SECTOR
UPDATE

2026. 3. 20

Autos / Batteries (OVERWEIGHT)

Applying EV-era lessons to humanoid robotics

EV/Mobility Team

Samsung Securities

WHY SHOULD
YOU READ THIS REPORT?

The current robotics hype closely echoes the EV frenzy of six years ago. Just as EV stocks (eg, Ecopro and Ecopro BM) surged before undergoing sharp corrections, this report aims to guide investors through the emerging robotics cycle with discipline and perspective.

We draw three key lessons from the EV era. First, while humanoid robot valuations remain at an early stage relative to the EV rally, we believe that, given the current interest rate environment, potential upside is likely to be less than half of peak EV returns. That said, with policy support in the US and Korea expected to strengthen around 2026, we still see ample reason for investors to remain constructive. Second, intelligence is likely to be the primary differentiator, and platform companies developing core AI and cognitive systems for robots should command the highest valuations. Tesla shares have reached all-time highs on robotaxi expectations, while battery stocks remain well below prior peaks.

Third, in the era of Physical AI—where hardware platforms are central to value the core business—a fast-follower strategy is not merely risky but structurally unsustainable. Tesla's leadership reflects its early positioning in the EV age and its ability to secure substantial capital ahead of competitors. For Hyundai Motor Group to achieve market leadership, it must establish itself as a first mover rather than continue to play catch-up.

Humanoid robotics is emerging as a new source of demand for the battery industry and presents a meaningful opportunity for Korean rechargeable battery manufacturers. While per-unit battery capacity is significantly lower than in EVs—limiting market scale in the near term—the application has several favorable attributes: robots operate continuously, require frequent battery swaps, and consume substantial power during task execution. At the same time, constraints on implementing high-voltage systems in compact, mobile designs favor high-nickel ternary chemistries. Battery costs represent a small fraction of total robot production, and development cycles are short, creating favorable conditions for rapid adoption of solid-state batteries. Because robots generate continuous operational data and rely on wireless communication in industrial settings, global markets outside China—where security considerations are paramount—should favor Korean suppliers with established track records.

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A key parallel between the EV battery market and the humanoid robotics battery market is the growing bifurcation between Chinese and non-Chinese ecosystems. China's dominance, already evident in EVs, is extending into humanoid robotics. However, there are important differences. Humanoid robots require batteries with exceptionally high energy density and power output to meet stringent performance and mobility requirements. Critically, because batteries account for only a small portion of total system cost, demand is far less sensitive to battery pricing than in EVs Two lessons from the EV battery industry stand out. First, Chinese firms' standardization efforts warrant close monitoring. Second, customers' optimistic demand forecasts can prove unreliable; suppliers should embed standardization into their roadmaps to maintain flexibility when the next "chasm" emerges. Korean battery manufacturers that apply these lessons should be well positioned to translate geopolitical advantages into a supply-chain premium—not only in energy storage systems (ESS), but also in robotics.

We hope this report helps clarify the path forward as the humanoid robotics era takes shape.

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EVs laying the technological foundation for robots

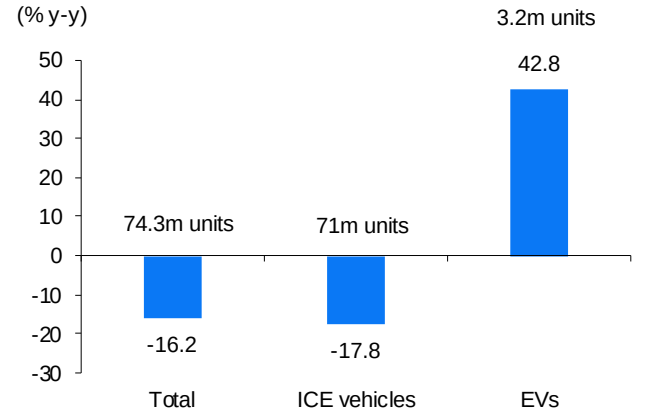
Robots as advanced versions of EVs

EVs and robots share foundational technologies

The current enthusiasm surrounding humanoid robots in equity markets closely mirrors the EV frenzy of six years ago. In early 2020, following the onset of the global pandemic, many countries cut interest rates to near zero and implemented expansive fiscal policies. As part of broader industrial strategies, governments introduced subsidies and infrastructure investments to support the EV sector. Despite strict mobility restrictions, global demand for EVs surged to 3.2m units in 2020 (up 42.8% y-y), with market penetration reaching 4.4%, reinforcing investor confidence. Following the European Union's launch of EV subsidies in May 2020, Tesla's share price surged alongside each reported sales milestone. In Korea, rechargeable battery manufacturers emerged as key beneficiaries of the rally. However, from Mar 2022, rising interest rates triggered a sharp withdrawal of liquidity. This was compounded by the early rollback of European subsidies in Oct 2023 and the expiration of US Inflation Reduction Act (IRA) incentives in Oct 2025. As a result, the term "EV chasm" entered mainstream discourse, and EV-related equities declined by as much as 70%.

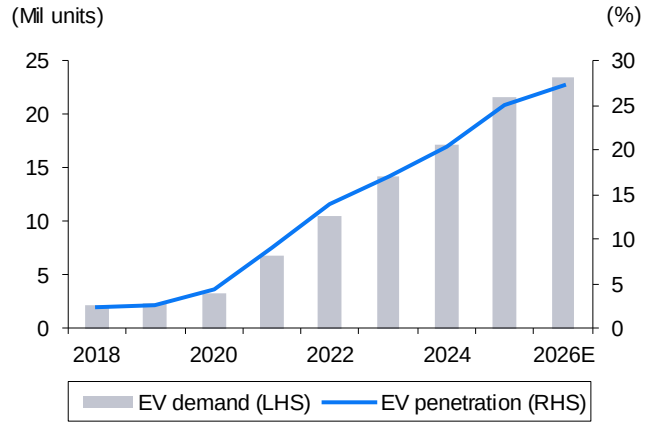
Notwithstanding this correction, global EV demand has continued to expand robustly. Between 2020 and 2025, EV sales grew at a CAGR of 46.5%, reaching 21.6m units in 2025 and implying a market penetration rate of 25%—far outpacing the 2-3% growth in global auto demand. In 2026, growth is expected to be driven by Europe and emerging markets. A select group of leading EV manufacturers has now achieved profitability. Reducing reliance on government support, they should be able to reinforce their competitive advantages over late entrants. In China—the most advanced EV market in terms of penetration—only six or seven players (*eg*, BYD, Li Auto, Xiaomi) are currently profitable out of more than 130 pure-play EV manufacturers. In 2026, China has reduced trade-in subsidies (from CNY20,000 to CNY15,000) and reinstated a 5% vehicle registration tax for the first time in 11 years. As a result, all but the leading six or seven players are likely to be forced out of the market.

EVs transition from a niche segment to the mainstream in 2020



Source: MarkLines, EV-Volumes, Samsung Securities

Global EV demand and penetration



Source: MarkLines, EV-Volumes, Samsung Securities

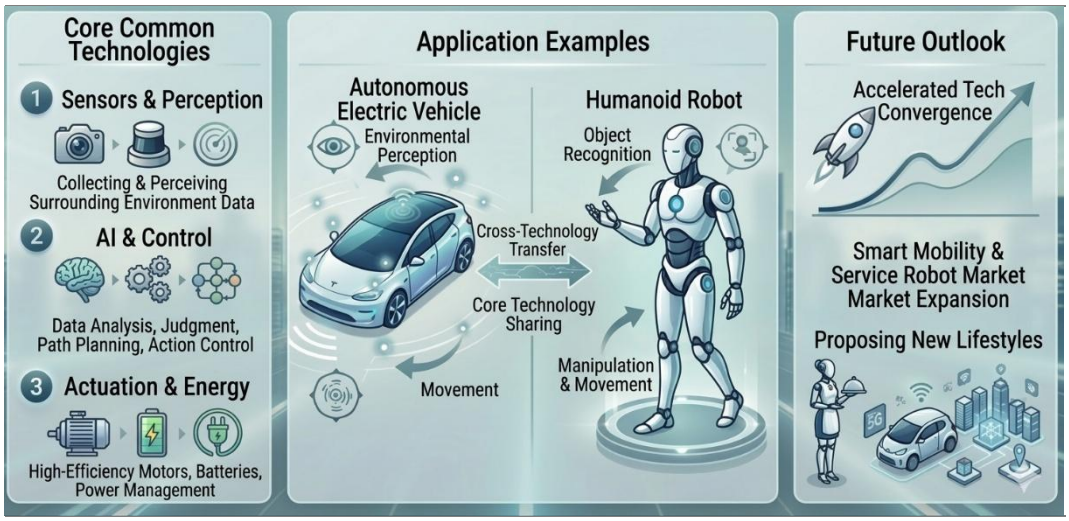
EVs are now evolving into intelligent, self-driving cars powered by advances in AI. The technologies underpinning EVs form the core building blocks for humanoid robots. Autonomous vehicles and robots share two defining trends—software-driven hardware and a shift in energy paradigms—suggesting that consumers already familiar with EVs are likely to adapt quickly to the robotics era.

First, both autonomous EVs and robots are built on electrification technologies, with batteries and motors as their primary power sources. While EVs typically carry batteries with capacities of 60-100 kWh, humanoid robots operate with much smaller packs of 3-4 kWh. Despite these lower capacities, robots must sustain continuous operation for at least eight hours. In the near term, battery-swapping systems are likely to be widely adopted, followed by the integration of solid-state batteries offering energy densities two to three times higher than conventional ternary lithium-ion chemistries. In robotic systems, motors are integrated with sensors, encoders, and speed reducers to form actuators.

Second, both autonomous EVs and robots depend on two core technology layers: sensors and AI models. In essence, an autonomous vehicle is a wheeled robot. Value creation in autonomous driving is driven by sensors—such as cameras, LiDAR, and radar—that perceive the environment, and by AI models that process this data and execute decisions. Autonomous vehicles operate in relatively structured environments defined by traffic signals, communication systems, and digital maps, performing primarily two-dimensional maneuvers. By contrast, robots must operate in diverse, unstructured settings and execute complex, dynamic tasks, requiring significantly more-advanced AI models. For example, Tesla's Optimus humanoid robot uses AI models with over ten times the parameters used in autonomous driving (1b vs 10b) and requiring an order of magnitude greater training costs (USD1b vs USD10b).

Third, both autonomous EVs and robots are built on software-centric architectures that enable continuous performance upgrades and feature expansion through over-the-air (OTA) updates. As a result, the primary source of revenue shifts from one-time hardware sales to recurring service-based revenue streams, such as autonomous driving subscriptions or robot-as-a-service (RaaS) models. This dynamic is reflected in Tesla's valuation: despite four consecutive years of subdued EV sales growth and weaker-than-expected earnings, its market cap has continued to expand, with a P/E multiple exceeding 200x. The market increasingly values Tesla not as an automaker but as a platform for future software-driven sales, including Full Self-Driving (FSD) subscriptions and, ultimately, humanoid RaaS.

Autonomous EVs and robots: Shared technological foundations



Source: Gemini, Samsung Securities

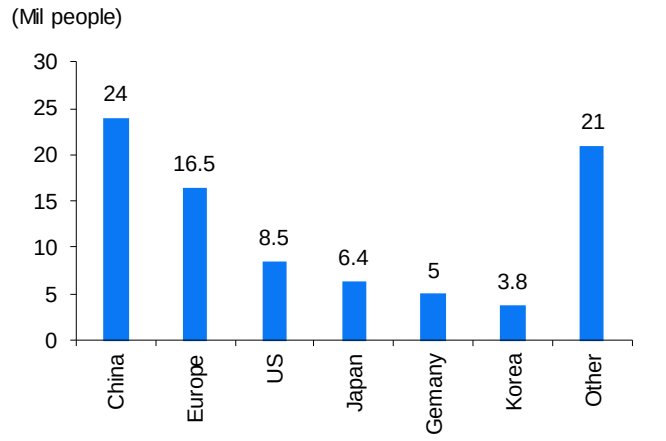
Lesson 1: Robotics hype—How much have equities priced in?

Humanoid robots are attracting increasing attention from capital markets, supported by the mass adoption of EVs and improving global liquidity. Structural drivers are also strengthening the demand outlook: aging populations are exacerbating labor shortages, while US policy initiatives to revive domestic manufacturing signal massive potential demand. Global liquidity conditions have also turned more supportive following the start of US rate-cutting in Sep 2024 (a 50bp reduction), alongside China's easing measures, including reserve requirement ratio cuts and major liquidity injections (in the order of trillions of yuan) into equity and real estate markets.

The global shortage of skilled labor further underpins the case for humanoid robotics. According to Korn Ferry, the world could face a shortfall of 85.2m skilled workers by 2030—roughly equivalent to Germany's entire population. Since 2020, the retirement of baby boomers has accelerated, while younger cohorts have struggled to accumulate sufficient skills amid overlapping challenges such as the pandemic, supply chain disruptions, and geopolitical tensions. At the same time, persistent aversion to physically demanding roles in sectors such as manufacturing and construction has deepened labor imbalances. The economic cost of this shortage is projected to swell from USD3.8t in 2025 to USD8.5t by 2030, equivalent to the combined GDP of Germany and Japan.

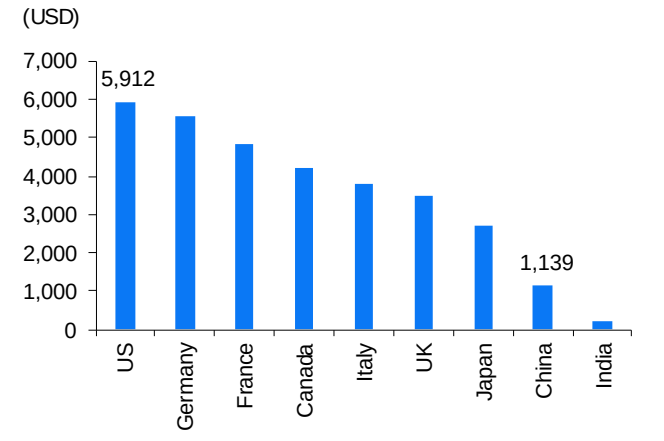
Amid intensifying strategic competition with China, the US is prioritizing the reshoring of manufacturing to strengthen national security and supply chain resilience. While the US maintains leadership in AI and software, it lacks the manufacturing base required to fully commercialize these capabilities. Without domestic production capacity for AI-enabled hardware, the feedback loop between innovation and deployment could weaken, increasing the risk of falling behind in the broader technology race. However, US manufacturing labor costs remain roughly six times higher than in China. In this context, automation through robotics is not merely advantageous—it is essential.

Global skilled labor shortage projections for 2030



Source: Korn Ferry, Samsung Securities

Monthly manufacturing labor costs



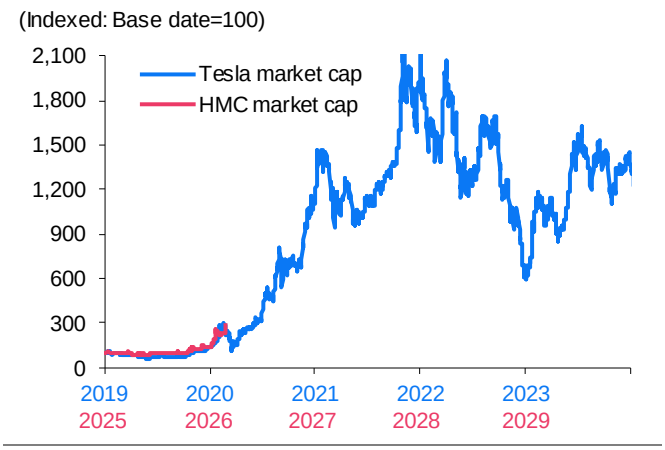
Source: CICC, Samsung Securities

Investors broadly recognize robotics as a megatrend, but concerns remain that valuations are being driven more by hope than by hard numbers. This reflects the EV experience: despite early expectations of rapid displacement of internal combustion engine (ICE) vehicles, EV-related equities declined by 70-80% over 2022-2023 amid interest rate hikes and reduced/terminated government subsidies.

Relative to the EV cycle, price appreciation among leading stocks in robotics remain modest. Thus far, appreciation appears to equate to only 10-20% of the magnitude observed during the EV rally. Tesla established itself as the flagship EV stock in 3Q19 its first profitable quarter, and subsequently delivered a more than 20x increase in share price, particularly through the pandemic period. By contrast, Hyundai Motor (HMC) was only recently repositioned as a robotics player following the unveiling of its Atlas robot at CES 2026. Since early 2025, its shares have risen by approximately 1.6x. As Hyundai Motor Group's (HMG) roadmap for robotics and autonomous driving becomes clearer through 2026, further upside is likely.

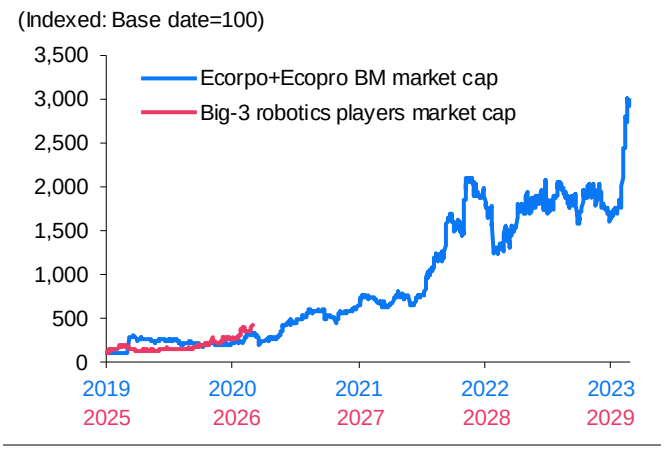
In the EV era, within the rechargeable battery value chain, material suppliers—those less directly exposed to battery cell form factor—have experienced significantly greater share-price appreciation than cell manufacturers. Ecopro and Ecopro BM, key beneficiaries of the US IRA (effective Aug 2022), delivered substantial additional gains despite a rising rate environment, with share prices increasing by as much as 30x from early 2019 levels. In contrast, leading Korean robotics names—Rainbow Robotics, Doosan Robotics, and Robotis—have seen their combined market caps increase roughly fivefold since early 2025.

Tesla vs HMC: Market cap



Note: Tesla indexed to Jan 1, 2019, and HMC to Jan 1, 2025
Sources: Bloomberg, Samsung Securities

Battery materials vs big-3 robotics players*: Market cap



Note: Batteries indexed to Jan 1, 2019, and big-3 robotics players to Jan 1, 2025;
*Rainbow Robotics, Doosan Robotics, Robotis
Sources: Bloomberg, Samsung Securities

Robotics equity upside is likely to be less than half that of the EV cycle, primarily reflecting a materially different interest rate environments. Rates are the dominant driver of growth stock valuations. In the immediate post-pandemic period, policy rates were effectively zero; today, the US policy rate stands at 3.5-3.75%, a meaningful shift. As such, expectations for 20-30x returns—seen in EV equities—are unrealistic. Even assuming identical earnings profiles and long-term growth over a 10-year horizon, a 3.75% policy rate implies roughly a 50% discount to valuations relative to a zero-rate environment. For long-duration growth assets such as EVs and robotics—which require considerable time to generate profits—the valuation headwind from higher rates is even more pronounced.

That said, 2026 is likely to mark a period of strong momentum in robotics equities, supported by both technological progress and policy tailwinds. First, 2026 represents the inflection point for mass-production. Several leading Chinese robotics companies are preparing for IPOs, with firms such as Unitree and Agibot targeting listings in 2026 after initiating mass-production in 2025. In the US, companies including Tesla, Agility Robotics, and X1 are also expected to concentrate their mass-production efforts in 2026.

Second, government subsidies and tax incentives for robotics in the US, China, and other major economies are likely to be formalized in 1H26. In the EV cycle, the tsunami of interest in EV stocks was driven by the clear signaling—and subsequent confirmation—of large-scale policy support. China has maintained EV subsidies since 2020, while Europe transitioned from scrappage incentives for ICE vehicles to EV purchase subsidies. In Aug 2022, the US enacted the Inflation Reduction Act (IRA), linking incentives to domestic production and excluding Chinese supply chains.

While the strategic importance of robotics is recognized across many nations, detailed policy frameworks (eg, taxes or subsidies) have yet to be fully articulated. In China, robotics has been designated a priority sector within the 15th Five-Year Plan (2026-2030), with 2026 identified as the year of humanoid robot mass-production. Although specific subsidy levels have not been disclosed, we expect substantial fiscal support (*ie*, tens of billions of yuan)—including subsidies and tax incentives—to be directed toward scaling production.

In the US, the 2025 AI action plan (the "Stargate Project") extends beyond software to include export controls and standardization for robotics hardware. In Feb 2026, Congress introduced the National Commission on Robotics Act, aimed at establishing a centralized body to assess national capabilities and develop a unified strategy. In addition, the Department of Commerce is expected to engage with robotics industry leaders in Mar 2026 to formulate sector-specific policies, with subsidy programs likely to be announced in 1H26.

In Korea, the Ministry of Trade, Industry and Energy plans to allocate KRW1.1t of its 2026 budget to AI transformation, including KRW157.5b earmarked for AI-enabled products such as robotics. Over the next five years, Korea intends to deploy KRW150t in financial support for strategic industries through vehicles such as the National Growth Fund, with robotics expected to be a key focus area.

However, since value creation in robotics will be driven less by hardware and more by intelligence, barriers to entry will be high. In a higher-rate environment, only a limited number of well-capitalized tech companies will be able to fund the development of advanced robotic intelligence. As a result, differentiation between industry leaders and weaker participants is likely to emerge more quickly than it did during the EV cycle.

Major countries' policy support: EVs vs robotics

	EVs	Robotics
US	• USD30.7b in total support through the *Inflation Reduction Act* • USD7,500 subsidy for EVs manufactured in the US, set to end on Sep 30, 2025	• Focus on AI infrastructure and robot intelligence development • USD500b allocated (including to projects like StarGate) • Reviewing a robotics executive order
China	• USD230.9b cumulative support over 15 years—subsidies for vehicle replacement and NEV purchases	• Estimated investment in the tens of billions of yuan • Part of the 'Made in China 2025' extension • Creation of a robot fund worth around KRW1.8t in Shanghai alone
Germany	• EUR3b total (policy reintroduced in 2026) • Up to EUR6,000 subsidy for low-income / multi-child households	• n/a
Korea	• KRW1.6t in 2026 • Reduction in per-unit subsidy amounts, but beneficiaries expanded to 300,000 units	• Budget of around KRW1.1t (Industrial AI transformation and robotics) • KRW157.5b newly allocated for commercialization of AI applications (including robots) • Includes KRW150t in financial support over five years under the "advanced strategic industry" policy
Japan	• n/a	• Approximately JPY200b annually (KRW1.8t) • 2026 budget increase under the 'New Robot Strategy' • Support for physical AI and next-generation robot semiconductors

Source: Media, Samsung Securities

How large could the robotics market become?

The AI-powered robotics market, led by humanoid robots, is entering an early growth phase, and market size projections vary widely across institutions. A consistent pattern, however, is that forecasts have been revised upward over time. Omdia projects global humanoid robot shipments of just 10,000 units by 2027, while Technavio forecasts 160,000 units. Goldman Sachs, which is actively supporting government-led robotics development roadmaps, has raised its 2035 market size forecast from USD6b to USD38b—more than a sixfold increase. Morgan Stanley goes even further, projecting a potential market of up to USD5t by 2050.

Morgan Stanley estimates that of the 1b humanoid robots expected to be deployed globally by 2050, 930m will be used in repetitive, structured applications across manufacturing, construction, and logistics, while only around 8% (80m units) will be deployed in residential settings. China is expected to emerge as the largest market, with more than 300m units in operation, followed by the US with an estimated 63m units.

China has designated 2026 as the "year of mass-production" for commercial humanoid robots and is moving to establish large-scale manufacturing capacity. By 2027, it aims to achieve technological parity with global peers, and by 2030, it targets full-scale production and market expansion. According to China International Capital Corporation (CICC), annual humanoid robot production in China could reach 350,000 units by 2030. The Gaogong Industry Institute of Robotics (GGII) projects a more aggressive trajectory, with annual production potentially rising to 2m units by 2035.

