

# 66 MUST-KNOW TECH STATS FOR 2025: MARKETS ON THE RISE & DECLINE



# FROM OUR CHIEF RESEARCH OFFICER



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We find ourselves at another pivotal moment as a community of technology implementers and innovators. The global economic landscape continues to stabilize, yet new challenges persist, particularly in the form of shifting market dynamics and geopolitical uncertainties. At this juncture, companies and organizations must make strategic decisions that will define their success in the near term.

To navigate these uncertainties, organizations must identify and capitalize on emerging technology trends while mitigating exposure to declining markets. They must prioritize agile investment strategies, partner with the right innovators, and ensure their technology roadmaps align with growth opportunities. Above all, businesses must leverage data-driven insights to maximize Return on Investment (ROI) and build resilience against potential disruptions.

This paper highlights 66 essential technology market shifts—33 sectors poised for growth and 33 facing contraction. These insights, backed by ABI Research's rigorous analysis, equip businesses with the intelligence needed to seize emerging opportunities and avoid stagnation. Our comprehensive, relevant, and timely forecasts provide the clarity required for making impactful decisions in 2025 and beyond.

We look forward to continuing to support our clients as they harness these insights to outperform their competition.

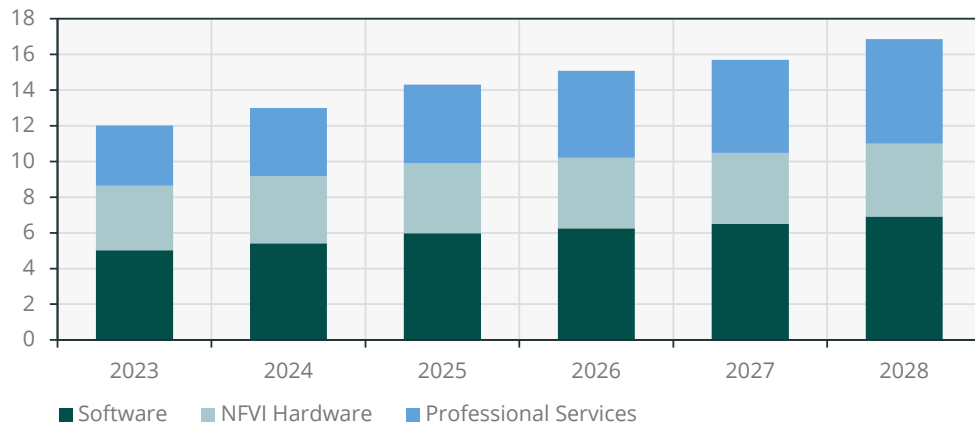
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**Professional services revenue will reach US\$6.56 billion by 2029, after surpassing hardware revenue for the first time in 2024.**

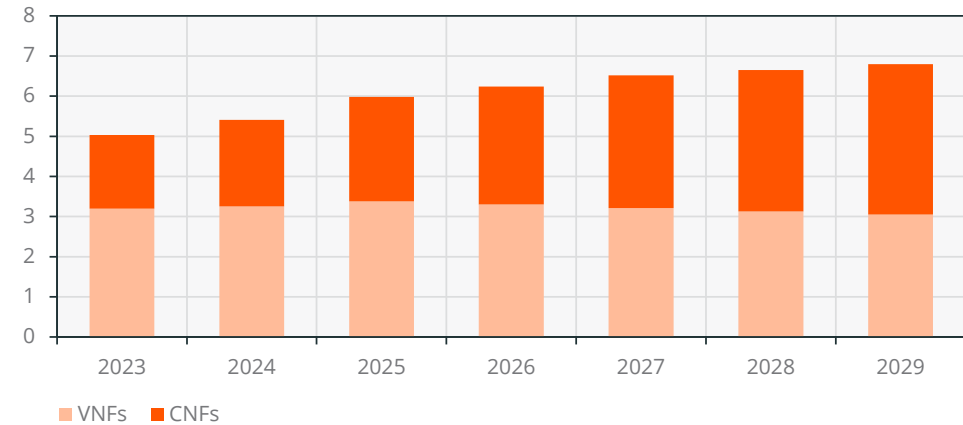
**The Virtual Network Functions (VNFs) market will slow to a halt, and may even begin to contract, losing US\$150 million between 2023 and 2029.**

Cloud Infrastructure Revenue by Segment (US\$ Billions)



One milestone in network digitalization is when infrastructure software and professional services become top market drivers instead of hardware. For the first time, this will be clear in 2025, when profits from professional services are expected to significantly surpass profits from Network Function Virtualization Infrastructure (NFVI) hardware. This is driven by: 1) maturity of market for network virtualization, and 2) expansion of professional services for cloud infrastructure, including cloud consulting, network automation, and systems integration.

VNF versus CNF Revenue (US\$ Billions)

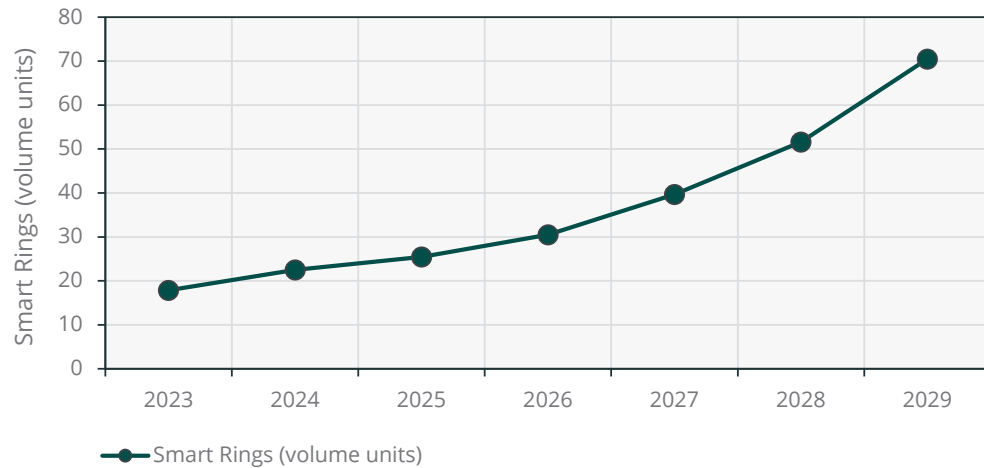


Operators still have many legacy physical and VNF applications that will need to be transitioned to cloud-native. A US\$3 billion VNF market has been supporting legacy operators and growing until 2025. We anticipate that, by the end of the year, revenue will stagnate and we may even see the first decline in VNF revenue. This will be an inflection point with a slow and steady decline of VNFs thereafter, with revenue eventually being surpassed by those of Cloud-native Network Functions (CNFs) around 2027. These transitions will be supported by cloud migration services and hybrid VNF-CNF infrastructure platforms, such as Red Hat OpenStack Services in OpenShift or Huawei's Dual-Engine Container solution.

Fueled by improvements in use cases, battery life, and affordability, ABI Research forecasts the smart ring market to grow by 26% in 2024, reaching 70.5 million in 2029.

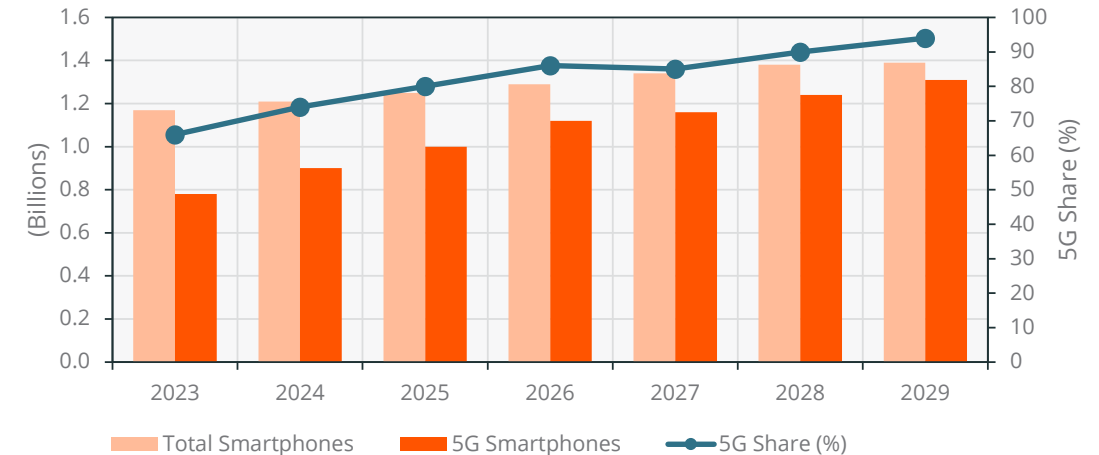
The smartphone system is banking on economic recovery, improved replacement cycles, and AI to boost shipments, which ABI Research expects to grow to 1.39 billion.

Smart Ring Shipments (Millions)



Smart rings have been growing in popularity in the wearables market, promising to drive growth in the sector through serving various use cases such as contactless payments, access control, health and fitness tracking, and smart home integration in an unobtrusive and comfortable form factor. Serving as companions to smartwatches, a smart ring sensor can generate information that is accurate and precise due to consistent proximity to the skin. Their use will also be driven by improved battery life (reaching up to 7 days), enhanced sensors, affordability, and greater choice of products across price tiers. The smart ring market is expected to diversify with premium offerings from established brands, such as Oura, Samsung, and potentially Apple, focusing on comprehensive health metrics, while more affordable options will target specific core use cases like fitness tracking and mobile payments. Enterprise adoption will emerge in specific verticals like healthcare and workplace security, though consumer applications will still dominate over the forecast period.

Smartphone Shipments by Segment

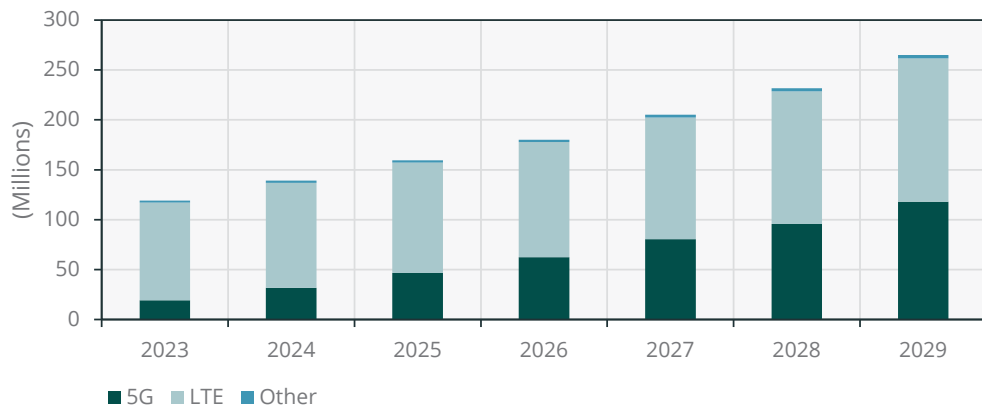


The smartphone market has been maturing with demand being hampered not only by economic headwinds in recent years, but also by a lack of compelling upgrades and lengthening replacement cycles. However, expected market growth through 2029 will be boosted by the addition of Generative Artificial Intelligence (Gen AI) in smartphones, which will provide a plethora of applications and features to help restimulate demand. Proportionally, sales of 5G smartphones have been accelerating by affordability and market adoption, driven by availability of models from all major brands across price tiers.

Despite the growth in 5G smartphone shipments and its growing influence across global markets, the ecosystem faces challenges ahead, notably the sea-change in industry attitudes away from connectivity toward compute and Artificial Intelligence (AI). In addition, the evolution toward 5G-Advanced is not expected to arrive with the fanfare once expected because there is still much that the industry needs to tackle before the value of the 5G ecosystem is unlocked and can realize its full potential.

**FWA subscriptions will reach around 265 million by 2029.**

Fixed Wireless Access Subscriptions

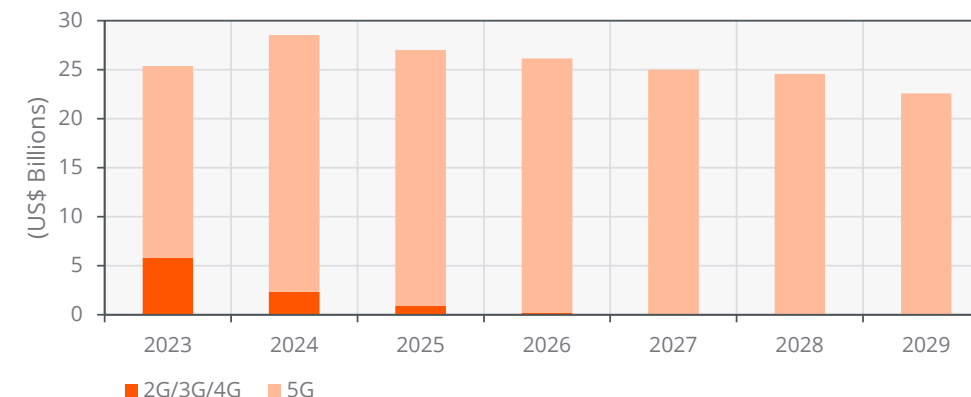


Fixed Wireless Access (FWA) has been one of the monetization success stories during the 5G era and services continue to be deployed worldwide. The more mature services are beginning to evolve in line with a wider industry trend shifting from a simple traffic monetization business model toward a service monetization model. The total FWA subscription market is expected to reach 265 million by 2029, with 5G subscriptions accounting for 45% of the market.

The U.S. market, which is an extremely mature 5G FWA market, is expected to continue to grow, albeit at a slightly slower rate than previously, as the leading operators, Verizon and T-Mobile US, announced their plans for expanding their subscriber base given that their initial targets were met ahead of schedule. The 4G subscriber base worldwide will remain prevalent worldwide, especially in regions such as Africa where many 5G spectrum auctions and initial network deployments have yet to be conducted.

**Annual revenue for macro basebands will continue to decline, dipping to US\$22.59 billion total by 2028.**

Macro Baseband Annual Revenue by Segment



As 5G Radio Access Network (RAN) continues to become more and more disaggregated, the revenue potential due to fewer hardware components continues to fall. In 2025, this trend is expected to continue, with legacy baseband revenue expected to completely diminish by 2028. Revenue for 5G basebands has peaked already due to ongoing initial deployments of 5G cell sites, and as greater disaggregation occurs, the revenue will continue to decline.

LLM enterprise spending grows rapidly (35% CAGR\*), while the vision AI market remains dominated by traditional ML due to commercial, operational, and technology considerations.

AI SOFTWARE REVENUE (US\$ MILLIONS)							
AI Software Revenue	2023	2024	2025	2026	2027	2028	2029
Computer Vision	15.82	21.37	27.08	32.82	38.45	43.19	47.73
LVMs	0.42	1.33	3.07	6.04	10.12	16.22	23.81
LLMs	28.34	53.8	80.63	106.45	129.86	153.08	176.09

Enterprise software spending on Large Language Model (LLMs) continues to grow rapidly as Proofs of Concept (PoCs) mature into scaled deployments embedded across entire companies. However, the vision AI market is a different story. Spending on computer vision will continue to overshadow new transformer-based, Large Vision Models (LVMs) over the next 6 years. The sustained dominance in this market can be chalked up to several commercial, operational, and technological factors:

- **Commercial:** Key verticals deploying vision AI at scale (manufacturing, healthcare, retail) have yet to see viable LVM use cases with clear Return on Investment (ROI). LVMs are much more expensive to deploy and operate given hardware and software development requirements.
- **Operational:** Deploying and scaling LVMs can be challenging, expensive, and bring significant risks (hallucinations, data privacy, regulation). Most use cases are mission critical and rely upon 100% accuracy.
- **Technology:** Most vision models are deployed at the edge due to latency and security requirements. This brings memory, power, and performance constraints, which restrict deployment of LVMs.

Although new transformer-based, Gen AI models are, for good reason, dominating enterprise and vendor strategic planning, it is important that stakeholders do not forget about traditional Machine Learning (ML), which still offers significant long-term value. In 2025, we will see initial investment in hybrid AI deployments that merge Gen AI and traditional AI models to optimize cost, performance, and privacy.

\* Compound Annual Growth Rate (CAGR)

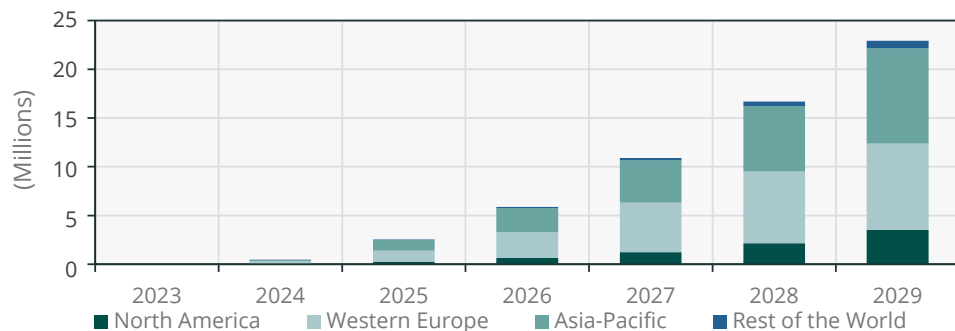
FPGAs share of total data center chipset shipments is set to decline over the decade, reaching a low of 1.4% by 2030.

DATA CENTER CHIPSET ARCHITECTURE SHARES							
	2024	2025	2026	2027	2028	2029	2030
CPU	29.0%	25.6%	23.0%	21.2%	20.0%	18.9%	18.2%
GPU	48.2%	50.8%	53.3%	54.7%	55.2%	55.5%	54.8%
FPGA	2.8%	2.4%	2.1%	1.9%	1.7%	1.5%	1.4%
ASIC	19.9%	21.2%	21.6%	22.2%	23.1%	24.1%	25.5%

Major Field Programmable Gate Array (FPGA) vendors Intel (Altera) and AMD (Xilinx) experienced a collapse in their FPGA revenue in 2024, blamed on inventory corrections, which starkly contrasts their performance in 2023. They are among a handful of data center AI compute FPGA players—along with Achronix, which specializes in the domain. Graphics Processing Units (GPUs) are set to dominate throughout the rest of the decade in absolute and real terms. FPGAs have nonetheless proven themselves in smaller form factors, building on their legacy in computer vision applications.

The EU will represent 40% of new battery passports created in 2029 complying with DPP regulation and supply chain transparency regulations.

