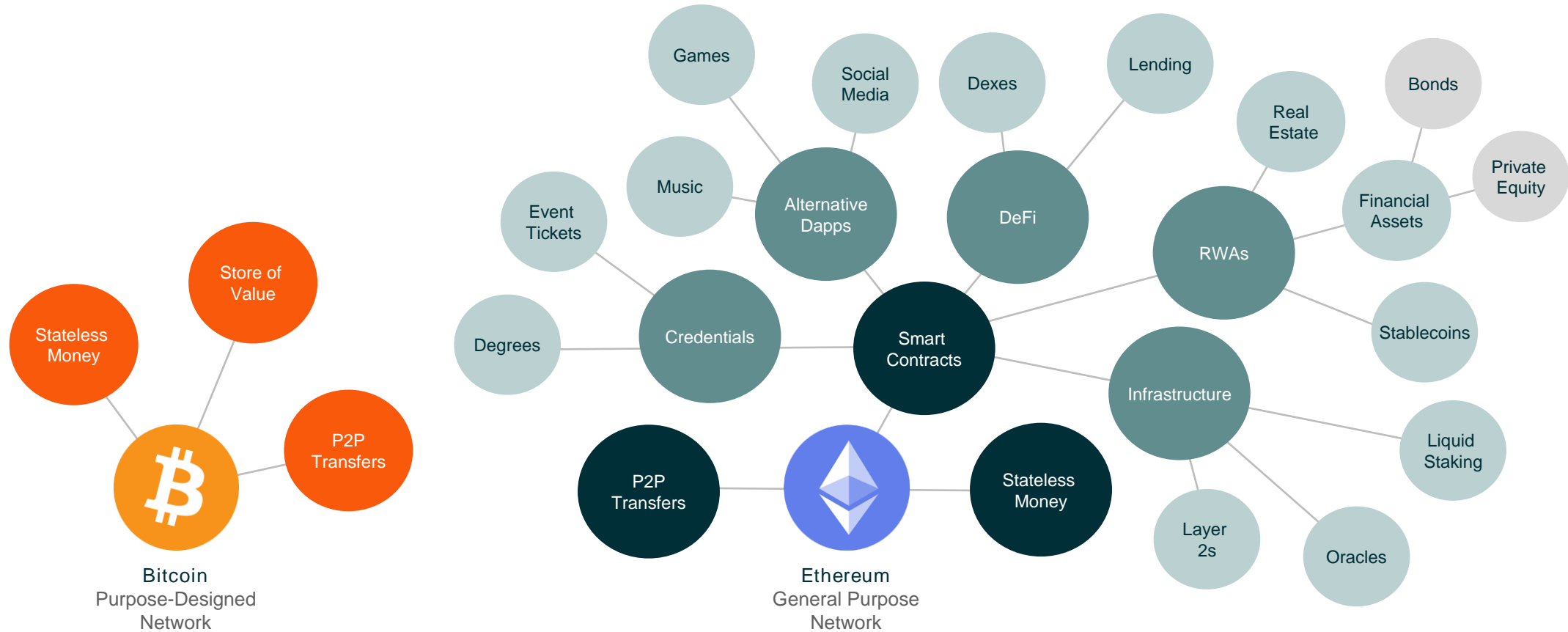
Exploring Infrastructure Upgrades

Ethereum, the leading smart contract blockchain, underwent a significant upgrade last year, transforming its security model, reducing its carbon footprint, and reshaping network economics. While Ethereum presently supports various applications such as stablecoins, decentralized finance (DeFi), and asset tokenization, enhancing transaction capacity and reducing settlement costs are crucial for the success of additional use cases. The recent network upgrade lays the foundation for achieving these objectives, with recent advancements in scaling technology underscoring layer 2 rollups (L2s) as the preferred solution to build upon this foundation.



Diverse Applications of Public Blockchain Networks

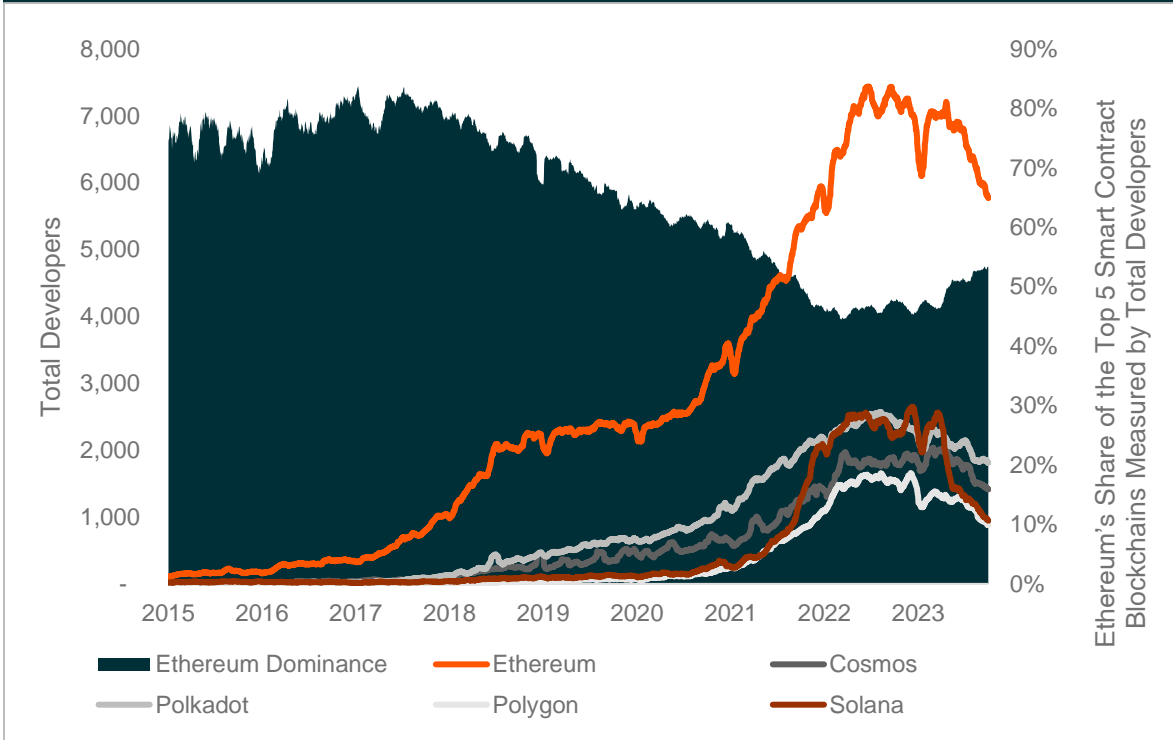
The blockchain landscape consists of both purpose-designed networks - such as Bitcoin, which secures the settlement of bitcoin (BTC) transfers - and flexible networks - like Ethereum, which can be a settlement layer for any arbitrary data.



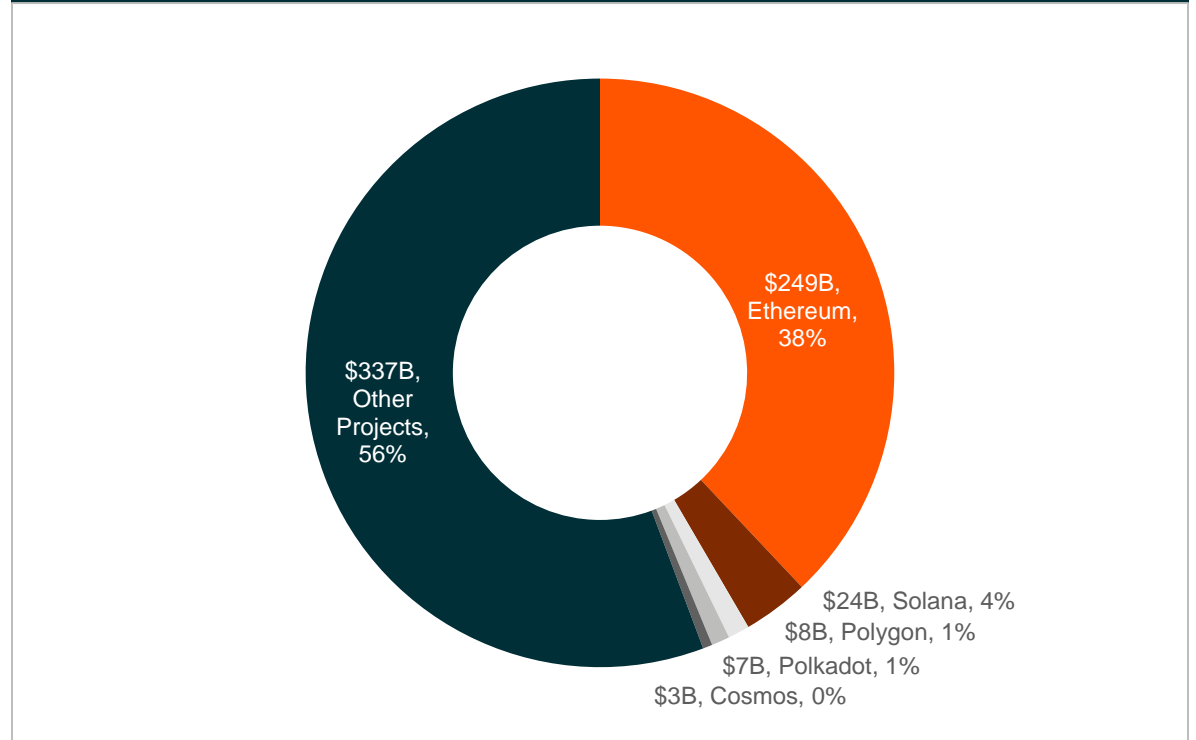
Ethereum Is the Leading Smart Contract Blockchain Ecosystem

Ethereum is the largest smart contract network as measured by developer activity and market valuation. Its significance lies in its robust infrastructure and versatile capabilities, which make it a hub for blockchain-based innovations.

Ethereum Commands the Largest Share of Developers



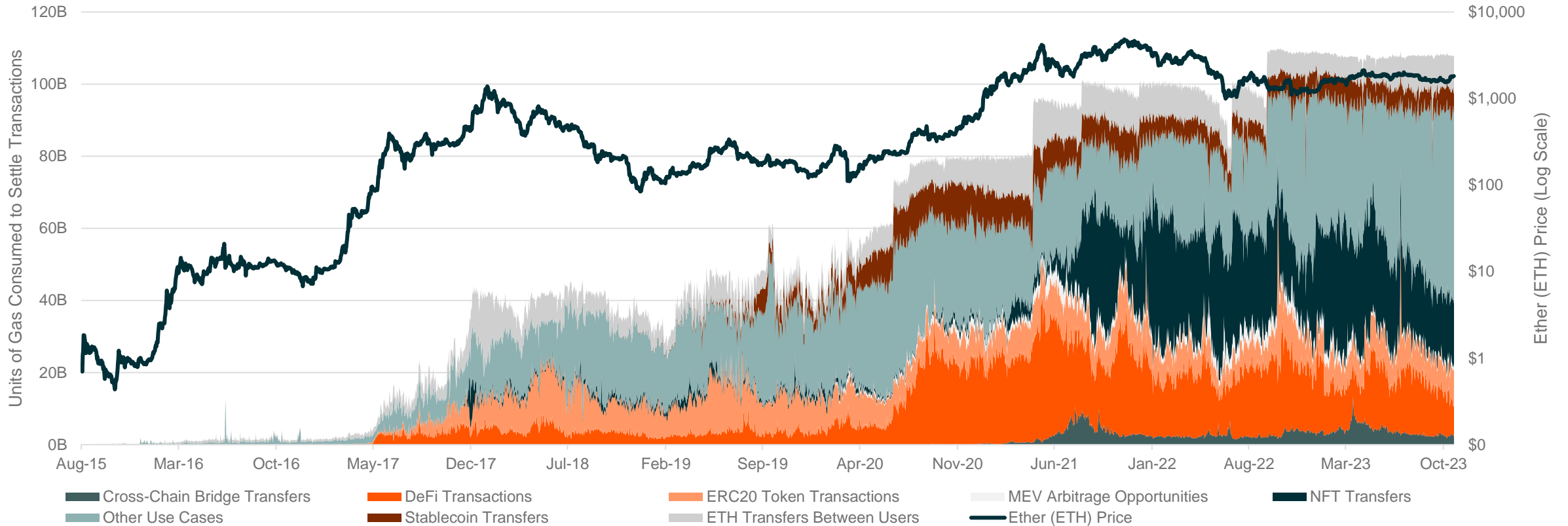
Excluding Bitcoin, Ethereum Holds 38% of the \$658B Market



Sources: Charts: Left: Developer Report, n.d. ; Right: TradingView, n.d.

Ethereum Infrastructure and Smart Contract Development Enable a Range of Applications

While decentralized finance (DeFi), P2P transfers, and tokenization are the largest demand drivers today, Ethereum's use cases are likely to continue to grow.

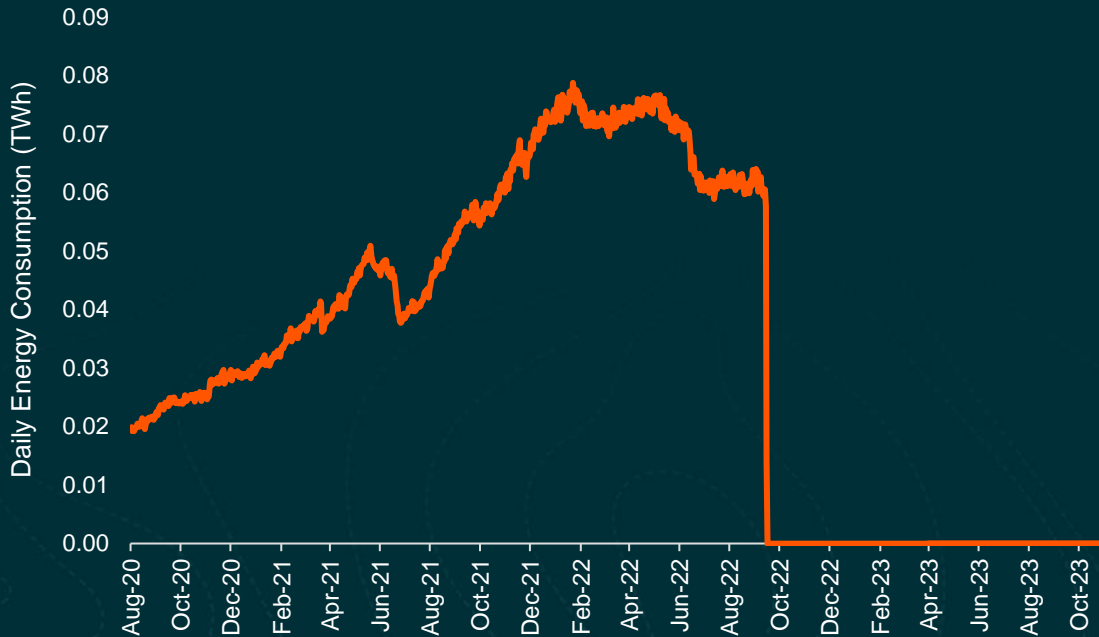


Sources: Glassnode, n.d.