Humanoid (AI) robot production forecasts, by institution

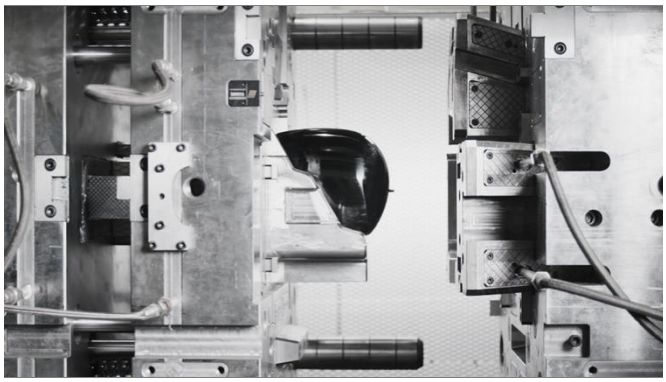
Institution	Timeframe	Scale	Note
Omdia	2027	Over 10,000 units	
	2030	38,000 units	
Technavio	2027	USD17.3b / 160,000 units	Upward revision from USD16b
Goldman Sachs	2035	USD38b / 1.4m units	Sixfold increase from USD6b
Morgan Stanley	2050	Up to USD5t / 1b units deployed	Long-term "Blue Sky" scenario
Bloomberg Intelligence	2035	USD154b	Projected one unit per household
Korea Eximbank	2030	USD17b	Focus on expanding markets in manufacturing and elderly care due to population aging
KPMG	2030	USD13b	Evaluated as complementary or replacement cobots within smart factories
Fortune Business Insights	2032	USD66b / 1.32m units	
Straits Research	2032	USD23.73b / 475,000 units	
Gaogong Robot Research Institute (GGII)	2035	755,000 enterprise units / 1.26m consumer units	

Source: Company data, Samsung Securities

Major global players are preparing to begin mass-production from 2026: 1) Tesla has indicated that it will unveil Optimus Gen-3 in 1Q26 and establish production capacity of 1m units by year-end; 2) Figure AI launched its BotQ manufacturing facility in early Mar 2025, with an initial annual capacity of 12,000 units and a target of 100,000 units over the next four years; 3) Agility Robotics, which is set to supply Amazon, plans to begin mass-production at 10,000 units by late 2026; 4) Boston Dynamics, owned by HMG, is targeting annual production of 30,000 units by 2028; and 5) Robotics Lab plans to unveil a robot with advanced manipulation intelligence by late 2026, followed by its first humanoid model thereafter.

Chinese companies are also moving aggressively: 1) Unitree Robotics aims to produce 10,000-20,000 units in 2026; 2) UBtech Robotics is targeting annual production of 5,000 units; 3) AgiBot, China's most experienced manufacturer in mass-production, shipped more than 10,000 units by end-2025 and is targeting full-year production of 10,000 units in 2026; and 4) Xpeng also plans to begin mass-production by year-end.

Figure AI: BotQ facility



Source: Figure AI, Samsung Securities

Figure AI: BotQ facility

Source: Figure AI, Samsung Securities

For our 2026-2027 demand forecasts, the EV/Mobility team used the midpoint between company production targets and third-party demand projections. We expect production volumes to accelerate sharply from 2028, as core technologies—AI models, batteries, and actuators—reach sufficient maturity. In 2H27, the United Auto Workers (UAW) is scheduled to negotiate new wage agreements with the US Big Three automakers. The partial strikes that began in Sep 2023 escalated to become the largest labor actions in US automotive history. If simultaneous action across all three automakers were to recur, it could become a major catalyst for faster deployment of humanoid robots in automotive factories.

Once leading manufacturers exceed annual production of 10,000-20,000 units in 2028, humanoid robot prices are expected to decline to around USD50,000. As annual production scales to 50,000-100,000 units after 2030, prices could fall further into the USD30,000 range, enabling adoption beyond manufacturing into service applications. China projects domestic demand for 2m humanoid robots by 2035. Incorporating growth in global demand, total worldwide demand could reach 5m units *pa* by that point.

Beyond 2040, the industry could enter an era of "robots building robots," with AI robot production reaching 50m units *pa*—equivalent to roughly half the current size of the global auto market. By 2050, projections have been revised down from the earlier "one robot per person" assumption to a more realistic target of 1.5b units—broadly in line with the scale of the global vehicle fleet. This adjustment reflects the high cost of universal deployment; adoption rates closer to vehicle ownership levels appear more plausible. Meanwhile, whereas the average vehicle lifecycle is 15 years, we assume a five-year replacement cycle for robots, noting that:1) robots are expected to operate continuously; and 2) the supporting AI training infrastructure, including data centers, has a depreciation cycle of just five years. For reference, current robot warranties are typically only one year, with after-sales service coverage extending to two years. On a five-year replacement cycle, the global AI-powered robot market would

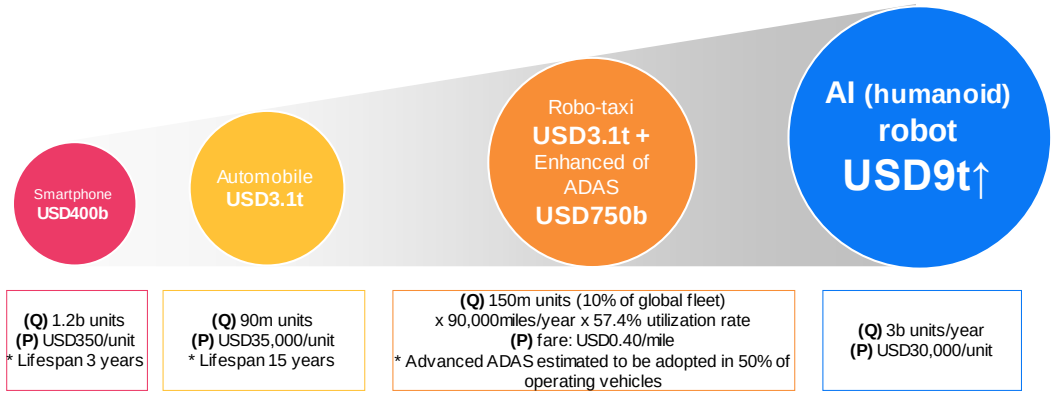
amount to 300m units *pa*. At an ASP of USD30,000 per unit, that would imply annual market revenue of USD9t.

Global: Humanoid (AI) robot production scale estimates

(Units)	Production volume
2024	2,300
2025	13,000
2026	100,000
2027	200,000
2030	1,000,000
2035	5,000,000
2040	50,000,000

Source: Samsung Securities estimates

Robotaxi and AI robot market-size estimates



Source: Samsung Securities estimates

From automotive exporter to robot exporter

Who will lead in mastering robot intelligence?

Economies of scale in robotics: One-tenth the complexity of automobiles

Autonomous electric vehicles (AEVs) and humanoid robots share significant technological commonalities, but their economics of scale differ materially. As electrification technologies mature, system architectures become progressively simpler. ICE vehicles typically comprise around 30,000 components. EVs reduce this to 12,000-15,000, representing a roughly 50% reduction. Humanoid robots simplify further, requiring only 5,000-10,000 components—an additional 30-50% reduction. This progression—from ICE vehicles to EVs to humanoid robots—drives a structural shift in the value chain, with mechanical components declining in number and importance while electric and electronic (E/E) systems take a more central role.

Automobile manufacturing remains one of the most complex industrial value chains due to its high component count. In Korea alone, HMC and Kia work with approximately 350 tier-1 suppliers. Including tier-2 and -3 suppliers, and upstream raw material suppliers (tier-4), the ecosystem expands to roughly 10,000 entities. This extreme complexity drives high break-even thresholds: a single vehicle model typically requires annual production of around 100,000 units, while plant-level profitability generally demands 200,000-300,000 units. Accordingly, when HMC and Kia expand overseas, they typically establish facilities with an annual capacity of around 300,000 units to ensure scale efficiency. For AEVs, the economics are further influenced by the high fixed costs associated with autonomy systems—including sensors, advanced semiconductors, and AI model training—raising the break-even threshold to over 400,000 units annually. Tesla, for example, achieved profitability in 3Q19 after delivering approximately 100,000 vehicles in a single quarter.

By contrast, robots exhibit a fundamentally different cost structure, with approximately 60% of hardware costs concentrated in actuators. A typical humanoid robot incorporates 30-40 actuators. Once the form factor stabilizes, actuator design can be standardized to just -three to four variants. Boston Dynamics' Atlas illustrates this trend: in its third-generation production model, the number of actuator types was reduced from eight in the second generation to three. Similarly, Tesla's Optimus has reduced actuator variants from 28 to six.

Standardization enables each robot to incorporate approximately 8-12 units of the same actuator type. At a production scale of 10,000 robots, this translates into 80,000-120,000 identical actuators, allowing suppliers to achieve meaningful economies of scale and dramatically reduce unit costs.

As a result, the break-even point (BEP) for a robot model is estimated at around 10,000 units, with plant-level profitability achievable at annual production of 20,000-30,000 units HMC's decision to set

initial capacity for its robotics facility at 30,000 units per year reflects a deliberate, scale-driven strategy rather than a conservative assumption tied to industry immaturity.

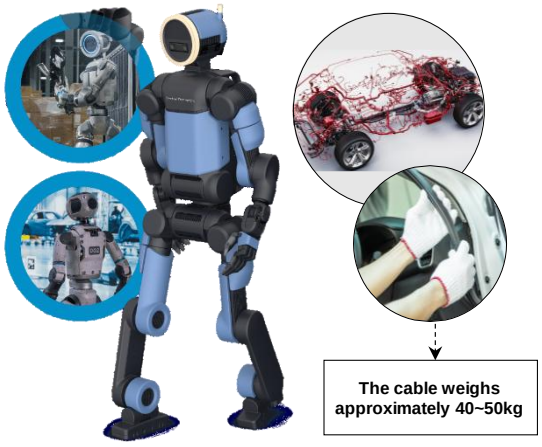
At CES 2026, the Chief Strategy Officer of Agility Robotics indicated that at annual production of 10,000 units, humanoid robot costs could decline to approximately USD30,000—roughly half the cost of early prototypes. Similarly, an engineer at Weave Robotics noted that in a real-world pilot, eight laundry-folding robots deployed in an unmanned laundromat achieved a 50% reduction in unit costs within just six months.

Economies of scale: Autos vs humanoid robots

Category	Automobile	Humanoid Robot
Number of parts	12,000 (EV) / 30,000 (ICE vehicle)	5,000-10,000
Parts standardization	Each part has an individual function (Material cost accounts for 55-60% of manufacturing cost)	Actuators can be standardized into 3-4 types (Actuator manufacturing cost accounts for 50-60%)
Modularization	Modularized into 6-8 units	Modularized into 6-8 units
Fixed costs	High fixed cost-to-sales ratio (6-12%), including factory structures, presses, molds, *etc*	Low fixed cost-to-sales ratio (1-2%) due mostly to modular assembly Still in the process of design standardization; mold production expected at 100,000+ units
Regulatory and certification costs	Complex regulations (collision, environment, safety)	Regulations are being developed to discriminate between humans and robots
Unit model BEP	100,000 units	10,000 units
Unit factory BEP	200,000-300,000 units	20,000-30,000 units

Source: Samsung Securities

Atlas Gen3: Employs cableless actuator structure



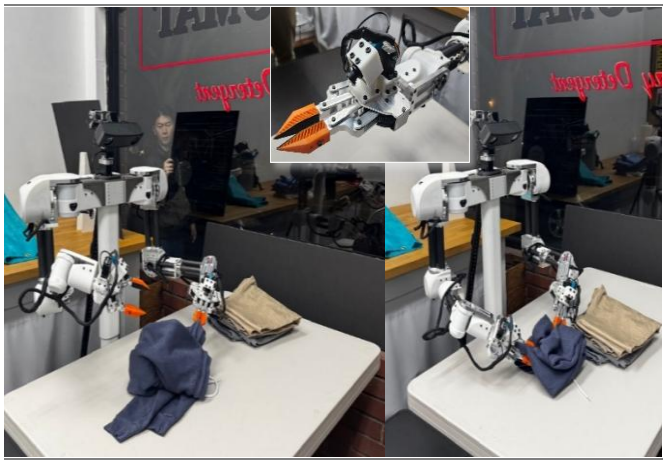
Source: Company data

Atlas: Cost breakdown (estimates)

Item	Unit cost (USD)	Quantity	Total cost (USD)
Rotary actuator	561	31	17,391
Vision sensor	41	3	123
Nvidia Thor chip	800	1	800
Gripper	800	2	1,600
Battery pack	200	4 kWh	200
Body			2,000
Subtotal			**22,114**
Data center depreciation*			26,666
Factory depreciation			442
Other operating costs			1,769
Total			**50,991**

Note: Assumes 10,000 units produced;
*Assumes usage of one-third of 50,000 Blackwell GPUs
Source: Samsung Securities estimates

Laundry robot: Production cost falls from USD20,000 to USD10,000 in 6 months



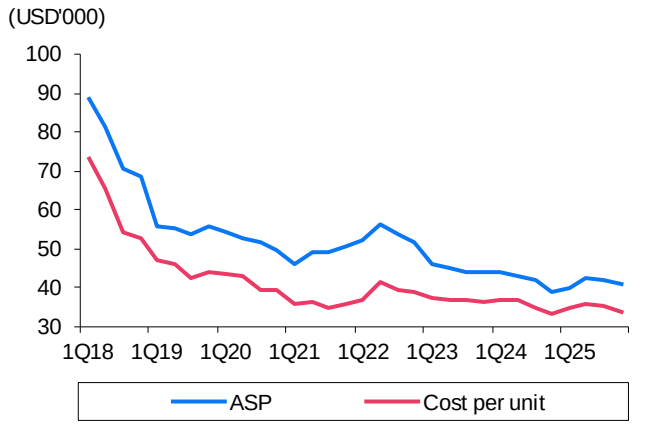
Source: Samsung Securities

Agility Digit: Unit cost down to USD30,000 at scale of 10,000 units

Source: Samsung Securities

Overall, humanoid robots can achieve economies of scale at roughly one-tenth the volume required in the automotive industry. Tesla currently produces 1.7m EVs annually, with unit costs around USD33,000. Its planned robotaxi (Cybercab) targets a unit cost of USD25,000, but this appears achievable only at scale of around 1m units, given the substantial capex required for new manufacturing processes such as unboxed assembly. By contrast, Boston Dynamics' Atlas initially carried a unit cost of USD130,000-140,000, with projections indicating a decline to USD50,000 at 10,000 units and further to USD30,000 at 50,000 units. Tesla's Optimus, given its focus on advanced dexterity and general intelligence, may require higher scale—around 100,000 units—to reach a similar USD30,000 cost level. In aggregate, the widely cited USD30,000 price point for humanoid robots—highlighted by both Elon Musk and Figure AI CEO Brett Adcock—appears achievable at production volumes of 50,000-100,000 units, (rather than 1m units or 10m units).

Tesla: Production cost vs ASP



Source: Company data, Samsung Securities

Atlas: Unit costs sensitivity to production volume

Year	Production volume	Robot unit cost (USD)
2028	5,000	135,000
	10,000	51,982
2029	20,000	38,649
	30,000	34,204
2030	40,000	31,982
	50,000	30,649

Source: Samsung Securities

Lesson 2: Intelligence is the ultimate competitive advantage

The rapid decline in robot manufacturing costs has two key implications. First, concerns over China's price competition are likely overstated. Yes, Chinese humanoid robot makers began mass-production in 2025, with unit prices already falling below USD10,000. Unitree's G1, for example, is priced at USD6,000. And, yes, China has consistently disrupted global industries—steel, chemicals, solar panels, displays, and EVs—through overcapacity and aggressive pricing, and early signs of similar dynamics are emerging in robotics.

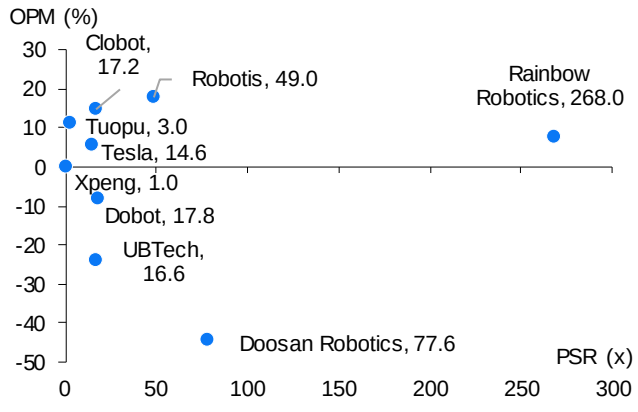
However, the critical point is that intelligence—not hardware—defines a robot's value. Without advanced intelligence, a robot is little more than a mechanical shell. Once production scales to 50,000-100,000 units, cost differentials across geographies (China, the US, and Korea) should be negligible. The key competitive question is which company can first achieve mass-production of intelligent robots.

Second, the company that controls the intelligence platform is likely to command the highest valuation. Currently, pure-play Korean robotics and actuator companies are trading at 30-100x P/E—above peers such as UBtech (39x), Dobot (27x), and Figure AI (32-33x).

Actuator manufacturers, in particular, trade at a significant premium, reflecting three factors: 1) actuators account for roughly 60% of total robot cost; 2) suppliers typically serve multiple robot companies, enabling diversified and scalable revenue streams; and 3) there are growing expectations that Chinese-made actuators and robots will face restrictions in Western markets (including the US and Europe) due to geopolitical considerations.

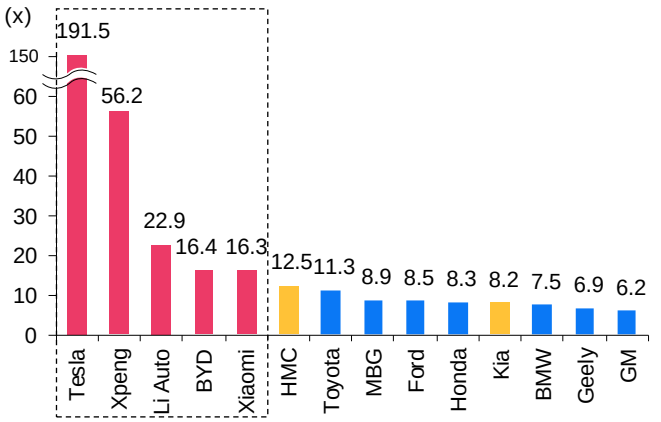
This dynamic mirrors the early EV cycle. Battery manufacturers (*eg*, LG Energy Solution, SK On, and Samsung SDI) initially traded at higher valuations than EV makers (*eg*, Tesla and BYD), based on three assumptions: 1) batteries accounted for approximately 40% of EV cost; 2) battery suppliers could serve multiple automakers; and 3) the US Inflation Reduction Act (IRA) of Aug 2022 effectively constrained Chinese battery participation, supporting a premium for Korean suppliers. However, as the EV market matured and competition intensified, and as autonomous driving and AI became the true differentiators , companies such as Tesla and Xpeng ultimately achieved the highest valuations, driven by their AI software and autonomy stacks. Today, EV valuations are largely determined by AI capability, and we expect a similar pattern to play out in robotics—the company that leads in AI-driven intelligence should ultimately capture the greatest value.

Robotics and actuator companies: P/S ratio (2026E)



Source: Bloomberg, Samsung Securities

Automakers: 12-month forward P/E valuation



Source: Bloomberg, Samsung Securities

Not all robots are equally intelligent

A key distinction between AEVs and humanoid robots is the central role of intelligence in value creation. An EV without autonomous driving capability remains functional—it can still be driven. A robot without intelligence, by contrast, has little practical utility.

Robot intelligence is far more complex than autonomous driving and requires significantly more-advanced models. Driving is a relatively structured task compared with the wide range of activities humans perform daily. Elon Musk has suggested that general-purpose robotics will require more than an order of magnitude increase in both model scale (from around 1b parameters to over 10b) and training cost (from around USD1b to over USD10b) relative to autonomous driving systems.

Robot intelligence can be viewed across two layers. The first is the foundation model, which provides generalized reasoning akin to human common sense, enabling contextual understanding, decision-making, and transfer learning across tasks. Once established, a robot can learn a specific skill and generalize it across multiple applications. Early examples include models such as GPT, Google's Gemini, and Nvidia's GR00T and Isaac Sim. Leading tech giants are now incorporating "world models"—internal simulations of the physical environment that allow robots to anticipate the outcomes of actions before execution. Without such capabilities, even the most sophisticated language-based foundation models struggle in real-world environments as they lack an intuitive grasp of physics and spatial reasoning. World models remain at an early stage, with meaningful progress largely confined to a small group of well-capitalized players, including Google, OpenAI, Nvidia, and Tesla. HMG's Robotics Lab is also developing domain-specific foundation models tailored to applications such as indoor and outdoor navigation. Beyond these leaders and a limited number of specialized robotics firms, most companies remain dependent on large technology platforms for access to foundational and world models. Even Boston Dynamics has indicated plans to collaborate with Google in this area.

The second layer is motor intelligence, or action control, which translates decisions into physical movement—analogous to the cerebellum in humans. Advances in simulation platforms and physics engines, such as Nvidia's Isaac Sim and Google DeepMind's MuJoCo, have dramatically lowered the barriers to developing these capabilities.

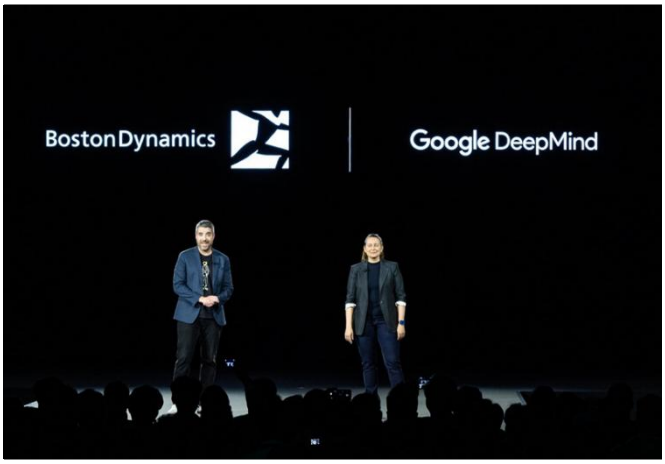
The prevailing approach to robot intelligence is the development of end-to-end Vision-Language-Action (VLA) models. A representative example is Figure AI's Helix model, introduced in 2025, which separates intelligence into two complementary systems. System 1 governs action—fast, reactive, and driven by real-time sensory input—while System 2 handles perception and reasoning. System 1, with approximately 80m parameters, processes visual data from head-mounted cameras and tactile input from palm and fingertip sensors to generate immediate motor outputs—such as reaching, grasping, and grip adjustment—at 200 Hz. System 2 operates at a slower cadence (7-9 Hz), using a 7b-parameter vision-language model to interpret higher-level instructions, such as "clear the table," and decompose them into steps that can be executed safely and efficiently.