New DPPs Created for EV Batteries by Region

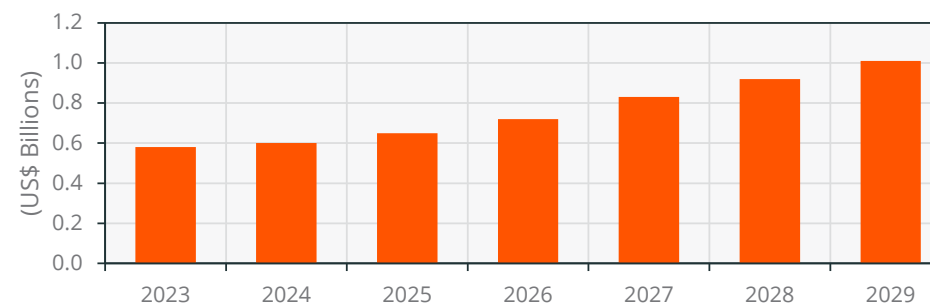


The regulation and Digital Product Passport (DPP) requirements are still being formalized and come will into effect by 2026/2027. Batteries & vehicles, chemicals, construction & buildings, electronics & Information and Communication Technology (ICT), furniture, plastics, and textiles are the prioritized industry groups based on their environmental impact. The production of batteries is a global issue, and regulations cannot be considered in isolation, while all Electric Vehicles (EV) in the European Union (EU) will have a DPP by 2027. Over the forecast period, by 2030, more than 45% of the EVs in North America and Asia will have region-specific DPP's. EVs will demonstrate a CAGR of 102% over the forecast period with solution providers directing their efforts to meet regulatory compliance by 2027 with a grace period. Geographically, as EU regulations establish blueprints for EVs and different product groups, North America, Asia-Pacific, and the Rest of the World (ROW) will soon follow with region-specific DPPs, as suppliers find value in sharing data to improve and optimize supply chains.

Vendors and service providers in the EV sector are looking at absorbing the cost of creating a DPP, while tapping into the dynamic system-level data to create sales opportunities for servicing, maintenance, and parts sale. DPP tools need to be priced in the range of Product Lifecycle Management (PLM)/Enterprise Resource Planning (ERP), and battery management software, while seamlessly extracting dynamic data from existing Battery Management Systems (BMSs). Solutions providers are exploring various models—a flat fee model independent of volume of batteries produced, or a flat fee with an annual recurring fee paid by the economic operator. The value of DPPs will create second-life use cases of EV batteries, and transparency of refurbishment, service, and maintenance processes, as well as an increase in the recovery rate of critical raw materials and hardware components during a battery's lifecycle.

Global revenue of the PLM software market with sustainability features, valued at US\$575.3 million in 2023 and slow growth until 2026, is forecast to reach US\$1.01 billion by 2029.

PLM Software Supplier (with Sustainability Features) Market Revenue



Currently, Autodesk, Dassault Systèmes, PTC, and Siemens are increasing capabilities for sustainable product design and circular design development through partnerships, Research and Development (R&D), and Mergers and Acquisitions (M&A). The Product Lifecycle Management (PLM) market with sustainability features is currently in the development phase with R&D funding of 3% to 5% of the total revenue of leading PLM software providers. As the market matures post-2026 regulatory enforcement, the sustainability features will transition from a software feature of the PLM software to a fully functional standalone tool. The current drivers are regulations on circularity, carbon emissions, and digitalization of factories to boost productivity. The global revenue of the PLM software market with additional sustainability features is valued at US\$575.3 million in 2023 with slow growth through 2026 and, once matured, is forecast to reach US\$1.01 billion by 2029 with an advancing CAGR of 9.79%.

In 2023, Europe and America are currently the largest user bases of PLM and Computer-Aided Design (CAD) software, as most of the products are designed in these regions. Over the next decade, as circular design capabilities mature and expertise continues to develop in Europe and America, the Asia-Pacific region will project a marginal increase in user base and market share, as focus will remain on manufacturing.

The number of U.S. Mobile Driver's Licenses (mDLs) issued every year will increase by more than 60 million (at a 52.33% CAGR).

U.S. MOBILE DRIVER'S LICENSES ISSUED (MILLIONS)						
	2024	2025	2026	2027	2028	2029
mDLs Issued	8.41	19.91	31.72	43.83	56.26	69.00

The total number of issued mobile driver's licenses is set to increase by a CAGR of 52.33% from 2024 to 2029, with 69 million mDLs set to be issued by 2029, with the United States leading the market charge.

mDLs are a current focus for U.S. states. With 233 million U.S. citizens having physical driver's licenses, they are, by far, the most used form of identification in the country.

Fourteen states have either begun a full-scale rollout of mDLs or are in the pilot stage with 8.4 million Americans having a digital driver's license as of 2024, making up 3% of the total American driving population. By the end of 2025, ABI Research estimates that half of U.S. states will have either adopted an mDL or started a pilot for one with most of the mDLs being developed in conjunction with Apple.

DTCs will play a revolutionary role in passenger trips, but mobile passports will only account for 0.7% of total passports by 2029 as the infrastructure is not ready to support widespread adoption.

PASSPORT TYPES (MILLIONS)							
	2023	2024	2025	2026	2027	2028	2029
Mobile Passports	2.8	3.0	4.1	5.1	6.3	7.4	10.0
Physical Passports	1205.6	1256.8	1295.2	1334.4	1375.3	1417.2	1460.1
Mobile Passports Penetration Rate (%)	0.2	0.2	0.3	0.4	0.5	0.5	0.7

Rapid digital transformation and digitalization of identity, particularly following the COVID-19 pandemic, have produced an ever-expanding identity metasystem, of which Digital Travel Credentials (DTCs) are expected to become a significant part. However, uptake has been slow, thus far, and is not expected to significantly pick up until late in the decade and from 2030 onward. An amalgamation of factors is hampering growth in this prospective subsegment, including lagging standardization pertaining to two types of DTCs and the stringent interoperability requirements that all passport documentation must adhere to. Garnering sufficient passengers for piloting and convincing governments to collaborate on DTC trials have proven difficult, especially considering the potential security, privacy, and usability challenges posed by DTC technology.

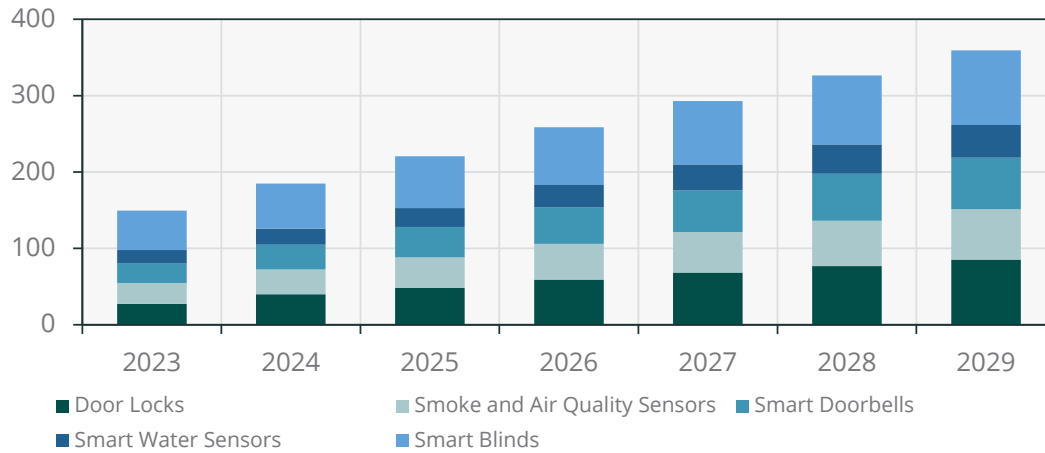
While the DTC is pegged for success within the travel vertical, this is still a long way down the line. The ecosystem remains unsettled and although the technology is largely ready, the infrastructure is not yet there to support it. This is particularly the case in less digitally mature states that will face onerous development costs in the short- to mid-term period.



**Smart home devices for safety, security, and convenience see robust growth with a CAGR of 14% from 2024 to 2029, reaching total shipments of 500 million by 2029.**

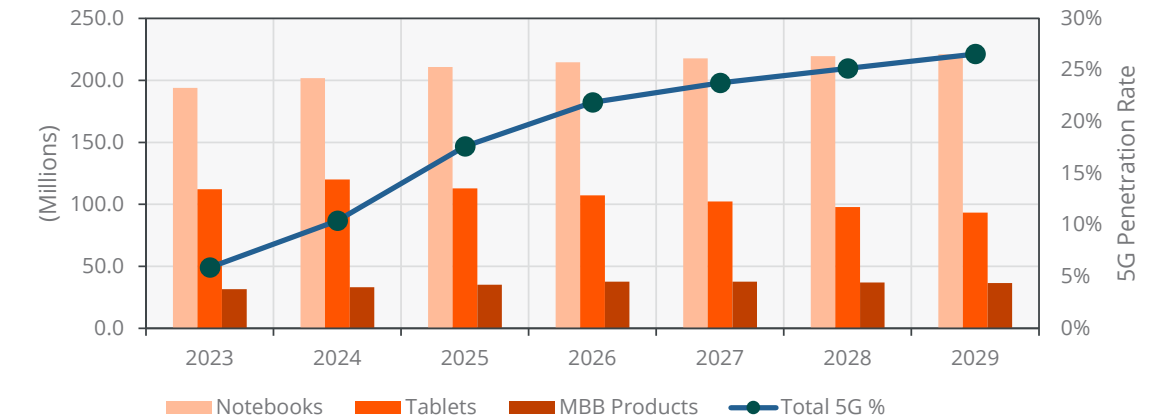
**Despite a 7% increase in 2024, tablet shipments will decline slowly through 2029.**

Consumer Device Sales (Millions)



Smart home adoption is steadily increasing with its rate and speed being dependent on multiple factors such as increased connectivity in households, price points, installation type, and customer service. The increase in awareness and concerns about home security and public-private investment in smart infrastructure are key drivers boosting adoption among consumers. Advancements in technologies, product innovation, cloud-based services, remote monitoring, digital security, affordability, and customer engagement will accelerate the up-take of smart home security devices and increase household penetration rates over the forecast period. The sector is led by outdoor security cameras, door locks, an

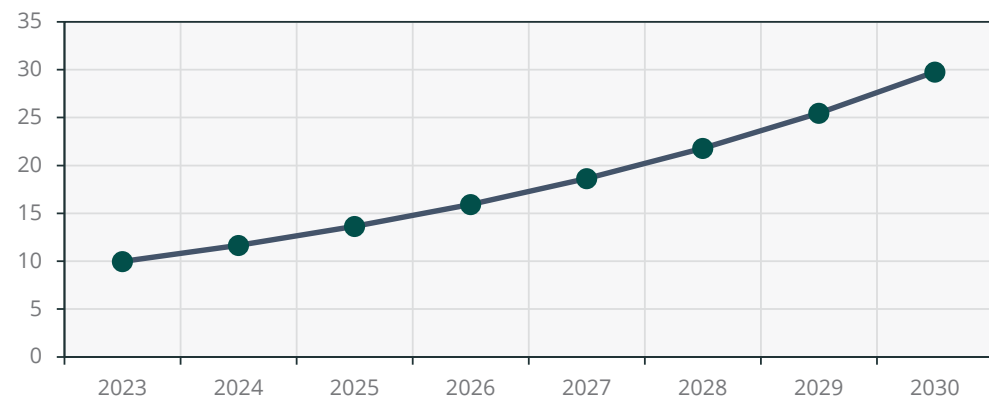
Consumer Device Sales and 5G



Shipments fell 3% and 19% in 2022 and 2023, respectively, to reach 100 million. The market saw a 7% increase in 2024, but is expected to decline slowly thereafter to 2029. However, future demand may be driven by improved cellular attach rates with more aggressive pricing, new form factors (foldable/flexible displays), and adoption of AI features.

QR payments are set for a 16.9% CAGR in global value by 2030.

QR Payments Market Value (US\$ Billions)



The QR payments market value is projected to grow at a 16.9% CAGR from 2023 to 2030, reaching US\$29.77 billion. The main reason for this increase is continued interest in QR payments in Southeast Asia.

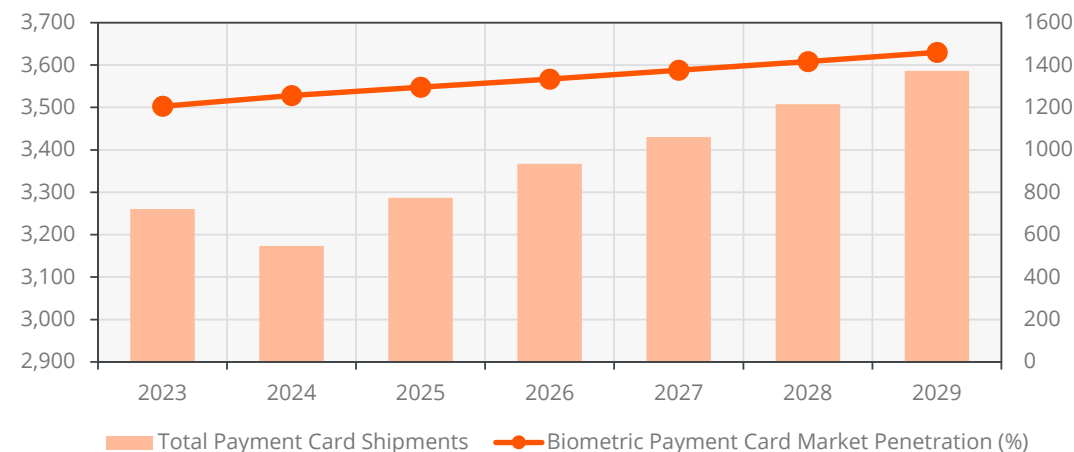
Countries inside the Association of Southeast Asian Nations (ASEAN) have seen a marked increase in their digital footprint with the digital economy value in the region set to be nearly worth US\$2 trillion by 2030, as predicted in the ASEAN Digital Economy Framework Agreement (DEFA).

QR payments solve one of the main barriers to entry for merchants as they provide a cost-effective secure digital payment technology for merchants without them having to purchase expensive hardware.

To help facilitate this increased use of QR payments, the ASEAN government over the last decade has not only introduced regulation to help standardize QR payments, but also make sure these standards are interoperable with the end goal being a seamless ASEAN QR payment landscape.

Penetration of biometric payment cards will account for less than 1% of all payment card shipments.

Biometric Payment Card Shipment Penetration Rates



Significant investments in the development of the biometric card have been made across the entire value chain. Although all vendors want the biometric payment card to succeed, market adoption has been extremely slow and nowhere near the levels originally expected.

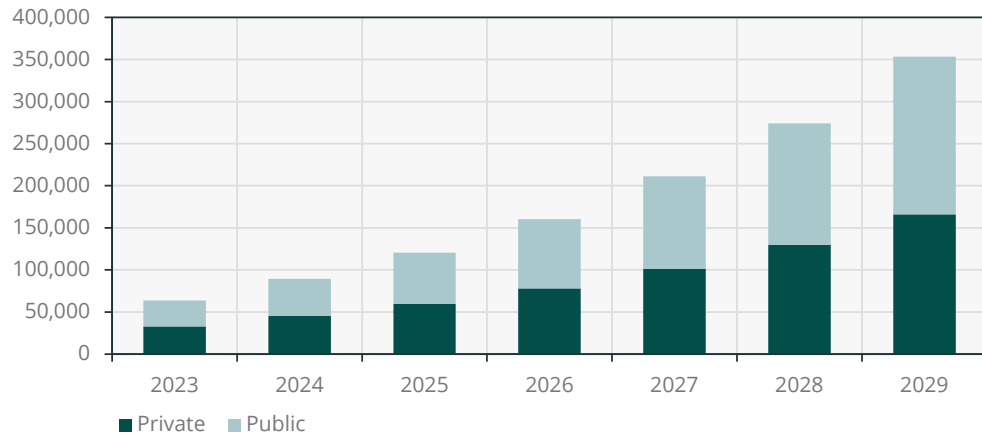
There has been a notable tone change in the market and a realization by ecosystem players that the biometric payment card will remain a niche solution. This has been further reinforced by a strategy shift by some vendors looking to explore other end verticals outside of payments, most notably access control and crypto cold wallets.

Although the biometric payment cards market will have some success, the measure of success and expectations need to be reevaluated. It is clear that biometric payment card volumes will not hit billions of units and will remain extremely niche, accounting for a mere 0.009% of total payment card shipments in 2023, growing to account for 0.067% in 2029.

**Public charging energy demand will exceed private charging energy demand in 2025, growing to 187.5 Terawatt Hours (TWh) by 2029.**

**Plug-in hybrids will only account for 1-in-5 PEV sales by 2029.**

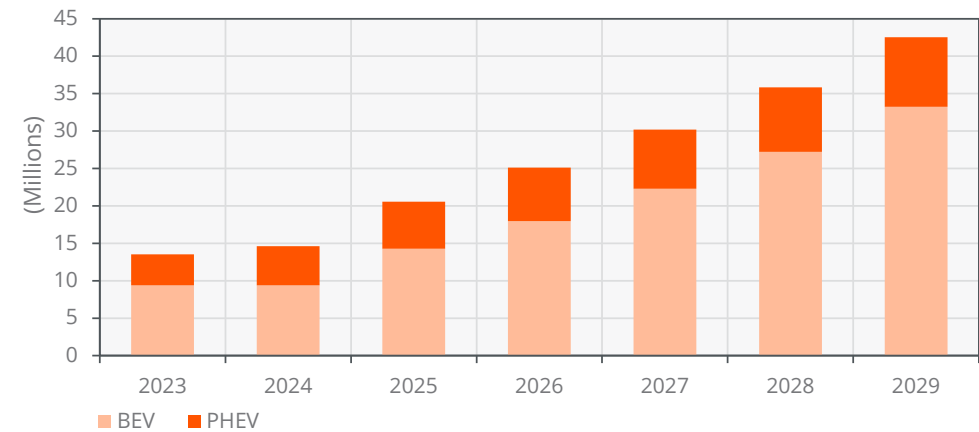
Charging Energy Demand by Access



Historically, energy demand for Electric Vehicle (EV) charging has been dominated by home charging, due to the tendency for first wave EV adopters to have access to off-road parking in the key regions that initially led EV adoption, such as North America and Western Europe. From 2025, public charging energy demand is set to exceed private charging energy demand for the first time; a trend that is expected to continue in the coming years.