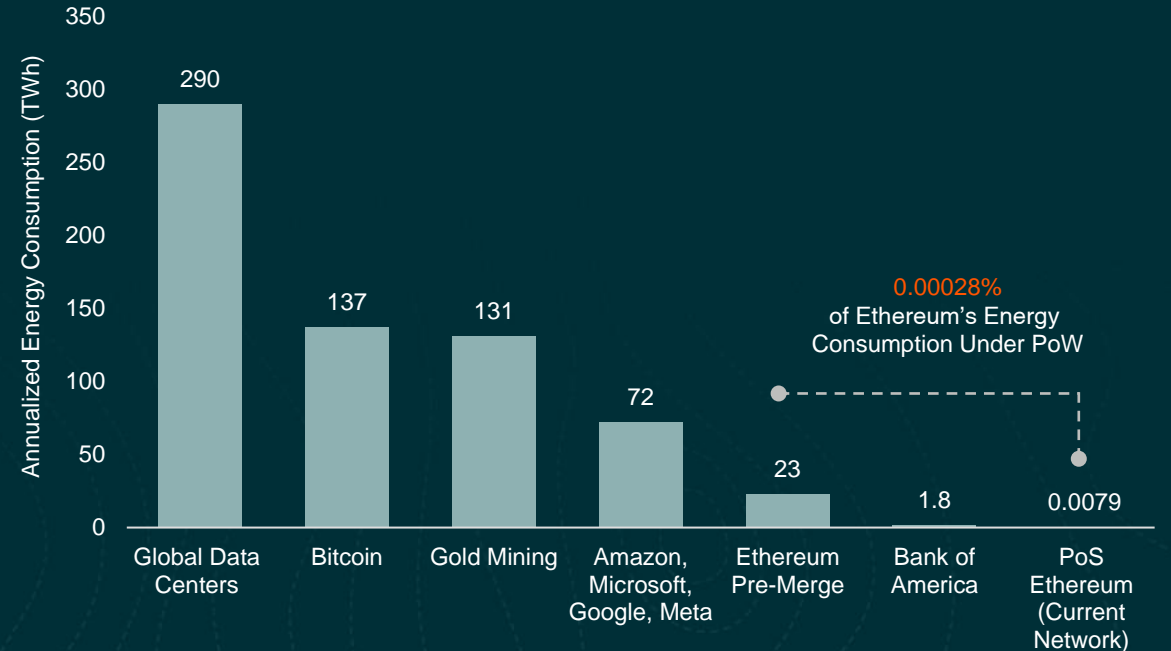
The Merge Fundamentally Overhauled Ethereum's Energy Profile

At the precise moment Ethereum transitioned to Proof-of-Stake (PoS), the network's energy consumption was reduced by roughly 99.9%, making it one of the most eco-friendly global networks in a matter of minutes.¹

The Merge Reduced Ethereum's Electricity Use by 99%



Contextualizing Ethereum's Energy Consumption

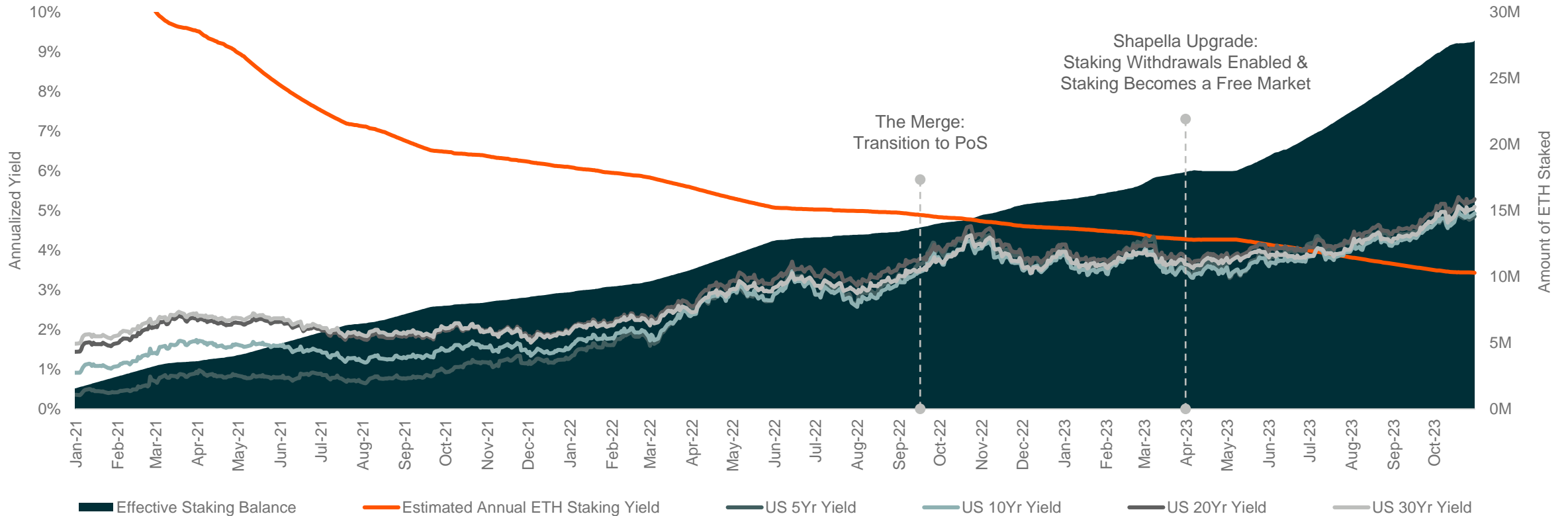


Note: Global Data Centers data represents midpoint of estimate of 240 – 340 TWh/year and excluded energy used for crypto mining.

Sources: Text: 1. Ethereum, 2023; Charts: Left: Crypto Carbon Ratings Institute, n.d.; Right: Crypto Carbon Ratings Institute, n.d.; Bank of America Corporation, 2023; International Energy Agency, n.d.; Cambridge Centre for Alternative Finance, n.d.

Ethereum's New Security Model Gives Rise to the Internet Bond

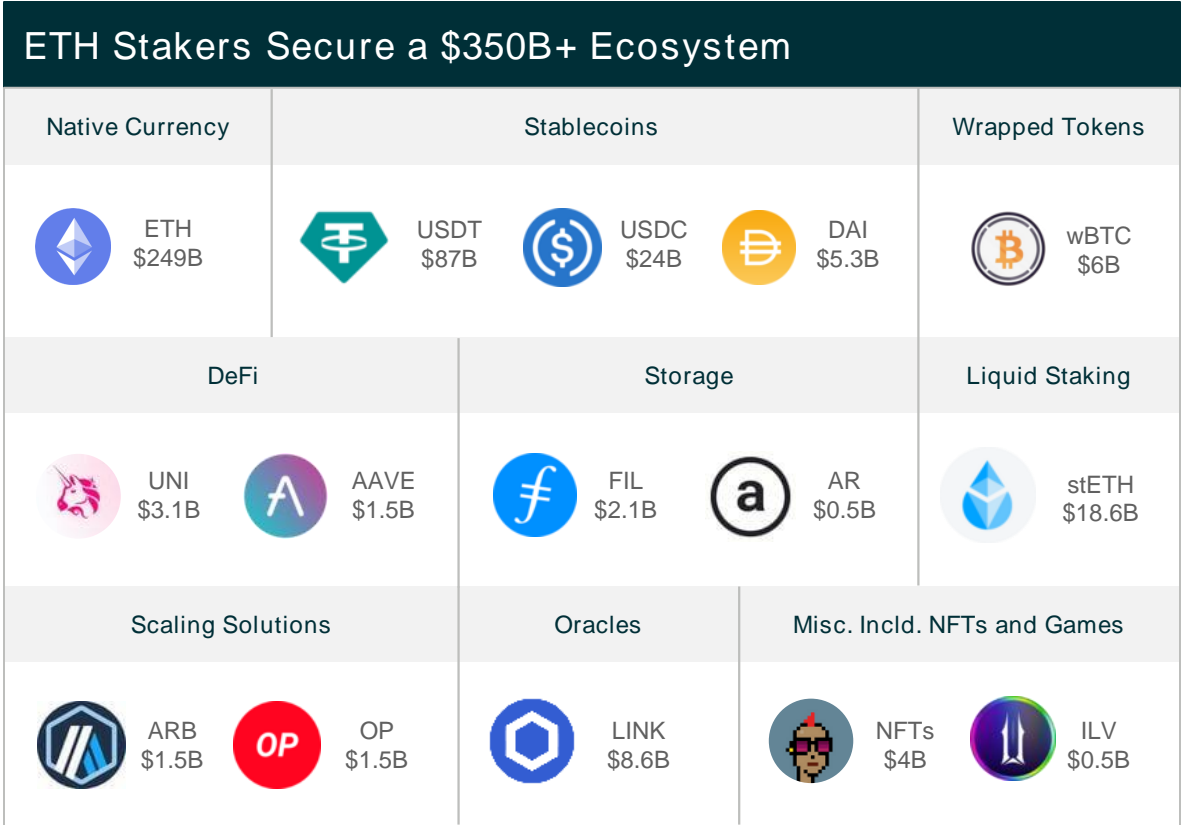
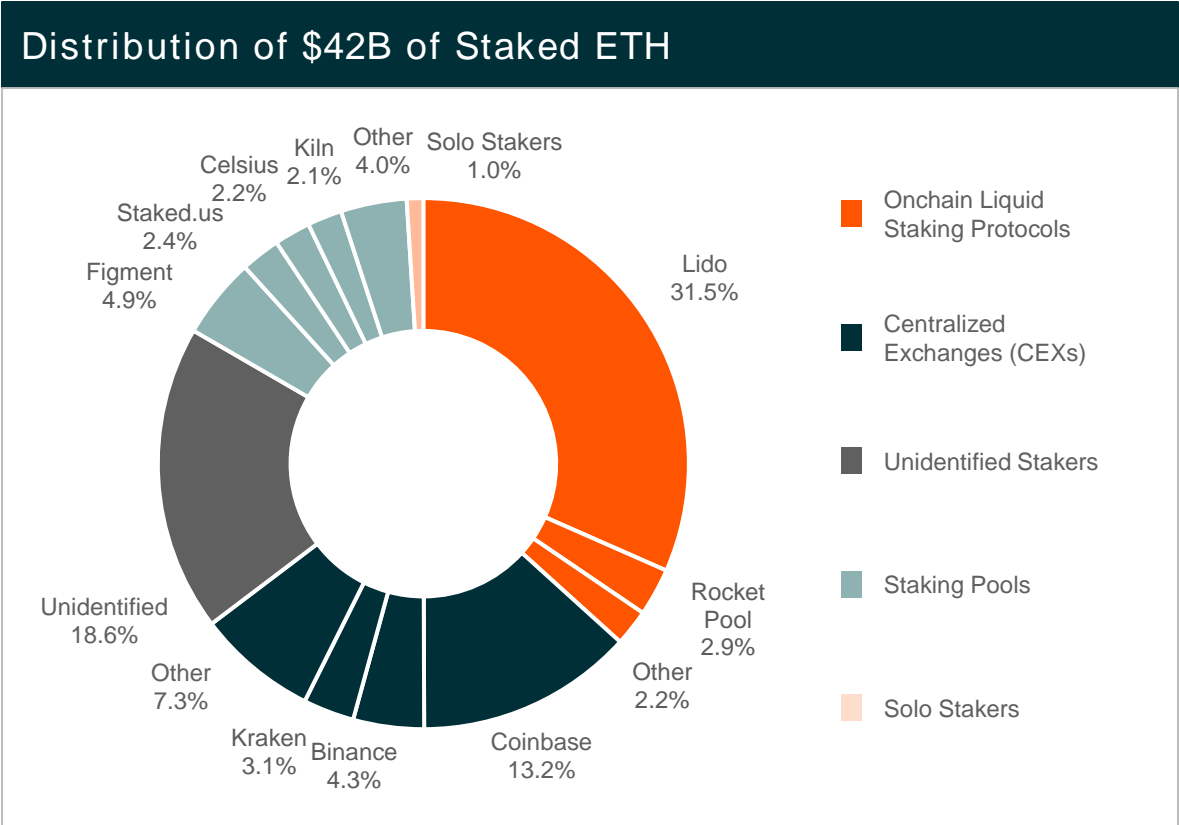
Ethereum's shift to PoS changed how the network reaches consensus, replacing mining with staking. Under PoS, consensus is coordinated by users who collateralize ether (ETH), earning a dynamic ETH-denominated yield in return.



Sources: Bloomberg, n.d.; Glassnode, n.d.

Ethereum Staking Has Become a Multi-Billion Dollar Security Barrier for an Ecosystem of Value

Ethereum's economic security is underpinned by capital commitments made by a decentralized network of participants. This community safeguards all the value settled on Ethereum.

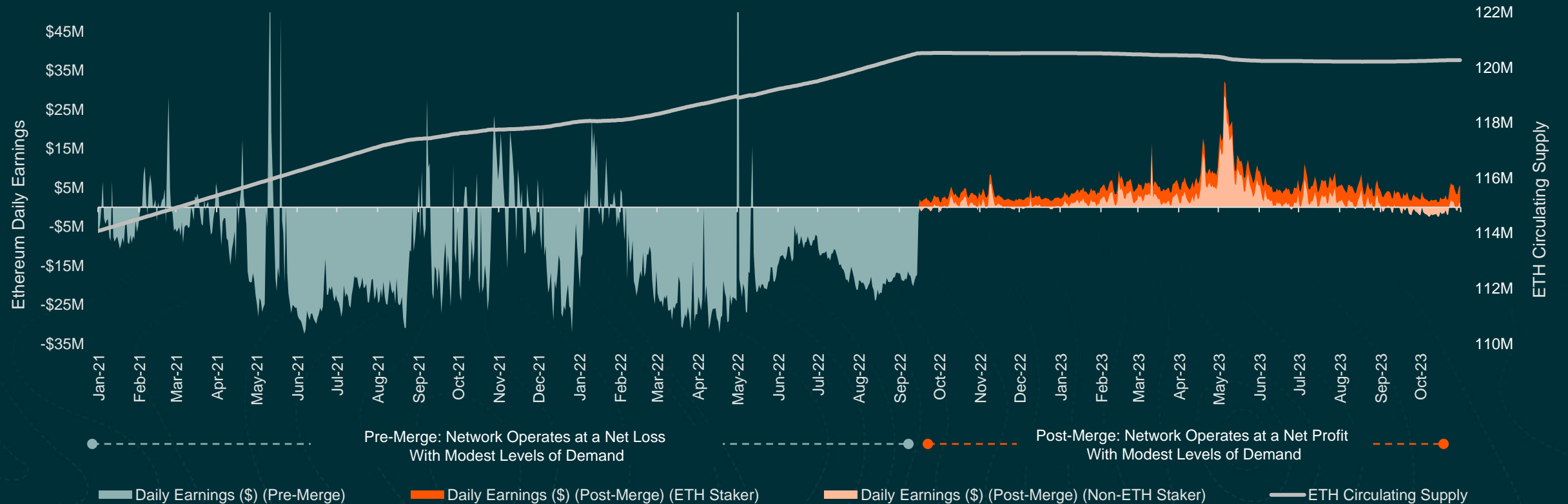


Note: Unidentified stakers could be composed of solo stakers. Solo stakers include known addresses from community members.

Sources: Charts: Left: Dune, n.d.; Right: Ultrasound Money, n.d.; TradingView, n.d.; CoinGecko, n.d.; Nftgo, n.d.

A Reduction in Issuance Makes Ethereum a Sustainably Profitable Protocol

The shift to PoS increased Ethereum's profitability by eliminating the need to pay external actors (miners) for security. Instead, consensus rewards are now distributed to ETH holders who participate in staking.

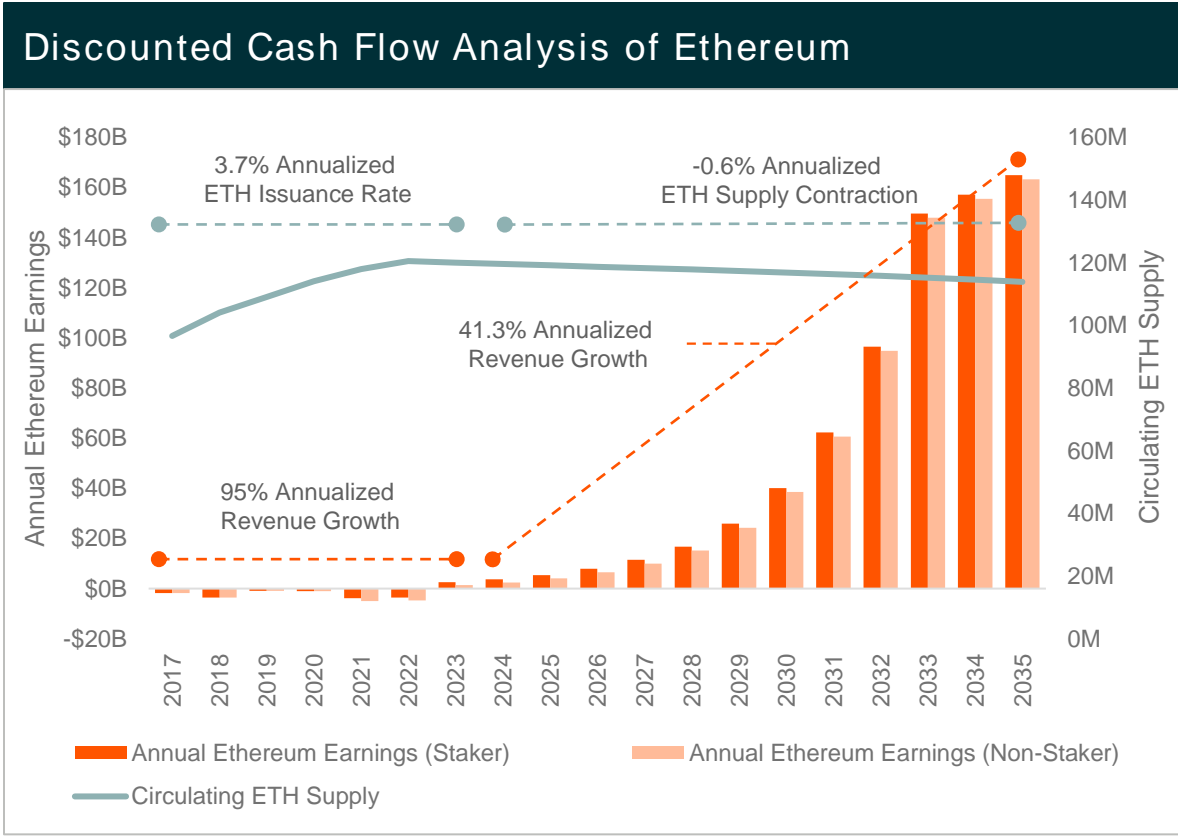


Note: While ownership of ETH is a prerequisite to participate in staking and earn staking yield, staking is an opt-in activity. As a result, the population of ETH holders is composed of both stakers and non-stakers. We have conducted an analysis of post-Merge network profitability from the standpoint of both these participant categories.

Sources: Glassnode, n.d.

Fundamental Analysis Suggests Ethereum's Growth Potential Is Undervalued

Ethereum generates revenue from gas fees, which users pay to execute transactions and deploy smart contracts on the network. Ethereum's global reach and vast functionality create significant revenue growth potential.