The hierarchical classification of robotics technology

Layer	Function	Components
AI system (brain)	Information processing, high-level decision making	AI chip, AI algorithms (AI models)
Motion control system (cerebellum)	Motion control, balance maintenance	Controllers, motion-control algorithms, ROS
Hardware (body)	Physical movement, Data collection	Vision, sensor, actuators

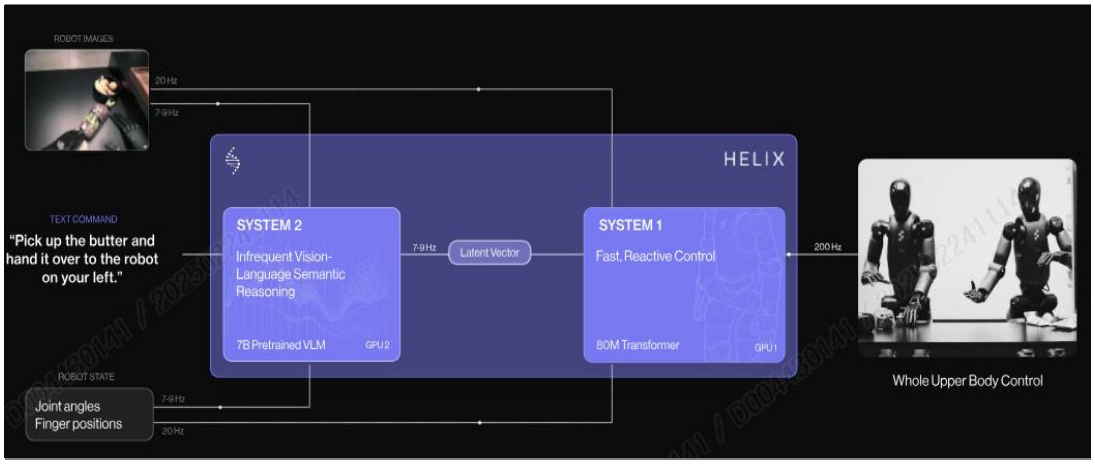
Source: Press release, Samsung Securities

Boston Dynamics-Google DeepMind partnership



Source: Boston Dynamics

Figure AI: Helix architecture



Source: Company data

A profound technological gap—and corresponding valuation gap—is emerging between companies that develop end-to-end robot intelligence, spanning foundation models to motor control, and those that rely on third-party AI systems. Figure AI, which develops its own foundation models, is valued at roughly seven times Apptronik, which depends on Google's models. Agility Robotics, which leverages Nvidia's foundation models and focuses on logistics applications, is valued at only one-twentieth of Figure AI.

Figure AI's valuation increased sharply from USD2.6b in 2024 to USD39b in Feb 2025—a roughly 15x increase in around a year. This rerating was driven by two key developments: 1) the independent release of its Helix model in 2025, a proprietary VLA architecture comprising System 1 and System 2; and 2) the announcement of initial deliveries of its Figure 02 robot to a new customer, following BMW.

Meanwhile, Apptronik raised USD520m in Feb 2026 at a valuation of USD5.0b-5.5b. A spin-off from the Human Centered Robotics Lab at the University of Texas at Austin, the company contributed to the development of NASA's Valkyrie humanoid robot. Building on this foundation, Apptronik has focused on designing for mass-production, targeting an initial price point of USD80,000 for its Apollo

robot. The humanoid robot is currently undergoing testing in Mercedes-Benz production facilities and relies on a foundation model developed in partnership with Gemini Robotics.

Agility Robotics, which has been first to deploy humanoid robots in commercial logistics environments, raised USD400m in a Series C round in early 2025, implying a valuation of USD2.1b-2.8b. Its Digit robot features a distinctive "reverse-joint" leg design, inspired by avian biomechanics, enabling efficient sitting, standing, pivoting in confined spaces, and stair climbing. While Agility utilizes Nvidia's GR00T and Isaac Sim for training and foundational modeling, its proprietary Motor Cortex control system is developed in-house. Unlike competitors pursuing general-purpose robotics, Agility has taken a more focused approach, optimizing Digit specifically for logistics rather than prioritizing broad versatility.

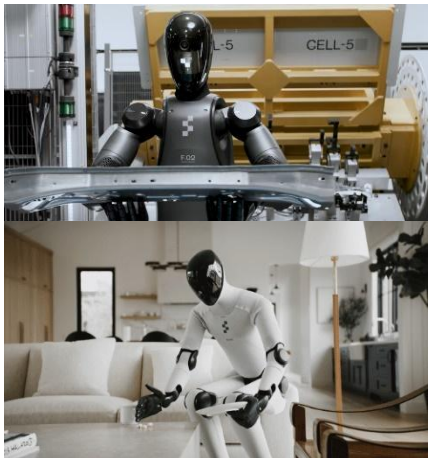
Boston Dynamics remains the industry leader in robotic motion control but continues to rely on Google DeepMind for its foundation models. As a result, despite its unmatched expertise in dynamic movement, its valuation has yet to converge with that of Figure AI. To narrow this gap, Boston Dynamics will need to accelerate mass-production and broaden its customer base, particularly in logistics and manufacturing. The company plans to begin securing external customers in 2027, with a potential IPO thereafter.

Robotics companies side-by-side: Apptronik, Figure AI, and Agility

Feature	Figure AI	Apptronik	Agility
Robot	Figure 02/03	Apollo	Digit
Valuation	USD39b	USD5.5b	USD2.1b-2.8b
Funds raised	USD1.9b	USD1.0b	USD400m
Investors	OpenAI, Nvidia, Microsoft, Jeff Bezos	Google, Mercedes-Benz, John Deere	OpenAI, Nvidia, Microsoft, Jeff Bezos
Strengths	Autonomous intelligence, Nvidia chip-based learning	Cost-efficient production, NASA-derived hardware reliability	Human-like ankle design; superior ability to rotate in tight spaces and climb stairs
Foundation model	In-house	Google DeepMind	Nvidia, SoftBank, Nvidia
Customers	BMW (manufacturing, precision tasks)	Mercedes-Benz (logistics, material handling)	Amazon (box moving, sorting), Schaeffler, GXO

Source: Company data, Samsung Securities

Figure AI: Testing at BMW factories



Source: Company data

Apptronik: Testing for logistics tasks

Source: Company data

Agility: Digit

Source: Company data

Robotics companies: Level of in-house technology stack integration

	Company	World model/ Foundation model	Vision/ Action model	Inference chip	Body design	Mass-production	Notes
Full stack	Tesla	In-house (FSD)	In-house (FSD)	In-house (AI5)	In-house	2H26	
	Xpeng	In-house	In-house	In-house (Turing AI)	In-house	End-2026	
Model-based full stack	Figure AI	In-house	In-house	Nvidia Thor	In-house	2026	Foundation model independent from OpenAI
	Robotics Lab	In-house	In-house	DeepX	In-house	1H26	Based on mobile robot 'MobED'
	Agibot	In-house	In-house	Nvidia Thor	In-house	2024	Cumulative production of 5,000 units
Big Tech collaboration	Boston Dynamics	Collaboration with Google DeepMind	In-house	Nvidia Thor	In-house	2028	Actuator standardization, collaboration with Hyundai Mobis
	Agility	Collaboration with Nvidia	In-house	Nvidia Thor	In-house	2026	5th generation by end-2026
	Aptroniks	Collaboration with Google DeepMind	In-house	Nvidia Thor	In-house	202	
	1X	Collaboration with Nvidia	In-house	Nvidia Thor	In-house	2026	Subscription model launched in April
	Unitree	Collaboration with Nvidia	In-house	Nvidia Thor	In-house	2025	500 units produced in 2025

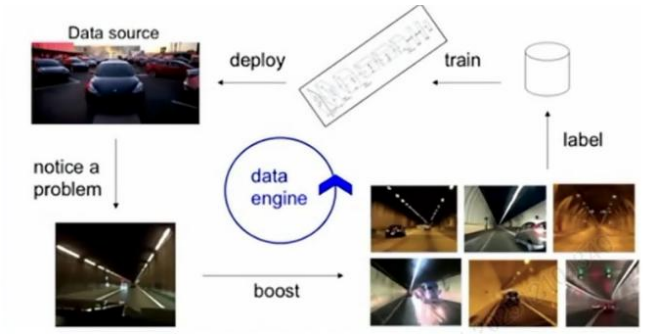
Source: Company data, Samsung Securities

Lesson 3: How Tesla became the undisputed leader in physical AI

In both autonomous vehicles and robotics, a company's value is ultimately determined by the quality of its AI. While data is often described as the lifeblood of AI, the true differentiator is not volume but quality—and, critically, the feedback loop that converts data into continuous performance gains. The core mechanism is the "fleet data loop": collecting real-world driving data, using it to refine models, deploying updates back to the fleet, and then harvesting richer data from subsequent operation. This closed-loop system captures tacit, context-rich information—subtle cues around timing, speed, and behavior—that cannot be manually encoded. Within this framework, world modeling, decision-making, and motor control are integrated into a unified neural network, enabling a probabilistic understanding of physical dynamics and, over time, improving the system's ability to handle rare, high-impact edge cases (tail risks).

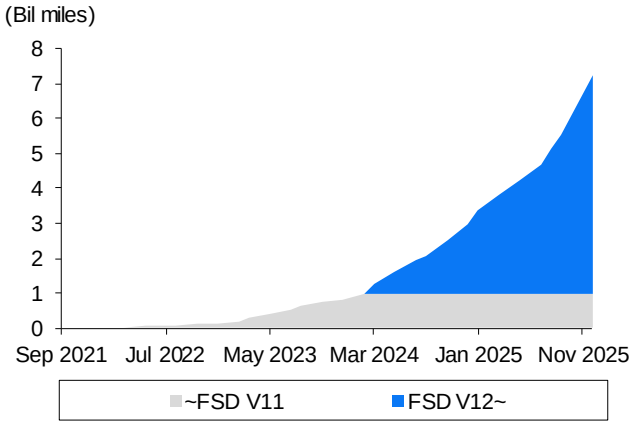
Tesla's leadership in physical AI reflects an early and consistent strategic focus on real-world data as a core asset. Even before Full Self-Driving (FSD) became a marketed feature, Tesla equipped all vehicles—regardless of whether customers purchased the feature—with the necessary hardware, including proprietary AI chips and a full sensor suite. These vehicles operated in "shadow mode," passively collecting driving data without affecting driver control. Given an estimated hardware cost of around USD1,500 per vehicle, such an approach would have been difficult for legacy automakers, which typically operate with margins of just 5-6% and face intense pressure to deliver short-term earnings. Tesla, by contrast, leveraged capital raised during the early surge of enthusiasm for EVs to prioritize long-term AI leadership over short-term profitability.

Tesla: Fleet data loop



Source: Company data

Tesla: FSD cumulative mileage



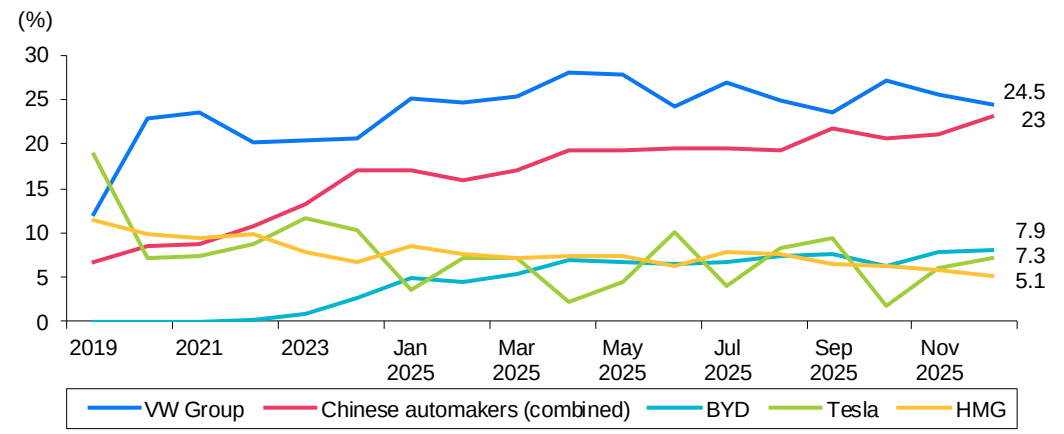
Source: Company data, Samsung Securities

Markets do not reward companies for being first to invent a technology; they reward those that scale it profitably. Tesla did not lead the EV market by launching the first EV, but by being the first to achieve scale and converting it into sustained profitability. The company acted decisively following its first profitable year in 2020, raising USD12.3b (over KRW17t) across three equity offerings. Rather than penalizing dilution, investors interpreted these capital raises as validation, driving the share price higher. The scale of capital raised was substantial—sufficient to fund production capacity of 3.7m vehicles or to acquire approximately 200,000 Nvidia Blackwell GPUs.

Transformational innovation requires countless failures, immense capital, and top-tier talent. Capital markets tend to concentrate funding in perceived leaders, reinforcing competitive advantages. Companies that secure the most capital attract the strongest engineering talent, the sharpest minds, and the most-driven problem-solvers. These people's careers become intertwined with solving the hardest challenges, creating a self-reinforcing cycle of innovation. As a result, in this new era of technological transition, the gap between first movers and fast followers is widening steadily.

In the era of physical AI—where hardware platforms anchor the business model—the fast-follower strategy is not merely risky; it is increasingly untenable. This dynamic is evident in the automotive sector. HMC and Kia, despite being among the world's highest-volume automakers—selling more than twice Tesla's volume and generating over 40% higher operating profit—trade at a fraction of Tesla's market cap. This reflects investor prioritization of AI leadership over current financial metrics. Without a credible path to AI-driven differentiation, markets can have no confidence that these Korean carmakers will remain competitive five years from now. In Europe, for example, HMC and Kia have seen EV growth lag the broader market, ceding share to Tesla and Chinese EV makers.

Automakers: European market share, by company



Source: EV-Volumes, Samsung Securities

Encouragingly, HMG is moving with remarkable speed in robotics. At CES 2026, alongside the unveiling of its Atlas robot, it announced a landmark partnership with Google DeepMind—directly addressing the intelligence gap that had long been Boston Dynamics' key limitation. In early February, CEO Robert Playter stepped down, followed by the head of robotics research. These leadership changes mark a clear inflection point: the company is transitioning from a research-driven organization to a commercial platform focused on scale and mass-production. We expect the Atlas developer to appoint a new leadership team with expertise in mass-production and strong market credibility, in preparation for a future IPO. At the same time, HMG is building a robotics value chain across the US and Korea, anchored by key Korean auto parts suppliers.

In late February, HMG announced a plan to invest nearly KRW9t in Saemangeum (Jeonbuk province) to build AI data center infrastructure and robotics manufacturing & component cluster. The group is likely to produce Boston Dynamics' robots in the US and Hyundai Motor Group Robotics Lab's products in Korea. A robotics training center should be announced in March, and a dedicated robotics factory in April. HMG's aggressive pace reflects a hard-learned lesson from the EV era: if you don't seize market leadership early, the technological gap only grows wider over time. In robotics, HMG is no longer playing catch-up—it is positioning itself as the first mover. We believe Boston Dynamics will go public by late 2027 or early 2028, when it should secure non-captive customers and complete its robotics production facility.

HMG: Physical AI momentum in 2026E

Jan	Feb	Mar	2Q	3Q	4Q
• Atlas unveiled at CES • Partnership with Google DeepMind announced	• Boston Dynamics CEO replaced • Building a robotics value chain • Announced KRW9t investment in Saemangeum	• Announcement of RMAC investment structure	• Announcement of robot factory, SDV roadmap (Kia CID) • US robotics policy announcement	• Solid-state battery technology announcement (HMC CID) • RMAC operations begin	• Motional robotaxi service launches • Hyundai Ioniq 5 supply to Waymo begins • Anseong battery campus operational

Source: Company data, Samsung Securities

Robotics Lab: MobED value chain

Component	Company	Remarks
Lidar	SOS Lab	2 units per robot / Supplied as a module by SL Corp
Battery	Samsung SDI	Cylindrical
Edge Chip	DeepX	DX-M1 NPU / Computing power: 30 FPS / Power consumption: 5 W
Actuator	Gyeyang Electric	12 units per robot
Contract Manufacturing	SL Corp	Includes battery pack

Note: The target is to sell 10,000 to 15,000 units over the next three years.
Source: HMC, Samsung Securities

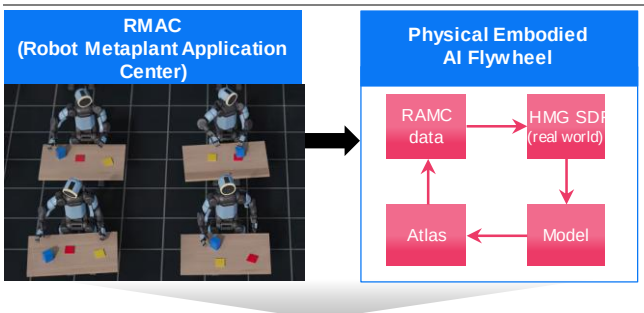
Boston Dynamics: Robot value chain

Product	Component	Company	Notes
E-Atlas	Actuator	Hyundai Mobis	Sub-component sourcing status is undecided
	Head module	Hyundai Mobis	
	Body module, arm, leg	Hwashin	
	Battery	LG Energy Solution	
	Smart lighting	n/a	Bidding in progress
	SI / Control system	Hyundai AutoEver	
Spot	Actuator	HL Mando	2nd generation release planned for 2027
	Leg Module	SL Corp	
Stretch (Logistics Robot)	Turn Signal	SL Corp	

Source: Company data, Samsung Securities

HMG has seized a rare opportunity as AI performance in robotics becomes increasingly dependent on real-world data. Google DeepMind's partnership with Boston Dynamics reflects HMG's controlling stake, which enables deployment of robots across its global manufacturing network and the generation of high-quality behavioral datasets at scale. HMC and Kia can not only collect data but also validate and refine AI models in live industrial environments. This positions HMG to capture a meaningful share of future robot subscription revenues. While initial deployments within HMG facilities from 2028 will not immediately translate into external revenue, participation in the core AI training loop implies a structural shift in the group's business model.

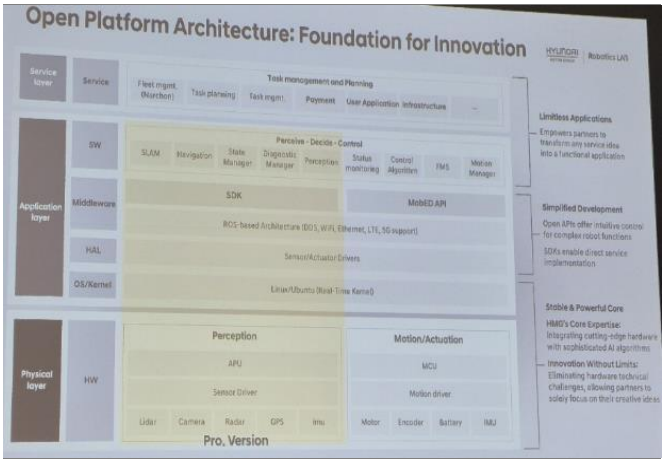
HMC: Physical embodied AI flywheel



The process of **data → model training → robot application → real-world operation → new data generation** repeats continuously, allowing for the ongoing accumulation of high-quality datasets and enabling continuous improvement in model performance.

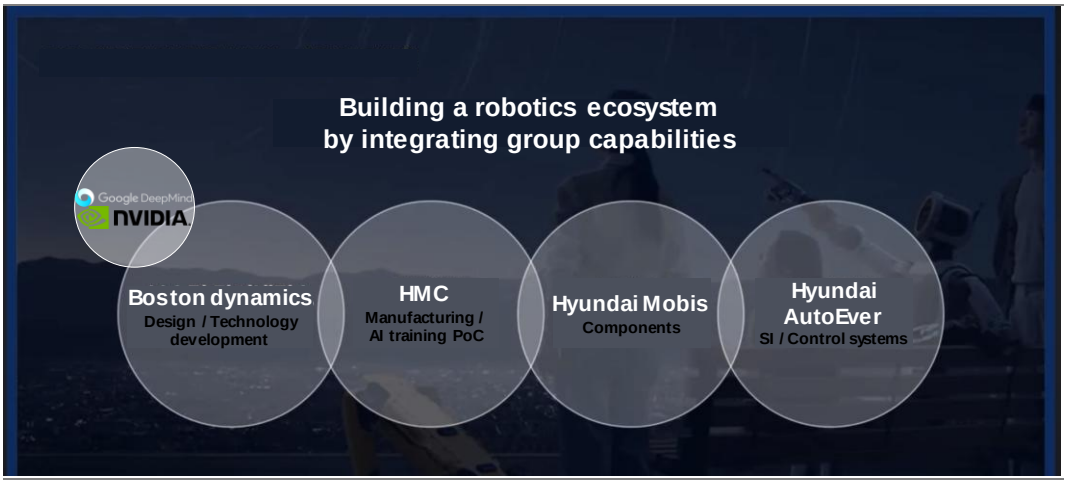
Source: Samsung Securities

MobED: Open platform architecture



Source: Company data, Samsung Securities

HMG: Robotics ecosystem



Source: Company data, Samsung Securities

Korea needs to evolve into a robotics export nation

Korea is the world's fourth-largest automobile exporter. However, failure to establish leadership in the global robotics industry could accelerate a structural shift from being a major exporter to a net importer. China, now the world's largest auto exporter, is investing aggressively in robotics despite labor costs at roughly one-sixth of US levels and elevated youth unemployment (16.5% as of end-2025). With EV penetration already exceeding 50% and subsidies reduced from 2026, price competition in China has intensified—prompting even Tesla to introduce 60-month, zero-interest financing. Chinese EV manufacturers are responding by expanding exports, while increasing deployment of robotaxis from 2026 is widely expected to dampen demand for new vehicles. Given that HMG's production costs already exceed those of Chinese EV makers, maintaining cost competitiveness will require a transition toward fully automated manufacturing, including the integration of humanoid robots into assembly lines.

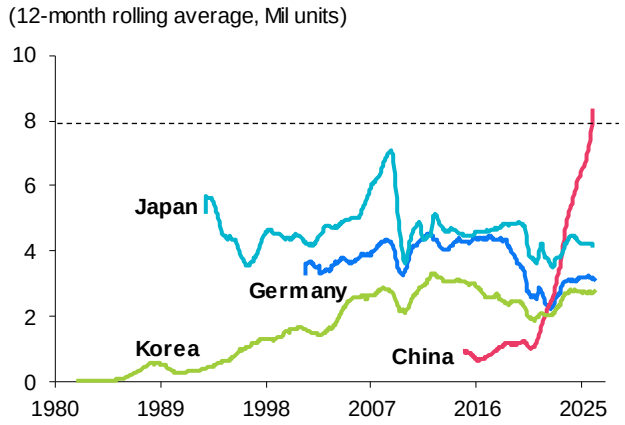
Korean factories currently function as export hubs due to their relative cost advantage over plants in the US and Europe. However, once robotic automation is fully deployed in those regions, production costs could fall to a fraction of current Korean levels. HMG already produces 52% of its vehicles overseas. Even if robotics deployment is constrained domestically, production can still be scaled through automation of overseas facilities, where unmanned, 24/7 operations can increase output by more than 68% within existing capacity. If overseas production costs fall below those in Korea, the rationale for maintaining Korea as an export base weakens materially. In addition, if Chinese EV manufacturers move more quickly to adopt fully automated systems and export vehicles to Korea at significantly lower price points, even differentiated subsidy policies may be insufficient to offset competitive pressures.

In this context, the Korean automotive industry—working in coordination with labor unions—must prioritize the development of a domestic robotics ecosystem. This includes the active deployment and validation of robotics within automotive manufacturing to sustain cost competitiveness. The strategic objective should be to transition from an automotive export model to a robotics export model. Full substitution of human labor on assembly lines will be a multi-year process, likely requiring at least a

decade. As robot deployment expands across industries, the total addressable market could grow to two to three times the size of the automotive sector.

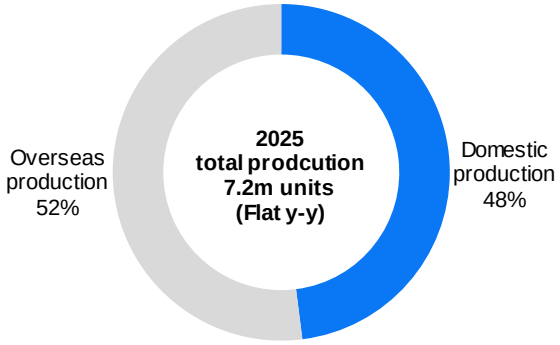
There is also a case for repurposing underutilized automotive capacity for robotics production. Tesla has already converted portions of its Model S and Model X lines—now representing only a small share of deliveries—to manufacture its Optimus robots. HMC and Kia currently operate flexible production systems capable of assembling ICE vehicles, EVs, and hybrids on the same lines, and have demonstrated the ability to convert ICE vehicle lines to EV lines, or even repurpose entire ICE vehicle factories into EV factories. As carmakers' strategies evolve, parts suppliers will also need to pivot towards the robotics value chain.