This will be driven by a number of factors, including leadership in EV adoption in regions that typically rely on shared charging infrastructure, such as China. Furthermore, the number of Direct Current (DC) fast chargers is set to increase, as well as the average charging speed of the installed base of DC chargers. Finally, in the longer term, EV ownership is expected to expand into a new wave of secondary adopters in the North American and Western European markets who do not have the same level of access to off-road charging as historical users have enjoyed.

New PEV Shipments by Powertrain



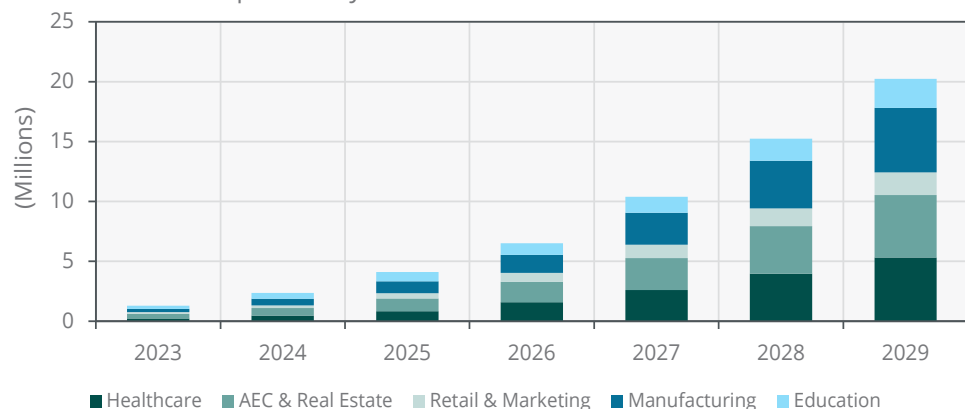
Plug-in Electric Vehicle (PEVs) hit their peak market share of PEVs in 2024, accounting for over a third of PEVs shipped that year. This is expected to drop in the coming years, eventually declining to around 1-in-5 PEVs shipping in 2029. This will be driven by a number of factors, most significantly the reduction or outright elimination of subsidies and other incentives, as most governments seek to cut back public expenditure or reprioritize subsidies/incentives to increase adoption of pure Battery Electric Vehicles (BEVs), which are better aligned to overall net-zero goals. More generally, BEVs are approaching price points, energy densities, and recharge rates that negate the need for a back-up or primary Internal Combustion Engine (ICE).

While some Original Equipment Manufacturers (OEMs), against the backdrop of stuttering BEV shipments, are reconsidering the horizon for withdrawing their Plug-in Hybrid Electric Vehicle (PHEV) models, the significance of subsidies and incentives in shaping the fortunes of the PEV market cannot be underestimated, so PHEVs are likely to continue their decline as a share of the PEV market.

**High-value Extended Reality (XR) use cases and novel devices like AI-enabled smart glasses will propel enterprise XR adoption, which will reach 20.23 million shipments by 2029.**

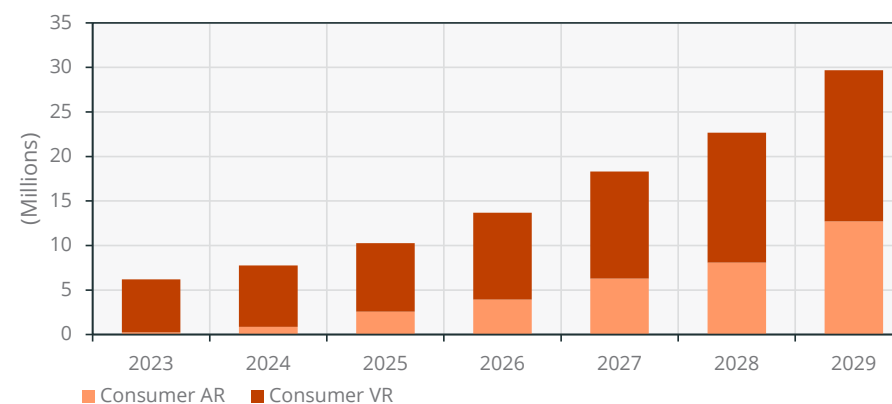
**While both consumer AR and VR device shipments will grow, consumer AR device shipments will continue to lag behind consumer VR.**

Total XR Device Shipments by Vertical



Both Augmented Reality (AR) smart glasses and Virtual Reality (VR) Head-Mounted Displays (HMDs) will play a role in enterprise segments over the next 5 years. Historically, the market favored smart glasses at first, then moved to VR headsets, and now is moving back toward AR glasses. This back and forth is a reaction to the maturity and availability of devices, as well as where value was identified: glasses are best for hands-free data access and environments where safety is a focus, and VR headsets are best for controlled environments where visual fidelity and interaction are most important (e.g., training and data visualization). As expected, segments where these strengths are most impactful show the most XR adoption.

Consumer AR and VR Shipments

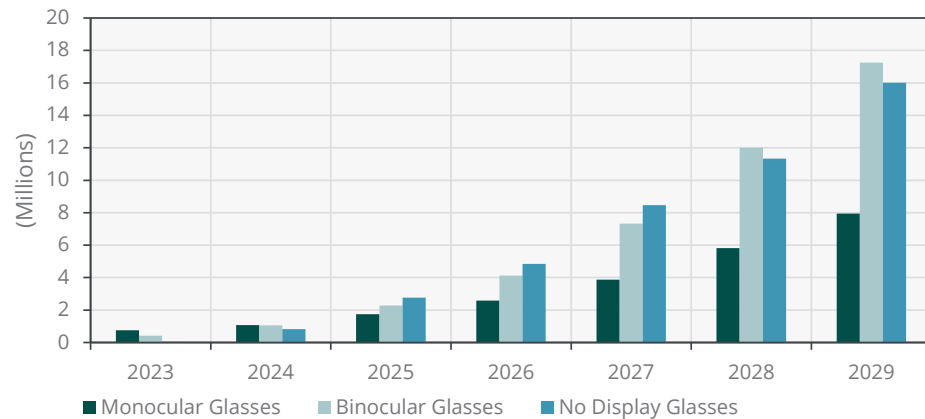


Consumer VR shipments are still expected to grow over the next few years, though the rate of growth is slowing, and is notably slower than was expected 1 to 2 years ago. Apple's somewhat muted Vision Pro campaign showcased that VR at scale for the company was still a few years away. Meta leads the VR charge, though it has not yet captured the same level of success as the Quest 2. Combined with increasing interest in AR devices, and the capability of those devices also growing through Artificial Intelligence (AI) and component advancements, the role of VR is not shrinking, but rather remaining more narrow and focused—gaming remains the dominant use case.

**AI-enabled no-display glasses will hit the market and see significant growth, reaching a 170% CAGR from 2023 to 2029.**

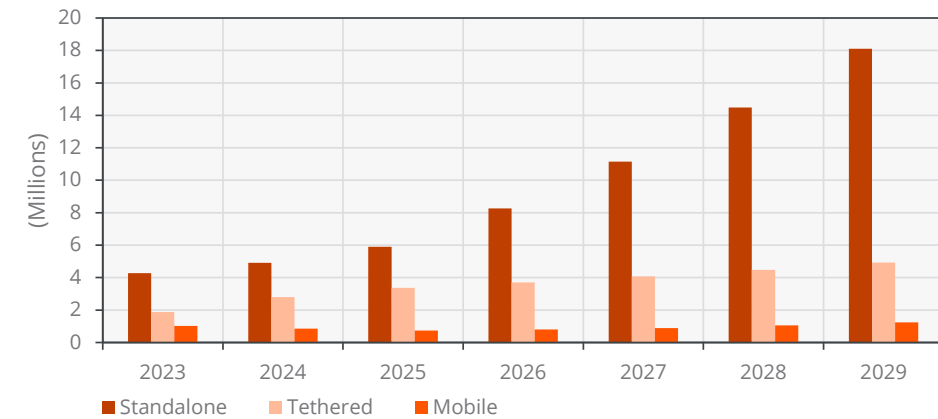
**Shipments of tethered and mobile-based VR devices will plateau, accounting for only 34% of all shipments by 2029.**

Smart Glasses Shipments by Form Factor



No-display smart glasses are the latest trend in the Extended Reality (XR) space. Despite being a relatively new product category, shipments have already quickened mostly through Meta's success with its Ray-Ban glasses. These devices forego a display to keep the cost down and design attractive, while focusing on audio input/output, AI assistants, and, increasingly, machine vision through an onboard camera. Over time, glasses with displays drop in price, while growing in capability and quality, and thus some of the momentum of early AI-focused no-display glasses moves toward true Augmented Reality (AR) glasses, bringing with it the AI capabilities.

VR Device Shipments by Type

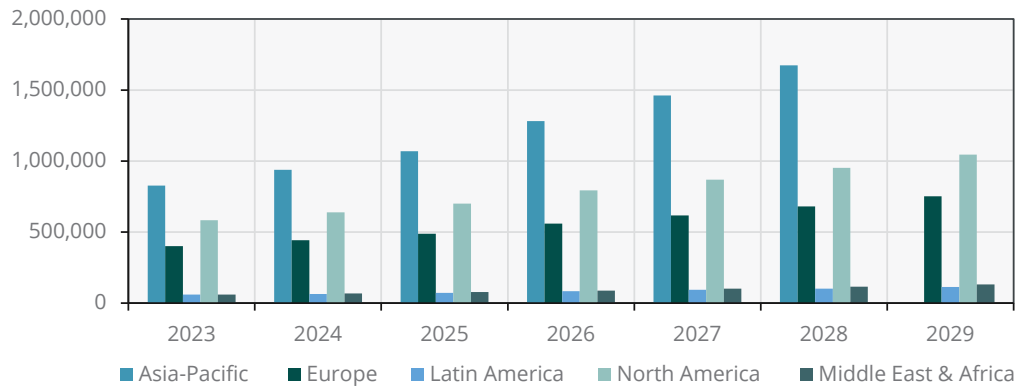


While standalone VR devices are expected to continue to see shipment growth over the next 5 years, the rate of growth is slower than previously expected. At the same time, the market for tethered and mobile device-based VR headsets remains limited, although not zero. Game console VR, primarily in Sony's PSVR2, remains on the market and is expected to see slightly quickened growth thanks to price cuts as the device ages. High-end Personal Computer (PC)-tethered VR remains valuable where fidelity is paramount, common in location-based VR experiences and in the enterprise sector. VR headsets leveraging mobile devices, whether through a wire or as a housing, remain viable as a low-cost option, though these have not seen enough device options or potential interest in the space.

**By 2029, industrial enterprises will generate almost 4 zettabytes of data, underscoring the critical need for seamless data integration to unify diverse formats and enable advanced analytics.**

**Albeit at a slower pace, the private networks market will grow to US\$75.9 billion in 2030—this more conservative growth poses challenges for pure connectivity providers.**

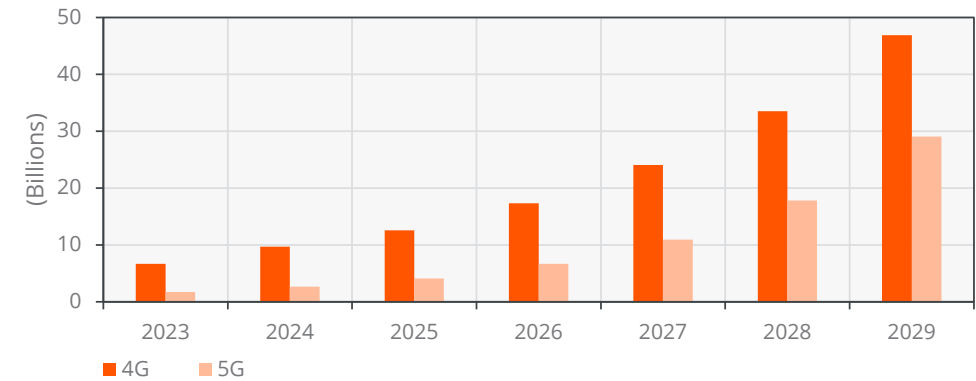
Data Generation in Industrial Verticals (Petabytes)



The explosion of industrial data demands scalable data fabric solutions that seamlessly integrate diverse formats, unify structured and unstructured data into standardized frameworks, and enable advanced analytics like Large Language Model (LLM) training. This requires robust connectivity, with private cellular networks emerging as a key option to support real-time data transmission and ensure reliable performance across complex industrial environments.

Scalability alone is not enough—robust data governance frameworks are essential to ensure data integrity, security, and compliance in highly regulated environments. The emergence of sovereign clouds will be pivotal, offering jurisdictional control alongside agility and scalability, forming the backbone of resilient, future-ready industrial data strategies that drive timely insights and global standards adherence.

Private Network Revenue by Technology



Even as demand for private networks remains on a positive trajectory, forecasts through 2030 have dipped. Previously estimated to generate US\$82 billion in 2030, this figure has dropped to US\$75.9 billion, marking a 7% fall. Clients do not look for pure connectivity, but instead consider private cellular as an enabler for their use cases. Enterprise Artificial Intelligence (AI), for example, requires robust connectivity to train and utilize, often containing sensitive data in the process. The provision of private networking, in conjunction with AI applications, makes for a more actionable, attractive proposition than cellular connectivity alone.

Vendors must compound offerings with software and hardware that solves recurring problems within their verticals of choice. Leveraging partnerships with hardware and software firms, as well as vertical-specific leaders, will allow companies to create relevant solutions, and motivate firms to adopt private cellular. Several firms have explored this, such as NTT, Zebra Technologies, and Nokia, which offered Device-as-a-Service and Use case-as-a-Service solutions in 2024. However, this is not the norm, and more of these new models need to emerge in 2025 to keep vendors' private cellular dreams alive. The discussion surrounding enterprise AI can reignite enterprise interest in private networks, but it will not free providers in redesigning their offerings to create demand.

**Humanoid robot shipments will pick up pace in 2025, reaching over 180,000 per year by 2030—regardless of technological maturity and practical value.**

HUMANOID ROBOT SHIPMENTS							
	2024	2025	2026	2027	2028	2029	2030
Europe	2	12	714	1,250	2,497	9,891	19,779
Asia-Pacific (Without China)	2	7	1,409	5,296	11,071	24,299	54,355
China	63	270	2,016	7,313	15,464	33,218	58,956
North America	36	259	834	5,099	11,570	22,927	39,550
All Other Regions	2	15	220	930	1,993	4,244	8,876

Despite the current inability of humanoid robots to provide 1:1 human equivalence for rapid, complex, and dexterous tasks, the commercial humanoid market will rapidly grow. Driven by lowering costs and novelty, humanoid robots for service, hospitality, and entertainment will buoy demand in the near term. For many stakeholders, the true Total Addressable Market (TAM) for humanoids lies in industrial manufacturing and logistics. With stringent demand for Return on Investment (ROI) and productivity, these remain complex verticals to penetrate from a technological perspective. Yet, other humanoid vendors target the service and healthcare sectors; here, regulatory obstacles must be addressed before technical shortcomings.

**Robotics offline programming software revenue will grow at a modest 8.5% CAGR, resulting in turbulent years for smaller software vendors.**

ROBOTICS OFFLINE PROGRAMMING SOFTWARE REVENUE (US\$ MILLIONS)							
	2024	2025	2026	2027	2028	2029	2030
Europe	33.31	33.59	37.95	41.86	44.33	45.75	55.01
Middle East & Africa	1.55	1.90	2.89	3.95	5.50	5.91	11.42
Asia-Pacific	58.70	60.20	70.10	71.31	71.40	75.12	95.55
North America	23.79	24.86	29.62	30.64	31.23	33.61	43.37
Latin America	5.55	7.01	8.34	8.68	8.73	9.08	15.55

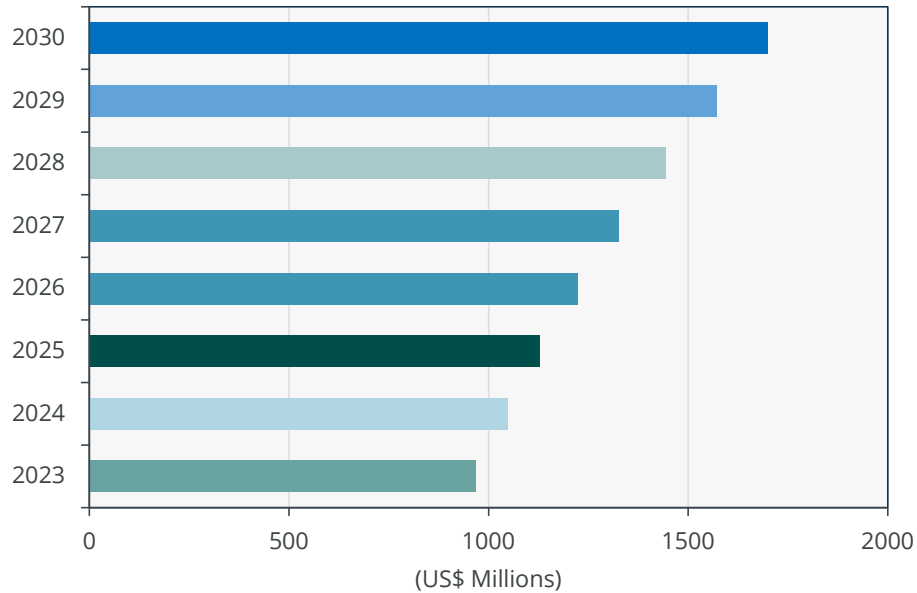
The advantage of robotics offline programming software is most obvious when implemented in a mature process or ecosystem. For example, the augmentation of existing robot cells in manufacturing—via Product Lifecycle Management (PLM) or Artificial Intelligence (AI) for optimized robot path planning—is of value because those processes are sufficiently mature for innovators to improve an existing process. Forecast robotics uptake touches on many severely under-automated industry verticals such as pick-and-place processes in logistics, automating crop processing, and hospitality robotics. These sectors remain fertile, but new sectors for robotics automation. Here, service providers and Original Equipment Manufacturers (OEMs) must provide programming software at a minimal cost to demonstrate the working viability of their products. The value of third-party offline programming software is best demonstrated years after automation has taken root in an industry; an iterative process the first stage of which is beginning to take shape for much of the economy.