DCF Inputs & Growth Assumptions

	Base Case	Bear Case	Bull Case	
Inputs	Initial Rev. Growth (2024 - 2028)	45%	15%	55%
	Mid-Term Rev. Growth (2029 - 2033)	55%	20%	70%
	Perpetual Rev. Growth (2034 -)	5%	2%	6%
	Equilibrium Staking Yield	2%	5%	1%
	Annual ETH Gas Fee Growth	3%	1%	4%
Outputs	Annual Earnings (Yr. 2035)	\$165B	\$13.6B	\$372.5B
	ETH Supply (Yr. 2035)	113.2M	113.9M	113.6M
	Staked ETH Fair Value	\$6,446	\$579	\$15,785

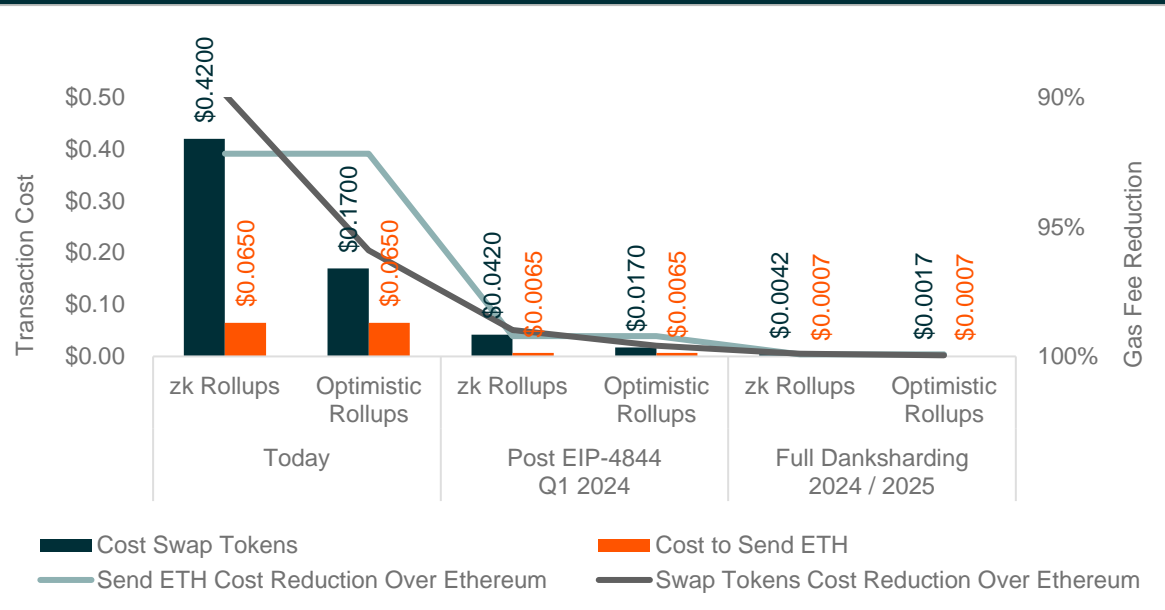
Note: The discounted cash flow (DCF) valuation of ETH is assessed from the standpoint of an ETH staker.

Sources: Charts: Glassnode, n.d.

Scaling Throughput Is at the Forefront of Ethereum Innovation

Ethereum’s transactional capacity is intentionally limited to optimize for secure and decentralized data settlement. Layer 2 (L2) rollups allow Ethereum to exponentially scale transaction execution without sacrificing its core values.

Advancements in Scaling Infrastructure Reduces L2 Costs



The Traits of the Main L2 Rollup Categories

Category	Optimistic Rollups	zk Rollups
Transaction Finality	Seven days due to the arbitration period required to audit fraud proofs	12 minutes due to the mathematical assurances of zero-knowledge proofs
Transaction Costs	Lower	Higher
Compatibility with Ethereum Virtual Machine (EVM)	Easier to program	Harder to program
Security	Strong due to the economic incentives of fraud proofs	Strong due to the cryptographic proofs generated

What Are Layer 2 (L2) Rollups?

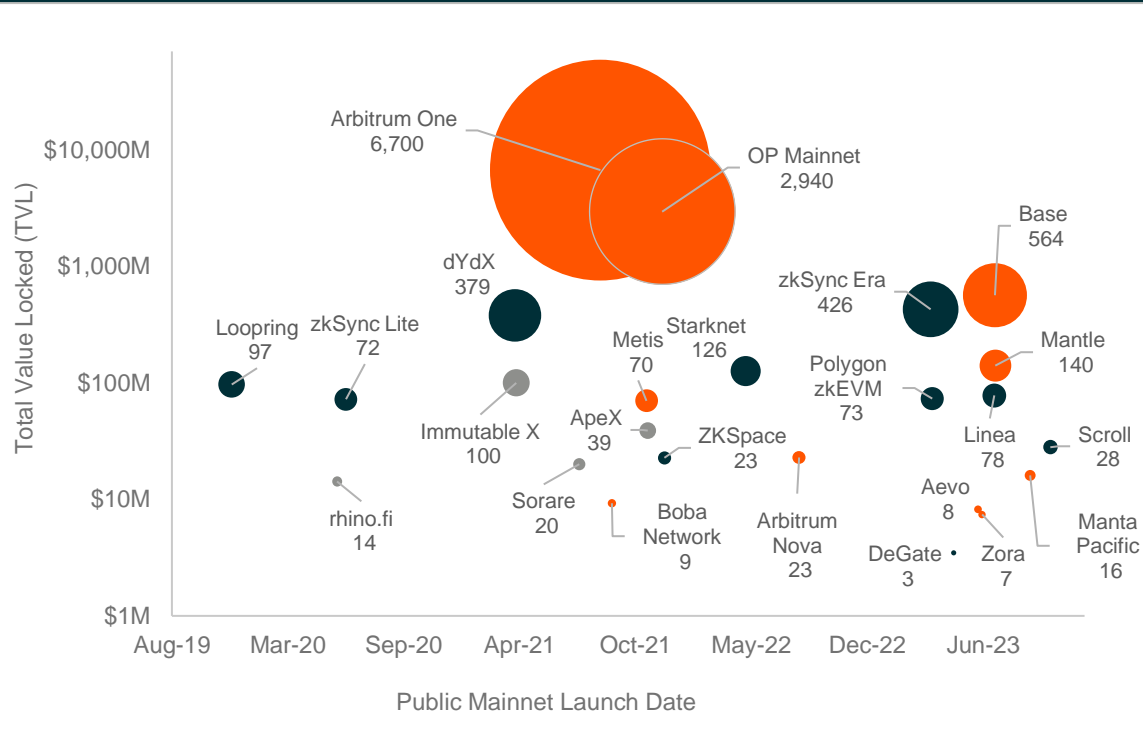
L2 rollups are a blockchain scaling solution that moves transactions off the main Ethereum blockchain (Layer 1) to improve speed and reduce fees. L2s batch multiple transactions into a single cryptographic proof and submit this aggregated data to Ethereum.

Sources: Charts: Left: L2fees.info, n.d.; EIP-4844, n.d.; Right: Blockchain Council, 2022

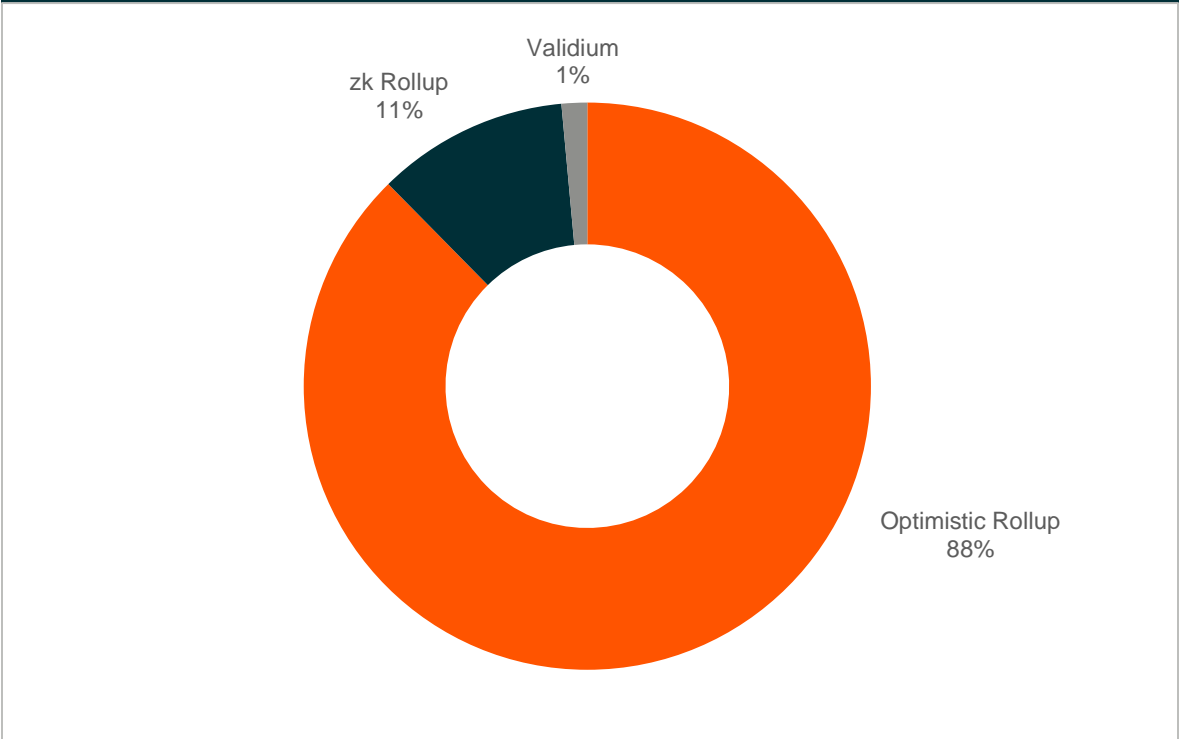
The Race to Develop Cheap, Fast, and Secure L2 Execution Is Heating Up

Competition across the L2 ecosystem has accelerated substantially over the past two years. This competition is driving innovation, leading to diverse approaches to scaling, each tailored to different use cases.

L2 Networks Have \$11.9B in Total Value Locked



Optimistic Rollups Dominate, zk Rollups Gain Ground

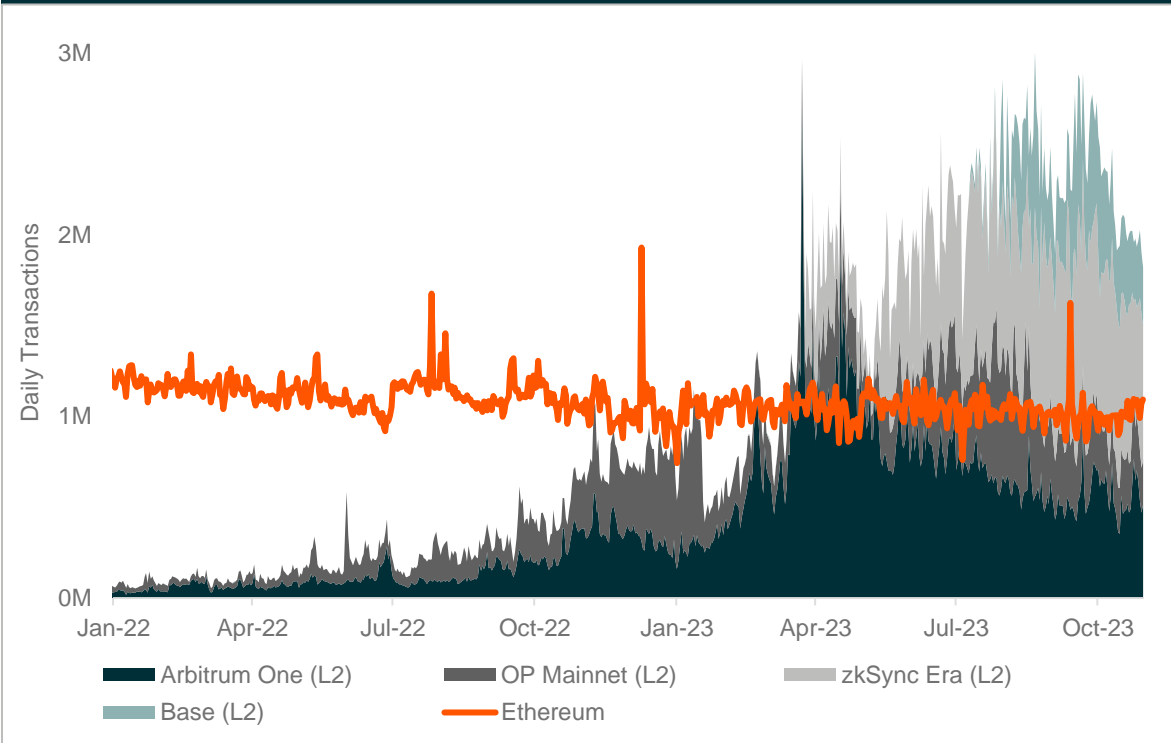


Sources: Charts: L2 Beat, n.d.

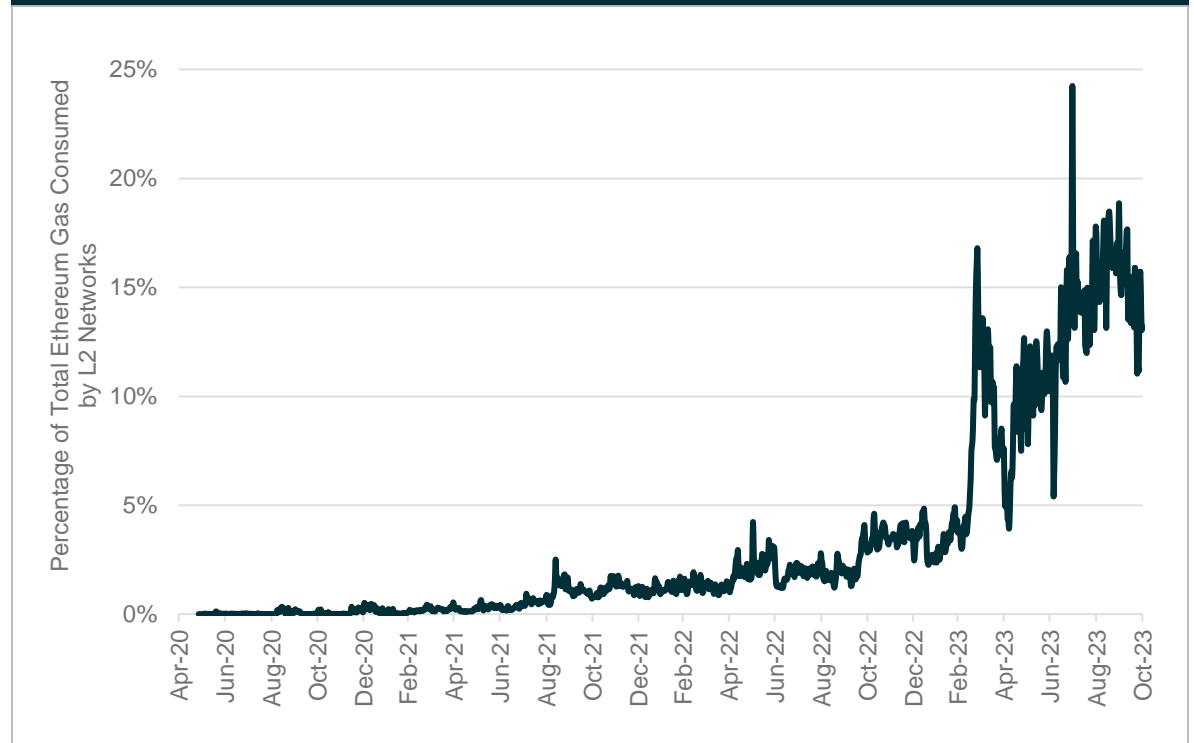
Ethereum's Scaling Strategy Is Working as More Transactional Demand Migrates to L2 Networks

Ethereum L2s capture a growing portion of Ethereum's transaction demand, providing a boon to Ethereum's throughput. L2s have already expanded Ethereum's transactional bandwidth by more than double.