Auto exports, by country



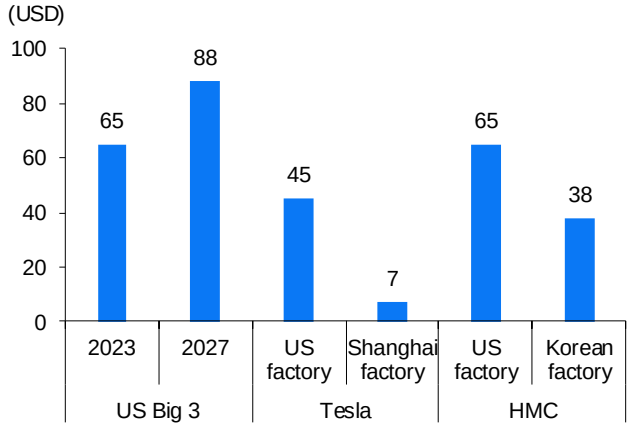
Source: CEIC, KAMA, Samsung Securities

HMG: Domestic vs overseas portion of production



Source: HMC, Kia, Samsung Securities

Hourly wages in the US, China, and Korea



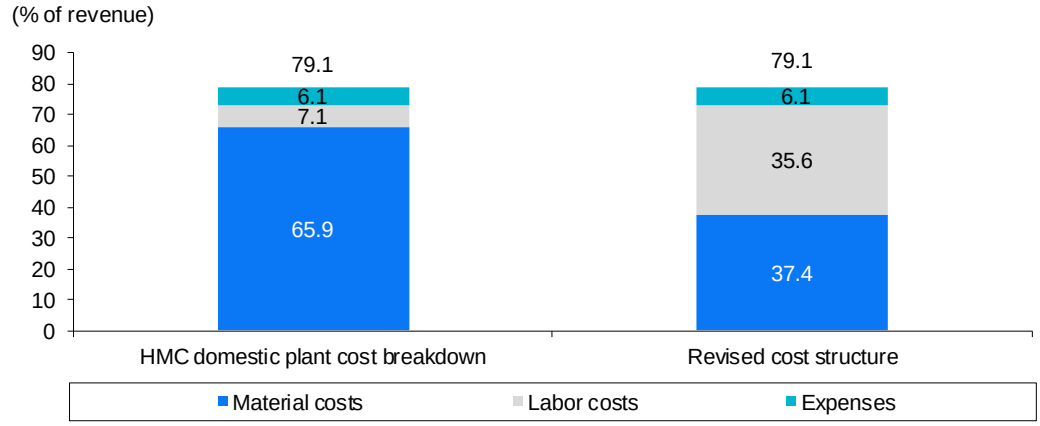
Source: Company data, media, Samsung Securities

Humanoid robot: Cost per hour

(USD)	Case 1 (initial price)	Case 2 (price if 30,000 units made *pa*)	Note
Useful life	2 years	5 years	
Robot price	135,000	33,000	
Software cost	2,376	5,940	USD99/month * 3 years
Maintenance cost	13,500	8,250	5% of purchase price * 3 years
Total robot cost	150,876	47,190	
Hourly cost	**9.4**	**1.2**	**22 hours/365 days/ /useful life**

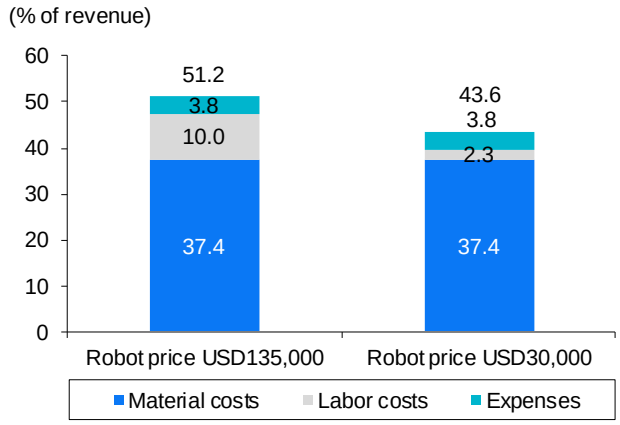
Source: Samsung Securities estimates

HMC Korea plant: Cost structure



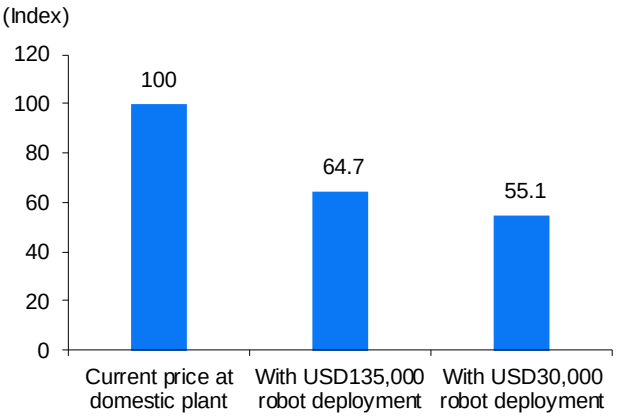
Source: Company data, media, Samsung Securities

Humanoid robot deployment: Cost structure scenarios



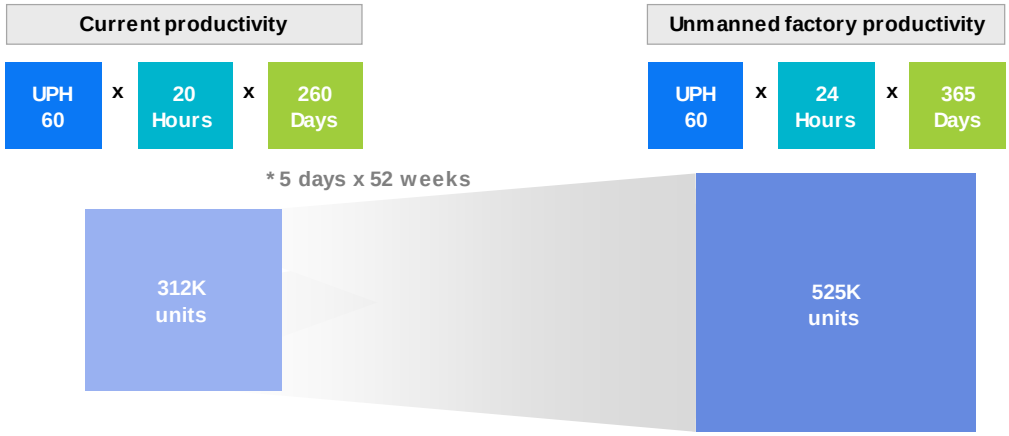
Note: Assumes domestic plant's revenue remains the same
Source: Samsung Securities estimates

Humanoid robot deployment: Vehicle price drop scenarios



Source: Samsung Securities estimates

Annual production: Manned factory vs fully unmanned factory



Source: Samsung Securities estimates

New markets, new competition, new opportunities

Opportunities in the emerging humanoid robot market

Battery requirements for humanoid robots

Batteries for humanoid robots possess shorter cycle life but much lower cost burden: The humanoid robot market is poised to grow in labor-intensive industries that have high wage costs—sectors where robots should replace human workers operating around the clock. To succeed in this role, batteries must deliver consistent, high-performance output capable of sustaining continuous operations. Given the requirements, lithium-ion batteries—already mass-produced for EVs—are the most practical choice. As a result, the performance of humanoid robot batteries should hinge primarily on energy capacity and cycle life.

But usage patterns differ sharply from EVs', introducing unique challenges in terms of charging cycles and longevity. Lithium-ion batteries degrade with each charge-discharge cycle. Moreover, under 24/7 operational loads, battery lifespans should be drastically reduced due to the cells' chemistry.

Lithium-ion battery environment comparison: For EVs vs humanoid robots

	Criterion	EV battery	Humanoid robot battery
Commonalities	Both are based on lithium-ion chemistry Shared priorities: Energy density, lifespan, stability, and charging efficiency		
Differences	**Replacement cycle**	**8-10 years (infrequent)**	**1.4-4.4x *pa* (frequent)**
	Usage pattern	Irregular usage (*eg*, varying driving distances)	Regular, repetitive usage patterns
	Design focus	Optimized for driving range	Emphasis on portability, constrained by weight and volume
	Operating environment	Outdoors (wide temperature fluctuations)	Indoors; need to control in confined space
	Charging infrastructure	Requires large charging stations	Compatible with dedicated charging stations or swappable battery systems
	Battery energy capacity	**30-100 kWh+**	**2-4 kWh**
	Battery pack cost share	**18-34% of total vehicle cost**	**0.2% of total cost**

Source: Samsung Securities estimates

(Cost) Significantly lower battery cost burden vs that for EVs: When comparing lithium-ion applications, humanoid robots and EVs present a clear contrast. EVs benefit from mature markets and massive investments, while humanoid robots remain in the early stage of commercialization—robot batteries are often priced 2-3x higher per cell vs cells in EV batteries. Yet, battery capacity for a humanoid robot is only about 1/20 that of a typical EV battery. As a result, the absolute cost of the battery pack represents a negligible portion of the total system cost. In North American mass-market

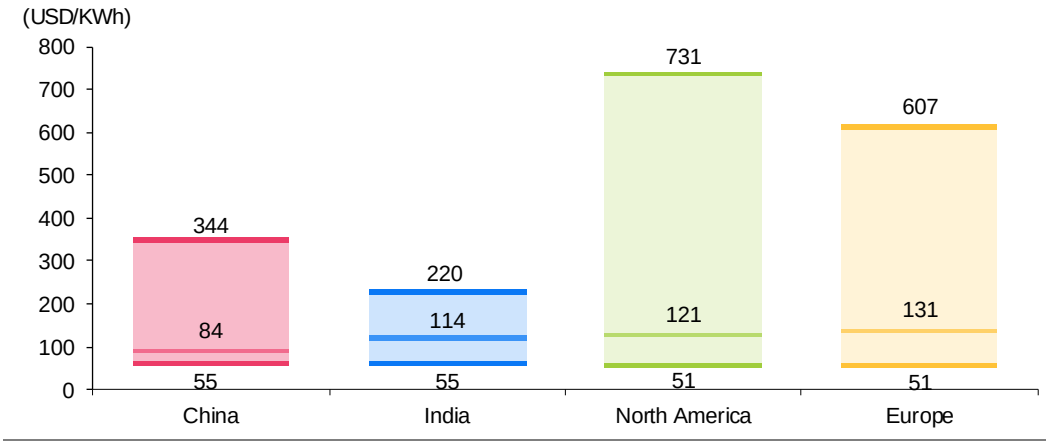
EVs, battery costs account for 19-30% of the total system cost. For humanoid robots, that figure is estimated at just 0.2%. This means manufacturers can afford to prioritize higher-performance, higher-cost batteries without suffering from a major financial impact.

Cost share of electric vehicles considering EV battery pack prices

	Budget EV		Tesla Model 3	
NCM pack ASP (USD/kWh)*	121	200	121	200
Assumed battery capacity (kWh)	60	60	60	60
Estimated battery cost (USD)	7,260	12,000	7,260	12,000
EV ASP (USD)	35,000	35,000	40,240	40,240
Battery cost as % of total vehicle cost (%)	21	34	18	30

Note: *Prices vary due to differences in tariffs and manufacturing costs depending on the sourcing region.
Source: BNEF, Cox Automotive, Samsung Securities estimates

Comparison of average EV battery pack prices in 2025, by region



Note: Volume-weighted average price
Source: BNEF

(Replacement cycle) Ternary batteries every 3 months, LFP batteries every 8 months: All batteries degrade over time, with usable life (cycle life) determined by the number of charge-discharge cycles. The point at which runtime drops sharply after a full charge is considered the end of the battery's practical life. The industry standard for measuring this is State of Health (SoH)—the remaining capacity as a percentage of original capacity. When SoH falls to 80%, the battery is typically replaced. Theoretically, LFP batteries reach 80% SoH after about 3,000 cycles, while high-nickel ternary batteries reach that threshold after around 1,000 cycles.

Unlike EVs, which are usually driven 2-3 hours per day, humanoid robots may run for 2 hours per charge cycle—they must be charged many times a day. Under this assumption, the LFP battery in a robot would need to be replaced every 250 days and a ternary battery every 83 days (roughly 3x more often). Of course, under identical workloads, LFP batteries tend to discharge faster than ternary batteries, increasing their cycle frequency and shortening the replacement gap.

For robots designed with swappable batteries (*eg*, HMC's Atlas or UBtech's Walker), keeping spare packs on hand enables seamless, continuous operations. For docking-based systems (*eg*, Tesla's Optimus or Figure AI's robots), the time and logistics of battery swaps must be factored into operational efficiency. From the user's perspective, frequent battery replacements for robots also mean ongoing maintenance costs[1] that cannot be ignored.

Humanoid robot batteries: Lifespans and replacement cycles, by chemistry

	LFP	NCM
Charge cycles (*)	3,000	1,000
Daily operating hours	24	24
Daily charging cycles	12	12
Replacement interval (days)	250	83

Note: Based on SoH of 80%
Source: Samsung Securities estimates

(Power consumption) 1-2 kW for humanoid robots: A humanoid robot's energy needs in a real-world setting depend entirely on the tasks it performs and usage intensity. Unlike industrial robots, humanoid robots rely solely on onboard batteries. Without precise data about specific tasks or component specs, we can estimate power draw based on typical robot subsystems: High-resolution lidar, cameras, ultrasonic sensors, motors, and high-performance computing modules. Together, these devices require a baseline power draw of around 1.3 kW. Tesla's humanoid robot, equipped with a 2.3 kWh battery, has been estimated to run for about two hours under full load[2].

Actuation consumes 80% of total power: A humanoid robot's energy use breaks down into three core functions—actuation (movement of joints and limbs), computing (AI processing and control systems), and sensing (*eg*, cameras, communication modules, and environmental sensors). Of these, actuation consumes 70-80% of a robot's power needs, computing 15-25%, and sensing less than 5%.

Power consumption of humanoid robots, by function

Category	Key power consumers	Portion	Notes
Motion	Walking (acceleration/deceleration), balance maintenance, load support, joint motors	70-80%	Largest share; scales with walking speed and payload
Computing	AI inference (VLA/LMM), path planning, control algorithms	15-25%	Increasing share due to adoption of high-performance GPUs
Sensing & Other	Cameras, lidar, various sensors, cooling fans, *etc.*	Less than 5%	Power used for sensor operation, data transmission, and thermal management

Source: IEEE, arXiv, IDTechEx

Power consumption related to actuation varies significantly depending on the task load. For example, Tesla's Optimus is estimated to use 100 W when sitting, 500 W for brisk walking, and 800-1,200 W when lifting/carrying objects. Due to its bipedal locomotion, a humanoid robot must continuously supply current to its joint motors even when motionless, to counteract gravity (gravity compensation). This constant energy drain reduces overall operational times. According to Frontier, vertical

[1] Certainly, replacement of components such as actuators, sensors, and computing systems will also be necessary, and the use of lubricants—such as grease or oil—at friction points including motors, gearboxes, and bearings should be considered.
[2] Samsung Securities, *Autos (OVERWEIGHT)/Batteries (NEUTRAL) - Beyond the EV chasm: Batteries as the lifeblood of robotics* (Mar 28, 2025)

movements such as climbing stairs consume 2.5-3x more peak power than horizontal movements on flat ground—the motors must lift the robot's entire body weight when the robot moves vertically.

Estimated average power consumption of humanoid robots, by activity

Activity	Average power consumption*	Power consumption characteristics
Idle/conversation	100 - 200 W	Minimal power for balance maintenance and AI inference
Standing/simple upright motion	300 - 400 W	High proportion of power used for gravity compensation
Walking on the flat (1.2 m/s)	500 - 700 W	Repeated acceleration and deceleration of leg joints
Lifting/carrying objects (10-20 kg)	800 W - 1.2 kW	High load concentrated on arm actuators and torso joints
Stair climbing/inclined surfaces	1.5 - 2.0 kW	Highest energy consumption due to vertical (Z-axis) motion

Note: *Based on Tesla Optimus
Source: Samsung Securities

(Charging profile) Runtime of 2-3 hours & charging time of 1-2 hours at voltages below 60V: The performance of humanoid robot batteries depends on their energy density. Given the technical challenges of implementing high-voltage systems in these applications, the battery specs of commercially available/publicly disclosed humanoid robots should serve as useful benchmarks.

Leading commercially deployed humanoid robots, such as Unitree's G1 and UBtech's Walker, which preceded Tesla's Optimus, operate on a 54 V system. While actual runtime depends on usage (*eg*, walking, running, lifting, or carrying), the recommended discharge time is approximately two hours. The Unitree G1 is equipped with a 9 Ah battery (a similar capacity to that in a high-end laptop battery). However, with its 13-series configuration, its total energy capacity is estimated at 433 Wh, allowing for about two hours' worth of operations under a 200 W load. UBtech's Walker features a 54.6 V, 10 Ah LFP battery pack, which can reportedly be used for two hours—equivalent to an energy capacity of around 1.1 kWh. Its two-hour runtime implies an average power consumption of 550 W during operations.

Tesla's Optimus is reported to charge at 52 V, but its charging capacity remains undisclosed. However, with a 2.3 kWh battery, it would take two hours to fully charge at 20 A, or one hour at 40 A. Thus, enhancing charging capacity should be critical to improving Optimus's operational efficiency. Figure AI's robot has a 2.25 kWh battery. Assuming the same 52 V, 20 A charging parameters as Tesla, it would take about two hours to fully charge. If the charging current is increased to 40 A (as in the case of Tesla's higher capacity scenario), a full charge could be achieved in one hour. Given that most recent humanoid robots feature battery capacities of around 2 kWh, charging times typically range from 1.5-2 hours (depending on the charging method).

Battery performance, by robot model

	Unitree	UBtech	Tesla		Figure AI	Boston Dynamics
	G1	Walker	Optimus (Scenario 1)	Optimus (Scenario 2)	Figure 02	Atlas
Battery chemistry	n/a	LFP	NCMA	NCMA	NCM/NCA	NCM/NCA
Charging voltage (v)*	54	54	52	52	52	n/a
Charging current (A)**	5	5	20	40	20	n/a
Battery pack capacity (Wh)	433	546	2,300	2,300	2,250	2,400
Full charge time (minutes)	96.2	120	133	66	130	n/a

Note: * LFP cells assumed at 3.2 V per cell; ternary (NCMA/NCM/NCA) cells assumed at 3.7 V per cell. For the G1 robot, the voltage is calculated based on 13 series-connected cells with 9 Ah capacity.
** G1 and Walker data are from publicly disclosed specifications. Tesla and Figure AI voltage values are aligned for comparative purposes. Tesla's current values reflect two scenarios: 20 A and 40 A.
Source: Unitree, UBtech, Tesla, Figure AI, Samsung Securities

Autonomous charging strategies to minimize downtime: Given the inherent challenges[3] of integrating high-voltage battery systems into humanoid robots, advances in charging technology are as vital as improvements in battery energy density—particularly when aiming for seamless, uninterrupted operations. While UBtech's Walker relies on a conventional wired charging cable, platforms such as Unitree's G1, Apollo, and Atlas utilize battery-swapping mechanisms. Recently, more advanced approaches have emerged, such as Agility's Digit robot, which autonomously replaces its own battery, or systems that use autonomous docking stations—robots navigate to a charging station when needed, recharge fully, and then resume operations, enabling fleet-level coordination.

Charging method, by robot model

Charging method	Downtime	Key features & advantages	Limitations & challenges	Representative robot models
Battery hot-swap	≤ 5 minutes	Enables 24/7 continuous operations; instant power restoration in the field	Requires dedicated robotic arms or trained personnel for battery replacement	Apptronik Apollo, UBtech Walker S2
Auto-docking	1.5 - 3 hours	Fully automated charging process with zero human intervention	Robot remains idle during charging (reduces operational uptime); requires precise alignment technology	Figure 02, Agility Digit, Tesla Optimus
Wireless inductive charging	≤ 1 hour	No connector wear or fire risk from physical plugs	Energy transfer efficiency loss (~10%); high infrastructure cost for dedicated charging pads	Figure 03
Wired / Plug-in	1.5 - 2 hours	Stable power delivery; enables simultaneous high-bandwidth data transfer; ideal for high-load R&D	Requires manual connection; limited mobility and safety constraints due to cables	UBtech Walker S1/G1

Source: Unitree, UBtech, Tesla, Figure AI, Samsung Securities

3 Samsung Securities, *Autos (OVERWEIGHT)/Batteries (NEUTRAL) - Beyond the EV chasm: Batteries as the lifeblood of robotics* (Mar 28, 2025)

Case study: Characteristics of robot operation and Figure AI's power consumption

Energy consumption profile of Figure 02 in logistics environment: As of 2026, Figure AI's second-generation humanoid robot, Figure 02, is among the most actively deployed models at logistics and manufacturing pilot sites. It features a 2.25 kWh battery, enabling continuous operations for up to five hours, and supports rapid charging via autonomous docking (just 1.5 hours to fully charge). Based on operational data from BMW's factories and logistics centers, the energy consumption of Figure 02 can be categorized into three distinct operational phases: 1) perception and path planning (perception and planning); 2) object grasping and lifting; and 3) transport and movement.

Power consumption and required power levels for Figure 02 in logistics operations

Stage	Stage 1	Stage 2	Stage 3
Task type	Perception and path planning	Grasping and lifting	Transport and movement
Power consumption (W)	250 - 400	800 - 1,500	600 - 900

Source: Figure AI, Robozaps, BWM, Samsung Securities

During the first phase (perception and path planning), power consumption ranges 250-400 W. This reflects the energy required by Helix (six RGB cameras and the onboard vision language model (VLM)) to scan package barcodes and determine the optimal task sequence. In the second phase (grasping and lifting), power demand spikes to 800-1,500 W. This surge is due to the high torque demands on the robot's hand and arm actuators, which must support loads of 20-25 kg. For every additional 10 kg of payload, power consumption rises linearly (15-20%). During the third phase (walking and transport; where the robot moves at 1.2m/s (4 km/h) while carrying loads), power consumption averages 600-900 W.

Figure 02: Specifications and features

Category	Specification	Notes
Battery capacity	2.25 kWh	50% improvement compared to previous model (Figure 01)
Continuous operational time	~5 hours (active operation)	Based on real industrial environment conditions (active runtime)
Charging method	Autonomous docking station (1.5-hour fast charging)	Enables operational uptime of approximately 75%
Processing module	Dual Nvidia RTX GPU modules	3x higher AI inference performance compared to previous model

Source: Figure AI

Compared to its predecessor, Figure 02 not only features a larger battery capacity but also achieves a 400% improvement in energy efficiency. This is attributed to several key innovations: 1) consolidated cable architecture (reduces wiring resistance and minimizes thermal losses); and 2) the integration of the onboard AI Helix (enables real-time decisions to be made locally, thus eliminating reliance on wireless communication, thereby reducing both latency and associated power overhead).

Considering the various power demands across its operational phases, a fully charged 2.25 kWh battery would be depleted in just 3-4 hours if used exclusively for transporting goods. However, Figure AI reports that under real-world logistics conditions—where the robot cycles through all three tasks (perception, grasping, and transport)—it typically operates continuously for up to five hours. While Figure AI aims for 24/7 operations, current estimates suggest that replacing a single human worker's 8-hour shift would require two Figure 02 robots due to the charging downtime. Given that each robot requires 1.5 hours to fully charge via autonomous docking, a minimum of two units per shift would be necessary to maintain continuous operations.

Autonomous shift handoff and wireless inductive charging—'No Babysitter' protocol: In real-world deployments, however, factors such as maintenance cycles, variable workload intensity, and task transition delays make it more practical to operate three robots per shift to ensure seamless 24/7 coverage. The recently announced Figure 03 and Helix 02 systems introduce an advanced 'autonomous task handoff' capability: Robots autonomously monitor their batteries and, when power depletion is imminent, transfer ongoing tasks to their nearby peers—enabling true fleet-level coordination without human intervention. A key enabler of this system is wireless inductive charging. Figure 03 has charging coils in its feet, allowing it to initiate automatic charging simply by stepping onto a charging pad/station. With a charging rate of 2 kW (equivalent to 1C for its 2.25 kWh battery), the robot can be fully charged in under 1.5 hours, minimizing operational interruptions and maximizing uptime.