Further, programming software is often packaged with other, further reaching, Enterprise Resource Planning (ERP) software. If a software vendor does not offer Warehouse Management Software (WMS), Manufacturing Execution Software (MES), or an emerging technology, such as reinforcement learning capabilities, they will struggle to compete with incumbent giants such as Siemens, Dassault Systèmes, and, recently, NVIDIA with primary revenue driven by hardware sales or a large software ecosystem; robotics offline programming software is merely a value-add.

**Adoption of EHS software by process manufacturers will grow 8.36% between 2023 and 2030.**

**Discrete manufacturers' adoption of EHS software will lag behind, with a CAGR of 4.36%.**

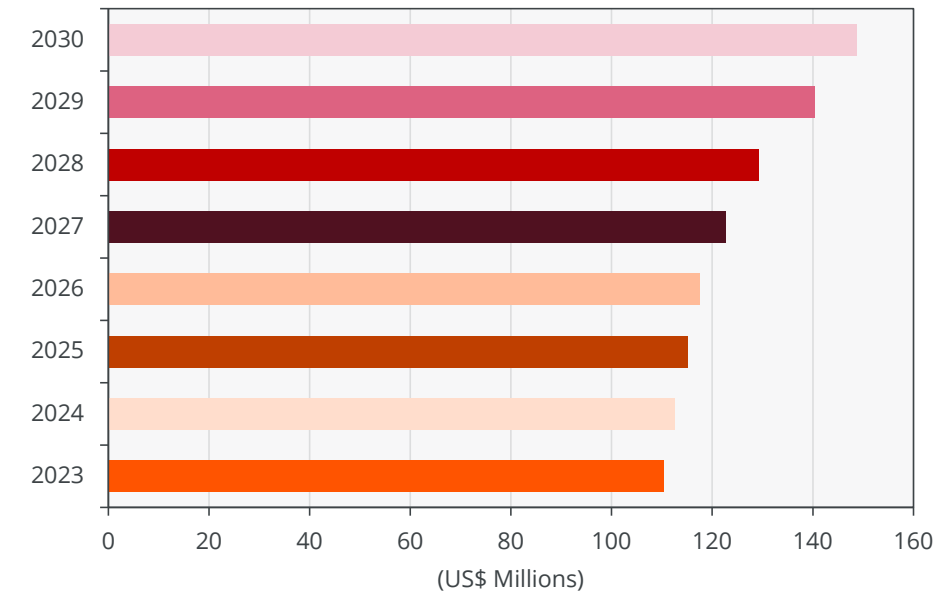
Process Manufacturers EHS Software Spending



Environmental, Health, and Safety (EHS) software can be used both to reactively report and track issues and incidents, but also proactively by enabling staff to report potential hazards as part of a safety management program to demonstrate compliance and develop training programs.

Chemical plants and mines are some of the most hazardous working environments. Furthermore, other process manufacturers such as pharmaceutical firms and food & beverage manufacturers are subject to stringent regulations. EHS software can help them remain compliant. Spending on EHS software in these verticals is forecast to grow by a Compound Annual Growth Rate (CAGR) of 8.36% and reach US\$1.7 billion in 2030.

Discrete Manufacturers EHS Software Spending

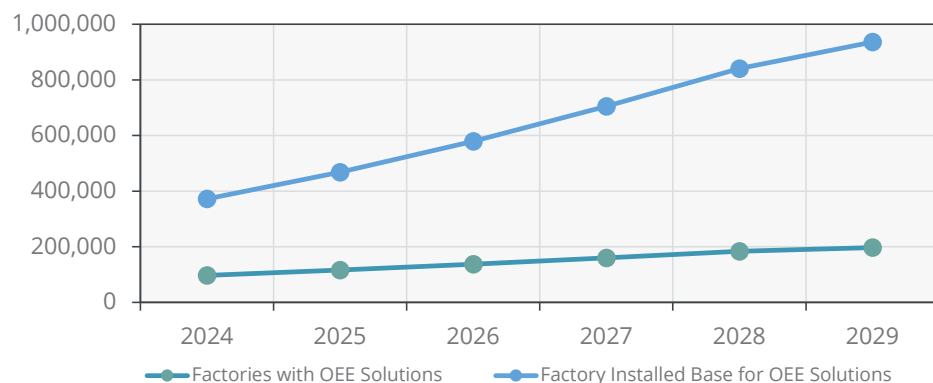


Manufacturing verticals have unique characteristics and appetites for adopting software applications. While hazards, dangers, and regulations are factors affecting discrete manufacturers in facilities producing airplanes or automobiles they are not at the same magnitude as at a chemical plant or oil rig. For example, safety is an underlying concern when monitoring asset performance or introducing robots on a production line, but can be handled by Programmable Logic Controllers (PLCs) and/or robot programming software. Spending on dedicated safety tools will be constrained and spending on EHS software is forecast to reach US\$148 million in 2030.



**Data analytics for OEE will see a significant boom in 2025 and persist throughout the decade, growing at a revenue CAGR of 13.2%.**

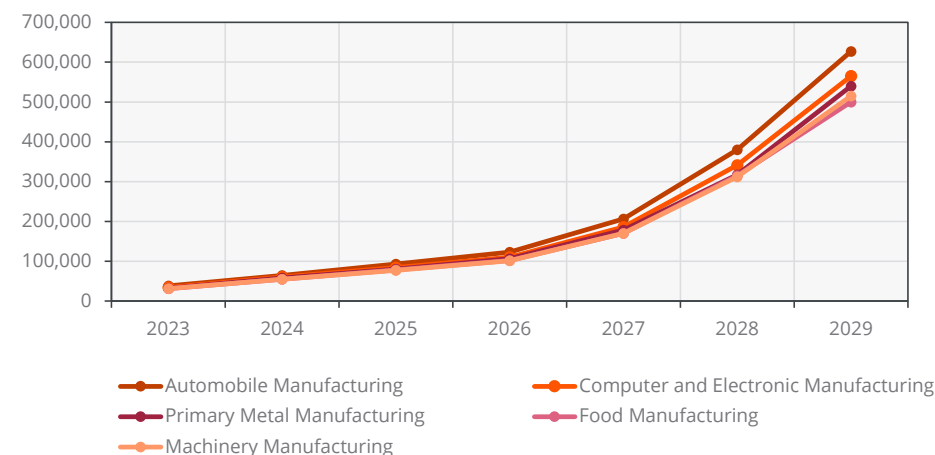
Data Analytics for Overall Equipment Effectiveness (OEE)  
(Millions Actual)



Overall Equipment Effectiveness (OEE) is not a new technology and has been used by manufacturers for decades as the lynchpin to assess how production lines and factories are performing. However, with the increasing importance of data utilization, along with the never-ending goal for complete transparency into factory floor operations, OEE is making a resurgence as a key steppingstone to effectively tackle these issues. With investment levels and constant refinements to AI and ML models by supplying vendors, prescriptive and predictive analytics are becoming more mainstream with manufacturers that typically could not deploy data analytics solutions. Although AI and ML models are paramount to prescriptive and predictive analytics, OEE is the first datapoint relied upon to start performing actionable changes to the factory floor. Inherently, OEE does not provide tangible revenue for manufacturers, but rather a simple explanation of problems within a factory. With the increased demand for prescriptive and predictive analytics, OEE will naturally see a revenue uptick as these solutions go hand in hand.

**Hidden costs and the monetization of Gen AI will cause a revenue boom in 2025 and beyond, but the burden will be placed on manufacturers.**

Generative AI Added Revenue by Manufacturing Vertical (US\$ 000s)

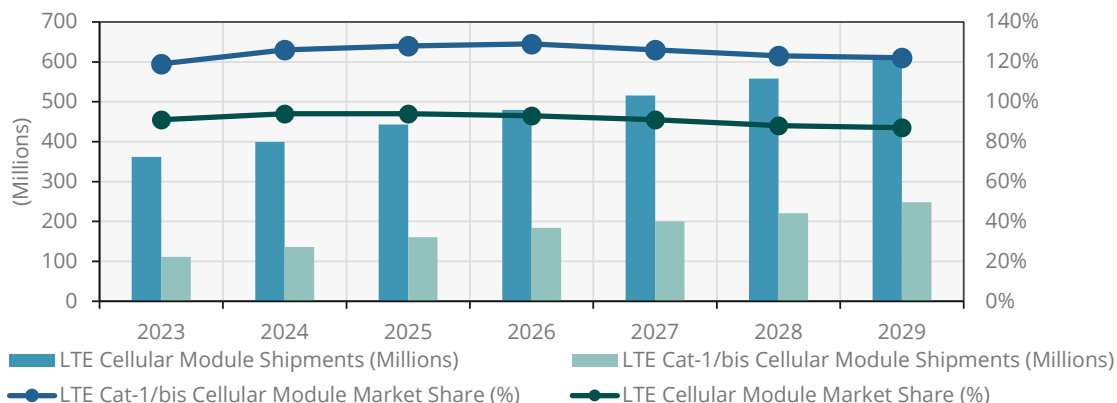


Vendors that provide Gen AI solutions to manufacturers are incorporating functionality into existing software such as Manufacturing Execution System (MES) and Product Lifecycle Management (PLM); however this has not justified the Research and Development (R&D) investment as the price of MES and PLM solutions have not changed to reflect the incorporation of Gen AI. Moving forward, the cost of Gen AI will be shifted to end-using manufacturers so vendors can recoup the price of development.

Also impacting the Gen AI market are the hidden costs when not utilizing Gen AI through embedded manufacturing software. Manufacturers will have sticker shock when examining the cost for standalone deployments of Gen AI. For a successful deployment, manufacturers must scrutinize all facets such as the collecting and storing of clean data, new hardware to manage larger workloads, and the acquisition of skilled labor, which are often overlooked when deploying Gen AI.

**LTE Cat-1 will experience 100% shipment growth as part of the cellular IoT volume success story.**

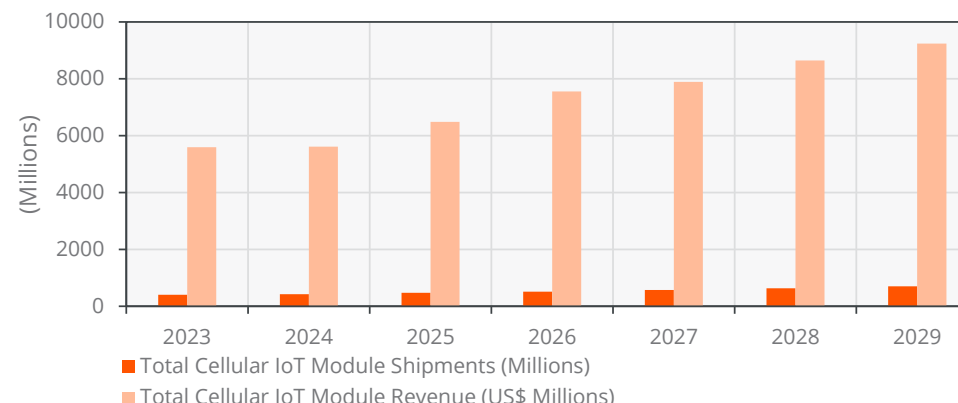
LTE & Cat-1/bis Cellular Module Shipments



The technology dynamic in the cellular Internet of Things' (IoT) module market is clear. Long Term Evolution (LTE) is categorically dominant and will be for the foreseeable future. In 2024, 94% of cellular module sales were LTE and at the end of this forecast horizon, in 2030, it will still be 85%. Barely anyone in the mobile industry mentions 2G and 3G today, but, perhaps surprisingly, it remains relevant to the IoT. 2G and 3G chipsets are no longer available, but vendors still have inventory of 2G and 3G modules, and device Original Equipment Manufacturer (OEM) customers will keep buying them until those stocks are exhausted. 2G and 3G module shipments are very low now, but it is the message of those technologies' legacy that matters: value for money and maximal availability rules all in the IoT. LTE is the most ubiquitously available cellular network technology worldwide, and Cat-1bis, specifically, has, by far, the best price-to-performance trade-off we have ever seen. This is why Cat-1 accounted for 136 million module unit sales in 2024, or 32% of the total module market, and thanks to Cat-1bis, this figure will increase to 276 million units in 2030. Even as LTE's overall market share starts to wane in the IoT, Cat-1's will still be growing. OEMs have IoT device designs they will maintain and provide spare component support for until the last viable moment, before redesigning with a new technology. And that is why despite discussions about LTE sunsets, LTE will persist as a leading enabler in the IoT for as long as it is available.

**The cellular IoT module market will start to emerge from its slump in 2025, but risks remaining relatively flat.**

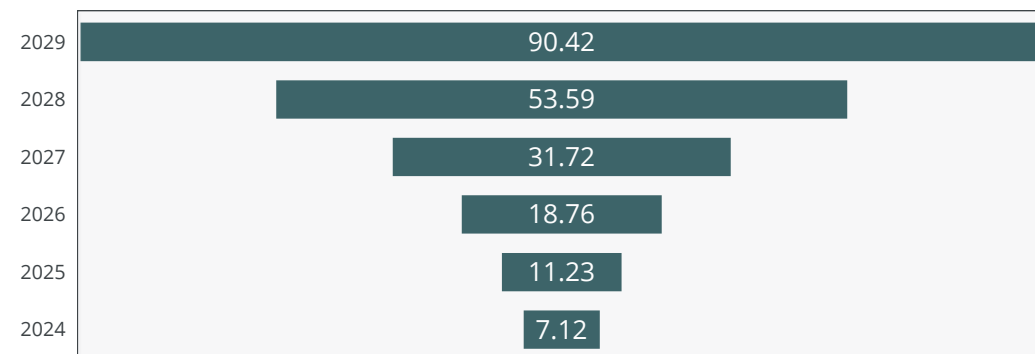
Cellular IoT Module Shipments and Revenue



The cellular module industry has been in the doldrums for the last 2 years, following the surge in shipment growth during 2021 and 2022. A reset is taking place as the customers who over-ordered in the wake of COVID-19 and in the face of the chipset crisis continue to work through their inventory of components. No one wanted to risk being unable to fulfill their pipelines for fear of losing business to competitors during a period of acute supply chain reinforcement. In the meantime, module vendors have had to play an expensive waiting game during an extended period of reduced sales. And in a market of tightening margins where consolidation has already occurred, not all vendors have or will survive. The IoT is not a dying market, it grows organically as and when it is natural. The IoT does not experience growth based on hype or innovation, but the affordability and ubiquity of enabling technologies. It is taking time for the demand-side of the cellular module market to rebalance and 2025 seems a likely year for that, with the vendors that had business in automotive and consumer Mobile Broadband (MBB) to tide them over emerging the healthiest. But there is a risk that 2025 could still be relatively flat, with 469 million cellular module shipments currently expected. Meanwhile, revenue for 2025 is anticipated to be US\$6.48 billion.

**Shipments of Wide Area Network supply chain monitoring devices will continue to expand at a rapid rate as the technology becomes mainstream and new device types emerge.**

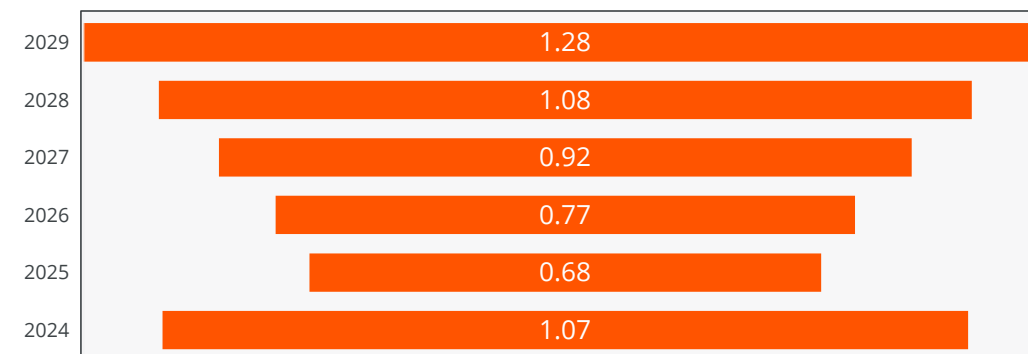
Supply Chain Monitoring Device Shipments (Millions)



Supply chain monitoring devices are one of the fastest-growing asset tracking device categories. These devices were brought into the mainstream by the COVID-19 pandemic, and have continued to proliferate in different markets since then. Supply chain monitoring solution providers, initially focused on offering devices, sometimes with a basic platform, have spent the last 5 years adding value to their software, service, and ecosystem partnerships to maximize the potential Return on Investment (ROI) for customers. Now, the value of these solutions is clearly recognized. New device types like smart labels have finally moved from the design board to commercialization and adoption, offering lower-cost and more flexible ways of tracking goods, with companies such as OnAsset Intelligence, Roambee, Reelables, Sony Sensos, Controlant, Linxens, and Giesecke+Devrient (G+D) offering versions. Across solution providers, Year-over-Year (YoY) shipment growth rates over 50% are not uncommon. The last 12 months have seen enormous funding and important technology launches in the industry, both for hardware and software, which promises continued interest in the development of this market.

**Intermodal container device shipments hold steady, pending new major announcements by shipping container operators.**

Intermodal Container Tracking Device Shipments (Millions)

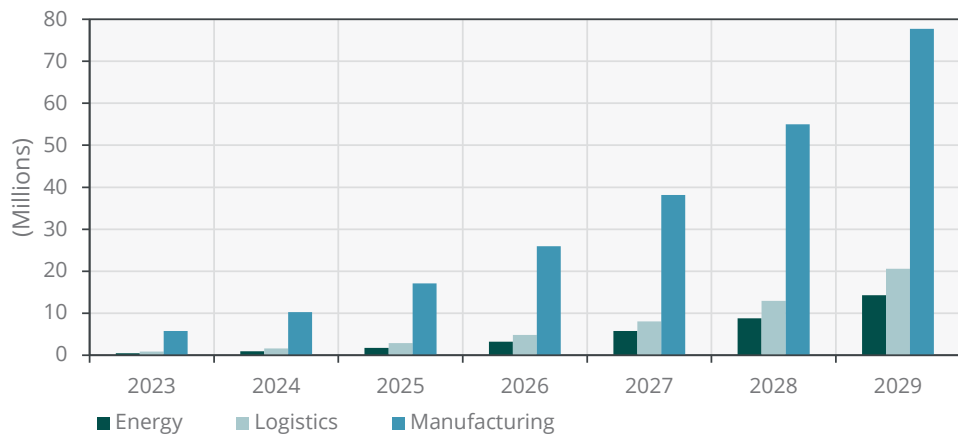


[Hapag Lloyd's announcement in 2022](#) that it would equip its 1.7 million-strong dry container fleet with Nexxiot and ORBCOMM tracking devices made a big splash. Certainly, it was a visionary move from a company investing heavily in its transformation into a digital and data-driven company. The rollout has gone as planned, with the vast majority of containers equipped. Few other dry container fleet operators have followed in their footsteps, and those that did only did so reluctantly. Large operators like Maersk, CMA-CGM, MSC, COSCO, and others have all trialed Internet of Things (IoT) technologies, but have not found a positive Return on Investment (ROI). This is understandable: much of the ROI will come from the data derived over years, not months, and the upfront investment is large (Hapag Lloyd's was in the realm of US\$250 million). Where container operators do use tracking devices, they usually use them on a shipment-by-shipment basis, offering it as a premium service to their customers without the need to have a permanently installed device. While some asset owners such as DHL continue to buy a few tens of thousands to fit out their various country fleets, the industry's growth continues to be steady. Things can change; high volumes in this market segment are driven by large projects, rather than continually large Compound Annual Growth Rates (CAGRs). In the meantime, shippers and service providers alike can carve out small but valuable businesses offering premium monitoring services to their customers, with both monitoring devices and smart container locks.