L2s Now Execute More Transactions Than Ethereum



L2s Utilize a Growing Share of Ethereum Compute

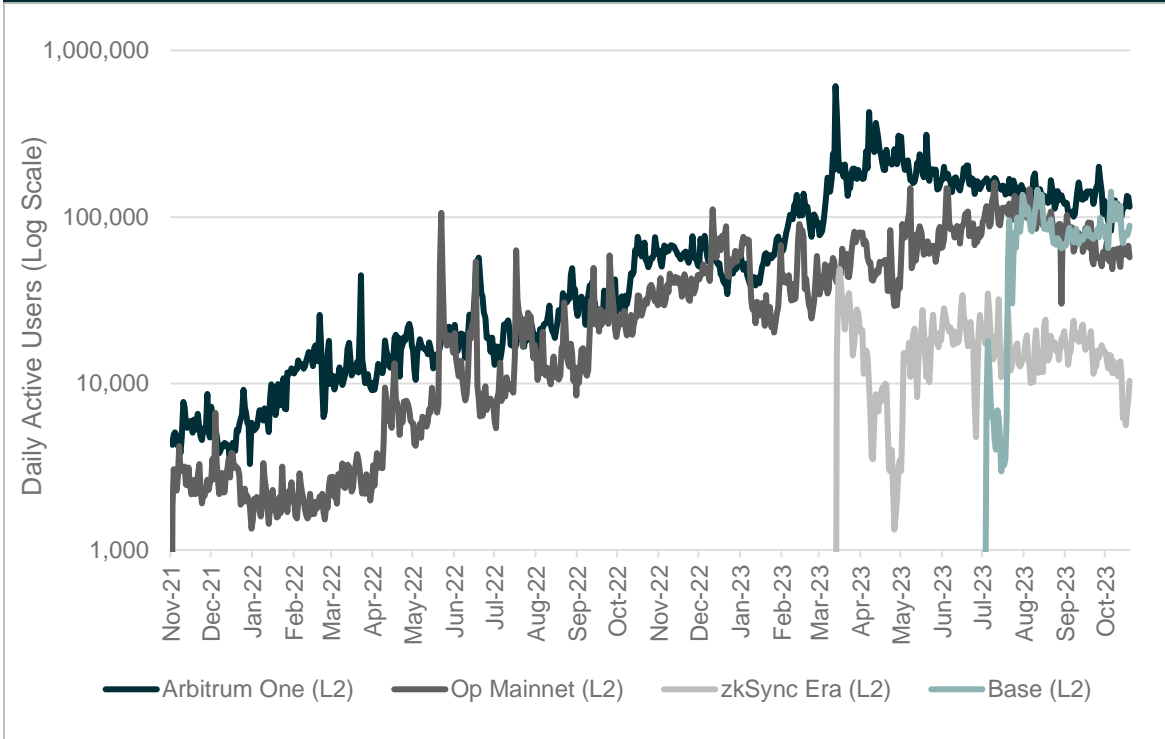


Sources: Charts: Left: Etherscan, n.d.b; Arbiscan, n.d.; Optimism, n.d.; Dune, n.d.b; Dune, n.d.c; Right: Etherscan, n.d.a; Dune, n.d.a

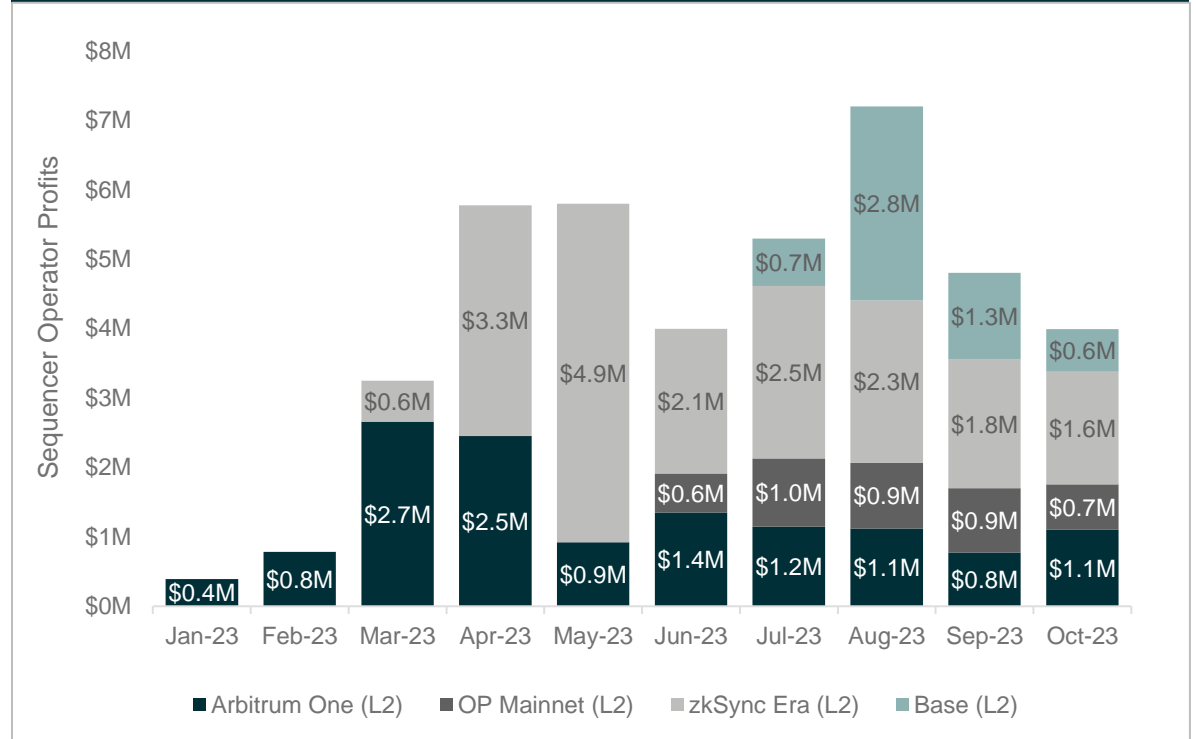
Adoption of L2 Networks Is Driving Transactional Demand and Growing Profits

Accelerating adoption of L2 networks is driving an increased appetite to transact across the Ethereum ecosystem, leading to growing profitability of L2 operators.

L2 User Onboarding Rates Are Accelerating



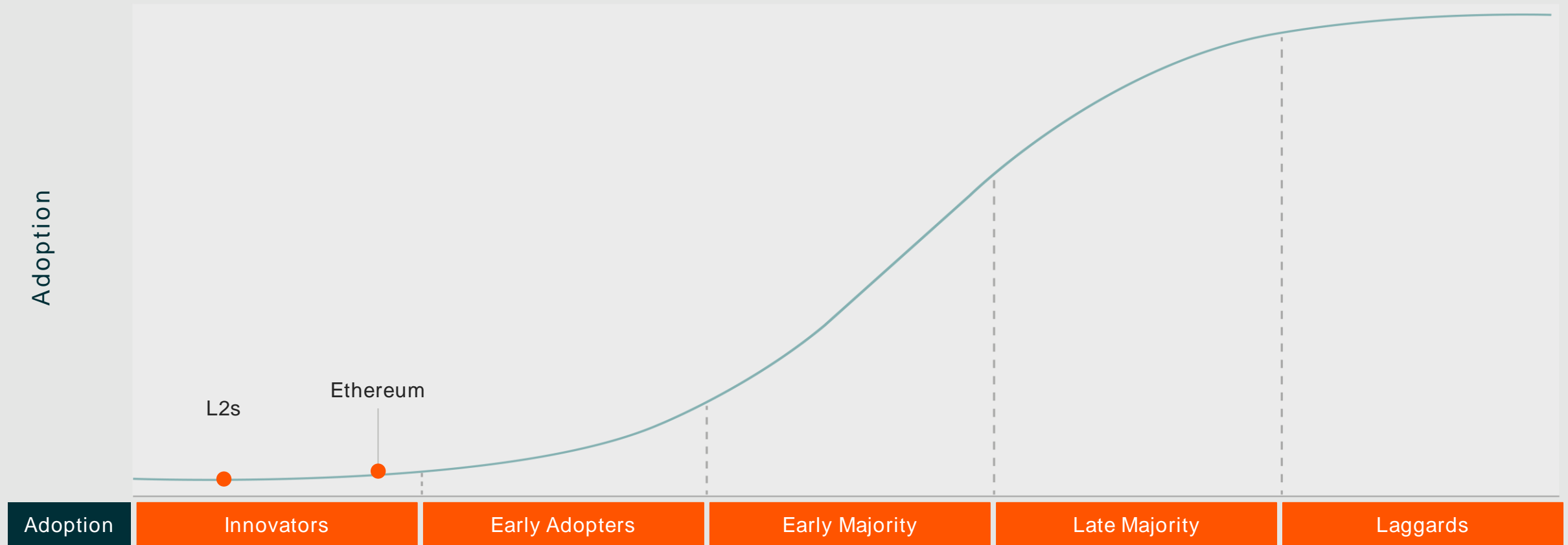
Growing L2 Demand Drives Sequencer Profitability



Sources: Charts: Dune, n.d.a; Dune, n.d.b; Dune, n.d.c; Dune, n.d.d

Ethereum's Blueprint: S-Shaped Curve of Adoption

Ethereum and L2s are currently in the Innovator's stage on the adoption curve, indicating that they are still in the early phases of widespread adoption and implementation.



Note: For illustrative purposes only.

Crypto & Blockchain Quests

Blockchain Trends

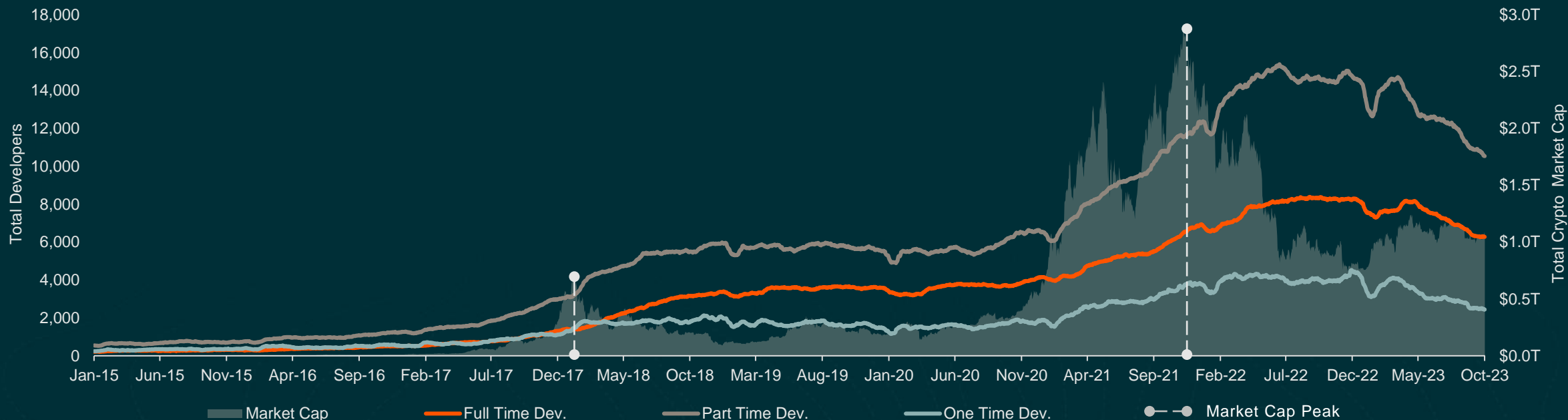
Applications of the Technology

Blockchains are adapting to accommodate a variety of applications, fueled by growing developer engagement and infrastructure improvements that ensure cost-effective, fast, and secure computing. Decentralized finance (DeFi) applications are establishing credible alternatives for asset exchange, credit, and yield opportunities. The tokenization of real-world assets is opening the door to enhanced liquidity and capital efficiency while fundamentally transforming how ownership is represented. Beyond financial applications, consumer-oriented uses like onchain social networks, data storage, and map navigation infrastructure are broadening the scope of blockchain applications.



Full Time Developer Activity Remains Unchanged Since the Peak of the Market in Q4 2021

Software developers are invaluable in driving innovation and long-term growth of crypto ecosystems. Code commitments from full-time developers have been resilient and steadily rising through market cycles.



Performance 12 Months Post-Market Cap Peak

January 6, 2018 – January 6, 2019

November 7, 2021 – November 7, 2022

Full Time Developer Growth

131%

28%

Market Cap Growth

-82%

-70%

Sources: Charts: Developer Report, n.d.; TradingView, n.d.

Global Brands Are Progressing Beyond Blockchain Experimentation

Raghu Yarlagadda

Global brands are no longer just exploring blockchain technology. They are also leveraging it as a strategic tool to enhance business operations, build new revenue segments, and create innovative customer experiences.



Supports Building on Ethereum

EY is pioneering an Ethereum-based carbon emission tracking platform and contributing to zero-knowledge tech to enable privacy-preserving features on public blockchain networks.



Tests Tools to Simplify Crypto UX

Visa deploys its first paymaster smart contract on the Ethereum Goerli testnet, demonstrating its commitment to investing in account abstraction research.



Unveils USD Stablecoin on Ethereum

PayPal is the first major U.S. financial institution to launch a dollar-backed stablecoin with the goal of streamlining digital payments.



Generates \$185M in NFT Sales Since 2021^{1,2}

Nike's NFTs can be used to unlock exclusive content and experiences, such as early access to new products and virtual events.



Enables USDC Payments & Token-Gated Sites

Solana Pay integrates with Shopify to enable USDC payments. Also, Shopify is experimenting with token-gated websites.



Launches Ethereum Layer 2 Network

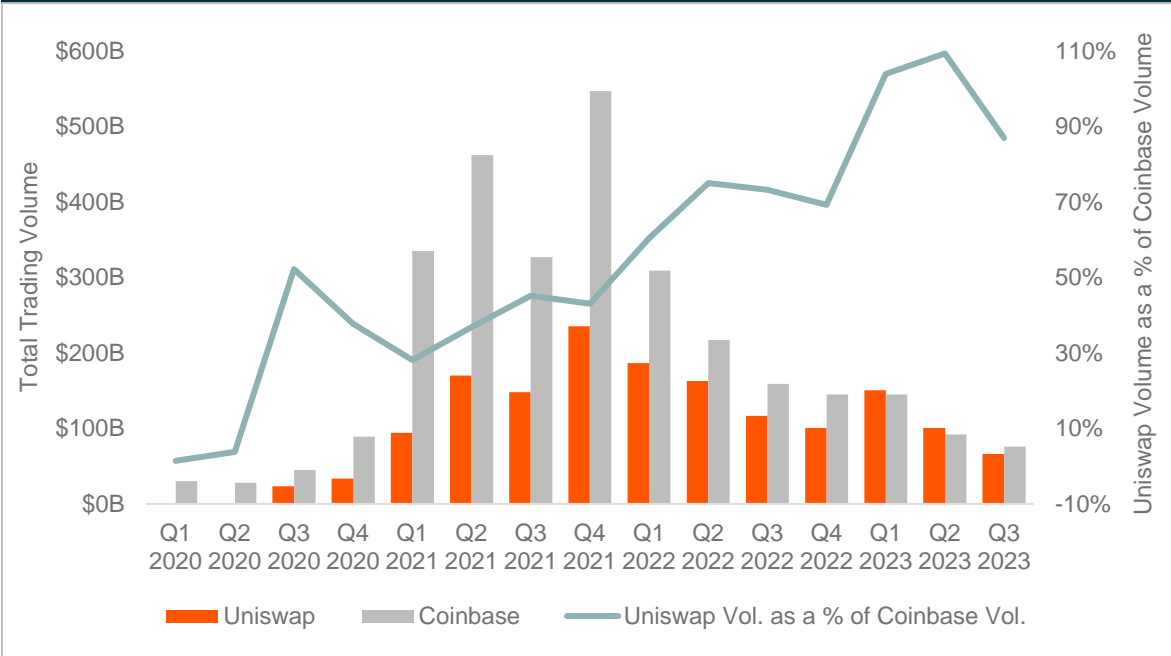
Coinbase's first-of-its-kind Ethereum layer 2 (L2) blockchain, Base, is designed to improve Ethereum's scalability and user experience.

Sources: Text: 1. Blockworks, 2022; 2. Dune, n.d.

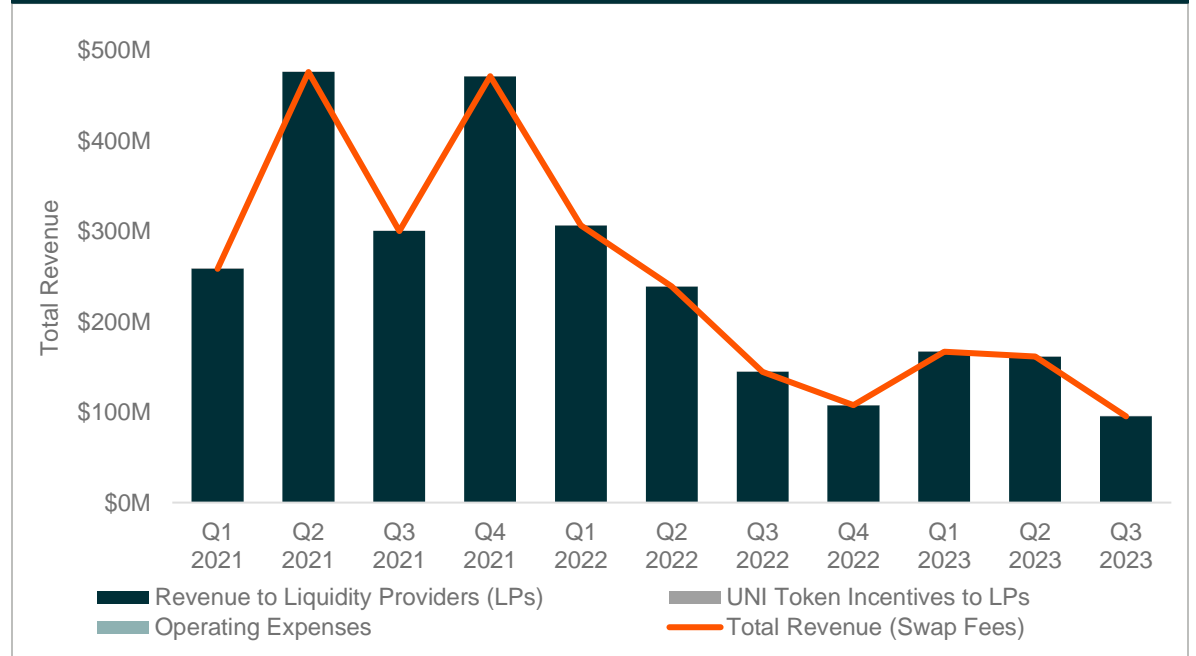
Uniswap Emerges as a Legitimate Competitor to Centralized Exchanges

A decentralized application (dapp) on Ethereum, Uniswap is a leading global crypto exchange that facilitates hundreds of billions of dollars of trading volume every quarter, surpassing most centralized exchanges.