Figure AI's autonomous task handoff

Category	Details
Battery telemetry	Robot continuously monitors its battery in real time. Upon reaching a predefined threshold, the system immediately initiates the active handoff process.
Digital signal	When Robot #1 begins moving toward the docking station, Robot #2 instantly receives a digital signal and departs from the dock to proceed to the work site.
Wireless inductive charging	Charging occurs at 2 kW when the robot stands on a charging pad, using induction coils mounted on its feet.

Source: Figure AI, Samsung Securities

Battery takes up only 0.2% of robot's total cost (USD130,000): Figure AI robots are currently offered to enterprise clients like BMW under a lease model, with an initial acquisition cost of about USD130,000 (or KRW190m), which is inclusive of maintenance and AI software licensing. CEO Brett Adcock has publicly stated a long-term goal of reducing the robot's price to under USD20,000/unit. For the Figure 02, with its 2.25 kWh battery, the estimated battery pack cost is USD 248[4]—just 0.2% of the robot's total price. Even if next-generation solid-state batteries (which cost over 8x more than conventional high-nickel ternary cells) were adopted, the battery would still represent less than 1.5% of the robot's total cost. Battery costs are not high, and the robot's price is significantly higher than the cost of its power system.

4 The projected price of high-nickel NCM811 cells in 2026 is $100/kWh (BNEF forecast), with the incremental pack-level cost assumed to be approximately 10% of the cell price.

Cost estimates for Figure AI robot, by battery type

Criteria	Category	Price (USD)
Figure 02 robot supply price		130,000
With high-nickel NCM 811 battery	Figure 02 battery pack price	248
	Battery cost as portion of total	0.2%
With solid-state battery	Figure 02 battery pack price	1,980
	Battery cost as portion of total	1.5%

Note: * The battery capacity (2.25 kWh) and pack costs are based on an assumption that the pack cost is 10% of the cell cost. Solid-state batteries are assumed to cost 8 times more than conventional batteries.
Source: Figure AI, BNEF, Media, Samsung Securities estimates

Implications of Figure AI's robot developments for battery industry, especially from a power consumption perspective: Given that the primary target market for humanoid robots are large industrial sites (*eg*, auto plants, where labor is intensive and repetitive), Figure AI's robot progress offer critical insights regarding future development direction in the rechargeable battery industry.

1) Enhancing onboard GPU performance for real-time perception and motion planning increases power draw; 2) vertical lifting motion in the grasping and lifting phase imposes high mechanical loads, resulting in significant power spikes; and 3) physical constraints in terms of battery size and weight require charging infrastructure innovation for continuous operations—spurring demand for docking stations, wireless inductive charging, and battery-swapping systems. Figure AI's robots are being developed with an eye to: 1) optimizing computational power (perception and planning); 2) improving sensors and actuators (grasping and lifting); and 3) utilizing autonomous charging infrastructure for continuous operations (walking and transport). These trends point to a broader opportunity for the rechargeable battery industry's ecosystem. Beyond improving the energy density and charge/discharge performance of the battery cells themselves, the battery sector should enjoy direct and indirect business opportunities in the areas of material development and other operations in relation to supporting the smart charging infrastructure (*eg*, AI-enabled docking stations, wireless charging pads, and fleet coordination software).

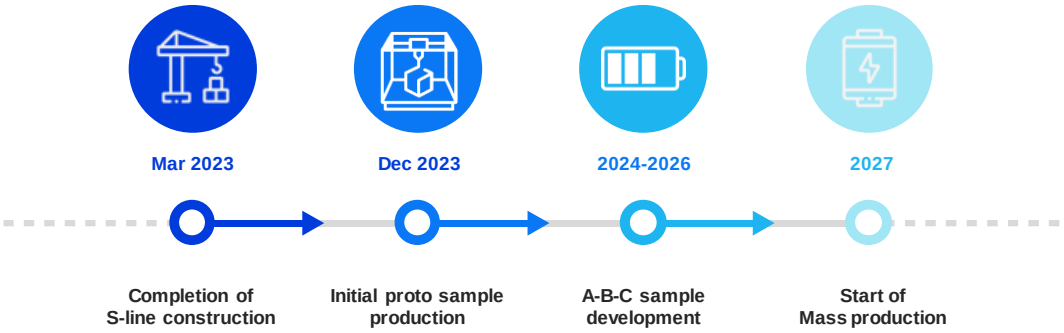
Opportunities in humanoid robot battery market: Commercialization of solid-state batteries and supply chain security issues

Humanoid robots, which need low-voltage designs, currently favor high-nickel ternary batteries: At present, batteries for humanoid robots are being tested or commercially deployed using two main chemistries: LFP (due to their abundant raw material supply) and high-nickel ternary (the latter is widely used in EVs and power tools). Given the difficulty of using high-voltage designs for humanoid robots, high-nickel ternary batteries—which offer higher energy density and superior power output—are likely to remain the preferred choice for robot manufacturers for the time being. LFP batteries, with lower energy density and greater volume (vs high-nickel ternary batteries) are less suitable for industrial-grade humanoid robots. Their use is likely to be limited to low-power applications such as home assistants or entertainment robots.

Humanoid robots as ideal testbed for solid-state battery adoption: Solid-state batteries have long been anticipated as the optimal solution for EVs, offering superior safety and energy performance vs conventional liquid lithium-ion batteries. However, the commercialization of sulfide-based solid-state batteries—which exhibit the highest lithium-ion conductivity—has been delayed due

to challenges in adapting deposition technologies and achieving scalable manufacturing yields. Compared to EVs, humanoid robots require smaller individual battery capacities, are less price sensitive to battery costs, need smaller production volumes, and have shorter development timelines. These factors suggest that solid-state batteries will achieve commercial deployment in humanoid robots first (*ie*, before EVs).

Samsung SDI: Solid-state battery commercialization roadmap



Source: Samsung Securities estimates

Competition with China in humanoid robot battery market unavoidable: In the EV battery market, the race for energy density is already underway, with manufacturers: 1) combining high-nickel ternary cathodes (around 95% nickel content) with increased silicon anode content; or 2) developing semi-solid designs[5] that blend liquid electrolytes with solid electrolytes (*eg*, gel polymers). These semi-solid batteries (which possess energy densities of 300-350 Wh/kg) are primarily developed by Chinese companies targeting the eVTOL, ESS, and EV markets, with a strategic goal of gaining an early lead before solid-state batteries are commercialized. Chinese companies such as CATL, BYD, and Gotion have publicly set targets for mass-production of EV-grade solid-state batteries (by end-2027). Gotion, in particular, reportedly expects its inhouse-developed sulfide-based solid-state battery (Jinshi) to power humanoid robots. Therefore, global competition with Chinese companies in the area of solid-state batteries used in humanoid robots looks inevitable.

According to a 2024 report from LG Business Research, semi-solid batteries are less stable and offer lower energy performance than solid-state batteries. But they can use conventional battery production lines, only requiring small changes to materials—they are thus cheaper to make than solid-state batteries. Still, semi-solid batteries are about twice as expensive as conventional lithium-ion batteries. That said, because semi-solid batteries offer more than double the energy density (vs conventional lithium-ion batteries), the higher cost is easier to accept, making them a strong candidate for commercialization. In the humanoid robot market, battery price sensitivity is significantly lower than in the EV market. As demand expands, companies will likely invest heavily to bring down the cost of solid-state batteries, narrowing the gap with semi-solid batteries. At least in the humanoid robot

[5] On Dec 30, 2025, China's National Technical Committee on Standardization for Electric Vehicles released a draft standard for "all-solid-state batteries for electric vehicles." In this document, the term "semi-solid" is defined as a "hybrid solid-liquid battery" (refer to the report: Samsung Securities, *Rechargeable Batteries (OVERWEIGHT) - Dialogue with market #48: Solid vs semi-solid, Industry Spot* (Jan 27, 2026).

market, solid-state batteries appear to have a higher likelihood of gaining an advantage over semi-solid batteries as the next-generation battery technology.

Semi-solid and solid-state batteries: Performance and cost estimates

	Conventional LiB	Semi-solid	Solid-state
Cost* (USD/kWh)	128-140	~280	520~
Energy density (Wh/kg)	150-260	360-500	450~
Stability	Low	Medium	High

Note: *Based on pack-level pricing (semi-solid data from Nio and CATL announcements)
Source: LG Business Research Institute (2024)

Korea: Solid-state battery value chain

Category	Company	Solid-state battery technology	Mass production	Capacity
Cell	Samsung SDI	Sulfide-based solid electrolyte; pilot line	2027	
	LG Energy Solution	Polymer-based solid electrolyte (under development)	2029 (EVs), 2030 (Humanoid)	
	SK On	Polymer-based solid electrolyte (under development)	2029	
Material	Isu Specialty Chemical	Lithium sulfide (Li_2S) production	Mass-production	40 tonnes/year
	Ecopro BM	Sulfide-based solid electrolyte	2027	40 tonnes/year
	Han Nong Chemical	Polymer electrolyte materials (under development)	TBD	
	Lake Materials	Lithium sulfide production process technology via Lake Technology	TBD	
	Lotte Energy Materials	Sulfide-based solid electrolyte; pilot line	TBD	
	Posco JK Lead Solution	Oxide/sulfide solid electrolytes (under development)	TBD	24 tonnes/year
	Jeongseok Chemical	Lithium sulfide (Li_2S) production	Mass-production	24 tonnes/year
	InChems	Sulfur-based solid electrolyte (atmosphere-stable)	Mass-production	120 tonnes/year
	Deoksan Futurecell	Oxide-based materials; semiconductor-based patents	TBD	
Equipment	CIS	Dry coater for solid-state batteries (under development)	TBD	
	Ilshin Autoclave	WIP (ultra-high pressure hot isostatic press) equipment production	Mass-production	
	mPlus	Press equipment for solid-state batteries (under development)	TBD	

Source: Media, Samsung Securities

Chinese robot vacuum cleaner security incident spurs realignment of humanoid robot supply chains outside of China: One of the key considerations when humanoid robots are widely adopted in industrial settings will be the security issues recently observed in the robotic vacuum cleaner market. Due to their built-in cameras, microphones, and mapping capabilities, robot vacuum cleaners inherently collect data about the space surrounding them. Popular Chinese-branded robot vacuum cleaners were found to transmit users' private information to servers located in China or were vulnerable to hacking[6], raising serious security concerns.

Humanoid robots, which are designed to enhance work efficiency, generate terabyte-scale data per hour—data that often contains manufacturing know-how relating to the industrial environments in which they operate. Therefore, data leakage through servers can expose not only corporate interests but also a nation's manufacturing competitiveness to significant risk. In January, exploitable Bluetooth flaws and unauthorized access pathways were identified in robots from Chinese companies such as Unitree, raising alarms about the potential for remote hijacking.

When humanoid robots are deployed for 24/7 operations, data such as battery charge level, remaining battery lifespan, distance to replacement robots or docking station, and available spare battery information are continuously transmitted via wireless communication systems to on-site networks or centralized management servers. This constant data flow makes security concerns around battery packs and battery management systems (BMS) particularly sensitive. Therefore, this is likely to serve as a decisive catalyst for reshaping supply chains and technological standards.

In fact, last year, the US House of Representatives urged the Department of Commerce to add Chinese robot manufacturer Unitree to its export control list, while also recommending to the Federal Communications Commission that Chinese-made devices be barred from use in US communication

[6] In Feb 2026, it was reported that a programmer exploited DJI's Romo robots to intercept camera feeds, microphones, and indoor maps from over 7,000 robots worldwide in real time. Last year, the Korea Consumer Agency also confirmed that hackers could extract data from cloud servers or forcibly activate cameras on Chinese-made robotic vacuum cleaners, such as ECOVACS products.

networks. Although no specific sanctions targeting humanoid robots have yet been announced, the broader context of the Trump administration's containment policy toward China creates a favorable competitive landscape for Korean companies.

Security issues of China-made robot vacuum cleaners vs risks in the humanoid robot market

Category	Robot vacuum cleaner (B2C / past)	Industrial humanoid robots (B2B / future)	Security issue reproduction and amplification factors
Data collection scope	Indoor maps, low-resolution photos/videos	Production blueprints, core technological assets, corporate secrets	Humanoid robots collect high-resolution visual-language model (VLM) data on all movement paths within factories, capturing sensitive operational data
Network connectivity	Home Wi-Fi, cloud servers	Corporate intranet, IT/OT integrated networks, 5G/6G	Direct connection to internal corporate networks; compromise could lead to enterprise-wide data exfiltration and system-wide paralysis
Physical threat level	Pet tracking, minor collisions	Heavy-load bearing, high-torque actuators	If hacked, robots could be weaponized to cause equipment destruction or even fatal accidents, far beyond data breaches
Supply chain & Backdoors	Low-cost components, standard firmware	Custom AI chips, on-device inference models	Hidden backdoors (eg, "CloudSail") embedded in Chinese-made chipsets or firmware may facilitate industrial espionage
National security implications	Privacy concerns of individuals	Protection of national core technologies and manufacturing competitiveness	In the context of US-China technological rivalry, Chinese-made humanoid robots are increasingly viewed as potential Trojan horses for strategic espionage

Source: Dbr77, SC Media, AI Certs, Samsung Securities

Humanoid robot battery market outlook and implications for Korean rechargeable battery industry

Despite rapid growth, humanoid robot battery demand to be less than 1% of EV battery demand in 2030: The outlook for humanoid robot batteries varies according to the scale of mass-production and length of replacement cycles (taking into account durability) assumptions. Market research firms present widely varying projections for humanoid robot production volumes. We assume annual production of 1m units by 2030, 5m by 2035, and 50m by 2040, projecting a CAGR of 151% over 2025-2030 and 48% over 2030-2040. Assuming a 5-year replacement cycle for humanoid robots, the cumulative number of operational robots should reach 2.5m by 2030, 17m by 2035, and 160m by 2040.

Assuming a battery capacity of 2 kWh per industrial humanoid robot, related battery demand in 2030 would reach 33 GWh. This would represent only 0.9% of the global xEV battery demand (3.7 TWh) and 5.3% of the ESS battery demand (616 GWh) that year. Looking ahead to 2040, if the number of operational robots reaches 160m and the battery capacity per unit doubles (to 4 kWh), the humanoid robot battery market could expand to 3.2 TWh. This would match the scale of the global EV battery market in 2030, establishing a significant market.

Estimated market size of battery market for humanoid (AI) robots

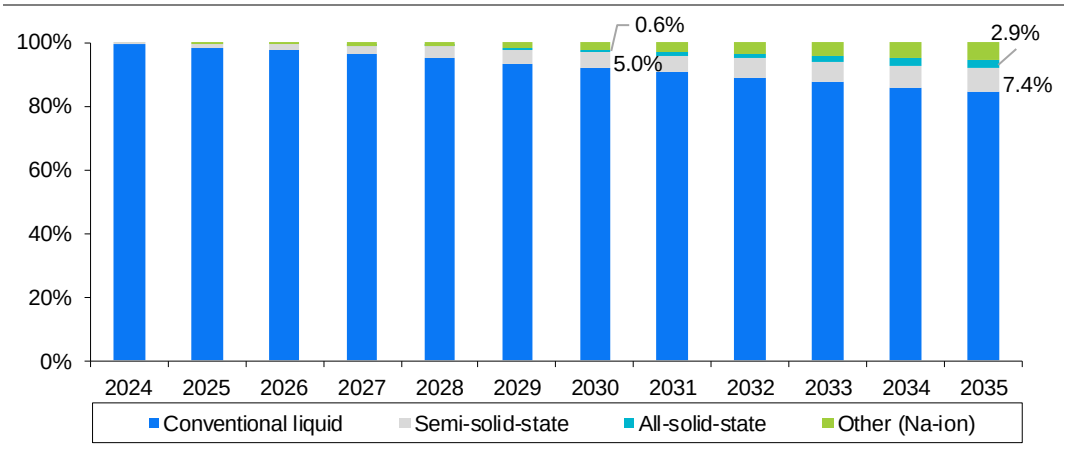
	2025	2026	2027	2030	2035	2040	CAGR ('25-30)	CAGR ('30-40)
Mass-produced robot ('000 units)	10	100	200	1,000	5,000	50,000	151%	48%
Operational robot ('000 units)	10	110	310	2,500	17,000	160,000		
Battery capacity per robot (kWh)	2	2	2	3	4	4	8%	3%
Total battery demand for humanoid (GWh)*	0.093	1.14	3	33	286	3,214	223%	58%
LFP battery portion	60%	55%	50%	40%	30%	20%	-	-
NCM (ternary) battery portion	40%	45%	50%	60%	70%	80%	-	-
Global xEV battery demand (GWh)	1,337	1,617	2,031	3,677	-	-	22%	-
Humanoid robot battery portion (vs xEV)	0.01%	0.07%	0.16%	0.89%	-	-		-
Global ESS battery demand (GWh)	247	360	425	616			20%	
Humanoid robot battery portion (vs ESS)	0.04%	0.32%	0.77%	5.30%				
Average battery price (USD/kWh)	**103**	**94**	**87**	**72**	**-**	**-**	**-7%**	**-**
Humanoid robot battery market (USDm)	**10**	**108**	**286**	**2,350**	**-**	**-**	**201%**	**-**

Note: * Demand includes both new installations (one additional battery per robot unit) and replacement demand (LFP: Replacement cycle of 160 days; NCM: Replacement cycle of 83 days). Operational lifespan of robots is assumed to be 5 years (unlike EVs, humanoid robots operate 24/7; manufacturers are expected to offer warranties of 5 years or less, compared to ~10 years for EV batteries).

Source: BNEF, Samsung Securities estimates

Meanwhile, even if semi-solid and solid-state batteries see increased adoption in the humanoid robot battery market, per-unit energy capacity would be limited. As a result, significant shifts in global market-share projections for these battery technologies—currently forecast at 0.6% for solid-state batteries and 5% for semi-solid batteries in 2030, rising to 2.9% and 7.4% respectively by 2035—are unlikely.

Global: Projected breakdown of demand for semi-solid and solid-state batteries



Source: BNEF, Samsung Securities

Short-term improvements in fundamentals to be limited, but trends surrounding solid-state batteries and de-risking supply chains from China positive for Korean firms: While demand for humanoid robot batteries is set to rise alongside growth of the humanoid robot market, it should do little in the short term to offset weak EV sales in North America. Therefore, even though high-nickel ternary products may benefit from the expanding humanoid robot segment, it should not meaningfully improve Korean battery manufacturers' fundamentals—they are disproportionately reliant on EV battery shipments.

However, there are two perspectives from which Korean battery manufacturers' stock prices can be viewed positively. First, as solid-state batteries are increasingly adopted in humanoid robots—a market with relatively low sensitivity to battery prices—the resulting accumulation of mass-production expertise and economies of scale (driven by increased investment) would position these batteries for seamless adoption in large-volume markets such as the EV market. Second, humanoid robots operating in key industrial environments continuously collect data, learn autonomously, and communicate wirelessly while performing physical tasks involving tool manipulation. This has heightened concerns over possible cyberattacks on robots. In this context, supply chain realignment to firms outside of China may work to Korea's advantage.

China and product standardization to become more critical

Lessons learned from EV batteries

What do EV batteries and humanoid robot batteries have in common and where do they differ?

Same market dynamic—both shaped by a clear divide between China and the rest of the world

The most striking similarity between the EV battery market and the emerging humanoid robot battery market lies in the divide between Chinese and RoW markets. Understanding which regions lead in EV and humanoid robot adoption is essential to forecasting battery industry trends. As seen in the evolution of the EV market, when mainstream manufacturers adopt innovations pioneered by early entrants, they become *de facto* industry standards. For humanoid robotics, this means the battery choices made by leading robot makers should define the technical benchmarks for the entire sector.

Among the top-10 global EV makers in 2024, Chinese EV makers accounted for 27% of global sales in terms of actual battery installations, rising to 31% in 2025 (*nb*, Sales volume is not used, as PHEVs are equipped with significantly smaller batteries than BEVs, which would skew comparisons). This growth was not led by BYD—the global leader, whose M/S actually slipped from 15.4% to 14.6% during the period—but by fast-rising Chinese automakers: Geely (5.8% to 6.6%), Xiaomi (1.3% to 3.3%), Leapmotor (2% to 3.1%), and Changan Auto (2.5% to 3%). China's deliberate protection of its battery industry during its EV expansion allowed local suppliers to scale alongside Chinese EV makers.

The humanoid robot market, though still in its early stages, is already showing a similar pattern. In 2024, Chinese firms captured 76% of global sales among the global top-10 humanoid robot makers. By 2025, that share had climbed to 87%. While total global shipments remained small (just 13,368 units in 2025), the overwhelming market concentration on China points to the nation's emerging role as the standard-setter. Just as with EVs, China is actively nurturing its humanoid robot battery suppliers. This means that Korean battery makers will need to build strong partnerships with humanoid robot companies outside of China.

Global EV battery demand based on EV sales*

(GWh)	Headquarters	2024		2025		
		Battery demand	M/S (%)	Battery demand	M/S (%)	Growth (% y-y)
Chinese EV makers in the global top 10		**234**	**26.9**	**330**	**30.6**	**40.7**
BYD	**Shenzhen, China**	**134**	**15.4**	**157**	**14.6**	**17.3**
Tesla	Texas, USA	128	14.7	120	11.1	-6.1
VW Group	Wolfsburg, Germany	62	7.1	87	8.1	40.0
Geely Auto Group	**Hangzhou, China**	**50**	**5.8**	**72**	**6.6**	**42.0**
GM	Michigan, USA	42	4.9	54	5.0	27.3
Hyundai Motor Group	Seoul, Korea	32	3.7	38	3.5	16.4
BMW Group	Munich, Germany	36	4.1	36	3.4	1.2
Xiaomi	**Beijing, China**	**11**	**1.3**	**35**	**3.3**	**216.5**
Leapmotor	**Hangzhou, China**	**17**	**2.0**	**34**	**3.1**	**95.4**
Changan Auto Group	**Chongqing, China**	**22**	**2.5**	**32**	**3.0**	**47.0**
Others		335	38.5	414	38.4	23.4
Total		**870**	**100.0**	**1,078**	**100.0**	**23.9**

Note: Battery capacity for PHEVs is significantly lower than BEVs, which can distort demand figures if based solely on unit sales. To prevent this, data based on actual battery installation (demand) per manufacturer.

Source: EV Volumes, Samsung Securities

Global humanoid robot sales

(Units)	Headquarters	2024		2025		
		Sales	M/S (%)	Sales	M/S (%)	Growth (% y-y)
Chinese robot makers in the top 10		**1,750**	**76.1**	**11,568**	**86.5**	**561.0**
AgiBot	**Shanghai, China**	**600**	**26.1**	**5,168**	**38.7**	**761.3**
Unitree	**Hangzhou, China**	**800**	**34.8**	**4,200**	**31.4**	**425.0**
UBtech	**Shenzhen, China**	**250**	**10.9**	**1,000**	**7.5**	**300.0**
Leju Robotics	**Shenzhen, China**	**100**	**4.3**	**500**	**3.7**	**400.0**
Engine AI	**Shenzhen, China**	**0**	**0.0**	**400**	**3.0**	**n/a**
Fourier Intelligence	**Shanghai, China**	**0**	**0.0**	**300**	**2.2**	**n/a**
Figure AI	California, USA	50	2.2	150	1.1	200.0
Agility Robotics	Oregon, USA	50	2.2	150	1.1	200.0
Tesla	Texas, USA	50	2.2	150	1.1	200.0
Others		400	17.4	1,350	10.1	237.5
Total		**2,300**	**100.0**	**13,368**	**100.0**	**481.2**

Source: Omdia, Samsung Securities

Key differences: Performance requirements and price sensitivity

The EV and humanoid robot battery markets differ fundamentally in their performance demands and price sensitivity because of distinct energy usage patterns and physical design constraints.