**Mission-critical, IIoT customers looking for a private network solution will choose private 4G or 5G over non-cellular alternatives, driving revenue to US\$112.6 million by 2029.**

**Private cellular network customers will connect more non-IoT devices in the future, with some verticals leaving legacy IoT devices and sensors as they are.**

Private 4G and 5G IoT Connections by Market Segment

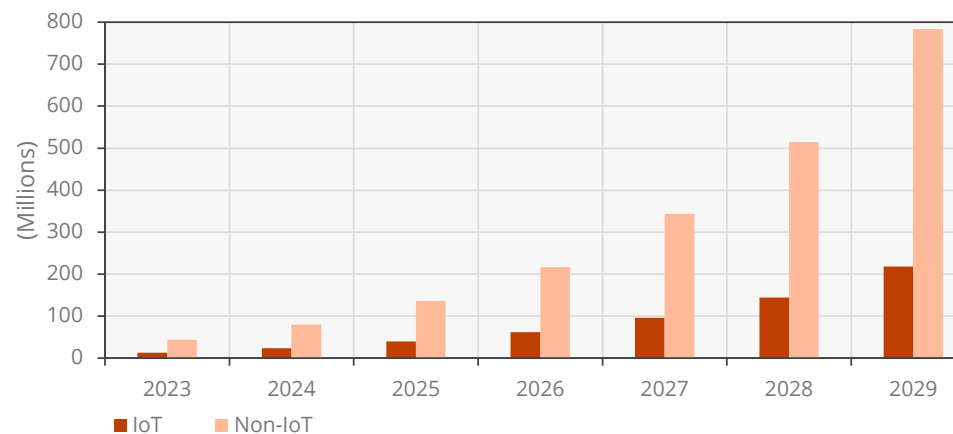


Internet of Things (IoT) customers have several options when choosing a private network deployment, including non-cellular technologies like LoRaWAN and DECT-2020 New Radio (NR). However, if an IoT customer with mission-critical needs invests in a private network, they will likely choose a cellular technology, given its performance and reliability.

Many mission-critical, private cellular IoT needs are found in industrial segments like utilities. Use cases might include health and safety monitoring in mines, where customers can leverage private 5G networks to automate mining equipment, such as drill rigs or haulage vehicles. Automating such heavy equipment can improve the safety of raw material transfers, while also producing important data for predictive maintenance.

Video surveillance remains one of the most relevant, mission-critical IoT applications for private 5G, with live remote video streaming being a critical operational tool for lone workers who must oversee industrial sites like utility plants or ports. Lone workers using a private 4G- or 5G-enabled camera can provide real-time feedback on their work and safety, rather than relying on voice-only communication. These critical, IIoT use cases can help justify the purchase of an expensive private cellular network and will partly drive total private network IoT connections in the future.

Private Cellular Connections by Connection Type

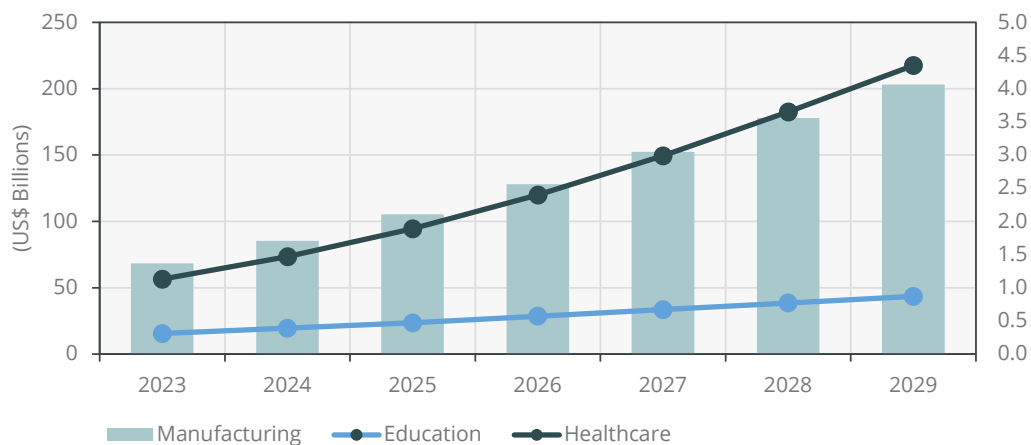


The total private cellular connection numbers above represent both private 4G and 5G connections. Private cellular networks are expected to modernize many Industrial Internet of Things (IIoT) use cases (as listed in the above section). However, any discussion of the IIoT opportunity in private cellular networks must contend with this fact—the predominant private cellular use case in industrial verticals is connecting workers' non-IoT voice/data communication devices like smartphones and tablets. IoT private cellular use cases will often occur downstream of non-IoT use cases, with customers first connecting their personal devices before going through the expensive and arduous process of overhauling their legacy IoT devices and sensors.

The exponential growth of cutting-edge technologies such as AI/ML and Gen AI is set to generate more than US\$200B worth of data management opportunities worldwide by 2029.

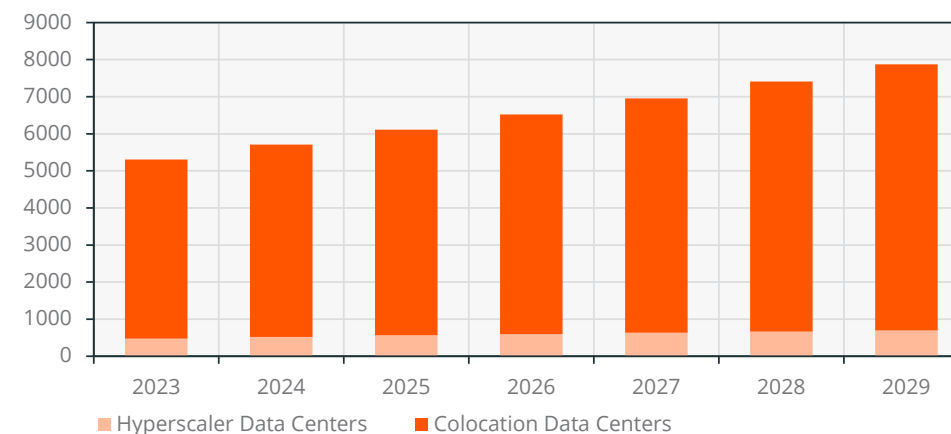
By 2029, with 7,800+ data centers globally, cloud hyperscalers face intense competition from colocation data centers as enterprises turn to localized entities.

Enterprise Data Fabric Revenue for Manufacturing, Education, and Healthcare



Manufacturers, healthcare providers, and education institutions have challenges in implementing AI/ML or Gen AI solutions with the availability and quality of relevant data at their disposal. The emergence of sovereign clouds underscores the need for better protection of personal and sensitive data. This gap has resulted in growing market demand for data management solutions, generating more than US\$200 billion worth of market opportunity for data management providers to help enterprises solve glaring data disparities and provide differentiated solutions to capture market demand.

Next-Generation Hyperscaler and Colocation Data Center Infrastructure Sites

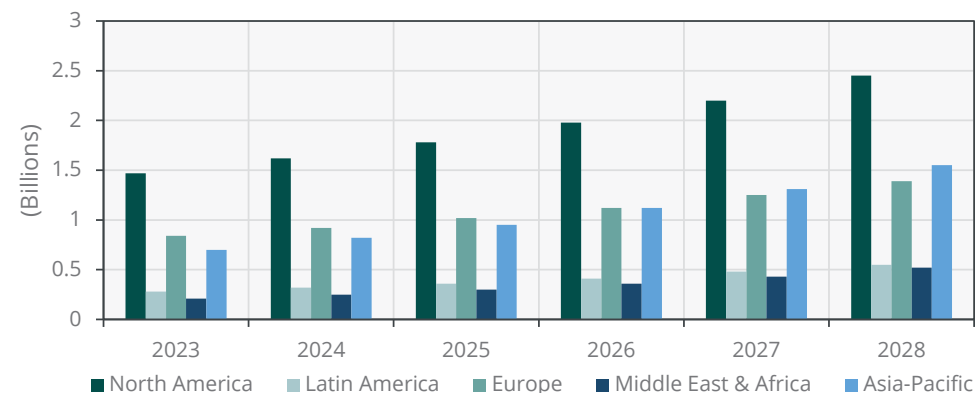


While cloud hyperscalers like Amazon Web Services (AWS) and Microsoft Azure have announced large investment plans for new data center infrastructure, colocation data centers will continue to play a major role as providers of cloud services for enterprises. Geopolitical challenges and sovereign data residency requirements for regions such as Asia-Pacific and Europe will hamper the demand for hyperscaler data center infrastructure. Colocation facilities allow enterprises to partner with local providers that understand the local regulatory landscape, allowing greater control over their data and infrastructure. Cloud hyperscalers will need to address sovereign data residency requirements, especially for industries that are highly regulated.

**Segmentation technologies for OT cybersecurity is the largest and most rapidly growing OT security technology segment in industrial environments, reaching US\$6.46 billion by 2028.**

**Revenue for industrial blockchain is set to decline between 2023 and 2029 by a -1.9% CAGR.**

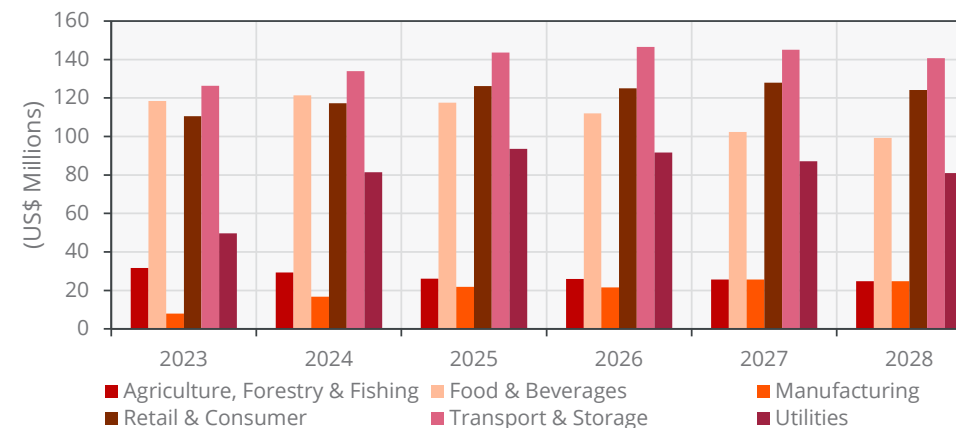
OT Cybersecurity Segmentation Technology Revenue by Region



Segmentation technology is at the core of protecting the Operational Technology (OT) environment and includes both hardware and software components. Distinct from general network security, segmentation in OT specifically involves subdividing network architectures into separate zones, or air gapping critical OT networks from Information Technology (IT). This is a critical method in OT environments to limit the spread of threats into the physical realm of industries.

Securing OT environments, especially from attacks originating in the IT environment, is one of the most crucial aspects of maintaining operations, in case IT systems are compromised, and limiting production downtimes. Technologies in this area include unidirectional gateways or data diodes, physical and software firewalls for network and micro segmentation strategies, Virtual Local Area Networks (VLANs), and Software-Defined Networking.

Global Industrial Blockchain Revenue by Sector



Most applications for industrial blockchain have failed to move past the pilot stages into successful commercial offerings. The issue is that many of these, while successful in their own right, do not provide a compelling enough use case that cannot be fulfilled by other technologies. In particular, the rise of private networks, sovereign clouds, and emergent confidential computing technologies can provide similar privacy and confidentiality capabilities, without having to significantly overhaul existing deployments.

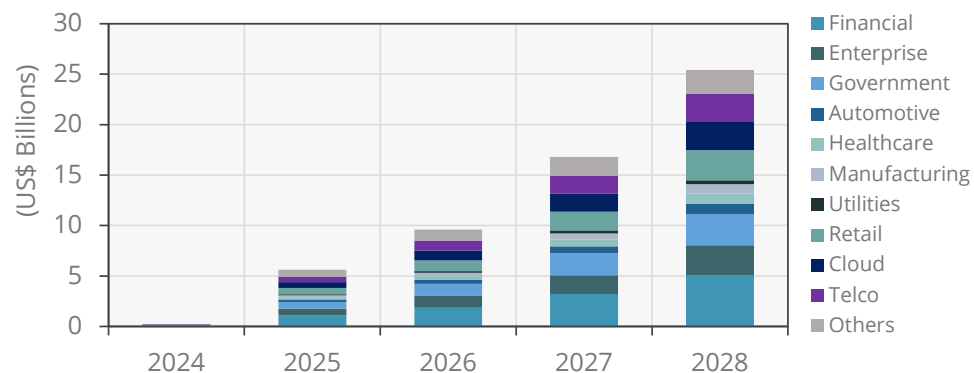
Further, greater maturity in the embedded security technologies space (notably around Trusted Execution Environments (TEEs) in microcontrollers) can provide high-level security for industrial devices. Provenance and lifecycle management can easily be anchored to device hardware roots of trust.

Finally, future concerns around the post-quantum readiness of blockchain technologies pose significant hurdles to wide-scale adoption in industrial settings, especially because many are long-lived deployments that are likely to still be in use post-2030, the emerging date for migrating to Post-Quantum Cryptography (PQC) algorithms. It is unclear how easy it will be for blockchain platforms to implement new PQC primitives.

**NIST announcement of official PQ algorithms is set to drive interest in quantum-safe PKI, translating into US\$25.2 billion in opportunities for vendors in the PKI and PQ spaces.**

**The HSM shipment market for the automotive, retail, utilities, and manufacturing segments is fairly saturated, with relatively flat product sales expected.**

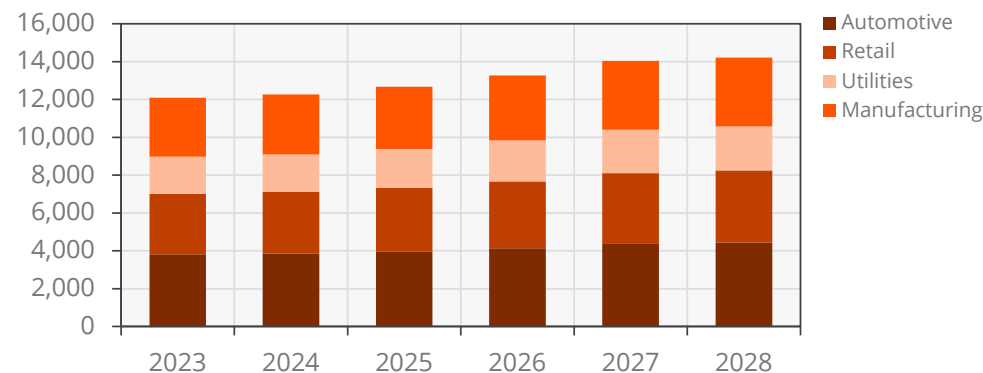
PKI-PQC Revenue by Vertical



Uptake of Post-Quantum Cryptography (PQC) within the Public Key Infrastructure (PKI) space has been limited due to persisting uncertainty on the standards for PQC algorithms; however, National Institute of Standards and Technology's (NIST) publication of four official algorithms in August 2024 is expected to restimulate market demand within the PKI-PQ subsegment, creating key revenue opportunities for digital trust and cryptographic vendors throughout the decade. While some oscillation in the market is expected as legacy system incompatibilities are tackled, momentum is expected to be built throughout 2025, with vendors reaping the benefits from 2026 onward.

This growth trajectory will be predominantly fueled by the stabilization of standardization efforts in this space, as well as emerging initiatives focused on maximizing the quantum-readiness and crypto-agility of digital trust systems, including efforts to reduce Transport Layer Security (TLS) certificate validity periods and the Commercial National Security Algorithm (CNSA) deadline for incorporating PQC into systems interacting with the U.S. Federal Government. Migration rates will still be dependent, to a degree, on vertical-specific use cases, upgrade cycles, and finite resources. Prioritization of data-sensitive and crypto-intensive applications, as well as backward compatibility with legacy systems, will be essential to limiting potential losses and tapping into critical capital opportunities throughout the transition to quantum-safe Public Key Infrastructure (PKI).