Uniswap Achieves Similar Volumes to Coinbase



Uniswap Trading Fees Accrue to Liquidity Providers



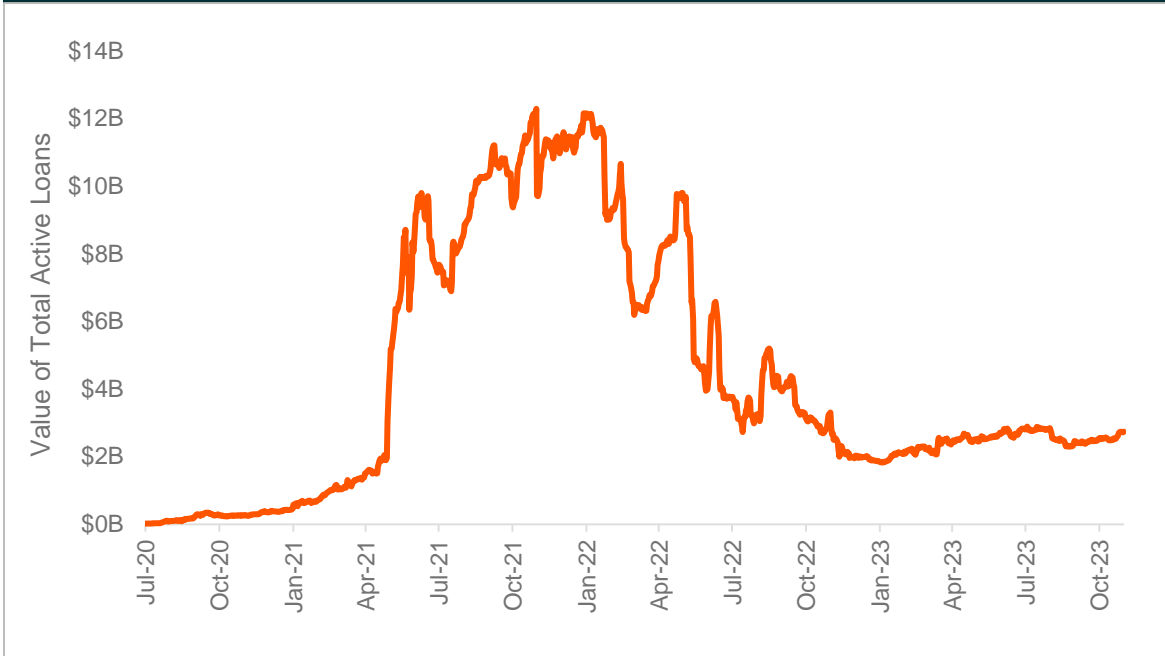
Uniswap Facilitates Onchain Asset Exchange Uniswap is a premier decentralized exchange protocol. It employs liquidity pools and a constant product function to form an automated market maker (AMM) system that enables anyone to provide liquidity without intermediaries or a traditional order book.

Sources: Charts: Left: Coinbase, 2023; DefiLlama, n.d.; Right: Token Terminal, n.d.

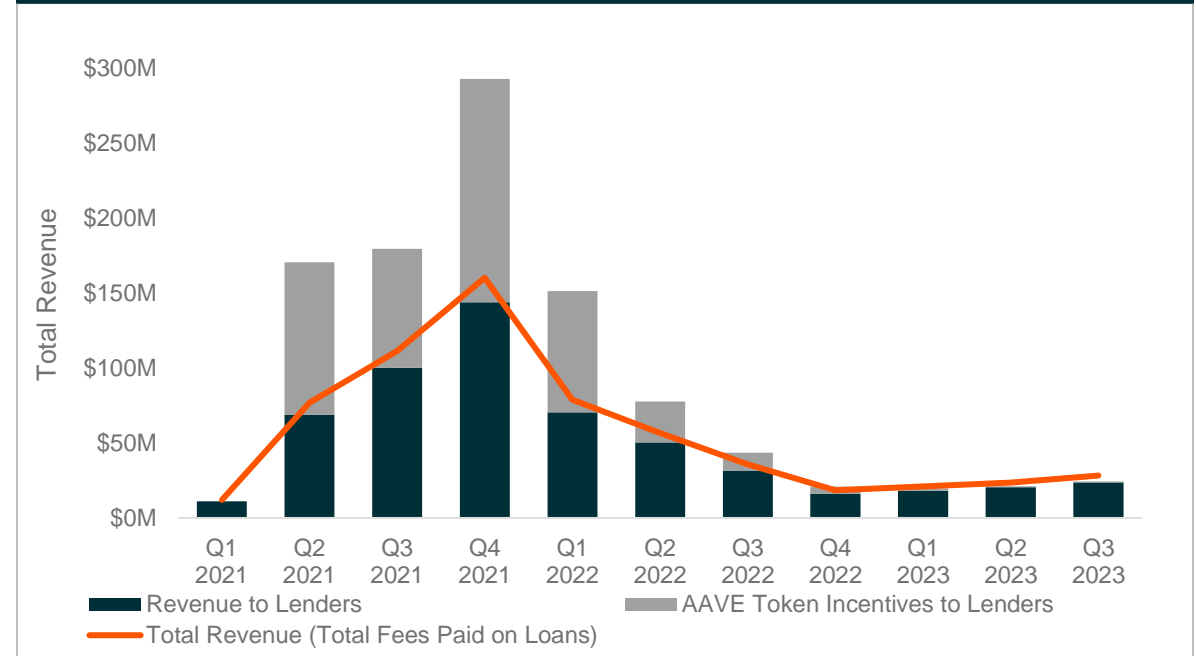
Aave Is the Leader in Decentralized Borrowing

Even amid a contraction in lending activity during the crypto bear market, Aave continued to facilitate billions of dollars of loans, underscoring its resilience and the global appeal of permissionless borrowing.

Aave Has Over \$2B in Active Loans



Aave Gives Most of Borrower's Interest Payment to Lenders



Leader in Decentralized Lending & Borrowing

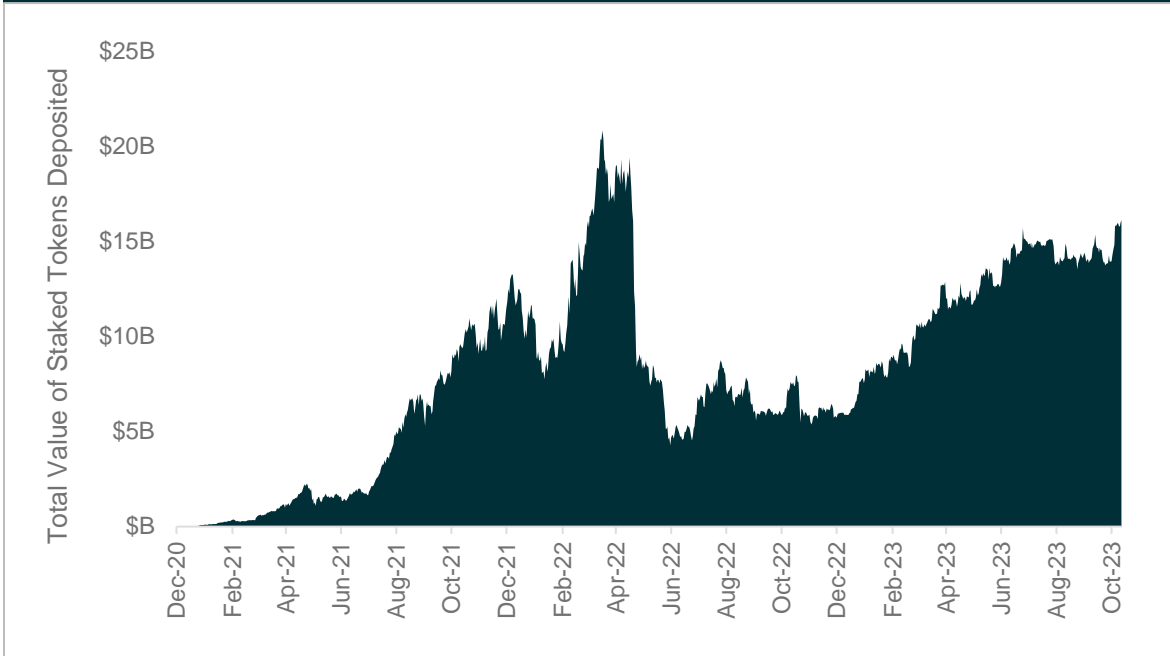
Aave links yield seekers with onchain liquidity providers, offering a cost-effective, globally accessible lending protocol. It minimizes credit risk by eliminating intermediaries, utilizing smart contracts, and over-collateralizing loans with digital assets.

Sources: Charts: Left: DefiLlama, n.d.; Right: Token Terminal, n.d.

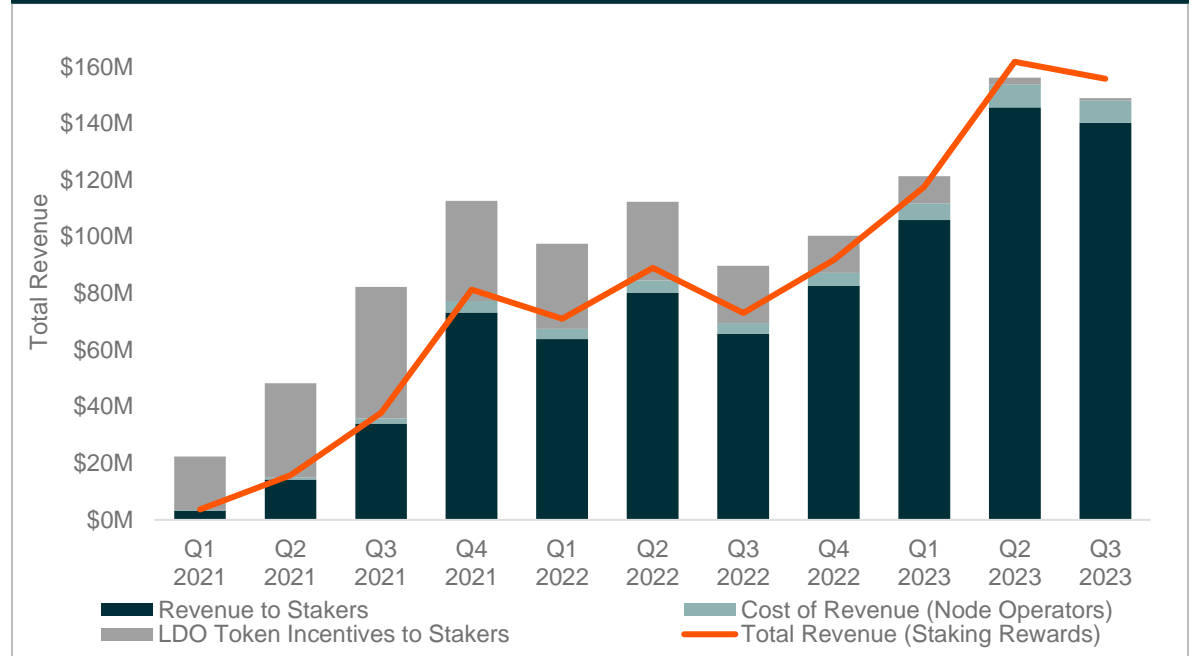
Lido Is the Leading Liquid Staking Platform, Managing Over \$13 Billion of Staked ETH

Ethereum’s transition to PoS gave rise to staking-as-a-service. Lido, a DeFi protocol, highlights the growing demand for DeFi-native services over centralized solutions.

Lido Now Manages Over 70% of Global Liquid Staking Value



Lido Gets a Cut from Staking Rewards



Lido Enables Liquidity for Staked Tokens

Lido users stake their assets on a Proof-of-Stake (PoS) blockchain and receive a tokenized receipt that represents their staked assets. This feature makes earning rewards easy because users avoid having to lock assets or manage hardware infrastructure.

Sources: Charts: Left: DefiLlama, n.d.; Right: Token Terminal, n.d.

Content Ownership and Digital Identity Are in Their Early Days

Raghu Yarlagadda

Although many crypto use cases today are financial, non-financial applications are beginning to proliferate, highlighting the ubiquitous potential of this technology.



121,000

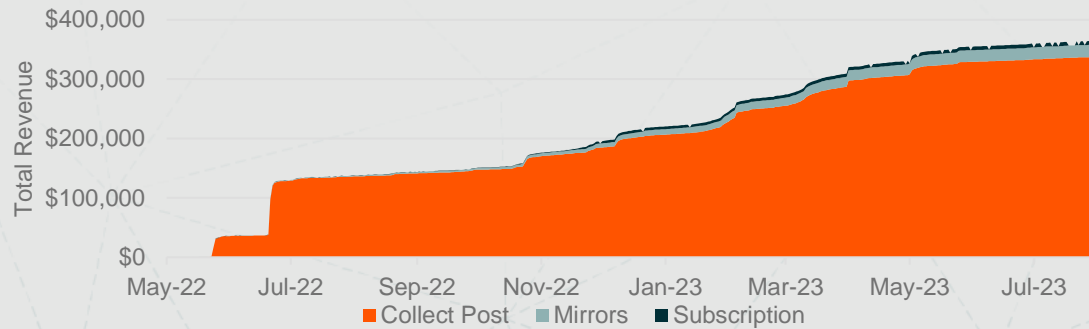
Unique Profile Owners on Lens (Closed Beta)¹



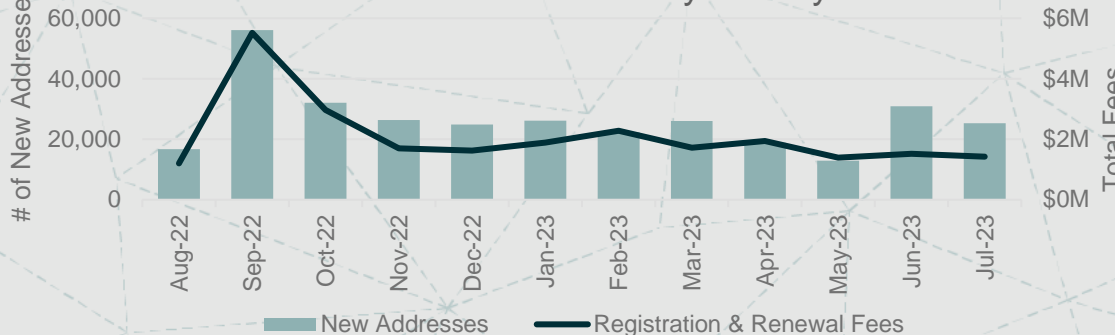
2,586,281

Number of Active ENS Names²

Lens (Closed Beta) Creator Revenue Breakdown



ENS Domains Monthly Activity



A New Digital Social Paradigm

- Lens Protocol is a decentralized social graph that empowers users to have greater control over their personal data and social interactions.
- Lens' popular Collect feature allows creators to tokenize and monetize content. Collect introduces new avenues for creators to engage with their followers and for followers to directly support creators.

Reducing Onchain Identity Complexity

- The Ethereum Naming Service (ENS) is a decentralized domain naming system that maps human-readable names (e.g., John.eth) to machine-readable identifiers such as a crypto wallet address. ENS is the crypto proxy for the Domain Naming Service (DNS) that associates human-readable names with IP addresses, simplifying internet navigation and accessibility.

Sources: Text: 1. Dune, n.d.a; 2. Dune, n.d.b; Charts: Dune, n.d.a; Dune, n.d.b; Token Terminal, n.d.

Crowdsourcing Resources Using Blockchains Enables Novel Applications

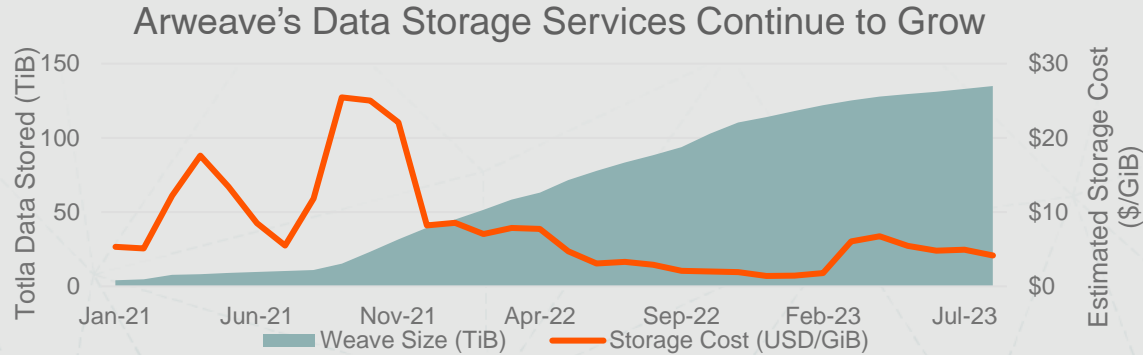
Raghu Yarlagadda

Protocols are exploring new ways to use the security properties of public, open-source blockchains to drive innovation across industries.



120 TiB +

Decentralized & Permanent Data Storage¹



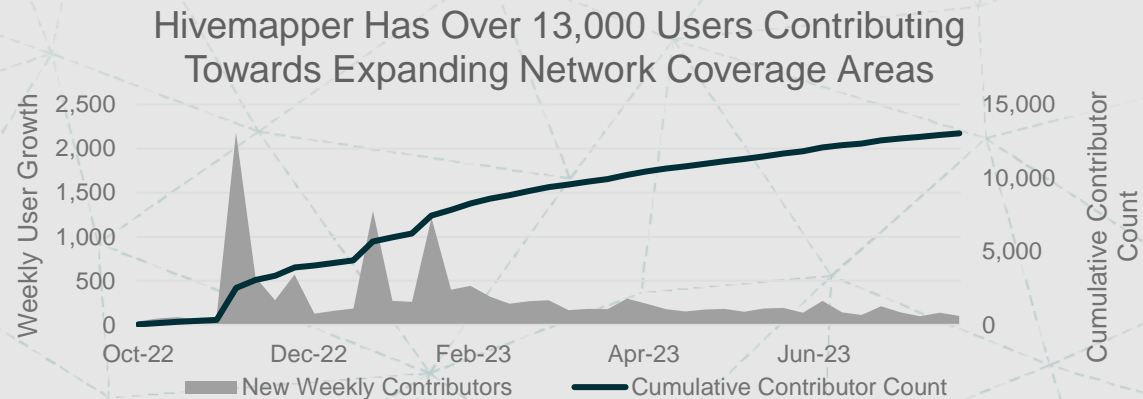
Revolutionizing Data Storage Onchain

- Arweave is a blockchain-based data store platform that makes permanent and tamper-proof data storage possible for a single, one-time fee.
- Arweave relies on a decentralized network of miners to secure the protocol and ensure that data remain accessible and immutable over time. Arweave is an attractive option for archiving and securing information in a censorship-resistant manner.