EV batteries must carry far greater energy capacity than humanoid robots. With typical driving ranges of 500-800 km on a single charge, EVs require batteries capable of storing substantial energy—hence, most BEVs are equipped with batteries of 60-200 kWh.

Humanoid robots, by contrast, face severe spatial limitations. Since their size is constrained to roughly that of a human body, there is little room for large battery packs. As a result, current models typically use batteries in the 2-4 kWh range. Future advances in energy density or custom form factor may allow for modest increases.

EV batteries are designed for sustained high-power output, maintaining performance during highway driving, hill climbing, and overtaking—not just while accelerating. But increasing power comes at a cost: Higher heat generation and accelerated battery degradation compromise range. To balance these trade-offs, EV makers have adopted high-voltage architectures, advanced thermal management, and intelligent battery management system (BMS) software.

Humanoid robots, however, require short, intense bursts of power. Unlike EVs, humanoid robots rely on multiple jointed actuators that must deliver high torque, rapid angular velocity, and sharp acceleration—all at once—while walking, balancing, lifting, jumping, or climbing stairs. These movements demand massive mechanical power in milliseconds. Consequently, the peak power requirements of a humanoid robot can surpass those of an EV or even an energy storage system (ESS).

These contrasting demands—especially the need for high peak power in a compact form factor—are pushing the humanoid robot battery market towards batteries with much higher energy densities.

Battery performance requirements by application

	EV	ESS	Humanoid robot
Energy capacity	Large (tens to hundreds of kWh)	Large (hundreds to thousands of kWh)	**Small (2-4 kWh)**
Energy density	High	Medium to high	**Very high**
Power characteristics	Sustained high power & efficiency balance	Low power allowed; Stable supply focus	**Instantaneous high power/voltage essential**
Operating time/cycle	Long duration / long-life design	Ultra-long life & low-cost focus	**Limited**
Safety	Safety design is critical	Fire/Stability is paramount	**Top priority (operating near humans)**
Form/ integrated design	Vehicle space optimization	Flexible installation space	**Robot structure optimization required**

Source: Samsung Securities

The second major difference between EV batteries and humanoid robot batteries is price sensitivity: Humanoid robot makers are far less sensitive to battery costs than either EV or ESS makers. This becomes evident when comparing battery cell cost as a percentage of total product price.

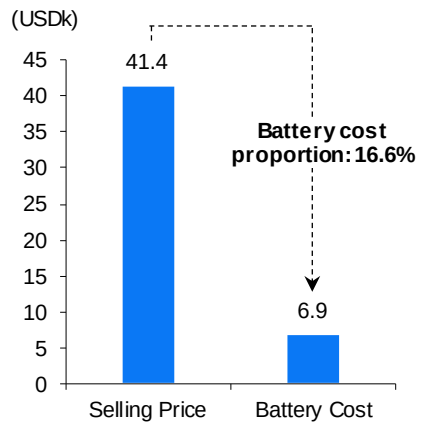
Take the Tesla Model Y—the world's best-selling EV. In the US, the base RWD model is priced at USD41,380 and comes with a 69.5 kWh battery. At a cell cost of USD99/kWh, the battery cells alone cost around USD6,881, representing roughly 16.6% of the EV's total price.

In the ESS market, Tesla's Megapack illustrates the point even more clearly. A single Megapack unit in California delivers 1.9 MW (3.9 MWh; 2-hour duration) at a price of USD1,028,580. Using a cell cost of USD70/kWh, the battery cells represent USD269,780, or 26.2% of the system's total cost. That's nearly 10%pts higher than EVs'. This high portion helps explain why LFP batteries dominate the ESS market: Their lower cost, enhanced safety, and long cycle life outweigh the energy density trade-off.

By contrast, battery costs in humanoid robots are negligible. Consider Unitree Robotics' G1, sold in China at a base price of USD13,500. It uses a 421 Wh (0.421 kWh) battery. While exact cell pricing for humanoids is not publicly available, applying the EV industry's USD99/kWh rate gives an estimated cell cost of just USD42—0.3% of the robot's price. This is much lower than the portion for EVs (16.6%) and ESS (26.2%).

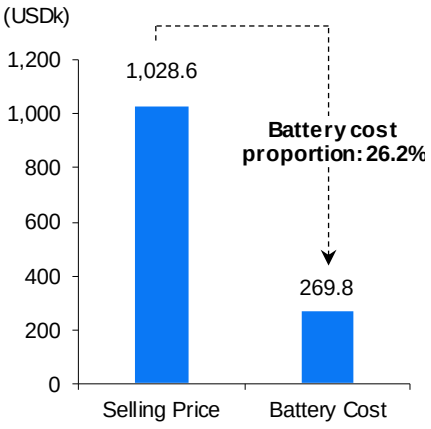
This low sensitivity to price means battery prices are unlikely to constrain the adoption of humanoid robotics—even if demand plateaus, as it has for EVs. Humanoid robot developers are likely to prioritize performance (high peak power and energy density) even if next-generation batteries cost far more.

EV Battery Cost Share:
Tesla Model Y RWD



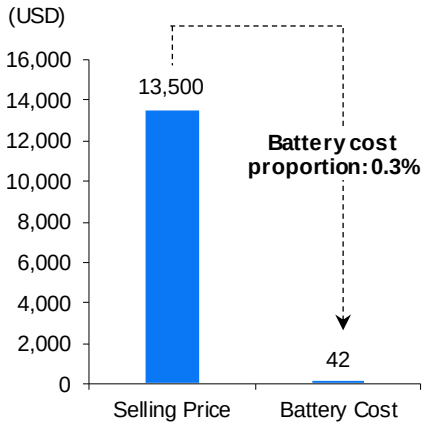
Note: Assumptions based on the 2025 BNEF Survey (EV Battery Cell Average Price $99/kWh)
Source: Tesla, Samsung Securities

ESS Battery Cost Share:
Tesla Megapack



Note: Assumptions based on the 2025 BNEF Survey (ESS Battery Cell Average Price $70/kWh)
Source: Tesla, Samsung Securities

Humanoid Battery Cost Share:
Unitree G1



Source: Unitree, Samsung Securities

Lesson 4: China—High potential for technological leadership in humanoid batteries

The greater the number of buyers, the more refined the suppliers' technology becomes

The first lesson the EV battery market offers to the humanoid robot battery market is that China's leadership in advancing technology—already evident in the EV sector—is highly likely. This trend stems directly from the same mechanism of technological evolution seen in the EV and solar equipment markets.

The mechanism of technological evolution operates through three key stages. First, when large-scale demand emerges in a particular industry, production volumes rapidly increase, leading to the accumulation of real-world usage data and manufacturing experience. This accumulated data drive design improvements, process optimization, and reductions in defect rates, thereby shortening the product improvement cycle. Additionally, customer feedback is rapidly incorporated, enabling next-generation products to be refined with greater customer-centricity. As a result, cost per unit continues to fall while performance improves. This cumulative process of iterative learning and enhancement is known as the experience curve. Notably, the greater the demand, the steeper the slope of this curve—a phenomenon observed in China's EV, EV battery, and solar panel industries.

China is the only market in the world where EV prices are, on average, lower than ICE vehicle prices. The rapid growth of EV demand spurred expansion of the EV battery market, with innovation in cost competitiveness and the widespread adoption of low-cost batteries (LFP batteries) making EVs more price-competitive than ICE vehicles.

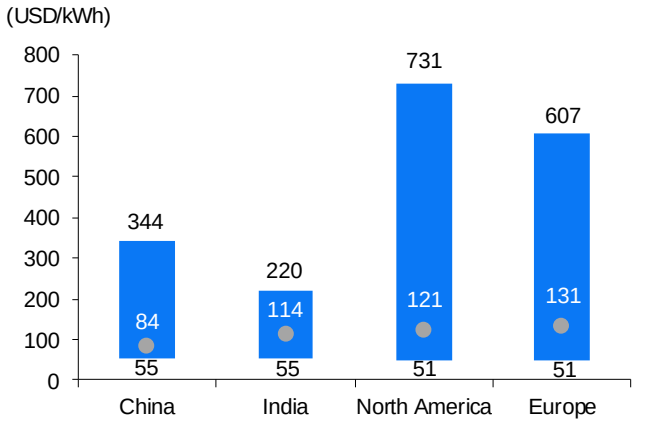
In other countries, EVs are still more expensive than ICE vehicles due to slower EV model launches, lower EV penetration, and underdeveloped battery supply chains. This has contributed to the so-called EV chasm (a critical gap or barrier that emerging technologies face when attempting to transition from early adopters to the early majority) and has resulted in EV market growth falling short of expectations.

Even though the humanoid robot market is still in its very early stages, Chinese companies in 2025 accounted for 86.5% (11,568 units) of global sales (13,368 units). There may be a difference in perspective between Chinese companies and non-Chinese companies regarding the pace of humanoid robot commercialization. However, when examining patent filings over 2020-2024 (10,548 applications), Chinese companies held 55%, followed by US firms at 14% and Japanese firms at 12%. As China's rise in humanoids mirrors its earlier trajectory in EVs, Chinese companies would want to shape the technical standards for humanoid batteries as well.

Technological evolution: Three-stage mechanism

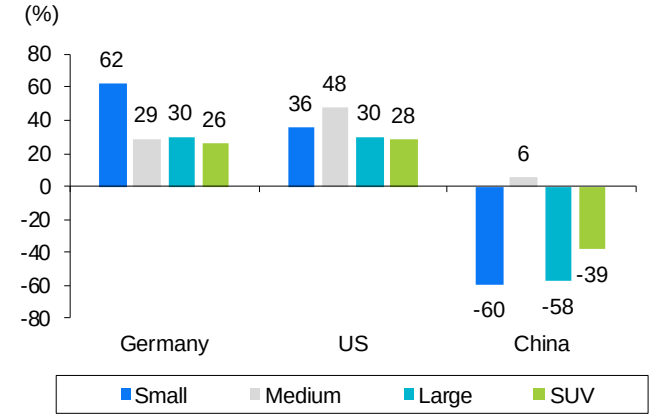
Source: Samsung Securities

Weighted average prices and price ranges of battery packs, by region



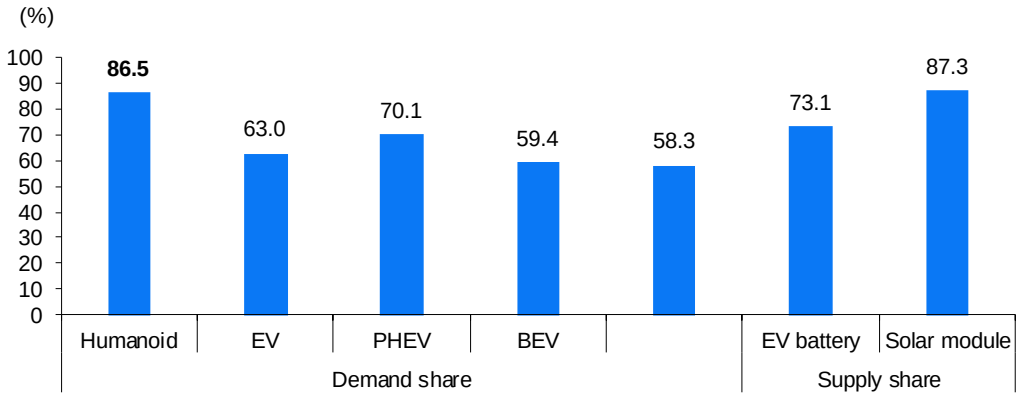
Source: Bloomberg NEF, Samsung Securities

Price gap between BEV and ICE vehicles, by region



Source: Bloomberg NEF, Marklines, CATARC, Samsung Securities

China's market share in advanced tech markets (2025)



Note: Humanoid Demand Share is based on Chinese OEM sales / 2025 total global sales.
EV (PHEV/BEV) Demand Share is based on China market sales / 2025 total global sales.
Solar Demand Share is based on China installations / 2025 total global installations.
EV Battery Supply Share is based on Chinese OEM sales (GWh) / 2025 total global EV battery sales.
Solar Module Share is based on Chinese OEM capacity / 2025 total global solar module capacity.
Source: Omdia, EV Volumes, Bloomberg NEF, Samsung Securities

Chinese humanoid batteries: Semi-solid batteries a stepping stone to solid-state battery commercialization

Due to the unique characteristics of humanoid batteries, the humanoid market is more likely to adopt higher-performance, higher-energy-density batteries—even at a premium price—before the EV market. In this context, Chinese companies are actively working on solid-state battery technologies specifically for humanoid applications. However, there is a discernible difference in the technological development trajectory between China and other countries.

China's approach to high-performance battery development is distinct from global trends, with a deliberate strategy to commercialize semi-solid batteries as an intermediate step before achieving solid-state battery deployment. Unlike many international competitors that aim for a direct transition from conventional liquid-electrolyte batteries to solid-state batteries, Chinese manufacturers have opted for a phased transition, with semi-solid batteries serving as a stepping stone.

Semi-solid batteries utilize an electrolyte that exists in an intermediate state (a gel or slurry) that blends liquid and solid electrolytes. These batteries can utilize existing manufacturing equipment that is designed for liquid-electrolyte lithium-ion batteries. Moreover, because they require a smaller amount of solid electrolytes compared to solid-state batteries, they offer production cost advantages. However, they exhibit somewhat lower energy density and stability than solid-state batteries. Additionally, since they still contain liquid electrolytes, they cannot be considered perfectly non-flammable.

China's decision to adopt semi-solid-state batteries as an intermediate step can be attributed to two primary considerations. First, this helps manage technology risk and reduce capex. While solid-state batteries remain technologically challenging, semi-solid batteries can utilize some existing liquid-electrolyte manufacturing processes, mitigating mass-production risk. The high process compatibility with conventional lithium-ion batteries also substantially reduces the capex burden. Second, this helps gain a speed advantage in the global technology race. Until solid-state batteries are developed, semi-solid batteries are being leveraged as a marketing tool to showcase improvements in safety and energy density—prioritizing early commercialization over technological perfection.

Major global battery manufacturers: Solid-state battery development roadmap

Technology route			Companies and headquarters location	
Pathway 1 – Incremental				
Liquid	Semi-solid	Solid-state	BAIC Group	Gotion
			Changan Automobile	WeLion
			FAW Group	Qingtao Energy
			Dongfeng Motor	Ganfeng LiEnergy
Pathway 2 – Leapfrog				
Liquid		Solid-state	Honda	LG Energy Solution
			General Motors	Samsung SDI
			Toyota	Panasonic
			BMW	Hytzer
			Solid Power	Great Power

Source: Bloomberg NEF, Samsung Securities

Comparison: Liquid li-ion vs semi-solid vs all-solid-state batteries

	Liquid li-ion (current)	Semi-solid state	All-solid-state (ASSB)
Cathode	NCM, LFP	NCM, LFP	NCM, LFP
Anode	Graphite, Silicon-based	Graphite, Silicon, Li-Metal	Graphite, Silicon, Li-Metal
Separator	Required	Required	Not Required
Electrolyte	Liquid (≥10% of weight)	Liquid/Solid Mix (<10%)	Solid (Polymer/Oxide/Sulfide)
Cost* ($/kWh)	128-140	250-320	520~
Energy Density (Wh/kg)	150-260	300-500	450~
Safety	Low	Medium	High
Pros	Mature tech, low cost	High performance/safety; uses existing production lines	Ultimate performance/safety
Cons	Fire risk (organic solvent); near density limits	Lower performance than ASSB; fire risk remains	High capex (new processes); low tech maturity

Note: * Costs are based on Battery Packs. Semi-solid estimates reference Nio/CATL; All-solid-state estimates reference Samsung SDI.

Source: LG Business Research, Mitsui & Co., Samsung Securities

An increasing number of Chinese companies have recently begun moving beyond semi-solid batteries, directly targeting the commercialization of solid-state batteries to capture a share of the humanoid robotics battery market. Among Chinese humanoid robots, Xpeng's Iron, GAC's GoMate, and EngineAI's T800 have been confirmed to use solid-state batteries in their designs. GAC has stated that it has adapted its own solid-state battery technology—originally developed for EVs—for use in its GoMate humanoid robot. Xpeng and EngineAI have not revealed their battery suppliers.

Among battery manufacturers, EVE Energy and Farasis have announced plans to mass-produce solid-state batteries for humanoid robots, while most other companies are targeting mass-production around 2027. EVE Energy began mass-production of its solid-state battery (Longquan 2) late last year, with its target markets spanning humanoid robots, low-altitude UAVs, and advanced AI equipment. Following the completion of its first-phase factory (at end-2025), the company aims to expand its solid-state battery production capacity to 100 MWh by end-2026 through its second-phase expansion. Farasis, meanwhile, has been targeting the low-altitude UAV and humanoid robot markets since last year using its second-generation semi-solid batteries. The company has also secured a production capacity of 200 MWh for sulfide-based solid-state batteries (energy density of 400 Wh/kg), and delivered its first units to strategic customers late last year. This year, Farasis is pursuing a significant capacity increase (moving towards GWh-scale production).

The majority of other battery manufacturers are targeting the commercialization of solid-state batteries by end-2027. In the runup to this milestone, the Chinese government is preparing to introduce a solid-state battery standard. The standard, which is expected to be released in July, will likely provide detailed classification to support the commercialization of solid-state batteries—including a definition of solid-state batteries (weight loss rate of ≤0.5% under dry conditions), subcategorization by electrolyte type, and a classification system distinguishing between liquid batteries, hybrid solid-liquid batteries, and solid-state batteries.

Global battery cell manufacturers: Solid-state battery roadmap

Headquarters	Company	Commercialization targets					
		2025	2026E	2027E	2028E	2029E	2030E
Korea	LG Energy Solution					○ (Sulfide-based)	○ (Sulfide-based)
	Samsung SDI			○ (Sulfide-based)			
	SK On					○ (Sulfide-based)	
Japan	Panasonic					○	
China	CATL			○ (Sulfide-based)			
	BYD			○ (Sulfide-based)			
	EVE Energy	○ (Sulfide-Halide composite system)					
	Gotion			○ (Sulfide-based)			
	CALB			○ (Sulfide-based)			
	SVOLT			○ (Sulfide-based)			
	Sunwoda		○ (Polymer-based)				
	WeLion New Energy			○ (Polymer-Oxide composite system)			
	Farasis	○ (Sulfide-based)					
	Changan Auto		○				

Note: Shaded areas represent solid-state battery products specifically targeted for humanoid robots.
Source: Samsung Securities

Lesson 5: Standardization—Battery manufacturers' strategies to avoid another chasm

Avoid taking customer optimism at face value

The second lesson that the EV battery industry offers the humanoid robot battery market is this: Business strategies must not be built on clients' optimistic forecasts.

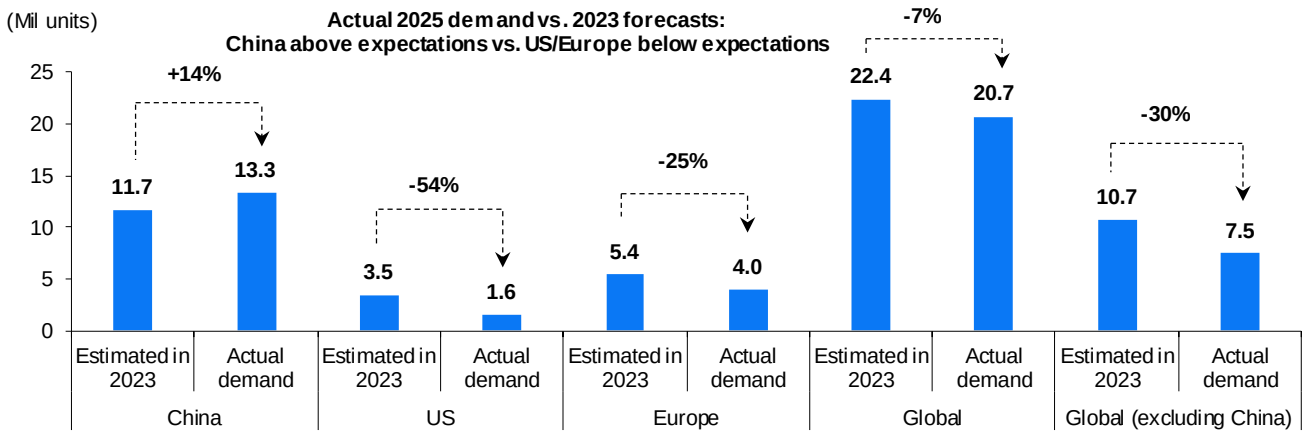
The current downturn in the EV battery industry stems from two factors: 1) overinvestment by battery manufacturers (due to overly optimistic demand forecasts from EV automakers); and 2) persistent EV demand shortfalls (caused by rising interest rates, the elimination of EV subsidies, and underwhelming EV performance). These trends are clearly validated by 2025 market data.

According to BloombergNEF (BNEF), global EV demand reached 20.7m units in 2025, which was 7% below the 22.4m forecast made just two years prior. Regional breakdowns reveal stark contrasts.

- China: Exceeded expectations. Actual 2025 demand reached 13.3m units—14% above the 2023 projection of 11.7m units.
- US: Fell far short of forecasts. Actual 2025 demand was only 1.59m units—54% below the 2023 forecast of 3.47m units. This miss was driven by the re-election of President Trump in 2024, which led to the immediate elimination of EV tax credits (up to USD7,500 per vehicle).
- Europe: Also fell short. Actual 2025 demand was only 4m units—25% below the 2023 estimate of 5.37m units. Weak consumer adoption and subsidy cuts in key markets contributed to this miss.

Notably, Korean battery manufacturers were disproportionately affected by the EV demand slowdown due their small exposure to China. Excluding China, global EV demand came to just 7.46m units in 2025, 30% below the forecast made in 2023 (10.69m units).

Major Countries: 2025 EV demand forecasts (made in 2023)* vs actual 2025 demand



Note: * Based on Bloomberg NEF 2023 EV Outlook
Source: Bloomberg NEF, Samsung Securities

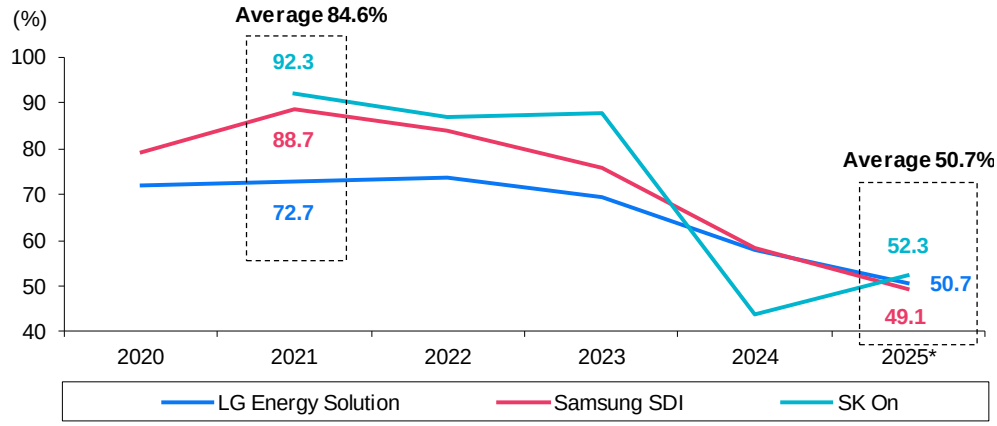
As a result, Korean battery companies have suffered over the past three years in two key areas: 1) utilization; and 2) operating margin. The average utilization at LGES, Samsung SDI, and SK On fell from a healthy 84.6% in 2021 to 50.7% in 2025 (Jan-Sep 2025). Samsung SDI and SK On, which had maintained a utilization above 80% in 2021, now have utilizations of around 50%.

The average operating margin for the three firms fell from -4.4% in 2021 to -7.5% in 2025. Excluding the IRA's advanced manufacturing production tax credits (AMPCs; subsidies received since 2023, which have partially mitigated losses), the underlying profitability erosion would have been far worse.

In sum, while battery manufacturers receive firm purchase orders, the actual volumes delivered vary greatly. As seen in the EV market, the humanoid robot market—being a nascent, demand-creating industry—demands an even more conservative interpretation of customers' demand forecasts.