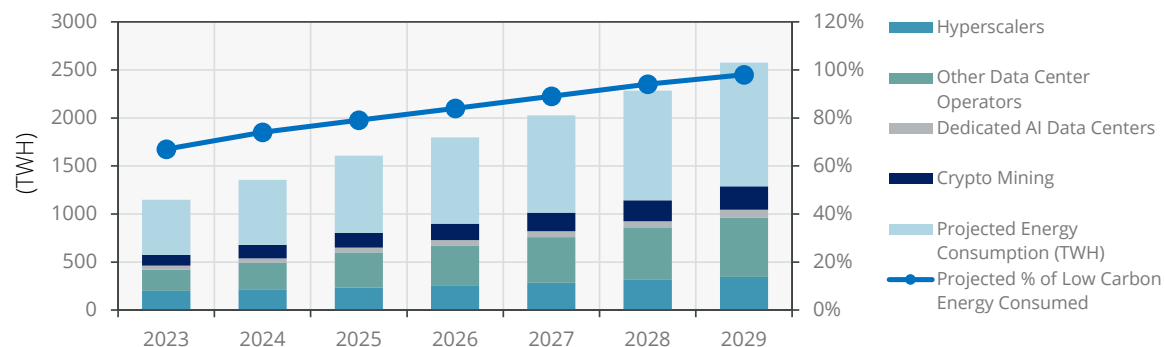
Global HSM Shipments by Vertical (Actual)



The Hardware Security Module (HSM) market is a mature and well-established market, meaning the growth in shipments Year-over-Year (YoY) is fairly low, dictated by replacement cycles primarily. Much of the dynamics is coming from the HSM-as-a-Service (HSMaaS) aspect, with multi-tenancy capabilities in existing hardware driving the growth for cloud-based services. Shipments in some sectors will continue to grow steadily (financial services, enterprise, government, cloud), but in others, they will be fairly flat going forward, notably in automotive, retail, utilities, and manufacturing. Macroeconomic pressures in these industries are redirecting budgets from Capital Expenditure (CAPEX) to Operational Expenditure (OPEX), favoring application- and service-based investments, rather than hardware. The market is not necessarily in decline for HSM product sales, but the pivot is more toward HSMaaS where there is demand for underlying applications. There will be a small growth peak toward 2026/2027, in line with concerns around PQC migration, but overall, the market is one of slow and steady growth, rather than exponential growth.

## Projected data center energy consumption will reach 1,288 TWh in 2029; global regulations and self-regulatory pledges are curbing uncontrolled demand.

Data Center Energy Consumption by Type & Projected Low Energy Consumption

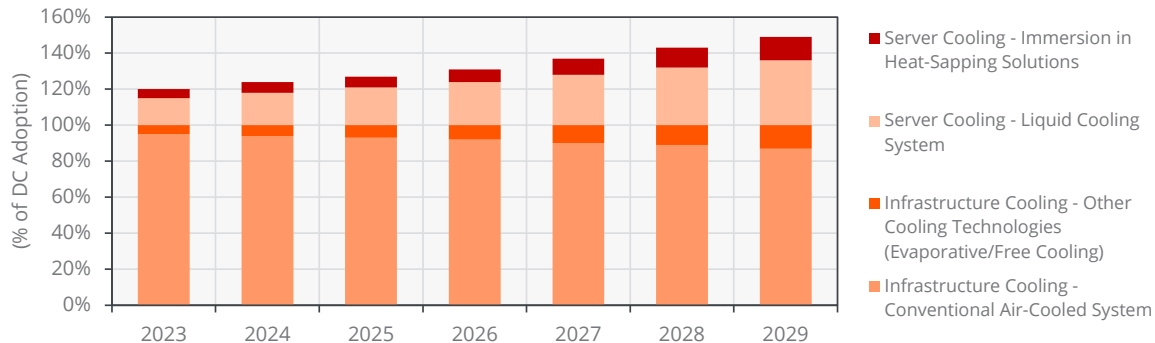


With the rise of digitalization, Artificial Intelligence (AI), and automation as common business practice, Data Centers (DCs) are becoming the backbone of Information Technology (IT) infrastructure and are set to double to over 24,000 in 2030 with a 12% Compound Annual Growth Rate (CAGR). Today, the key criteria for identifying and deploying a DC is access to electricity, as local and national power grids are strained to bridge the gap on the increased demand. ABI Research forecasts DC energy consumption to reach 1,288 Terrawatt-Hours (TWh) in 2029, with a 14% CAGR from 2023 in line with industry experts and the International Energy Agency's (IEA) predictions. According to the IEA's Electricity 2024 report, DCs in the United States and China consumed 180 TWh and 210 TWh in 2022, followed by the European Union (EU) with 100 TWh. The United States, the EU, and China represent more than 50% of the DC energy consumption globally in 2023, projected to triple by 2030.

Hyperscaler DCs are large facilities consuming between 30 Megawatts (MW) and 40 MW, catering to cloud computing, big data, and AI. In 2023, there more than 1,500 hyperscalers globally consuming 200 TWh forecast to reach over 3,000 DCs consuming 346 TWh by 2029. The top 20 hyperscalers consumed or offset 88% of their total energy consumption with renewables in 2023, ahead of the 75% renewable energy match by December 2025 and 100% by December 2030. By 2030, hyperscalers will consume 381 TWh low-carbon energy in line with the self-regulatory Climate Neutral Data Centre Pact (CNDPC)—a pledge from industry players and trade association of cloud infrastructure services and DCs to achieve climate neutrality by 2030. Amazon, Alibaba Cloud, Equinix, Google, Meta, and Apple operate on 100% low-carbon energy with Global Switch, Equinix, and Microsoft Azure operating on over 96%. Dedicated AI DCs are in the nascent stage of development and will be part of hyperscalers' DC campuses with a projected high CAGR of over 20% during the forecast period. With vigorous operational and efficiency regulations in effect for 2025, regulators are setting the stage to drive the need for green DCs over the coming years, while they trickle down to all data center types.

## Adoption of traditional air cooled Infrastructure in data Centers will drop over 8% by 2029, as advanced cooling solutions meet cooling demand.

Data Center Cooling Technologies Installed Base Penetration Share by System Type



ABI Research forecasts that DCs will grow exponentially from 10,978 in 2023 to more than double by 2030. Increased computing power results in more heat generated by IT equipment, which, in turn, results in higher cooling loads, currently representing 40% of a DC's energy consumption. To address the increased heat generated from compute, DC operators are adopting a two-step cooling strategy as demonstrated in the chart.

In 2023, 95% of DCs are cooled by traditional air-cooled systems with 5% relying on hybrid cooling, predominantly in the Nordics and Canada for free or evaporative cooling due to favorable climatic conditions such as low humidity. This is set to increase to 13% by 2029 due to pressing operational costs, regulations, and technological advancements of hybrid cooling technologies like adiabatic chillers. Today, 20% of DC operators (predominantly hyperscalers) are piloting liquid and immersion cooling systems, which are set to be implemented in over 55% of all DCs by 2030 as cooling load increases.

In absolute terms in 2023, conventional systems contributed to 40% of the DC cooling hardware revenue, followed by Variable Refrigerant Flow (VRF) systems at 25.6% and Direct Expansion (DX) units at 9.5%. Over the forecast period, shipments of conventional systems, VRF, and DX units will grow by more than an 11% CAGR, with system costs ranging from US\$250,000 to millions based on system complexities, cooling requirements, and location. Liquid cooling represents 15% of the hardware markets at US\$970 million and is forecast to grow to US\$3.5 billion by 2030 with a 20% CAGR, representing 20% of the DC Heating, Ventilation, and Air Conditioning (HVAC) hardware market share. Liquid cooling represents 15% of the hardware markets at US\$970 million and is forecast to grow to US\$3 billion by 2029 with a 20% CAGR, representing 20% of the DC HVAC hardware market share.



**Aggregated worldwide investments in electric energy transmission and distribution grid digitalization will grow from US\$81 billion in 2024 to US\$152 billion in 2030.**

**The cost of producing green Hydrogen (H2) will drop from US\$6/Kilogram (kg) in 2024 to US\$2.9/kg by 2029.**

**GRID DIGITALIZATION SPENDING BY REGION, WORLD MARKETS: 2023 TO 2030 (US\$ BILLIONS)**

	2023	2024	2025	2026	2027	2028	2029	2030
Europe	17.6	19.23	21.01	22.939	25.036	27.31	29.79	32.47
North America	26.31	28.02	29.84	31.776	33.841	36.04	38.38	40.88
Asia-Pacific	21.58	24.83	28.49	32.608	37.235	42.43	48.26	54.8
Rest of the World	7.865	9.317	10.98	12.884	15.058	17.54	20.36	23.58

During 2025, ABI Research anticipates a surge in overall grid digitalization investments fueled by growing awareness about and understanding of the benefits digitalization offers in terms of alleviating the stresses on energy networks in the wake of growing electrification. Digital grids enable unlocking additional grid capacity through real-time asset monitoring and reconfiguration based on advanced demand-response solutions such as Advanced Distribution Management Systems (ADMS). Additionally, digitalization enables realizing much needed flexibility to stabilize and protect the grid from increasingly distributed and unpredictable renewable energy assets through Distributed Energy Resources Management Systems (DERMS). Solutions from vendors such as GE Vernova will also allow energy utilities to engage in real-time energy trading of dispatchable energy to help match supply and demand and achieve much needed grid frequency stabilization.

Key grid digitalization technologies and tools include digital and virtual substation hardware and software (pioneered by Schneider Electric and ABB), energy digital twins (Siemens), advanced smart metering (Honeywell), cybersecurity solutions and grid orchestration software (GE Vernova), and, last but not least, (generative) Artificial Intelligence (AI) leveraged for an expanding set of uses cases ranging from grid automation and optimization to preventive maintenance and operations and service employee augmentation.

**LEVELIZED COST OF PRODUCTION BY HYDROGEN TYPE(US\$/KG)**

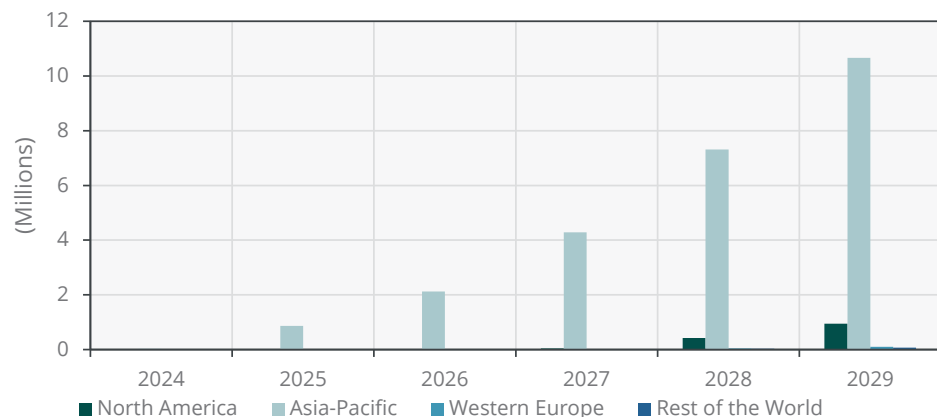
	2024	2025	2026	2027	2028	2029
Grey Hydrogen	2.1	2.1	2.1	2.0	2.0	2.0
Blue Hydrogen	3.0	2.9	2.9	2.8	2.8	2.7
Green Hydrogen	6.0	5.5	5.0	4.2	3.5	2.9

ABI Research forecasts that global Levelized Costs of Hydrogen (LCOHs) for green H2 will reach a cost-competitive level by 2030 and undercut polluting alternatives by 2040, paving the way for industrial adoption. The year 2025 will be pivotal in this timeline, during which falling Capital Expenditure (CAPEX) costs—driven by increased electrolyzer efficiencies and lower capital costs—will begin to push green H2 to economic viability.

In the coming year, innovations in Proton Exchange Membrane (PEM) and alkaline electrolyzer technologies driven by vendors such as ITM Power, Plug Power, SunGreen H2, PERIC, LONGi, and Siemens Energy will be crucial. Increasing governmental support—both on the national and regional levels – for electrolyzer producers will be equally important; increased protections for homegrown manufacturers and established markets for tendering demand will build momentum, reducing the risk—and, therefore, cost—of investment in the industry.

**In 2029, 11.8 million vehicles equipped with satellite connectivity will ship.**

Global New Vehicle Shipments with Satellite Connectivity (Actual)

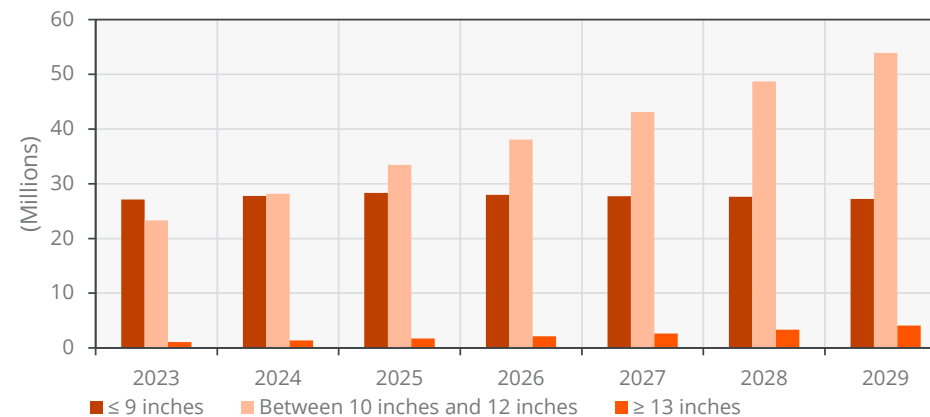


China is set to drive market adoption of satellite connectivity-based automotive services, with models such as the Geely Galaxy E8, Zeekr 007, Zeekr 001, Changan NEVO E07, and the BYD Yangwang U8 Off-Road set to ship with satellite services in either 2024 or 2025. Initially focused on narrowband services, the use of Non-Terrestrial Networks (NTNs) in automotive will increase reliability and availability of conventional safety and security telematics applications, rather than delivering any new use cases.

As a result, and due to the inevitable Bill of Materials (BOM) implication, initial deployments will focus on premium vehicle segments and Sport Utility Vehicles (SUVs), with the latter vehicle segment more likely to travel outside of conventional cellular network coverage.

**Smaller automotive head unit displays will peak in 2025 and decline in favor of larger displays.**

Global Head Unit Shipments by Size (Millions)



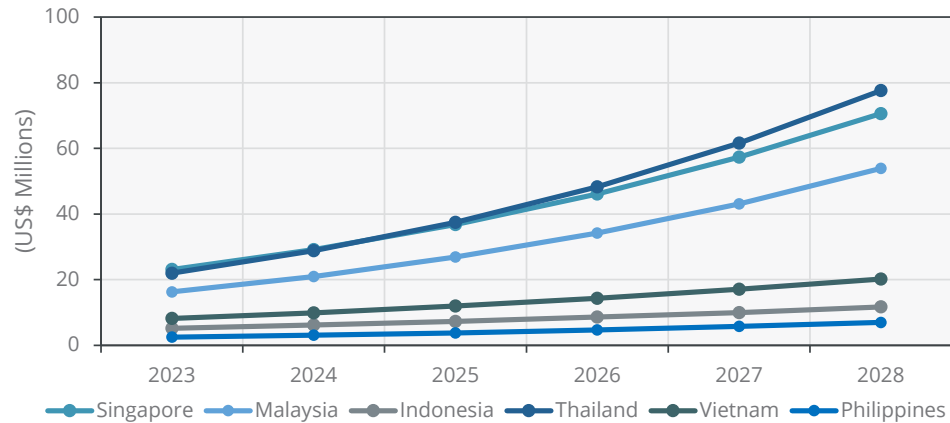
A growing focus on video and other multimedia content, as well as visually rich map content for exploration is driving demand for larger head unit displays. While still an important solution to deliver connected infotainment features on price-sensitive models, the overall market is trending toward larger displays and, in some cases, multiple displays serving individual passengers.

Larger displays also enable automakers to deliver table stakes smartphone mirroring experiences, while still retaining the necessary “real estate” to provide their own branded and, potentially, revenue-generating features and services to the driver and passengers.

**Investments in carbon management solutions within the Southeast Asian region are forecast to increase from US\$77 million in 2023 to US\$240 million in 2028 at a CAGR of 25%.**

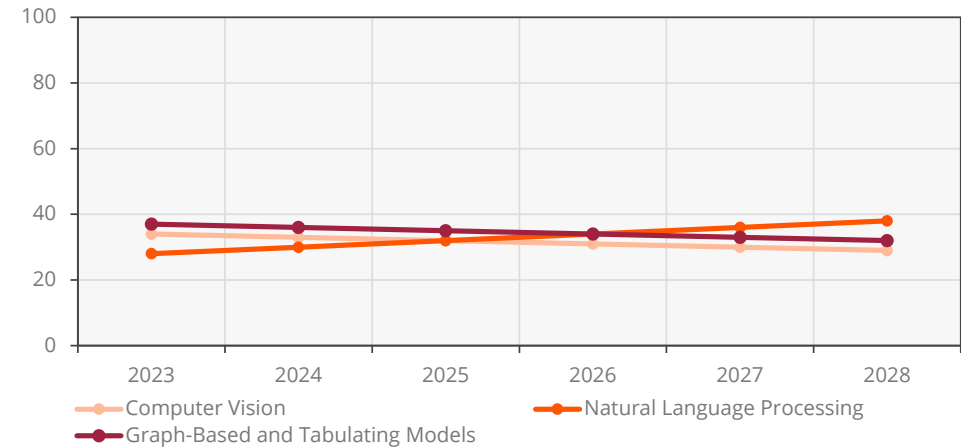
**The share of AI-enabled computer vision software revenue as a proportion of total AI revenue will decline as more investments are allocated to NLP in SEA.**

Global New Vehicle Shipments with Satellite Connectivity (Actual)



The sustainability market in Southeast Asia (SEA) is projected to develop at an increasing pace, with the impending commencement of the European Union (EU) Carbon Border Adjustment Mechanism (CBAM) in 2026 being a key driving factor for most SEA countries. Indonesia, Malaysia, Thailand, and Vietnam are expected to be most impacted due to their significant exports in sectors covered by CBAM, such as the cement, iron and steel, aluminum, fertilizers, electricity, and hydrogen industries. With developing domestic sustainability regulations, more companies in carbon-intensive industries are expected to adopt carbon management solutions to not only reduce Greenhouse Gas (GHG) emissions from their operations, but to also meet new GHG emissions reporting requirements.

Overall Business-to-Business (B2B) AI/ML Spending Percentage by Framework in Southeast Asia (%)



The AI software market in the SEA B2B market is projected to grow at pace. This is driven by major investments of global hyperscalers, such as Microsoft, Oracle, Amazon Web Services (AWS), and Alibaba, into the regional data center market. Over the next 5 years, investments are expected to shift to Natural Language Processing (NLP) software as development of localized Large Language Models (LLMs), enterprise-developed copilots, and global agentic AI advancements begin to gain commercial traction. It is not the case that overall investment in computer vision is shrinking, but rather that it is being overtaken by NLP and graph-based models. Total investment for the SEA AI/Machine Learning (ML) sector is expected to grow from US\$1.9 billion to US\$3.2 billion.