5,191,745

Unique Kilometers of Roads Mapped Globally²



Crypto-Incentivized AI-Powered Mapping

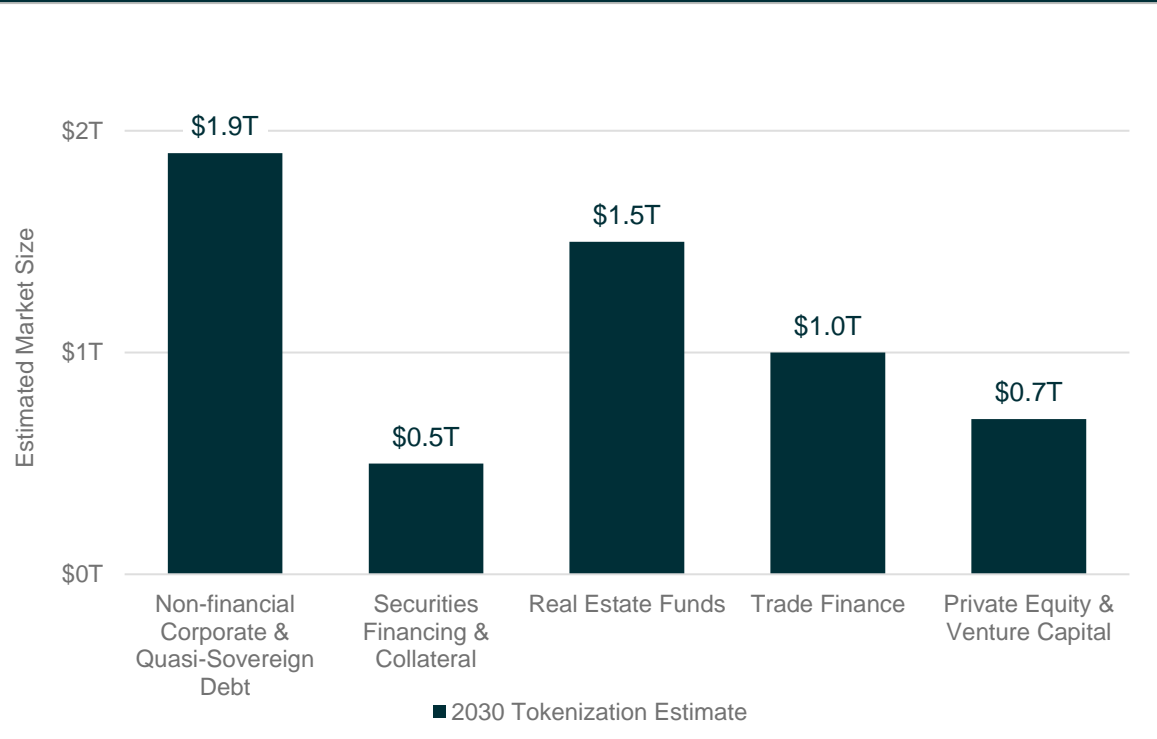
- Hivemapper is a decentralized mapping network built on the Solana blockchain that uses dashcam imaging and artificial intelligence to create frequently-updated 3D maps of the physical world.
- Hivemapper relies on a network of contributors to provide low-cost and frequently updated imaging. It can also set bounties for target regions, making it a constantly expanding resource.

Sources: Text: 1. ViewBlock, n.d.; 2. Hivemapper, n.d.; Charts: Dune, n.d.; ViewBlock, n.d.; CoinGecko, n.d.

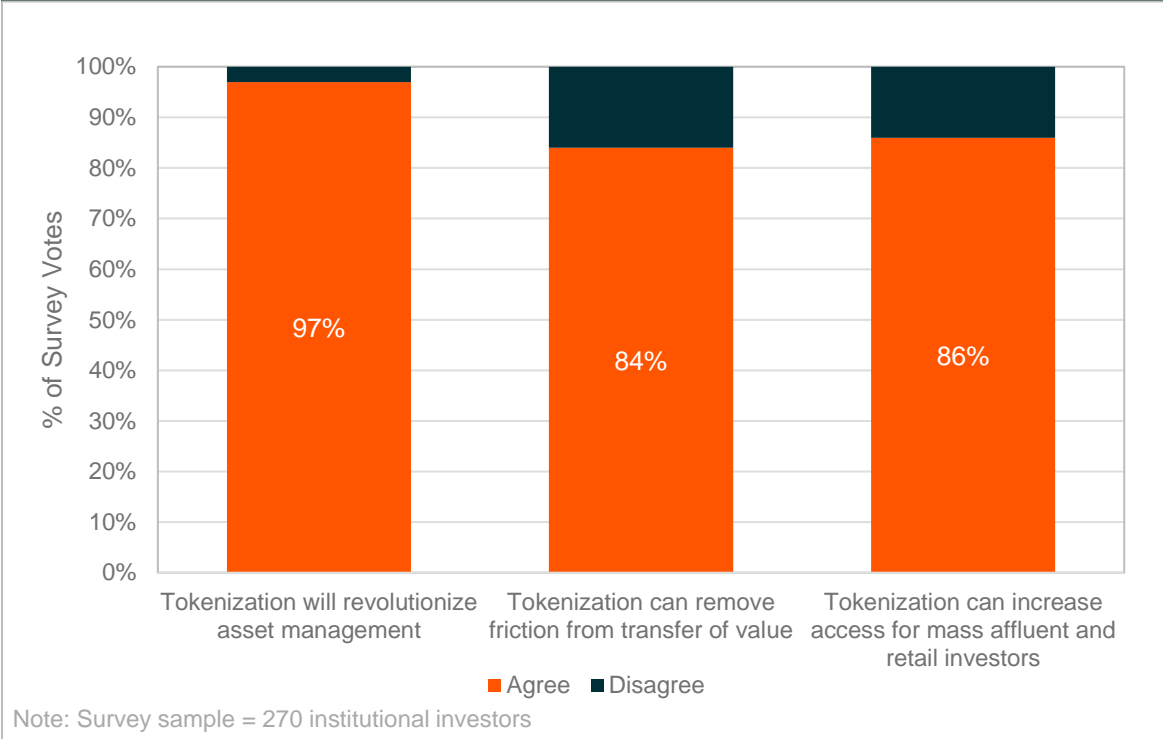
Tokenization of Financial Assets Is Expected to Drive Millions of Users to Blockchain Ecosystems

Tokenization is likely to be a powerful catalyst for blockchain adoption, with the market for tokenized financial assets expected to grow from under \$1 billion today to \$4 trillion by 2030.¹

Tokenization Is Expected to Play a Role in Financial Markets



Investors Acknowledge the Potential for Asset Tokenization

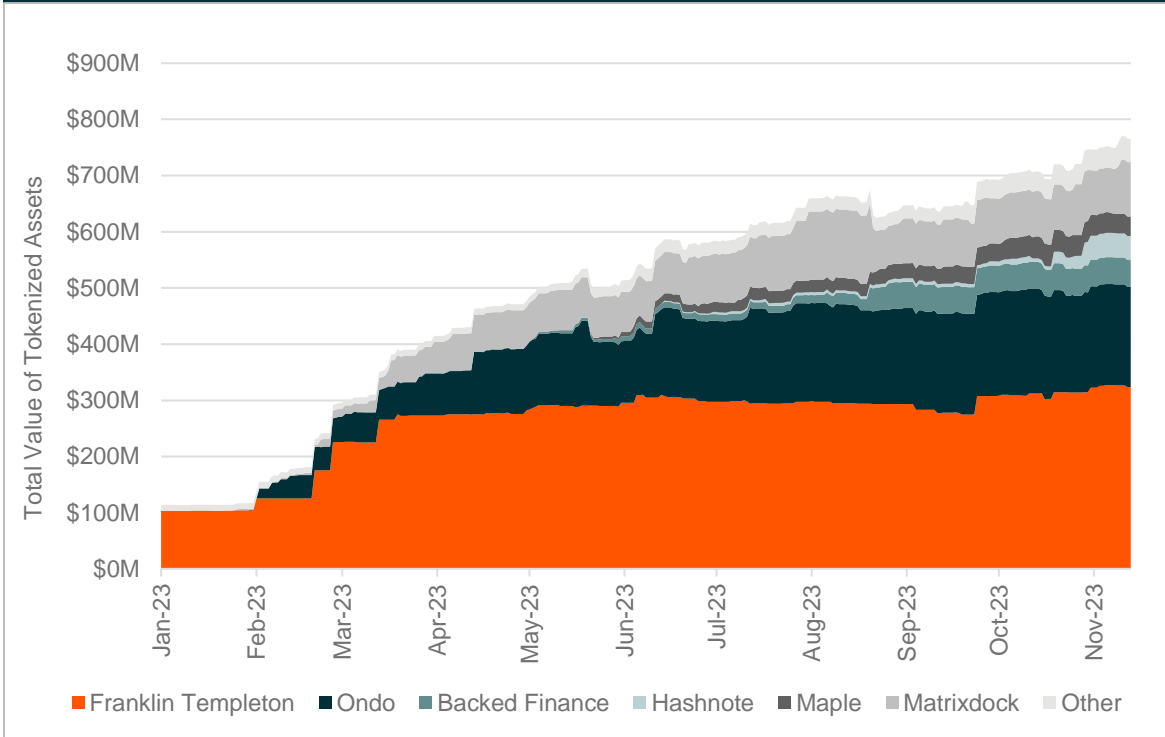


Sources: Text: 1. Citi, 2023; Charts: Left: Citi, 2023; Right: BNY Mellon, 2022

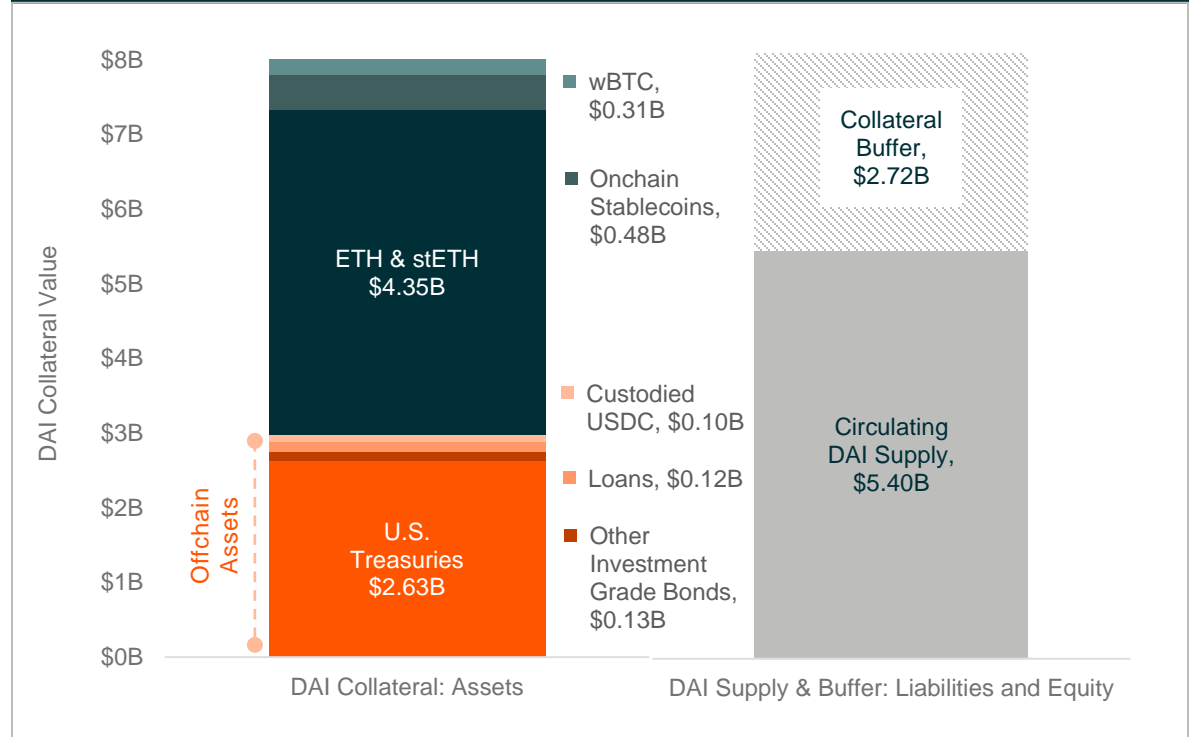
Blockchain Applications Start to Intersect with Traditional Fixed Income Opportunities

Fixed income products are finding synergies with blockchain platforms, broadening market possibilities by providing onchain access to their current yield opportunities and bolstering the resilience of crypto-native stablecoins.

Over \$700M Tokenized U.S. Treasuries Offering a ~5.2% YTM



~\$2.63B of U.S. Treasuries Back ~32% of DAI's Peg to USD



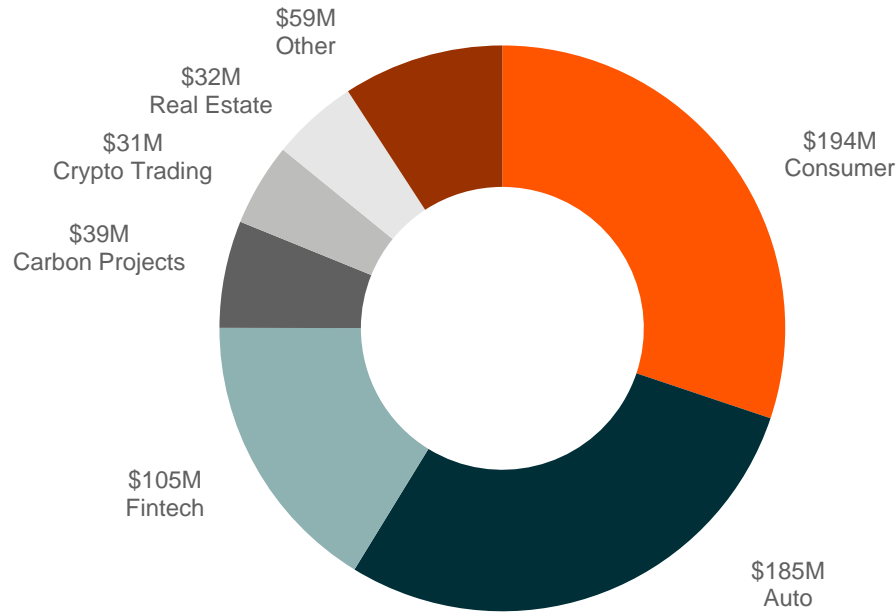
Note: Yield-to-maturity (YTM) is the total return anticipated on a bond if the bond is held to maturity. The average YTM refers to the weighted average of all tokenized treasury product tokens in circulation.

Sources: Charts: Left: RWA.xyz, n.d.; Right: Makerburn, n.d.

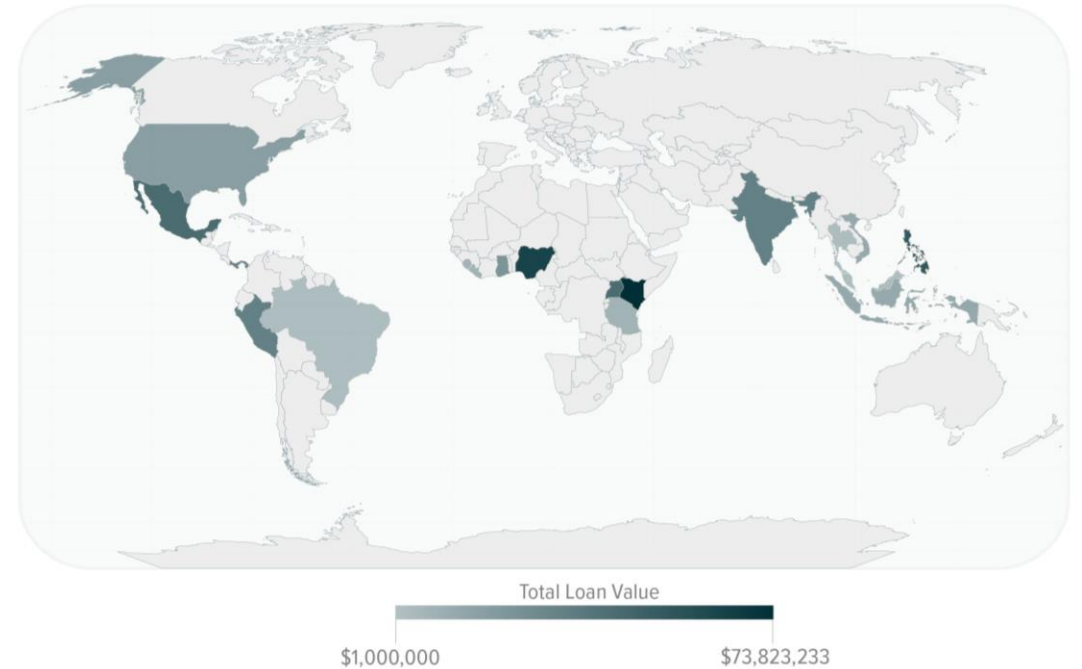
Private Credit Is a Growing Segment of DeFi

Blockchains' ability to coordinate capital is boosting capital efficiency within private credit. The growth of this market broadens access to credit for businesses around the world and reduces the friction of investing in private credit.