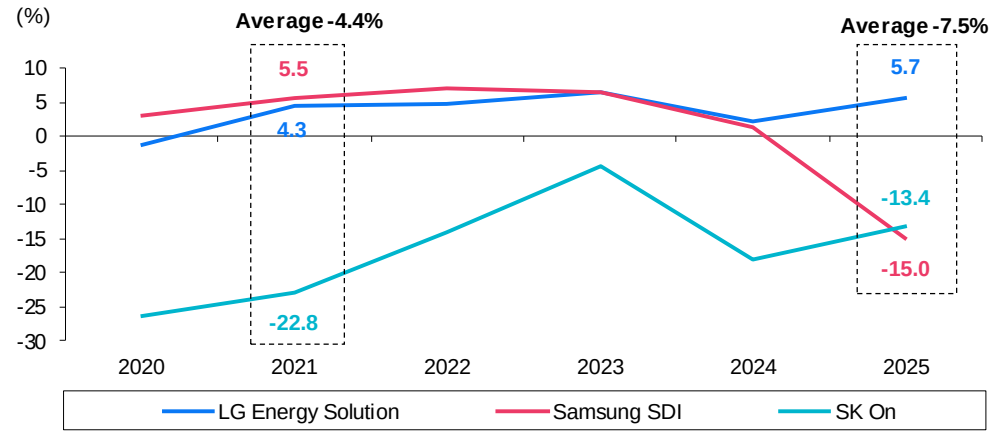
However, one key advantage exists for battery makers in the humanoid space: Alignment of interests. Unlike EV manufacturers, who can pivot to hybrids or PHEVs when EV demand falters (giving them a built-in plan B), humanoid robot manufacturers have no such fallback option. If their robots do not sell, they cannot simply switch to using fewer batteries or substitute another product. Their business models are inherently tied to battery performance. Thus, battery makers and humanoid companies share a more aligned risk profile, making collaboration more sustainable.

Korea's big-3 battery makers: Battery facility utilization rate trend since 2020



Note: * Based on cumulative figures as of 3Q 2025
Source: Company data, Samsung Securities

Korea's big-3 battery makers: Battery operating margin trend since 2020



Source: Company data, Samsung Securities

Standardization: Building plans B, C, and D to mitigate potential demand gaps

Even if battery manufacturers adopt conservative demand forecasts, their ability to respond to customer volume fluctuations would remain limited—after all, suppliers are obligated to deliver what their customers order. While contractual compensation mechanisms for under-delivery can be strengthened, such mechanisms risk damaging long-term relationships.

The most viable self-help strategy should be product standardization—developing batteries that can serve multiple customers and applications interchangeably. In the early years of the EV market, battery manufacturers often engaged in customization: Co-developing battery specs with specific EV makers to match unique vehicle designs. While this deepened customer loyalty, it also created inflexibility. When demand for a particular model fell, the customized battery lines could not be easily repurposed.

In other words, customization deepens mutual dependence, but also increases vulnerability (related to a short-term demand vacuum). Standardization, by contrast, reduces dependency on any single customer. But when demand from one client weakens, production capacity could easily be redirected to others—enabling plans B, C, or D.

Although the ideal form factor for humanoid robot batteries has not yet been standardized, cylindrical cells currently appear to be best suited. Unlike prismatic or pouch cells, cylindrical cells (*eg*, 18650, 2170, 4680) are defined by standardized physical dimensions (diameter × length in mm), and these specifications have been widely adopted as industry standards. Their jelly-roll structure, metal casing, and high degree of process automation make them highly adaptable across production lines. In contrast, pouch cells require equipment modifications when tab positions, thickness, or surface area change, and prismatic cells require new molds if casing designs are altered. Moreover, cylindrical cells are already widely used across diverse markets: EVs, power tools, e-bikes, ESS, drones, and now robotics. This broad application base reduces dependency on any single industry and facilitates smoother transitions between markets.

Required battery characteristics for humanoids and suitability by form factor

Characteristic	Description	Battery form factor		
		Cylindrical	Prismatic	Pouch
High energy density	• Need to increase energy density while minimizing weight/size	Neutral	**Suitable**	**Suitable**
Fast charging speed	• Faster charging speed required to maximize utilization	**Suitable**	Neutral	**Suitable**
Thermal management	• Prevention of overheating is essential for small devices like humanoids	**Suitable**	Unsuitable	Unsuitable
Safety	• Prevention of explosion/fire risk is top priority for indoor operation	**Suitable**	**Suitable**	Unsuitable
Standardization	• Advantageous for battery makers to standardize specs to manage demand uncertainty	**Suitable**	Neutral	Unsuitable

Source: Samsung Securities

Korean battery makers: Leveraging geopolitical advantages

Beyond technology: Building a trust-based supply-chain premium

In conclusion: 1) Korean battery manufacturers remain top-tier suppliers—especially when excluding China—as seen in the EV and ESS markets; and 2) global customers, driven by government policies and supply-chain diversification goals, are increasingly seeking alternatives to Chinese suppliers, and this trend is expected to extend to the humanoid robot market, which is also evolving under the same geopolitical dynamic: China's dominance vs other nations' efforts to catch up or counterbalance China's position.

Notably, in the humanoid robot sector, cybersecurity concerns in the US should further favor Korean suppliers—they are perceived as being geopolitically neutral. The US has already begun targeting Chinese-made ESS systems connected to the power grid on fears of remote hacking and physical disruption.

US House Republican Greg Steube on Feb 20 introduced the Countering Harmful Adversarial Rechargeable and Generative Energy Act (CHARGE Act), which aims to prohibit the import of certain Chinese-made ESS. The CHARGE Act would "bar the importation of specific ESS that possess remote monitoring capabilities" manufactured with technology licensed or owned by companies based in China; companies organized under Chinese law; or companies under the jurisdiction, control, or oversight of the Chinese Communist Party. If the bill is passed, the US Customs and Border Protection has 60 days to issue regulations to enforce the import ban. In short, the bill has been introduced to eliminate the possibility of Chinese-made remote monitoring features infiltrating the power grid. Actually, in Mar 2025, communication devices not listed in product documents were discovered in Chinese-made solar power inverters—a development viewed as a major security concern in the US because these rogue communication devices could potentially allow remote shutdowns of inverters, posing a risk of physically destroying the grid.

The core capability of physical AI (*eg*, humanoid robots) lies in accumulating real-world operational data to continuously refine foundation models. Battery performance data from humanoid robots should be particularly critical to improving performance (*eg*, motion control, energy efficiency, and safety). As a result, humanoid robot manufacturers should increasingly demand non-Chinese battery supply chains—not merely for performance but for cybersecurity reasons as well. In this context, Korean battery manufacturers are uniquely positioned to capture a trust-based premium in the humanoid robotics market, leveraging their geopolitical neutrality and strong alignment with global cybersecurity standards.

Overview of the CHARGE Act (Sanctions on Chinese ESS), introduced in the US Congress

Item	Details	Implications
Bill Name	CHARGE Act (Countering Harmful Adversarial Rechargeable and Generative Energy Act)	A bill to block ESS imports based on national security
Regulated Target	**Energy Storage System is any device, module, or product that stores and discharges power**	**Can include cells, modules, racks, and containerized ESS**
Core Condition #1	**Includes Remote Monitoring Capability**	**BMS, communication modules, and remote control systems become key issues**
Core Condition #2	**Manufactured using technology owned/ licensed by a PRC entity or CCP-controlled company**	**Technology ownership is more critical than the simple place of production**
Scope of Regulation	Total ban on US imports if conditions are met	A complete import block rather than just a tariff
Effective Date	CBP enforcement regulations to be announced within 60 days of enactment	Practical customs regulation begins within 60 days
Potential Expansion	Further restrictions reviewed after 180 days and annually thereafter	Risk of expanding the scope of regulation
Penalty Clause	Up to 5 years in prison + $250,000 fine per shipment for willful violations	Criminal penalty structure
Govt. Reporting Duty	Secretary of Commerce reports to Congress within 180 days, followed by annual reports (for 6 years)	Systematized tracking of Chinese ESS usage status

Source: Office of US Representative Greg Steube, Samsung Securities

COMPANY UPDATE

2026. 3. 20

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Hyundai Motor (005380)

The robot era: Lessons from Tesla

- Hyundai Motor (HMC) and Kia may lag in autonomous driving, but they have the potential to lead the global robotics market.
- Boasting capabilities in robotics, autonomous driving, and solid-state batteries, HMC is now directly comparable to Tesla, yet its market cap is just 1/20th that of the US firm. HMC is still in the early stages of its rerating.
- Autonomous EVs and robots both fundamentally rely on intelligence. As mass deployment and real-world data collection are critical to advancing that intelligence, HMC remains a top pick.

WHAT'S THE STORY?

Physical AI is essentially a hardware platform business; a fast-follower strategy is a losing approach: The funding and talent gaps between market leaders and fast followers will widen over time.

- **Capital markets funnel funding toward leaders that demonstrate execution in the new era:** Capital markets place significantly higher value on companies that achieve volume production and commercialization of new technologies than on those that merely develop them. Driving technological innovation that reshapes the world involves endless trial and error and requires vast capital and talent. Companies with deep financial resources can attract the talent needed to overcome technical bottlenecks, while talent joining leading companies focus on solving problems that advance their careers.

(Continued on the next page)

AT A GLANCE

BUY

Target price	KRW800,000	50.9%
Current price	KRW530,000 (3/11 close)	
Market cap	KRW108.5t/USD74.0b	
Shares (float)	204,757,766 (65.7%)	
52-week high/low	KRW674,000/KRW177,500	
Avg daily trading value (60-day)	KRW1,208.9b/ USD824.4m	

ONE-YEAR PERFORMANCE

	1M	6M	12M
Hyundai Motor (%)	4.1	137.7	171.0
Vs Kospi (%pts)	-0.6	41.7	22.6

KEY CHANGES

(KRW)	New	Old	Diff
Recommend.	BUY	BUY	
Target price	800,000	800,000	0.0%
2025E EPS	35,035	35,035	0.0%
2026E EPS	44,692	44,692	0.0%

SAMSUNG vs THE STREET

No of estimates	26
Target price	673,462
Recommendation	4.0

※ Rating: 4 < → BUY, 3 = HOLD, 2 > → SELL

SUMMARY FINANCIAL DATA

(KRWb)	2024	2025E	2026E	2027E
Revenue	175,231	186,254	197,797	207,561
Operating profit	14,240	11,352	13,138	14,357
Net profit (adj)	13,230	10,278	12,228	13,492
EPS (adj) (KRW)	46,042	35,035	44,692	49,312
EPS (adj) growth (% y-y)	5.6	-23.9	27.6	10.3
EBITDA margin (%)	10.6	8.6	9.1	9.3
ROE (%)	12.4	8.4	9.9	10.1
P/E (adj) (x)	4.6	8.5	11.9	10.7
P/B (x)	0.5	0.7	1.1	1.0
EV/EBITDA (x)	10.5	14.7	16.3	15.4
Dividend yield (%)	5.7	3.4	2.1	2.3

Source: Company data, Samsung Securities estimates

- **Lessons from Tesla in the EV era:** First, Tesla was recognized as the EV market leader not because it was the first to launch an EV, but because it was the first to mass-produce EVs and make them profitable. Second, Tesla effectively leveraged the dynamics of capital markets: in 2020, shortly after turning profitable, it raised USD12.3b (KRW17t) through three equity offerings. Third, in 2019, during the early stages of autonomous-driving development, Tesla equipped all its vehicles with self-driving chips and sensors—regardless of whether customers opted for "Full Self-Driving"—and collected real-world driving data in shadow mode. Tesla could afford to deprioritize profitability and pursue this strategy because it had secured massive funding early in the EV boom.

HMC/Kia latecomers to autonomous driving but emerging as global leaders in robotics: While Hyundai Motor (HMC) and Kia lag behind Tesla and Chinese EV makers in terms of autonomous driving technologies, they are likely to stand at the cutting of robotics thanks to two factors.

- **1) Boston Dynamics' leadership changes:** Boston Dynamics is transitioning from a research-focused venture to a mass-production company that is focused on commercialization. CEO Robert Playter resigned early this month, followed by the head of robotics research. The Atlas developer will likely appoint a new leadership team with expertise in mass-production and a strong public image to prepare for its IPO.

  The mass-production of 30,000 Atlas robots is only the first step. Going forward, Boston Dynamics must evolve into a company capable of selling more than 1m robots pa by: 1) securing new customers beyond Hyundai Motor Group (HMG) and Google DeepMind; and 2) developing general-purpose robots.

- **2) Formation of value chain:** HMC/Kia are rapidly selecting value-chain partners, prioritizing companies that are already in their value chains and have factories in the US. Decisions are being made quickly to align with the R&D timeline required for component development and the planned mass-production schedule (from 2H27). Actuators should be supplied by Hyundai Mobis, batteries by LG Energy Solution, body modules by Hwashin, and control systems & SI by Hyundai AutoEver. Smart lighting is now in the bidding process.

- **IPO may happen sooner than expected:** Boston Dynamics relies on Google DeepMind for its foundation model—a factor that limits its valuation compared to Figure AI (valued at USD39b in a recent Series C funding round). If Atlas can rapidly prove its ability to create value in manufacturing environments and secure clients beyond HMG, the robot company's valuation could surge.

Each quarter in 2026 to bring new momentum to physical AI

- **Robotics business:** First, the Robot Metaplant Application Center (RMAC) is set to begin operations near the Hyundai Motor Group Metaplant America in August. Investment size and equity stakes are expected to be announced in March. Second, the location for a robot production facility is under review, with mass-production targeted for 2028. Investment details and equity stakes should be announced in 1H26. Third, Hyundai Motor Group Robotics Lab's MobED will enter mass-production in 1H26, with commercialization of manipulation technology (grippers and hands) planned for end-2026. Fourth, the US is likely to roll out robotics industry policies in 1H26.

- **Autonomous driving business:** First, Kia's CEO Park Min-woo is likely to unveil the company's software-defined vehicle (SDV) roadmap at the CEO Investor Day event. Second, Motional plans to launch a Level-4 autonomous driving service in Las Vegas by end-2026, based on rule-based

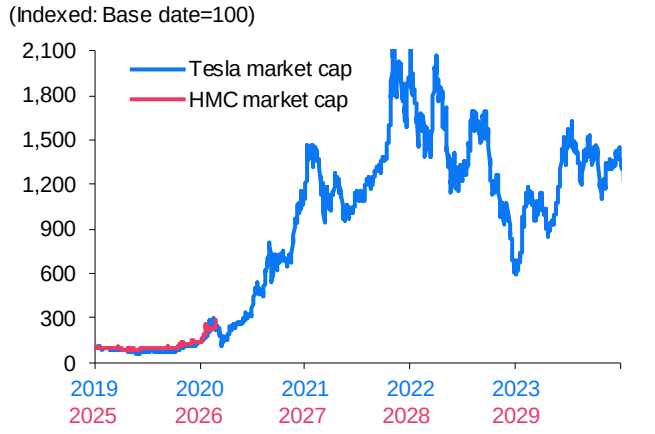
technology. It is likely to collaborate with HMC's AVP division on technology exchange. Third, HMC began to supply the Ionic 5 to Waymo in 4Q25. As Waymo expands services across the US, its solid demand should help improve utilization rates at the Hyundai Motor Group Metaplant America. We estimate that Waymo's fleet of autonomous robotaxis will reach 100,000 vehicles in 2028, with half that number to be delivered by HMC.

- **Solid-state battery technology development and mass-production roadmap:** In Mar 2025, HMC opened a next-generation battery research facility in Uiwang and began producing small quantities of solid-state battery prototypes (A-samples). Construction of the Future Mobility Battery Campus in Anseong is scheduled to be completed by end-2026. This large R&D hub for batteries, with an investment of KRW1.2t, should scale up technologies validated in Uiwang for mass-production. From 2027 to 2028, HMC plans to pilot solid-state batteries in Genesis-class flagship models to collect real-world driving data. In 2030, the company intends to launch vehicles based on a dedicated solid-state battery platform and apply the technology to robotics.

HMC to unveil three key technologies this year, sparking comparison with Tesla: Among global automakers, only Tesla and Hyundai Motor Group (HMG) possess comprehensive capabilities in autonomous driving, robotics, and battery technology. HMC's current target P/E of 18x is just a starting point, as its market cap remains at around 1/20th of Tesla's. The Korean carmaker is still at the start of its rerating.

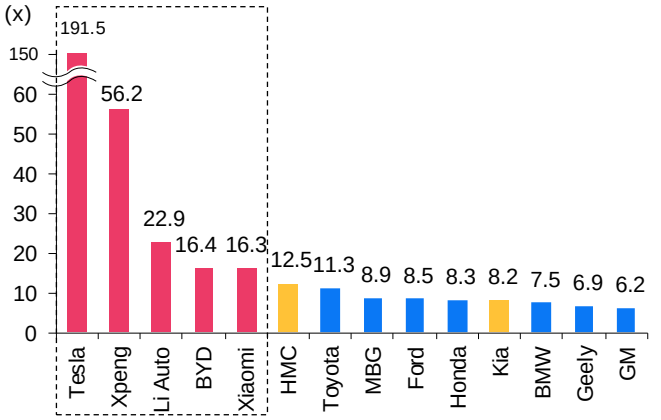
- **Following a path similar to Tesla's six years ago:** In 3Q19, Tesla achieved profitability in its EV business, cementing its status as the leader of the EV era. Following the pandemic, its share price surged 20-fold. By comparison, HMC has begun to be recognized as a robotics leader following the unveiling of Atlas at CES 2026, with its share price rising 1.6x since early 2025. As HMG reveals more-detailed roadmaps for robotics and autonomous driving throughout 2026, HMC is poised to gain significant upward momentum in its valuation.
- **Global investor feedback on Atlas:** Atlas has been well-received by global investors as a production-ready robot, not just a prototype. It features standardized components (arms, legs, left and right modules are identical, with three types of standardized actuators), swappable batteries, and a payload capacity of 30-50 kg, making it ideal for manufacturing environments. It is seen as more practical for industrial use than service-oriented robots like Optimus or entertainment-focused Chinese robots.
- **Autonomous driving:** Following the global pandemic, HMC and Kia traded at low valuations (P/E multiple of 4-5x), mainly due to weaknesses in autonomous driving technology. With the appointment of new leadership, technology development should accelerate.
- **Solid-state batteries:** HMC is on track to mass-produce solid-state batteries and fully integrate them into real-world applications.

Market cap: Tesla vs HMC



Note: Tesla indexed as of Jan 1, 2019 and HMC as of Jan 1, 2025
Sources: Bloomberg, Samsung Securities

Global automakers: 12-month forward P/E valuation



Sources: Bloomberg, Samsung Securities

HMC vs Tesla: Company valuation and "Physical AI" technology

Category	HMC	Tesla
Market cap and P/E ratio*	USD710b and 11x P/E	USD1.49t and 199x P/E
Revenue / Net income (2026)**	USD134.1b / USD7.7b	USD103.4b / USD6.7b
Cash cow	• Auto sales volume: 4m units (ICE, HEV, EVs)	• Auto sales volume: 1.7m units (EVs) • Energy division (expanding from 80GW)
Robotics	• Boston Dynamics (3 products, including Atlas) • Robotics Lab (14 products, including wearables and MobED)	• Optimus
Autonomous driving	• Advancing Atria AI, reviewing AlpaMayo applications • Motional robotaxi commercialization to begin in late-2026 • Supplying Hyundai Ioniq 5 to Waymo	• Deploying FSD version 14.3 • Cybercab production to start in Apr 2026 • Aiming to deploy robotaxis in half of US cities by 2026
Batteries	• Targeting solid-state battery mass-production by 2030	• Mass-producing 4680 batteries

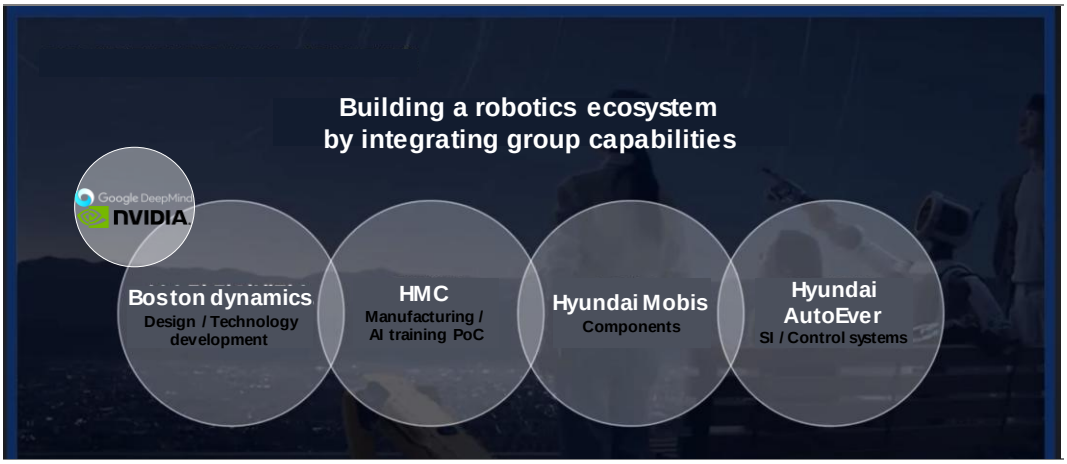
Note: Market cap is based on Mar 6 closing prices;
HMC's market cap is calculated using an exchange rate of USD/KRW1,450;
P/E ratios are based on 2026 consensus
Source: Company data, Bloomberg, Samsung Securities

HMC vs Tesla: "Physical AI" momentum in 2026E

	1Q	2Q	3Q	4Q
HMC	• Announcement of RMAC investment structure	• Announcement of robot factory, SDV roadmap (Kia CID) • US robotics policy announcement	• Solid-state battery technology announcement (HMC CID) • RMAC operations begin	• Motional robotaxi service launches • Hyundai Ioniq 5 supply to Waymo begins • Anseong battery campus operational
Tesla	• 3rd-generation Optimus unveiled • FSD deployment in China and Europe	• Cybercab production begins	• Expansion of robotaxis • US robotaxi fleet regulation easing	• Optimus mass-production begins

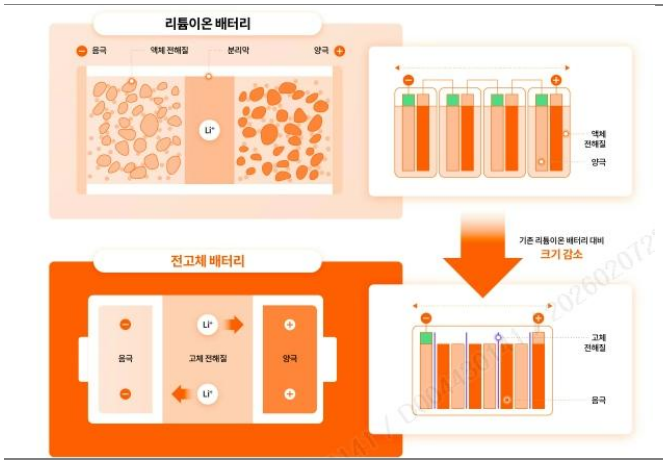
Source: Company data, Samsung Securities estimates