**D2C satellite connectivity over terrestrial 3rd Generation Partnership Project (3GPP) LTE/5G standards is expected to capture 78% of the market's connections by 2029.**

NTN D2C CONNECTIONS BY TECHNOLOGY STANDARD (MILLIONS)							
	2023	2024	2025	2026	2027	2028	2029
3GPP (LTE/5G)	0.00	0.35	1.62	3.29	5.74	8.98	13.11
3GPP NTN	0.03	0.06	0.07	0.24	0.44	0.79	1.36
Proprietary	1.41	1.62	1.77	2.02	2.15	2.23	2.33
3GPP (LTE/5G) Market Share	0.0%	17.2%	46.8%	59.3%	68.9%	74.9%	78.0%
3GPP NTN Market Share	2.1%	3.0%	2.0%	4.3%	5.3%	6.6%	8.1%
Proprietary Market Share	97.9%	79.8%	51.2%	36.4%	25.8%	18.6%	13.9%

With the launch of commercial services of Starlink Direct-to-Cellular (D2C) and soon AST Space Mobile, the D2C market is poised to expand rapidly. Early deployment of D2C in support victims of Hurricane Helene in the United States and for other natural disasters, alongside users in rural and remote locations, reflects the criticality and widespread applicability of D2C technology for the wider consumer market. Additionally, satellite service providers can act as a roaming partner with significant global coverage. Satellite (Long Term Evolution (LTE) connectivity supplementing terrestrial network coverage presents enhanced revenue opportunities and service differentiation for terrestrial cellular networks, with "LTE-Everywhere" Short Message Services (SMS) and Over-the-Top (OTT) messaging functionality enabling a truly nationwide solution. The ability for satellite operators to use cellular spectrum also opens new revenue opportunities for satellite connectivity over newer, previously unavailable bands.

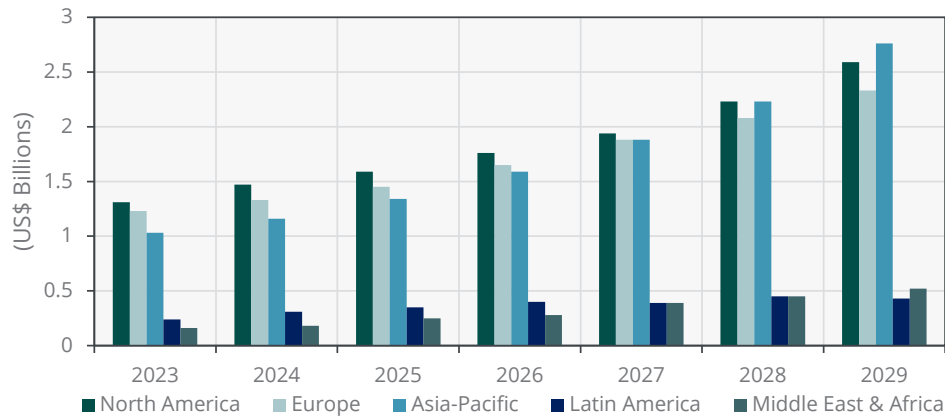
**GEO satellite deployments is expected to decline in the future, from roughly 7% of total deployed satellites in 2024 to 3% in 2029**

TOTAL LAUNCHED SATELLITES BY OPERATIONAL ORBIT (ACTUAL)							
	2023	2024	2025	2026	2027	2028	2029
GEO	1,037	1,056	1,070	1,080	1,088	1,094	1,098
Others	10,326	13,118	16,475	20,295	24,463	28,879	33,463
GEO Market Share	9.1%	7.5%	6.1%	5.1%	4.3%	3.6%	3.2%
Others Market Share	90.9%	92.5%	93.9%	94.9%	95.7%	96.4%	96.8%

Geostationary Earth Orbit (GEO) satellites have long been the gold standard for satellite connectivity, proven effective over decades. However, the advent of reusable launch vehicles and lower-cost, mass-produced satellite constellations has ushered in a new era of Low Earth Orbit (LEO) satellite networks. The breakthrough success of SpaceX's Starlink, which is rapidly becoming a leader in the satellite broadband market, alongside upcoming constellations like Amazon's Project Kuiper, signals a shift in the industry. As a result, the space industry's reliance on GEO satellite deployments is expected to decline in the future, from roughly 7% of total deployed satellites in 2024 to under 3% in 2029. As network operations evolve across orbital regimes, new GEO satellites are expected to become more software-defined and flexible, compensating for their smaller numbers with enhanced performance and adaptability.

**Investment in more advanced (WMSs) will continue, reaching US\$8.63 billion as warehouse picking operations balance manual with automated workflows, and AI-powered solutions.**

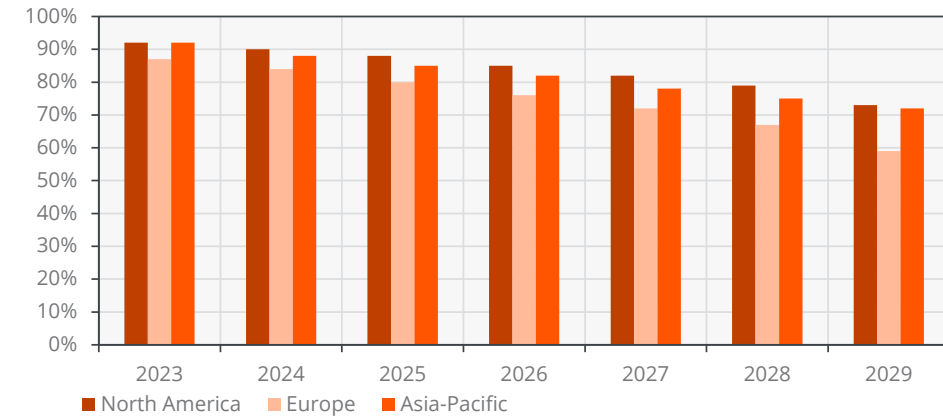
Warehouse Management System (WMS) Revenue by Region



The continued increase in investment in Warehouse Management Systems (WMSs), a well-established technology, will largely be driven by the introduction of advanced planning and analysis capabilities, as well as the increasing numbers of connected devices and automated material handling solutions requiring orchestration in the warehouse. Leading supply chain software providers, including SAP, Kinaxis, Infor, Manhattan Associates, and Blue Yonder, continue to report double-digit revenue growth, with a large portion of this attributed to Software-as-a-Service (SaaS) offerings and a shift to advanced cloud-native solutions. Ensuring that day-to-day task execution is improved by the advanced planning capabilities being introduced will be crucial for end users to see tangible Return on Investment (ROI) and continue to invest in new functionality.

**A growing number of ICE vehicles in last-mile delivery will be replaced by EVs as fleet electrification efforts continue to ramp up globally.**

Share of ICE Vehicle Deployments in Last-Mile Delivery

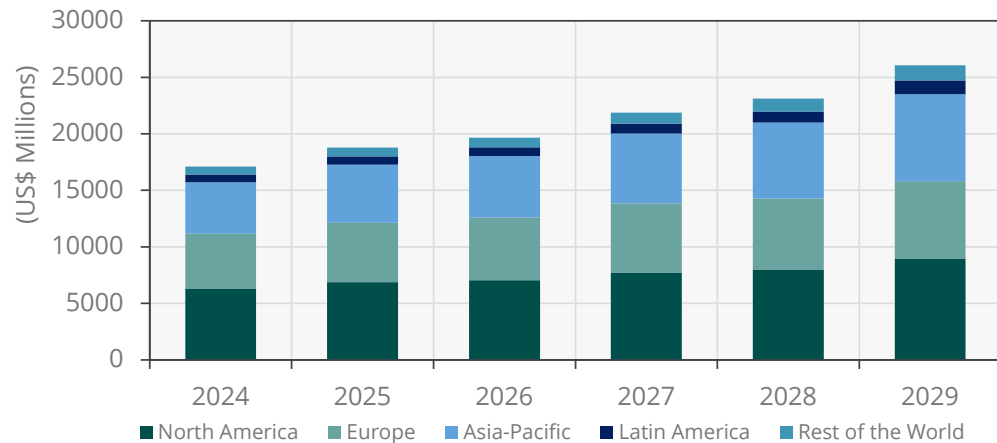


The growth in last-mile electrification, particularly for delivery services, is expected to be significant by the turn of the decade, which will lead to much fewer Internal Combustion Engine (ICE) vehicles being deployed. This includes two-wheelers, as well as cars and vans. Although government incentives have been a primary driver, factors such as lower operational costs, simplified maintenance, and enhanced performance are other prominent advantages that Electric Vehicles (EVs) have over regular ICE vehicles. As a result, many large commercial fleets have started investing heavily and are raising considerations toward full fleet electrification in the near future. Organizations like IKEA, Amazon, and the U.S. Postal Service (USPS) have invested heavily in electrification efforts and this trend will only continue in the coming years, leading to a lower share of ICE vehicles. Tools to aid fleets in their electrification efforts or streamlining EV operations via charging point mapping or battery management are potentially major growth areas in the coming years.

**Global Industrial IEMs revenue is expected to increase from US\$17.10 billion in 2024 to US\$26.07 billion in 2029 as industrial organizations seek more energy-efficient operations.**

**The carbon capture market is expected to see slow but steady growth as capture-only projects decline in favor of more full-scale CCUS projects.**

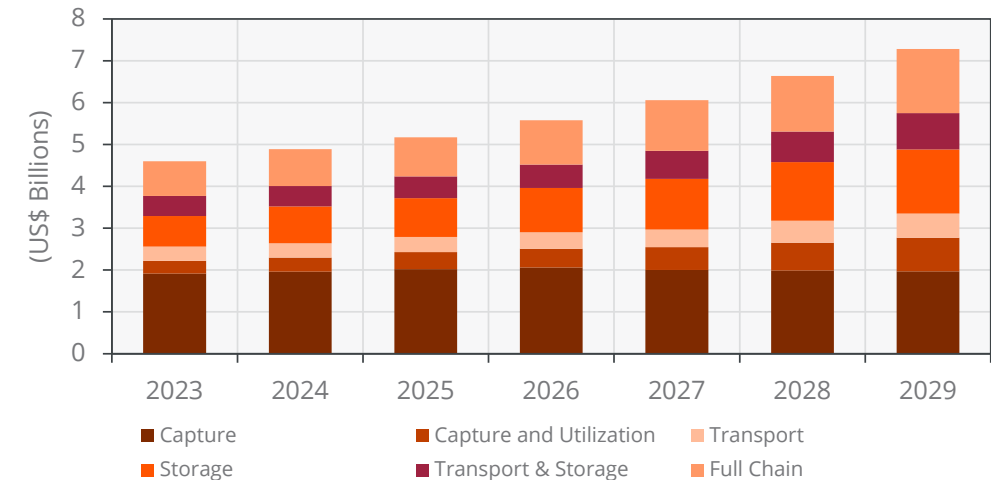
Industrial Energy Management Systems Revenue



Energy consumption continues to be a concern for enterprises globally due to recent spikes in energy prices, strict energy standards, and increasing demands to decarbonize energy-intensive industries. Energy consumption in the industrial sector accounts for around 20% of global emissions, so understanding and managing energy consumption has become a critical part of any business operations.

Energy Management Systems (EMSs) have proven to be instrumental in curbing consumption and improving efficiency through data-driven decisions. The software solution enables organizations to monitor and control energy in real time, perform predictive analytics, track and report consumption, and more. The potential for significant energy cost savings is a key driver of EMSs with typical solutions enabling energy savings of up to 30%. The emergence of Generative Artificial Intelligence (Gen AI) and other digital technologies is enabling new opportunities throughout the energy system. The ability of Artificial Intelligence (AI) to analyze vast amounts of data is creating huge potential to maximize cost savings, optimize operations, and improve energy efficiency, placing greater value on EMS adoption.

CCUS Market by Project Type



Carbon capture has been gaining momentum since around the start of 2018 due to its expected role in decarbonizing heavy industries and reaching net zero. In October 2024, the U.K. government approved £22 billion in funding to drive Carbon Capture, Utilization, and Storage (CCUS) development. The regional distribution of Carbon Dioxide (CO2) capture projects is also diversifying, with projects being developed in over 50 countries.

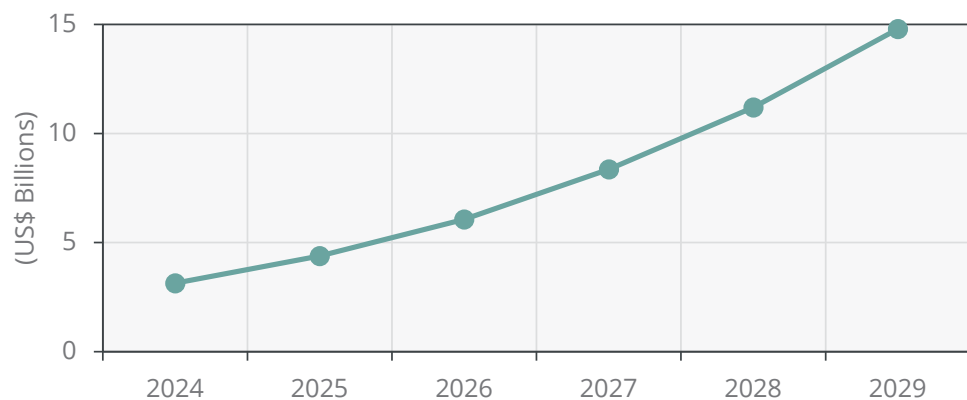
However, the technology continues to fail to live up to expectations for a number of reasons. While there has been an increase in the number of project applications, few projects end up reaching final investment decision. Many advanced projects in the development stage face delays due to permit issues and insufficient transport and storage. CCUS also has a history of poor performance. While project developers claim carbon capture rates of up to 95%, most projects fall short of this with some capture rates as low as 50%.

Despite these challenges, continued investment and technological advancements will continue to drive commercial viability of CCUS. It is expected that capture-only projects will gradually shift toward to more full-chain projects in an attempt to overcome existing storage and transportation infrastructure challenges.

**ABI Research expects AI market revenue in the global telecommunication industry to grow from US\$2.2 billion in 2023 to US\$14.8 billion in 2029.**

**Growth in telco Scope 3 emissions is expected to deteriorate by 2029 as company emissions reduction efforts ramp up.**

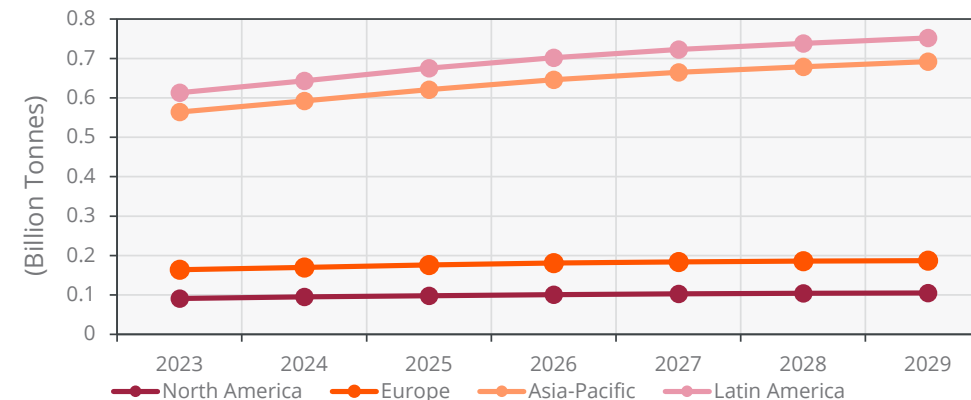
Global AI Revenue in the Telecommunications Market



AI adoption in the telecommunications sector has been propelled by increasing investments from Communication Service Providers (CSPs) over the last few years with a broad range of AI applications revolutionizing telco operations, particularly in 5G networks. Adoption of AI has been primarily driven by non-sustainability applications, including network security, customer service automation, and network self-diagnostics. However, it has become a crucial technology for improving the energy efficiency of telco networks.

For the majority of mobile networks, around 80% of energy is consumed in Radio Access Network (RAN) infrastructure. Considering this high proportion of energy use, AI has become a valuable technology for supporting energy-efficient RAN operations, enabling features that include network optimization and anomaly detection, autonomous base station shutdown, intelligent cooling, and predictive maintenance. As demand grows for increasingly energy-efficient networks, telcos will continue to serve as an integral tool to achieving sustainability objectives in the telco sector.

Scope 3 Emissions in the Telecommunications Sector

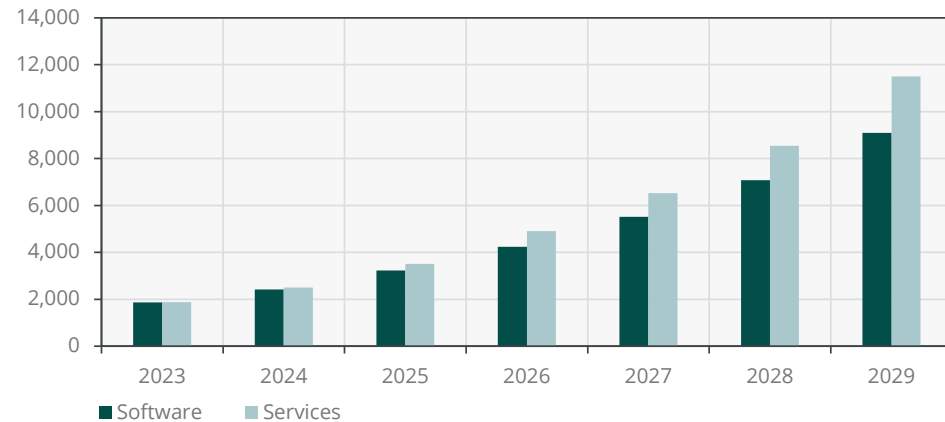


Scope 3 emissions in the telecommunications sector are expected to grow from 711 million tons of Carbon Dioxide Equivalent (CO<sub>2</sub>e) in 2023 to 873 million tons in 2029. Despite successful efforts from some telco operators and vendors to cut Scope 3 emissions, particularly European companies, it is expected that global emissions will increase throughout the forecast period as network traffic continues to increase.

However, telcos are beginning to take a more proactive approach to addressing Scope 3 emissions, particularly through close supplier engagement, shifting to green transportation, and integrating Artificial Intelligence (AI)-powered energy-saving solutions into network infrastructure. It is expected that as these efforts from operators and vendors continue to increase over the forecast period, growth in Scope 3 emissions in the industry will begin to decline. Nokia, for example, has had recent success in Scope 3 emission reduction with an 11% Year-over-Year (YoY) reduction in 2023, driven by AI-powered RAN energy-efficiency solutions such as its MantaRay energy solution.