Active Onchain Private Credit Loans Exceed \$640M



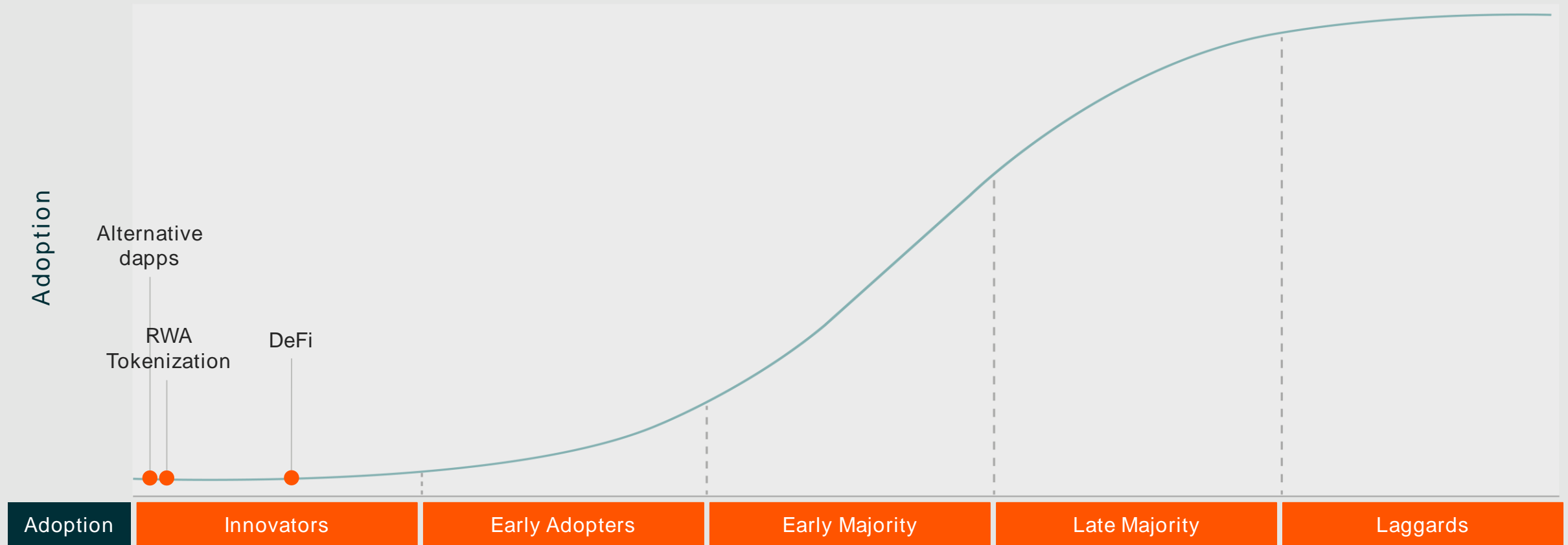
Private Credit Loan Distribution by Borrower Location



Sources: Charts: RWA.xyz, n.d.

Blockchain Trends: S-Shaped Curve of Adoption

DeFi, alternative dapps, and real-world asset tokenization are at the frontier of the adoption curve in the innovation stage, illustrating just how early they are in the process of gaining widespread acceptance.



Notes: For illustrative purposes only. RWA Tokenization excludes stablecoins.

Paradigm-Shifting Technologies

Pixels, Unleashed



Interactive Entertainment in the Age of Bits

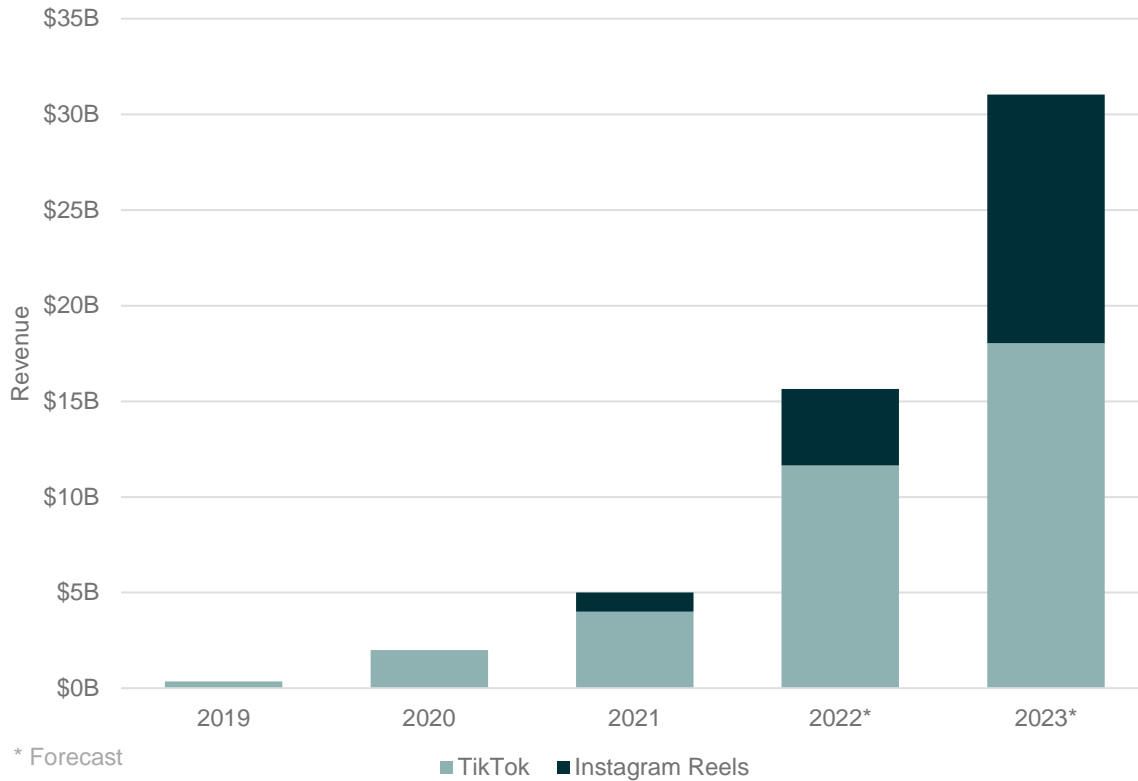
Digital experiences like streaming and social media continue to advance at healthy rates, discovering new frontiers for development based on format and feature innovation. For example, short video provides large platforms with alternative opportunities for growth. Similarly, gaming is on the rise again in key markets like the United States after its post-COVID slump. Meanwhile, Apple's Vision Pro Headset marks a major step in the build-out of immersive experiences, and early experiments show credible traction.



Short-Form Videos Are Boosting Digital Ad Revenues and Helping Platforms Return to Growth

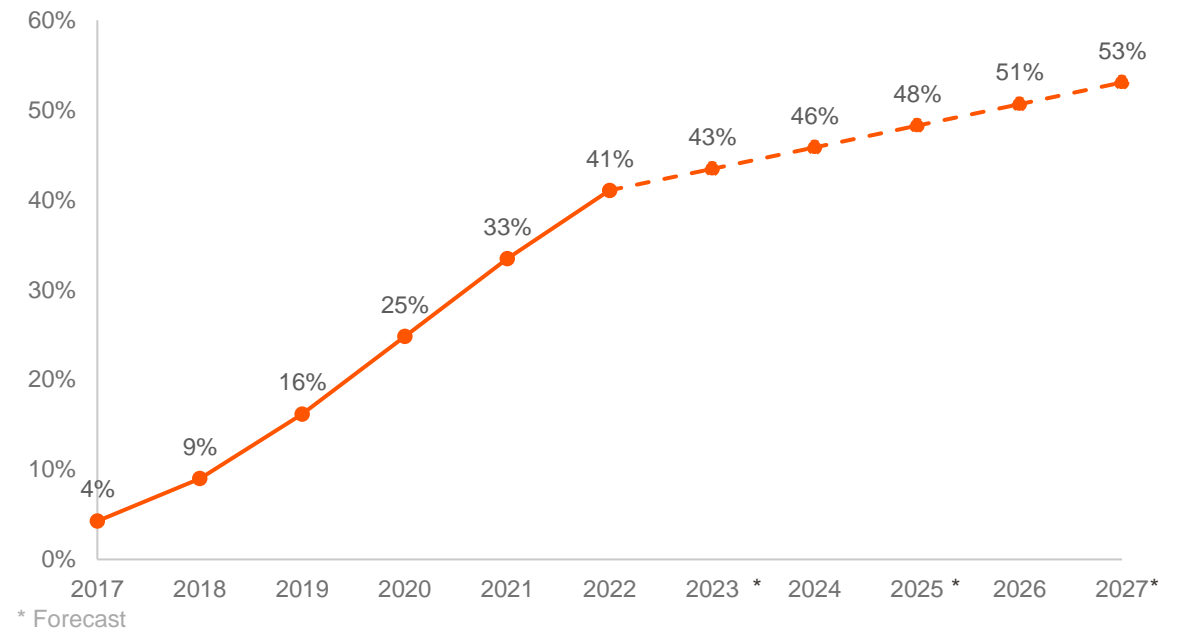
Online videos are in a format-driven transition, with short-form content driving growth for leading platforms. Meta's Reels is eroding TikTok's dominance and setting a course for the rest of the content industry to follow.

TikTok and Reels Short-Form Video Revenue



Short-Form Video Advertising Continues to Gain Traction

Short-Form Video Ad Share of Total Video Ad Spending in the United States



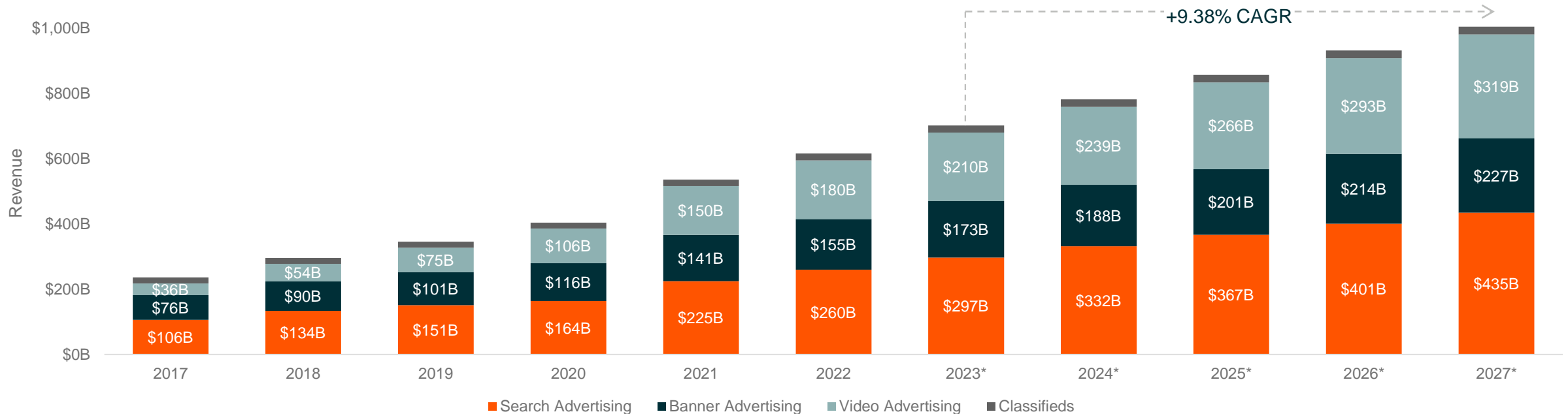
Sources: Chart: Left: eMarketer, 2022; Right: Statista Market Insights, 2023

Global Digital Advertising Market Is Far From Saturation

A handful of dominant platforms control a significant portion of the digital advertising landscape, capitalizing on emerging features and cutting-edge technologies to drive incremental profits.

Video Advertising Revenue Is Expected to Grow From 15% to 32% of Total Digital Advertising Revenue in 2027

Global Digital Advertising Revenue



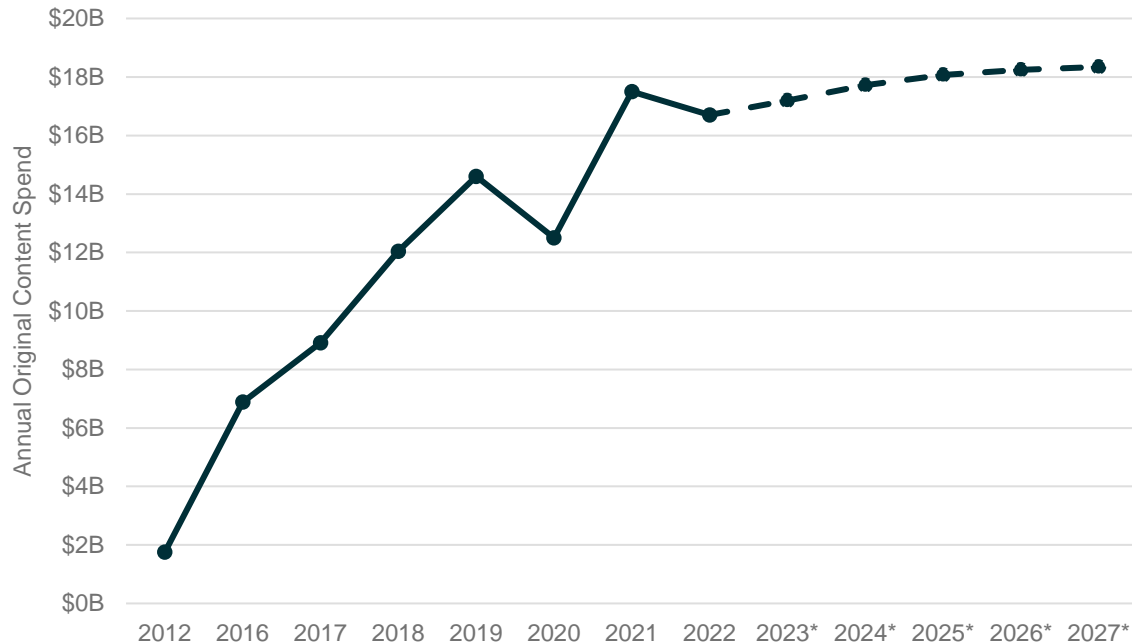
Sources: Interactive Advertising Bureau, PWC, 2023

Generative AI Could Simplify Content Creation, Boosting Impressions and Revenues

Generative artificial intelligence (AI) could play a pivotal role in entertainment and content production processes, to create an era of human-generated, AI-augmented content.

AI Could Cut Content Costs, Improving Streaming Margins

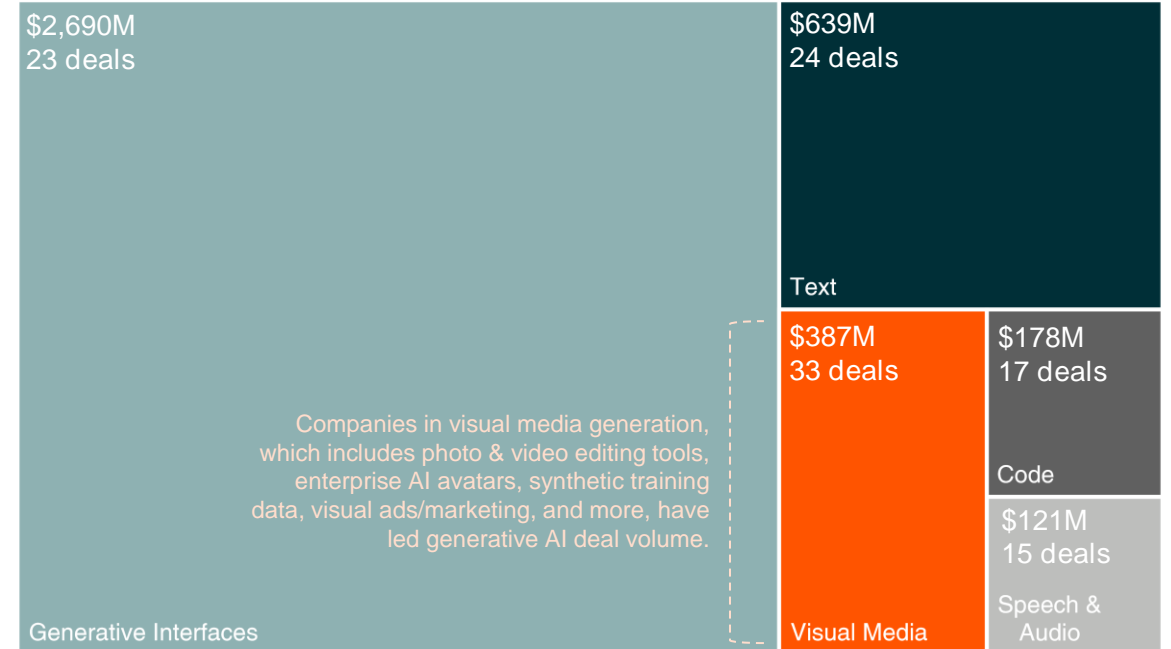
Netflix Annual Content Spending



* Forecast

Companies Spent \$387M on Gen AI Funding in Visual Media

Distribution of Generative AI Funding, Q3 2022 - Q2 2023



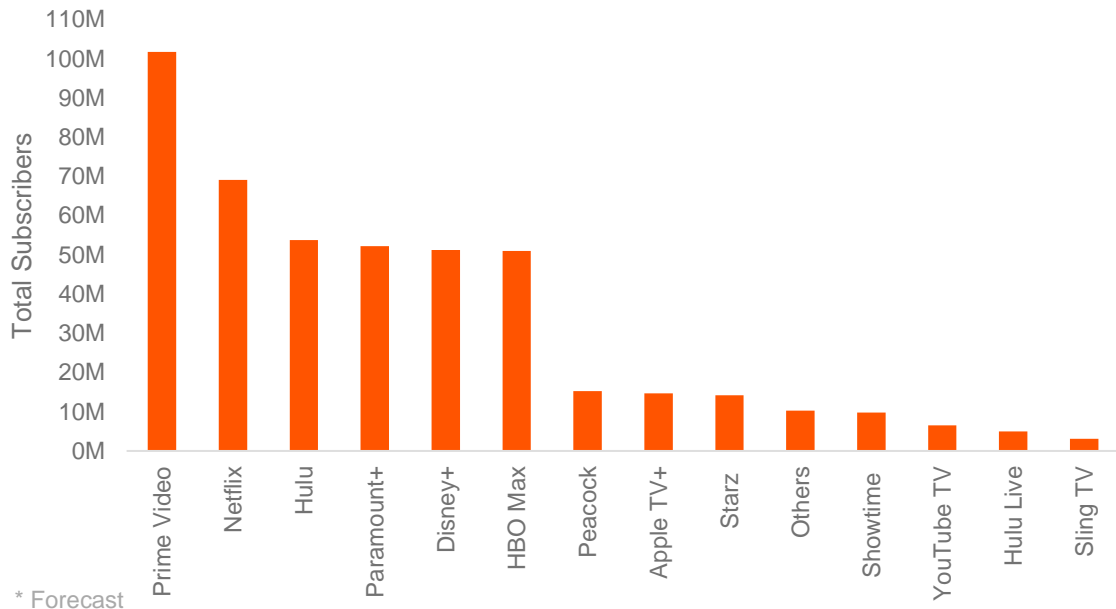
Sources: Charts: Left: Ampere Analysis, 2023; Netflix Investor Relations 2012 – 2022; Right: CB Insights, 2023

Favorable Pricing Power Can Help Streamers Thrive Despite Competition and Fragmentation

Consumers are expected to maintain a preference for diverse streaming options, intensifying competition among streaming providers. However, streamers have a track record of discovering new pricing strengths.

SVOD Market Is Expected to Remain Widely Fragmented

U.S. Subscription Video On Demand (SVOD) Subscribers by 2027

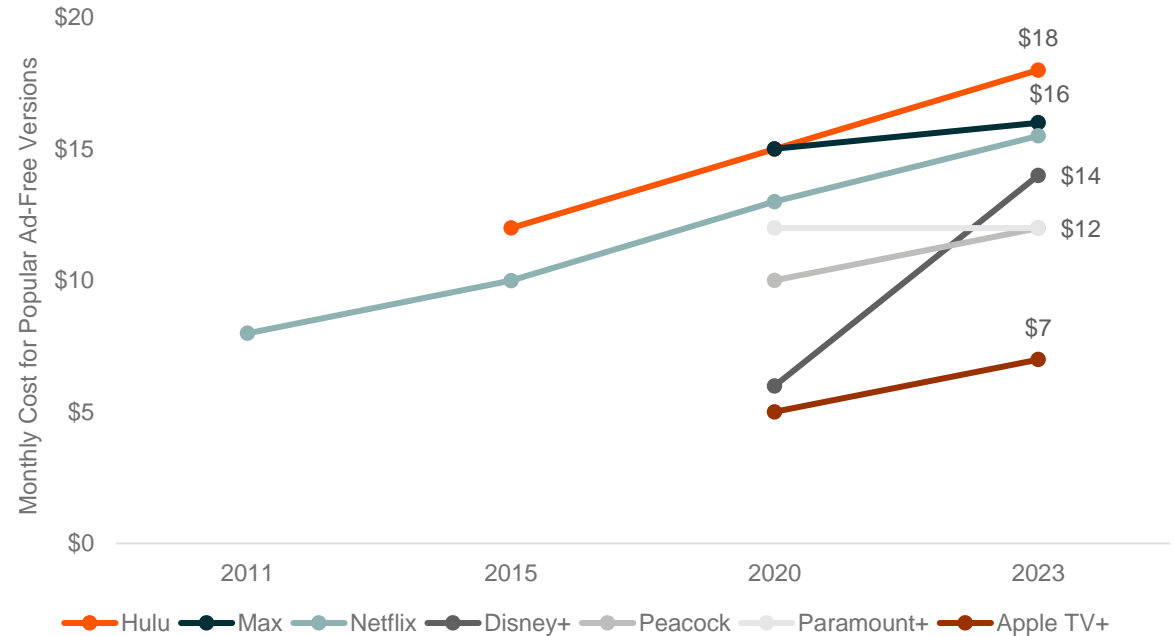


Note: Amazon Prime Video includes all Amazon Prime subscribers.

Sources: Charts: Left: Digital TV Research, 2022; Ampere Analysis, 2023; Right: The Wall Street Journal, 2023

Despite Competition, Streamers Have Strong Pricing Power

Prices Over Time for Leading Streamers

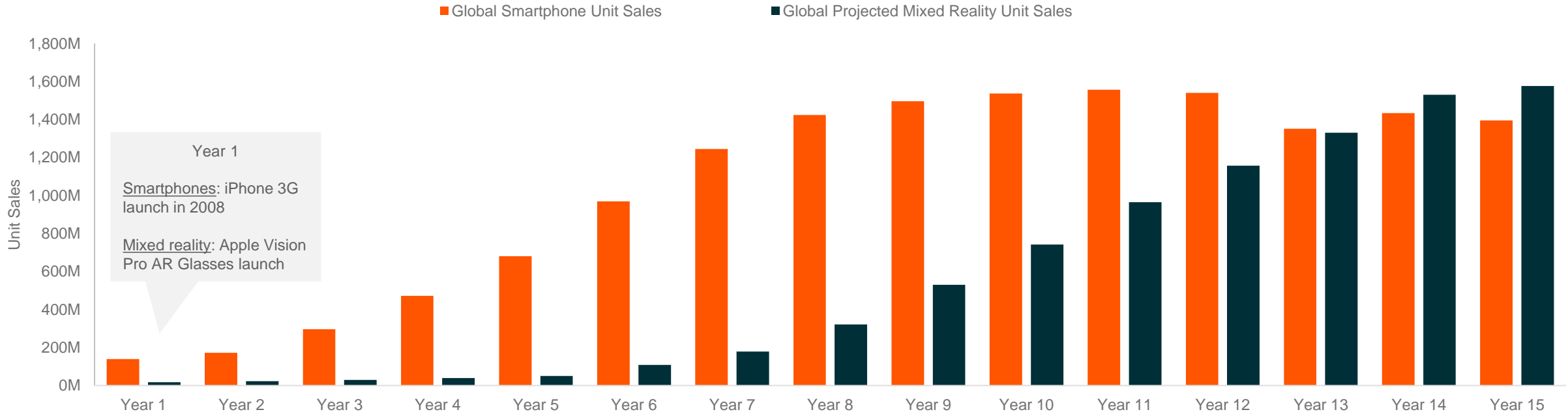


Immersive Technology Set to Revolutionize Consumer Devices

Mixed reality headsets are the next major innovation in consumer technology, allowing users to participate in immersive experiences. Headset technology must mature, but its adoption may rival smartphones in 15 years.

Apple's Vision Pro Launch in 2024 Will Likely Mark a Critical Moment for the Industry, Igniting a Cost Decline

Comparing Smartphone Unit Sales with Projected Mixed Reality Unit Sales



Note: For illustrative purposes only.

Sources: AR Insider, 2021; International Data Corporation (IDC), 2022

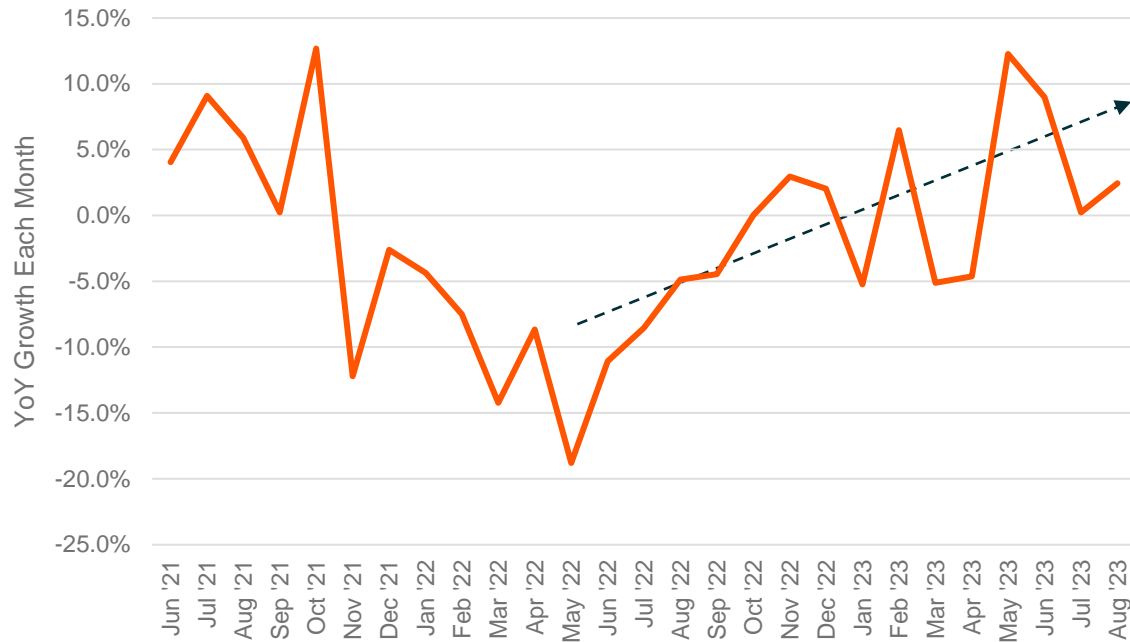
Video Games Are Returning to Growth After Post-COVID Withdrawal

After a brief pause in 2022, the video game industry already shows signs of recovery. U.S. gaming hardware sales, a leading indicator for software and services, grew 23% YoY in the first half of 2023.¹

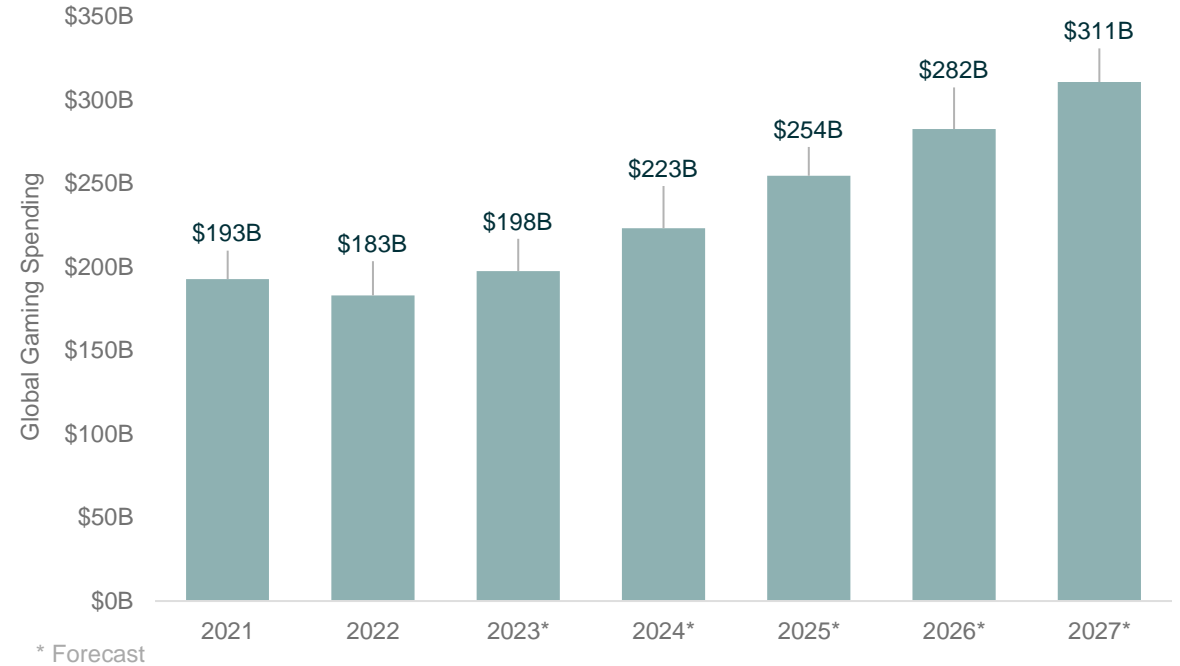
Total U.S. Gaming Sales Topped \$26.5 Billion in H1 2023

Global Game Spending Is Expected to Grow 12% in 2024

U.S. Monthly Gaming Sales YoY Growth



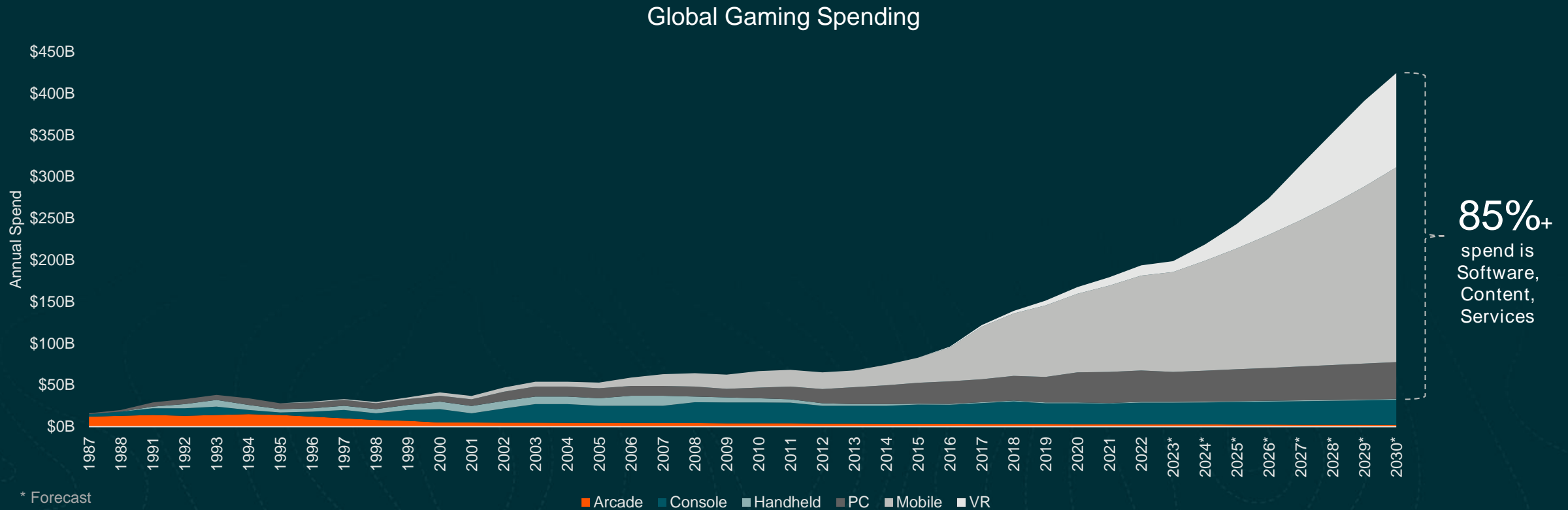
Global Gaming Spending Forecast



Sources: 1 Circana (2023, August 03), The Gaming Market in the U.S. Grew by 9% in June 2023; Charts: Left: Circana, 2023; Right: New Zoo, 2022

Software and Content Set to Power Video Games Value Creation

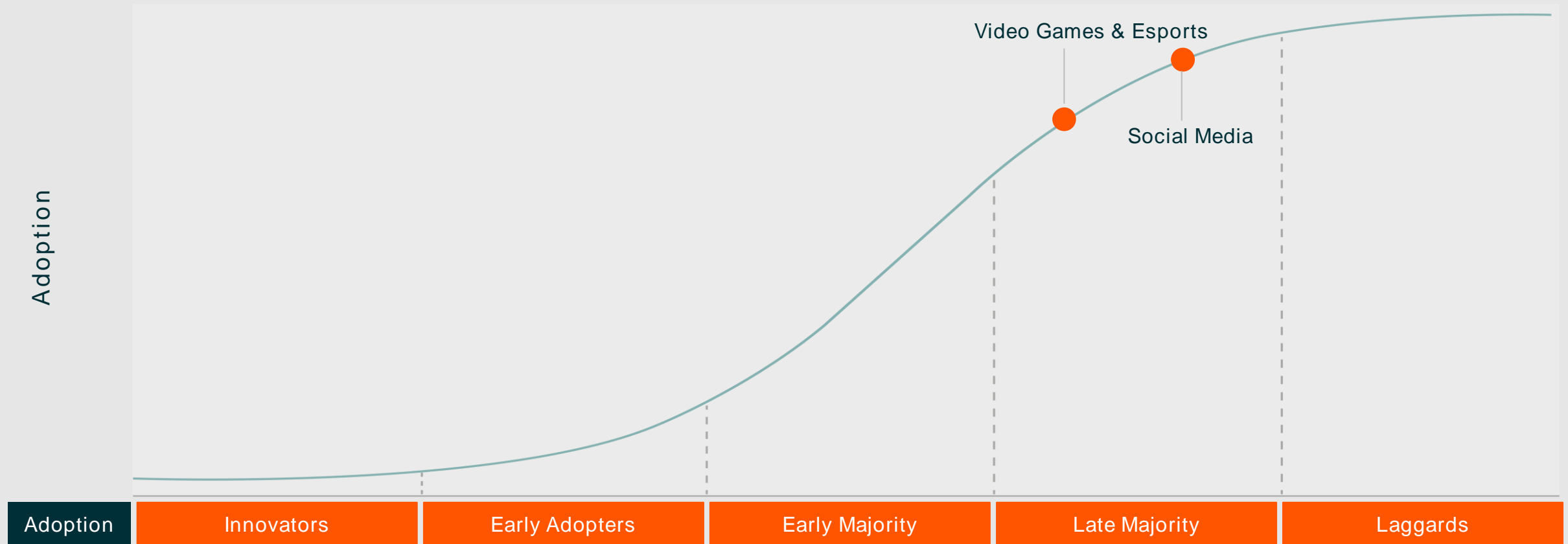
Software and mobile games are expected to supplant hardware and consoles as the main growth drivers for the gaming industry in the coming years. Immersive gaming, cloud gaming, and eSports are industry tailwinds.



Sources: World Economic Forum, 2020; New Zoo, 2022

Pixels, Unleashed: S-Shaped Curve of Adoption

Shift of consumer attention and dollars will continue to migrate to digital channels through this decade.



Note: For illustrative purposes only.

Sources: Text: 1 Gartner, 2023

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Appendix: Infrastructure, Reimagined

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