**High demand for 5G network security software and services will drive a CAGR of 30.2% for software and 35.3% in services.**

5G Network Security Software and Services Revenue (US\$ Millions)

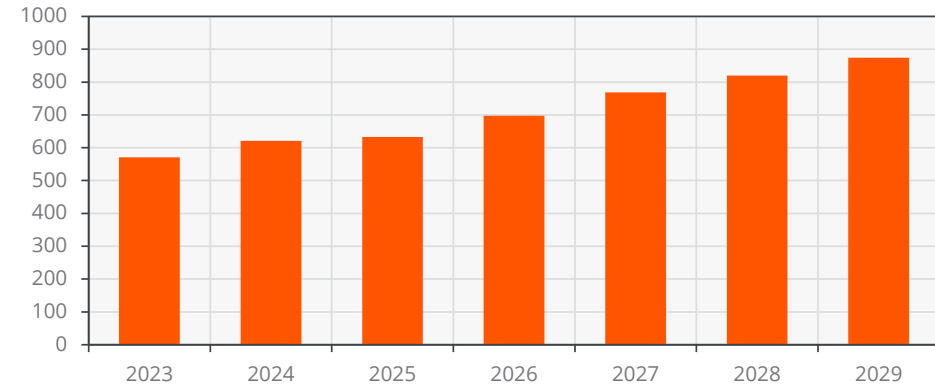


There are many pressures at hand driving security as a priority for 5G network operators, including increasing prevalence as a target for attackers and the introduction of more stringent national regulations. For many, however, this is a complex space, with a dearth of available experts prohibiting the growth of in-house security teams and driving the need for managed solutions. Opting for security delivered “as-a-Service” allows network operators to draw on highly expert personnel with visibility of myriad networks, driving the quality of threat intelligence and eliminating staffing concerns. Consulting services are also proliferating, with network operators relying on this expertise to manage security through a network’s digital transformation—particularly where an unfamiliarity with secure software development best practice might create friction. As a result, 5G network security service revenue is expected to reach almost US\$11.5 billion in 2029.

Software-based solutions are increasingly trusted by the industry where hardware may previously have been preferred, in part as interoperable and converged solutions eliminate significant traditional pain points. Software-based security management tools are available throughout the stack, with increasing emphasis on orchestration and strong integration to produce streamlined chains of intelligence, improving threat detection and eliminating time wasted on duplicate alerts. The wealth of increasingly trusted solutions will contribute to a total network security software revenue of over US\$9 billion in 2029.

**Slow Return on Investment (ROI) on 5G networks will suppress Capital Expenditure (CAPEX) investment, resulting in slowed growth of security hardware revenue.**

5G Network Security Hardware Revenue (US\$ Millions)



Slow ROI and macroeconomic headwinds, in combination with increasing concerns over complexity in security postures, will result in stagnating growth in network security hardware, particularly as telcos weather 2024/2025. While growth will improve from 2025, the CAGR for the 2023 to 2029 period will remain modest at 7.3%, despite legislative and ecosystem pressures increasing the priority of security investment. A key driver in this limited hardware investment is the growing prevalence of software-based alternatives to traditional hardware security tools such as firewalls, with the industry embracing these scalable solutions in a bid to avoid large-scale upfront investment.

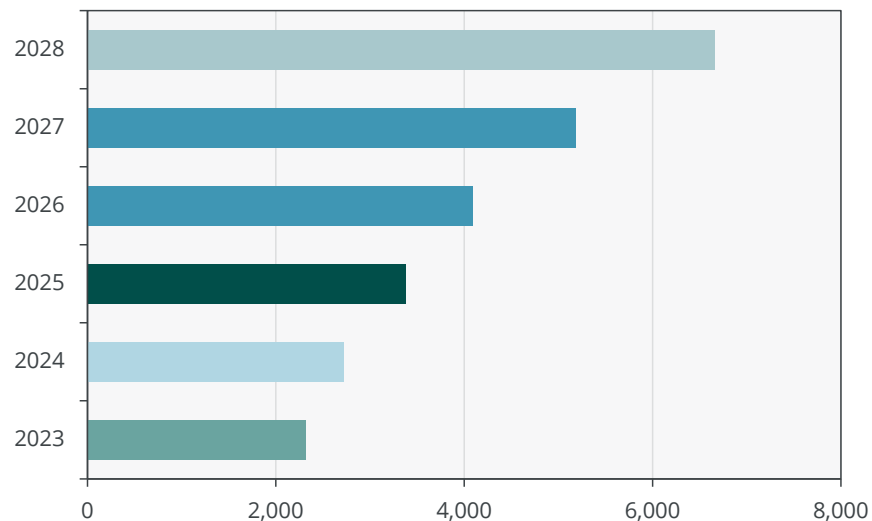
As well as economic factors, the move to software-based solutions reflects the need for cellular networks to become more flexible and adaptable, particularly in the security space. With telcos becoming increasingly targeted by attackers, particularly as a result of geopolitical influences, attacks are coming in greater volumes and at a greater pace, requiring network operators to be able to make security updates in days or hours, rather than the months required to update hardware.



**Significant revenue opportunity exists for the secure MCU market, due to strong demand and high selling price, which is forecast to be US\$6.7 billion by 2028.**

**The traditional smart card IC market will stagnate, achieving a CAGR of 1% between 2024 and 2029.**

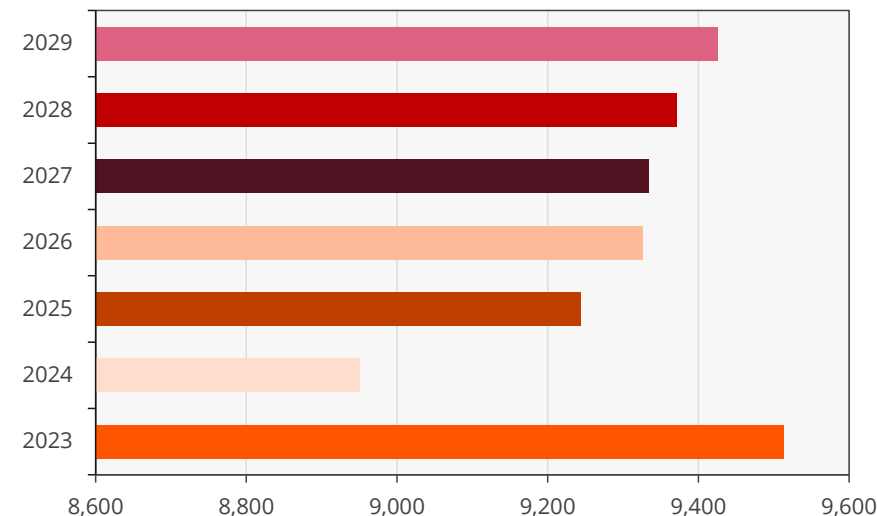
Secure MCU Revenue (US\$ Millions)



The demand for secure Microcontroller Units (MCUs) is reflective of strong traction in the Internet of Things (IoT) space. The advantage of secure MCUs is that the security features are integrated, if not necessarily used. Their usage can be later “turned on” in the field, if and when required. The flexibility of the MCU is what drives its popularity (and price point), making it most attractive for embedded security applications.

Better virtualization capabilities are found in Trusted Execution Environments (TEEs) for MCUs (notably with new Arm Cortex-M82 TrustZone and RISC-V TEE variants), which allows running several secure execution environments on the same chipset, driving demand in high-end IoT use cases that require multi-application and business logic capabilities. TEE is in demand notably for attestation and secure firmware upgrades, which is a key requirement for many IoT devices. This ability to be securely updated in the field provides a source of confidentiality and integrity for the device, enabling the management of the product throughout its lifecycle.

Traditional Smart Card IC Shipments (Millions)



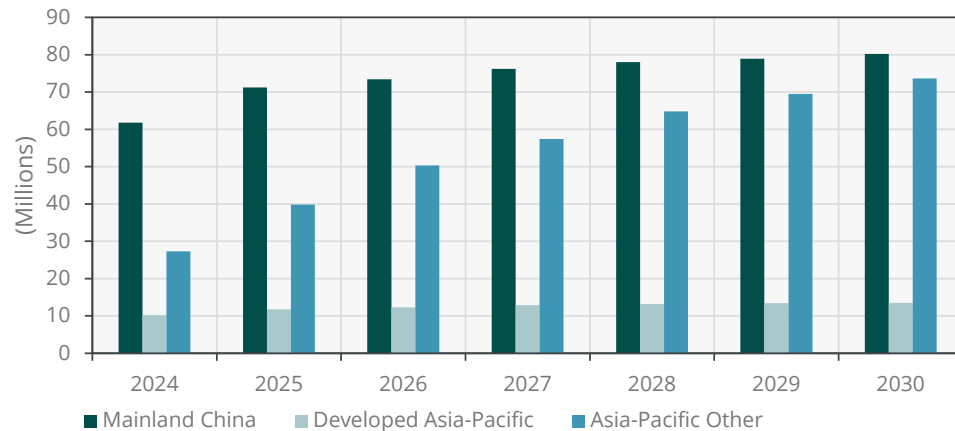
The smart card market has been through some turbulent times recently. COVID-19, followed by the chip shortage, and now allocation/inventory issues have hampered overall market growth over the past 3 to 4 years. Although some smart card Integrated Circuit (IC) markets are moving in a more positive direction (government Identity (ID) and transit), these growing markets will not be able to counteract negative and slowing activity in the key verticals of Subscriber Identity Module (SIM) and payments, which account for 82% of the overall smart card IC market.

The SIM, which at its peak was shipping in excess of 5 billion units annuals, will be significantly impacted by Embedded SIM (eSIM) over the forecast period, with shipments forecast to be as low as 3.9 billion by 2029. This is paired with the payments market, which although not forecast to decline, is likely to stagnate and slow, driven by high levels of market majority and saturation, alongside a trend in expiration extension, which will impact and reduce replacement cycles.

**Emerging Asia-Pacific markets will experience rapid expansion of Wi-Fi CPE shipments, growing 68.5% from 2024 through 2030.**

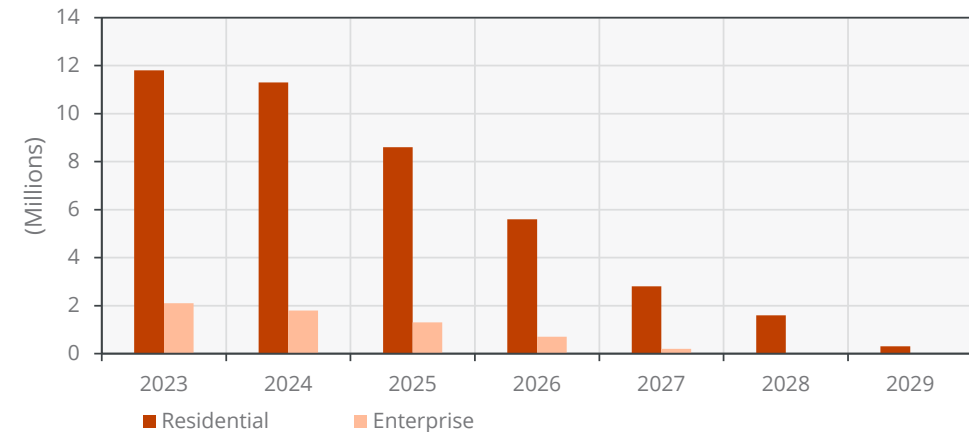
**Wi-Fi 6E is quickly approaching irrelevance, with just 0.3 million total shipments expected by 2029.**

Residential Wi-Fi CPE Shipments in Asia-Pacific



Asia-Pacific is the world's largest market for residential Wi-Fi Customer Premises Equipment (CPE), with 99.3 million shipped to the region in 2024. Yet, the future prospects for the various nations that make up this vast area vary considerably. While Mainland China has consistently been a key driver of demand expansion over the past several decades, going forward, the market is projected to witness only marginal growth, as most existing use cases have already been addressed and government policies prioritizing cellular technologies limit the emergence of future opportunities for Wi-Fi. On account of this reality, Mainland China is projected to witness a meager 4.4% Compound Annual Growth Rate (CAGR) in shipments between 2024 and 2030. The nations classed as Developed Asia-Pacific, which includes Japan, South Korea, and Singapore, collectively have only a slightly higher CAGR of 4.8%. In contrast, the CAGR from the emerging Asia-Pacific is forecast to be an astronomical 18.0%, spurred by deepening penetration of fixed broadband into homes, and a growing appetite for data due to the maturing of the digital economy. The growing availability of low-cost hardware is another significant factor behind this expansion. The countries in this grouping include the sizable and rapidly growing economies of India, Malaysia, and Indonesia.

Shipments of Wi-Fi 6E APs



After peaking in 2023, shipments of Wi-Fi 6E equipment in both the residential and the enterprise markets witnessed marginal declines in 2024 and, going forward, the shipment contraction is expected to accelerate. In 2025, shipments to the residential market are projected to contract by just under a quarter Year-over-Year (YoY), while in the enterprise market, they will decrease by over 27%. The main reason for this decline is the erosion of Wi-Fi 6E's value proposition following the arrival of Wi-Fi 7, with support for the 6 Gigahertz (GHz) band now no longer exclusive to Wi-Fi 6E. The majority of consumers and businesses are now gravitating to either the lower-cost dual-band Wi-Fi 6 option, or newer tri-band Wi-Fi 7 hardware. The former group of consumers are those that are cost sensitive or have no need for the new 6 GHz spectrum band, whereas the latter are those with 6 GHz demand, but due to the low price differential between Wi-Fi 6E and Wi-Fi 7 equipment, have jumped straight to the more advanced Wi-Fi 7 standard. Add to this that many vendors have begun to wind down their support for Wi-Fi 6E (or never released a Wi-Fi 6E product), and the conditions are perfect for the sunset of the standard.

## Wi-Fi HaLow will become a mainstream connectivity technology over the next 5 years, transforming the extended range IoT market.

Wi-Fi HaLow Device Shipments (Millions)



Wi-Fi HaLow offers robust, long-range connectivity with low-power consumption, making it an ideal solution for whole home, building, facility, or neighborhood-level IoT applications requiring reliable and scalable wireless deployments. By operating in the sub-1 Gigahertz (GHz) spectrum, Wi-Fi HaLow provides enhanced signal penetration, enabling operation of beyond 1 Kilometer (km) in certain configurations, an up to 10X longer range compared to 2.4 GHz Wi-Fi. Meanwhile, it can support thousands of devices from a single Access Point (AP), reducing deployment complexity and Total Cost of Ownership (TCO) compared to other IoT technologies.

Over the last 12 months, momentum for Wi-Fi HaLow technology accelerated. The arrival of new Intellectual Property (IP), chipsets, and modules from multiple vendors led to more and more commercial products hitting the market. This includes a range of device types, including home and enterprise cameras, smart doorbells, wireless sensors, and a diverse combination of enterprise, industrial, and agricultural APs, extenders, gateways, and bridges. In addition to these real-world products, in July 2024, the Wireless Broadband Alliance (WBA) made available its Wi-Fi HaLow for IoT: Field Trials Report, demonstrating the effectiveness of Wi-Fi HaLow across a range of environments, including smart home, industrial, warehouse, connected agriculture, smart city, and smart building environments.

While Wi-Fi HaLow has found it challenging to build an ecosystem, this is starting to change. Morse Micro announced the launch of its second-generation sub-GHz Wi-Fi chip, the MM8180 System-on-Chip (SoC), promising significant improvements in range, throughput, and power efficiency. The new chip is now capable of supporting data rates of up to 43.33 Megabits per Second (Mbps) over ranges that greatly surpass existing Wi-Fi solutions, thanks to its world's-first support for 256 Quadrature Amplitude Modulation (QAM) operation. However, arguably just as important is the availability of the MM8108-RDO9 Universal Serial Bus (USB) dongle reference design, aimed at speeding up the integration of Wi-Fi HaLow within new AP designs or existing Wi-Fi infrastructure. The company was also demonstrating its HaLowLink 1 router reference design, combining Wi-Fi HaLow and 2.4 GHz Wi-Fi to create dedicated Wi-Fi HaLow networks, extend the range of already deployed Wi-Fi devices, or extend the range of the existing Wi-Fi network. Meanwhile, other Wi-Fi HaLow solution providers such as Newracom were also present at the show, demonstrating the growing variety of chipsets, module partners, gateways, APs, bridges, sensors, and security cameras—all equipped with Wi-Fi HaLow technology.

## As audio innovation accelerates, standalone Bluetooth® Classic solutions will fall by the wayside.

Bluetooth® DR/EDR Device Shipments (Millions)



The wireless audio market is rapidly evolving, and while Bluetooth® Basic Rate (BR)/Enhanced Data Rate (EDR)-only (aka Bluetooth® "Classic") still has a strong presence in the audio realm, particularly for speakers and automotive use cases, a significant portion of the market has already transitioned to dual-mode solutions for more effective pairing and other benefits, while the next shift to dual-mode is coming from vendors enabling support for Low Energy (LE) Audio and Auracast™ broadcast audio, alongside Classic audio. This will help ensure backward compatibility with devices that do not yet support LE Audio, and retain their unique differentiators in the market.

In the longer run, as more and more source devices embed support for LE Audio, there will also be a significant portion of vendors that choose to adopt LE Audio-only solutions to further minimize power consumption and cost. This will enable new entrants in the audio market and open up new audio applications beyond headsets and speakers, potentially enabling broadcast capabilities in a range of IoT devices and appliances. Meanwhile, the push for Auracast™ broadcast audio within assistive listening spaces will lead to more and more LE Audio-enabled true-wireless earbuds, hearing aids, and Over-the-Counter (OTC) hearing aids.

However, further innovations are coming. At CES 2025, leading silicon and software Intellectual Property (IP) provider Ceva announced the Ceva-Waves Links200, the first multi-protocol platform IP to support next-generation Bluetooth® High Data Throughput (HDT). This feature will enable Bluetooth® LE to support data rates of up to 7.5 Megabits per Second (Mbps), a nearly 4X improvement over the current LE 2 Mb PHY and a 2.5X improvement over Bluetooth® Classic. This will enable a significant improvement in the Bluetooth® audio space, enabling lossless, multi-channel, and low-latency audio streaming.

Combined, these trends will help accelerate the transition away from standalone Classic audio solutions. In addition, they will help ensure the long-term success of Bluetooth® audio in a time of growing competition in the audio space from proprietary, Wi-Fi, and emerging Ultra-Wideband (UWB) solutions.



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