HMG: Robotics ecosystem



Source: Company data, Samsung Securities

Lithium-ion batteries vs solid-state batteries



Source: Company data

HMC: Anseong battery campus

Source: Media

Income statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Sales	**162,664**	**175,231**	**186,254**	**197,797**	**207,561**
Cost of goods sold	129,179	139,482	152,037	161,117	168,773
Gross profit	**33,484**	**35,749**	**34,217**	**36,680**	**38,788**
Gross margin (%)	20.6	20.4	18.4	18.5	18.7
SG&A expenses	18,357	21,510	22,865	23,541	24,431
Operating profit	**15,127**	**14,240**	**11,352**	**13,138**	**14,357**
Operating margin (%)	9.3	8.1	6.1	6.6	6.9
Non-operating gains (losses)	**1,750**	**3,251**	**2,374**	**3,165**	**3,631**
Financial profit	1,560	1,531	848	578	555
Financial costs	971	899	512	528	542
Equity-method gains (losses)	2,471	3,114	2,510	2,825	3,027
Other	-1,309	-496	-472	291	592
Pre-tax profit	**16,877**	**17,490**	**13,726**	**16,304**	**17,989**
Taxes	4,627	4,232	3,448	4,076	4,497
Effective tax rate (%)	27.4	24.2	25.1	25.0	25.0
Profit from continuing operations	12,992	13,549	10,278	12,228	13,492
Profit from discontinued operations	-720	-319	0	0	0
Net profit	**12,272**	**13,230**	**10,278**	**12,228**	**13,492**
Net margin (%)	7.5	7.5	5.5	6.2	6.5
Net profit (controlling interests)	11,962	12,527	9,367	11,861	13,087
Net profit (non-controlling interests)	311	703	911	367	405
EBITDA	20,073	18,527	16,096	18,036	19,390
EBITDA margin (%)	12.3	10.6	8.6	9.1	9.3
EPS (parent-based) (KRW)	43,589	46,042	35,035	44,692	49,312
EPS (consolidated) (KRW)	44,721	48,626	38,443	46,074	50,837
Adjusted EPS (KRW)*	43,589	46,042	35,035	44,692	49,312

Balance sheet

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Current assets	**58,604**	**64,336**	**52,200**	**52,903**	**54,994**
Cash & equivalents	19,167	19,015	3,139	976	641
Accounts receivable	4,682	5,908	6,280	6,669	6,998
Inventories	17,400	19,791	21,770	23,119	24,260
Other current assets	17,355	19,622	21,011	22,139	23,094
Fixed assets	**116,172**	**147,622**	**165,055**	**177,720**	**189,776**
Investment assets	33,054	41,392	49,389	54,254	59,075
Tangible assets	38,921	44,534	48,692	50,707	51,597
Intangible assets	6,219	7,683	7,781	7,868	7,945
Other long-term assets	37,978	54,014	59,193	64,891	71,158
Total assets	**282,463**	**339,798**	**357,879**	**378,279**	**399,808**
Current liabilities	**73,362**	**79,510**	**82,495**	**87,183**	**91,898**
Accounts payable	10,952	12,550	13,339	14,166	14,865
Short-term debt	9,036	9,327	8,827	8,827	8,827
Other current liabilities	53,375	57,633	60,329	64,190	68,206
Long-term liabilities	**107,292**	**140,013**	**148,252**	**154,366**	**160,584**
Bonds & long-term debt	90,603	120,420	126,420	130,420	134,420
Other long-term liabilities	16,689	19,593	21,832	23,946	26,164
Total liabilities	**180,654**	**219,522**	**230,747**	**241,549**	**252,482**
Owners of parent equity	**92,497**	**109,103**	**115,048**	**124,280**	**134,471**
Capital stock	1,489	1,489	1,489	1,489	1,489
Capital surplus	4,378	7,656	7,656	7,656	7,656
Retained earnings	88,666	96,596	102,426	111,658	121,849
Other	-2,036	3,362	3,477	3,477	3,477
Non-controlling interests' equity	**9,312**	**11,173**	**12,084**	**12,450**	**12,855**
Total equity	**101,809**	**120,276**	**127,132**	**136,730**	**147,327**
Net debt	99,174	130,142	150,916	157,006	161,355

Cash flow statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Cash flow from operations	**-2,519**	**-5,662**	**15,098**	**18,310**	**19,990**
Net profit	12,272	13,230	10,278	12,228	13,492
Non-cash profit and expenses	21,192	23,950	4,457	5,211	5,602
Depreciation	3,284	3,398	3,842	3,985	4,110
Amortization	1,663	889	902	913	923
Other	16,246	19,663	-286	313	569
Changes in A/L from operating activities	-30,365	-35,160	2,586	4,009	4,493
Cash flow from investments	**-8,649**	**-14,623**	**-28,439**	**-20,512**	**-20,260**
Change in tangible assets	-6,926	-7,890	-8,000	-6,000	-5,000
Change in financial assets	-1,131	-1,842	-1,476	-784	-610
Other	-592	-4,891	-18,964	-13,729	-14,650
Cash flow from financing	**9,393**	**19,493**	**2,255**	**1,906**	**1,635**
Change in debt	12,527	32,090	5,792	4,535	4,530
Change in equity	137	3,278	0	0	0
Dividends	-2,499	-3,913	-3,536	-2,629	-2,895
Other	-772	-11,961	0	-0	0
Change in cash	-1,698	-152	-15,876	-2,163	-334
Cash at beginning of year	20,865	19,167	19,015	3,139	976
Cash at end of year	19,167	19,015	3,139	976	641
Gross cash flow	**33,465**	**37,180**	**14,735**	**17,438**	**19,093**
Free cash flow	**-9,590**	**-13,723**	**7,098**	**12,310**	**14,990**

Financial ratios

Year-end Dec 31	2023	2024	2025E	2026E	2027E
Growth (%)					
Sales	14.4	7.7	6.3	6.2	4.9
Operating profit	54.0	-5.9	-20.3	15.7	9.3
Net profit	53.7	7.8	-22.3	19.0	10.3
Adjusted EPS**	63.9	5.6	-23.9	27.6	10.3
Per-share data (KRW)					
EPS (parent-based)	43,589	46,042	35,035	44,692	49,312
EPS (consolidated)	44,721	48,626	38,443	46,074	50,837
Adjusted EPS**	43,589	46,042	35,035	44,692	49,312
BVPS	351,861	413,568	438,025	473,172	511,975
DPS (common)	11,400	12,000	10,000	11,000	12,000
Valuations (x)					
P/E***	4.7	4.6	8.5	11.9	10.7
P/B***	0.6	0.5	0.7	1.1	1.0
EV/EBITDA	7.9	10.5	14.7	16.3	15.4
Ratios (%)					
ROE	13.7	12.4	8.4	9.9	10.1
ROA	4.6	4.3	2.9	3.3	3.5
ROIC	15.0	12.3	8.1	8.8	9.2
Payout ratio	19.4	19.5	21.7	18.8	18.6
Dividend yield (common)	5.6	5.7	3.4	2.1	2.3
Net debt to equity	97.4	108.2	118.7	114.8	109.5
Interest coverage (x)	27.1	31.5	22.2	24.9	26.5

Note: *Excluding one-off items;
**Fully diluted, excluding one-off items;
***From companies subject to equity-method valuation

Source: Company data, Samsung Securities estimates

COMPANY UPDATE

2026. 3. 20

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Kia (000270)

Profitability set for another leap in the autonomous-driving era

- Kia is expected to unveil its software-defined vehicle roadmap and outline its role in Hyundai Motor Group's robotics ecosystem at the upcoming CEO Investor Day.
- Kia plans to begin operating Pace Cars in 2026 to accumulate real-world data, with Level 2+ autonomous-driving features targeted for deployment in select models starting in 2027—signaling the emergence of software-driven revenue streams.
- In the physical AI era, the true protagonists are likely to be automakers with the financial strength and execution capability to embed intelligence into physical devices. Kia is our top sector pick, alongside Hyundai Motor.

AT A GLANCE

BUY

Target price	KRW270,000	66.7%
Current price	**KRW162,000 (3/11 close)**	
Market cap	KRW63.2t/USD43.1b	
Shares (float)	390,412,998 (60.4%)	
52-week high/low	KRW206,000/KRW82,000	
Avg daily trading value (60-day)	KRW266.9b/ USD182.0m	

ONE-YEAR PERFORMANCE

	1M	6M	12M
Kia (%)	0.1	52.0	64.6
Vs Kospi (%pts)	-4.4	-9.4	-25.5

KEY CHANGES

(KRW)	New	Old	Diff
Recommend.	BUY	BUY	
Target price	270,000	270,000	0.0%
2025E EPS	19,111	19,111	0.0%
2026E EPS	23,000	23,000	0.0%

SAMSUNG vs THE STREET

No of estimates	26
Target price	213,615
Recommendation	4.0

※ Rating: 4 < → BUY, 3 = HOLD, 2 > → SELL

WHAT'S THE STORY?

Market's perception of Kia to shift following CEO Investor Day (Apr 9): We expect two key outcomes from Kia's upcoming CEO Investor Day: 1) clear articulation of Kia's autonomous-driving technology roadmap should catalyze business model transformation and a step-up in profitability; and 2) greater visibility into Kia's role in Hyundai Motor Group's (HMG) robotics initiatives should help the automaker close its valuation gap with peers.

- **Clearer software-defined vehicle (SDV) roadmap:** We expect Kia to: 1) unveil detailed plans to enhance the "Atria AI" autonomous-driving inference model, including potential use of Nvidia's Alpamayo platform; and 2) disclose concrete timelines for deploying its Pace Car fleet and commercializing Level 2+ autonomous driving.

(Continued on the next page)

SUMMARY FINANCIAL DATA

(KRWb)	2024	2025E	2026E	2027E
Revenue	107,449	114,141	123,663	128,983
Operating profit	12,667	9,078	10,639	11,533
Net profit (adj)	9,775	7,554	8,972	9,659
EPS (adj) (KRW)	24,413	19,111	23,000	24,762
EPS (adj) growth (% y-y)	12.1	-21.7	20.3	7.7
EBITDA margin (%)	14.2	10.5	10.8	10.9
ROE (%)	19.1	13.0	14.1	13.7
P/E (adj) (x)	4.1	6.4	7.0	6.5
P/B (x)	0.7	0.8	0.9	0.9
EV/EBITDA (x)	1.6	2.5	3.0	2.3
Dividend yield (%)	6.5	5.6	4.3	4.6

Source: Company data, Samsung Securities estimates

- **Commercialization of Level 2+ autonomous driving—Catalyst for business model transformation and profitability improvement:** Kia is expected to pursue subscription-based revenue streams for advanced driver-assistance features, enabling stable earnings as customer adoption rises. Software revenue typically carries gross margins exceeding 50%. Under a subscription model, once sensors and computing hardware are embedded in the vehicle at the point of sale, software subscription revenue is recognized as operating profit, without COGS expenses.
- **Robotics business—Kia's role aligned with HMC's:** Kia's lower equity stakes in HMG's robotics initiatives relative to HMC's is already reflected in its share price. For example, in Boston Dynamics, HMC holds 27% vs Kia's 18%, while in Robotics Lab, HMC holds 60% vs Kia's 40%. Kia's share price has risen only about half as much as HMC's ytd, with its P/E valuation at roughly 60% of HMC's. However, Kia is expected to be equally as critical to HMG's robotics ecosystem as HMC is—including providing real-world action data for robots, operating robot training centers, and managing robot production facilities.

Commercialization of Level 2+ to reshape business model and lift profitability: HMC and Kia could significantly improve profitability by shifting from free to paid subscriptions for connectivity services and Level 2+ autonomous-driving features.

- **GM building a recurring revenue engine with Super Cruise:** Since 2017, GM has offered its Level 2+ autonomous-driving system, Super Cruise, free of charge for three years to new vehicle buyers. After the trial period, around 40% of customers transition to a paid monthly subscription of USD40. By 2025, Super Cruise had 620,000 subscribers, generating USD230m in annual revenue. The US carmaker has set revenue targets of USD400m for 2026 and USD2b by 2030. Super Cruise enables hands-free driving on more than 750,000 miles of North American highways using high-definition mapping. GM plans to upgrade Super Cruise for eyes-off driving in 2028, pushing closer to fully autonomous vehicle technology.

  GM sells roughly 3.3m vehicles annually in North America. Its software and connectivity services (*eg*, OnStar, over-the-air updates, and in-vehicle data) has already attracted 12m subscribers—roughly 20 times the number of drivers paying for self-driving features. With over 60m vehicles sold in North America over the past 20 years, GM's connectivity subscription penetration stands at around 20%.

  In 2025, total software-related recurring revenue (including Super Cruise) surged 65% y-y to USD5.4b. The company targets 13m OnStar subscribers and USD7.5b in software revenue in 2026, rising to USD25b by 2030 (equivalent to 13.5% of its 2025 total revenue of USD185b). While vehicle sales generate margins of 4-5%, software delivers margins above 40-50%, and subscription services can reach 70-80% as hardware costs are fully absorbed at the time of sale.
- **Tesla building a physical AI platform via FSD:** Tesla has fully transitioned to a subscription model for Full Self-Driving (FSD), offering it exclusively at USD99 per month starting Feb 14, 2026—more than double the price of GM's Super Cruise. The company is advancing toward Level 4 autonomy without driver intervention, with FSD designed not only for cars but as a foundational AI platform for humanoid robots.

  As of 2025, FSD had been activated on 1.1m vehicles, representing 12.3% of Tesla's cumulative 8.9m deliveries. Adoption remains confined to North America, where it reaches 30% of the 3.4m vehicles sold in the region. Based on Elon Musk's stock option targets, Tesla aims to sell 20m vehicles over the next decade, with 10m of them activated with FSD subscriptions (a target adoption rate of 50%).

Tesla's connectivity service is priced at USD9.99 per month (or USD99 annually) and is adopted on nearly all vehicles. Total software-related recurring revenue reached USD3.8b last year.

- **HMC/Kia: High ADAS adoption driving ASP growth:** Advanced driver-assistance systems (ADAS)—including smart cruise control, lane-keeping assist, and automated parking—are bundled into packages with adoption rates of 70% and 80% in the US and Korea, respectively. However, these features are typically available only on higher trims (adding KRW3m-4m to the vehicle price) or as a standalone option (around KRW2m). This helps explain why ASPs continue to climb despite rising incentives. As consumers in advanced markets grow more accustomed to advanced convenience features, demand for Level 2+ systems—enhanced with AI-powered capabilities—should rise sharply.
- **HMC/Kia's software sales to grow from 2027:** HMC and Kia currently provide connectivity services free of charge in North America and for five years in Korea, resulting in virtually no software revenue. At present, ADAS features rely on software hardwired into vehicle chips, limiting revenue to a one-time sale at purchase. With Level 2+ autonomy, however, software will be decoupled from hardware, enabling over-the-air updates. This unlocks flexible monetization options: customers can either pay an upfront fee or opt for a subscription model. This transition allows automakers to generate recurring revenue over a vehicle's lifespan (15-20 years).

  If HMC and Kia achieve a 40% paid subscription rate for Level 2+ autonomous driving and connectivity services (similar to GM's), vehicle-level operating profit could expand by 6-8% in the early stages (assuming sales at 2025 levels). Over a 15-year lifecycle, cumulative operating profit per vehicle should more than double. With widespread adoption of Level 2+ technology and connectivity services, Kia could achieve an operating margin above 12%.

  Kia has also strengthened its market position since 2019 through disciplined inventory and incentive management, leading to a significant increase in used-car values. As new-model launches are scheduled from 2026, these higher residual values should support new-car demand. With projected annual North American sales of around 1m units (on par with HMC), Kia is well-positioned to capitalize on future software revenue growth.

Global automakers: Software revenue (2025)

('000 units)	GM	Tesla	Hyundai	Kia
Global sales volume	6,182	1,636	4,138	3,129
North America sales volume	3,361	550	1,939	1,469
Cumulative North America sales volume since 2019	18,060	3,400	12,093	9,161
Consolidated revenue (USDm)	185,000	94,827	130,980	80,268
Connectivity subscription fee (USD/month)	Basic: 9.99 Max:64.99 (includes Super Cruise, Wi-Fi, app services)	9.99 (or USD99/year)	Free since 2023 (5-year free in Korea)	Free since 2023 (5-year free in Korea)
Level 2+ autonomous-driving subscription fee (USD/month)	40	99		
Connectivity subscribers ('000 people)	12,000	3,400		
Level 2+ autonomous-driving subscribers ('000 people)	620	1,100		
Deferred software revenue (USDm)	5,400	3,822		
Software portion of total revenue (%)	2.9	4		

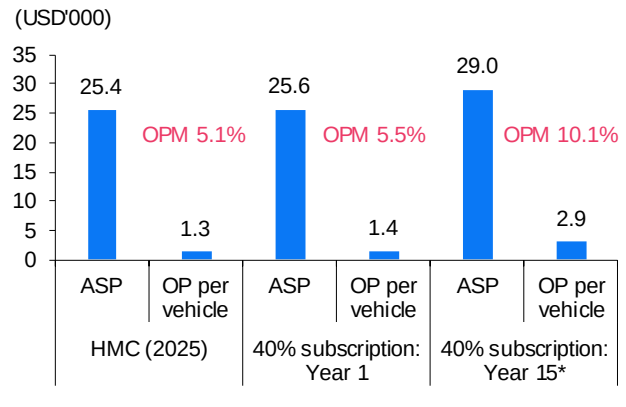
Source: Company data, Samsung Securities

GM: North America subscription programs

Subscription program	Key services	Monthly fee (USD)
OnStar One	Integrated package including safety, remote control, and app connectivity	34.99-39.99
Protect	Collision response, stolen vehicle assistance, 24/7 emergency dispatch	29.99
Remote access	Remote start and vehicle status monitoring via smartphone app	14.99
In-vehicle data	Wi-Fi hotspot and in-vehicle streaming app data usage	15.00
Super Cruise	Hands-free autonomous-driving technology	39.99

Source: Company data, Samsung Securities

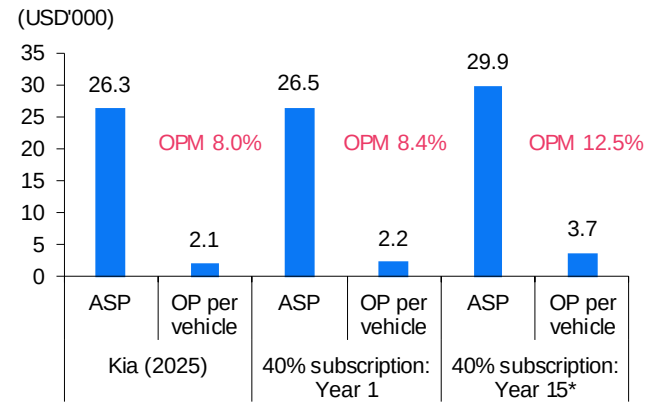
HMC: Estimated profitability changes from software sales



Note: *Assumes 15% subscription rate, 40% profitability for Level 2+ ADAS, and 70% profitability for connectivity

Source: Company data, Samsung Securities estimates

Kia: Estimated profitability changes from software sales



Note: *Assumes 15% subscription rate, 40% profitability for Level 2+ ADAS, and 70% profitability for connectivity

Source: Company data, Samsung Securities estimates

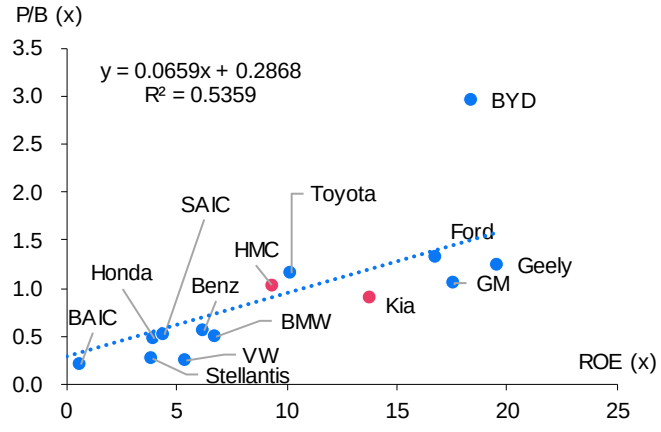
Favorable environment for growth stocks: Global automotive demand is forecast to decline 1% y-y in 2026. Advancing physical AI requires substantial capital investment, yet long-term interest rates remain elevated, with yields on 10-year USTs anchored near 4% amid persistent inflation concerns.

- **Kia to deliver solid growth:** Kia is the only major automaker expected to deliver top-line growth in 2026, targeting wholesale volume of 3.35m vehicles (up 6.8% y-y), revenue of KRW122.3t (up 7.2% y-y), and operating profit of KRW10.2t. Its financial plan assumes an exchange rate of KRW1,370/USD. With a KRW10/USD move translating into a KRW300b-350b increase in profits, we expect the carmaker to deliver an earnings surprise.
- **Solid financials:** Despite 2025 marking the most challenging operating environment since the global pandemic, Kia sustained positive free cash flow (up KRW430b) and increased its net cash position to KRW19.6t (up KRW897b y-y) equivalent to 33% of its market cap. For reference, HMC's net cash (excluding its financial subsidiaries) stood at KRW12.5t. Leveraging these strong operating results and financials, the company remains committed to its shareholder return policy, targeting a total payout ratio of 35%. Kia may also take on a larger role in HMG's growing investments in data centers, robot training facilities, and robotic manufacturing plants.

Hybrid momentum—Kia outperforming Toyota: Hybrid demand in the US is twice that of EVs.

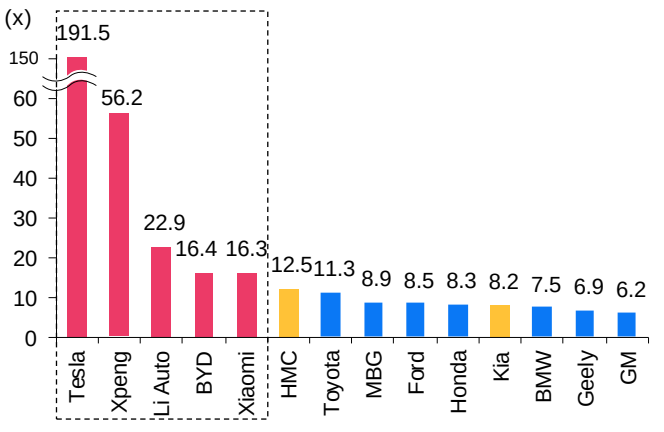
- **Model launches:** Kia plans to launch its second-generation Telluride in the US February, targeting full-year 2026 Telluride sales of 177,000 units (vs 127,000 units in 2025). The automaker also plans to launch the hybrid version of the Seltos (2nd generation) in the global market, targeting annual Seltos sales of 380,000 units (vs 300,000 units in 2025).
- **To begin hybrid production at Metaplant:** Kia plans to produce hybrid models at the Metaplant from 2Q.
- **Hybrid portion of sales rising:** We expect Kia's global hybrid sales to grow from 466,000 units in 2025 (up 21.8% y-y; 14.9% of total sales) to 600,000 units in 2026 (up 28.7% y-y; 18% of total sales). We also project its EV sales volume to rise from 305,000 units in 2025 (up 16.6% y-y, 9.8% of total sales) to 350,000 units in 2026 (up 14.7% y-y; 11% of total sales). In the US, its hybrid sales should jump from 130,000 units in 2025 (up 82% y-y; 15% of total sales) to 250,000 units in 2026 (up 92% y-y; 28% of total sales). Hybrids now offer higher profitability than internal combustion engine vehicles.
- **US hybrid market—HMC/Kia eating away at Toyota:** HMC/Kia are eroding Toyota's market share by building full hybrid lineups in the US. While Toyota's share of the US market for hybrids plunged 10.5%pts between Jan 2024 (59.8%) and Jan 2026 (49.3%), Kia's share leapt from 4.8% to 8% over the same period, while HMC's climbed from 5.6% to 7.5%.

Automakers: P/B vs ROE (2026E)



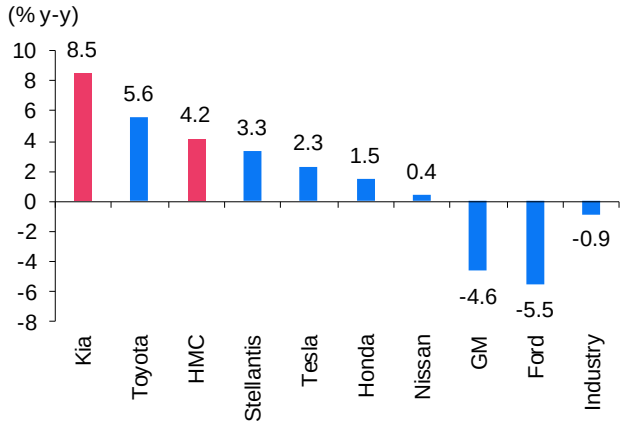
Source: Bloomberg, Samsung Securities

Automakers: 12-month forward P/E valuation



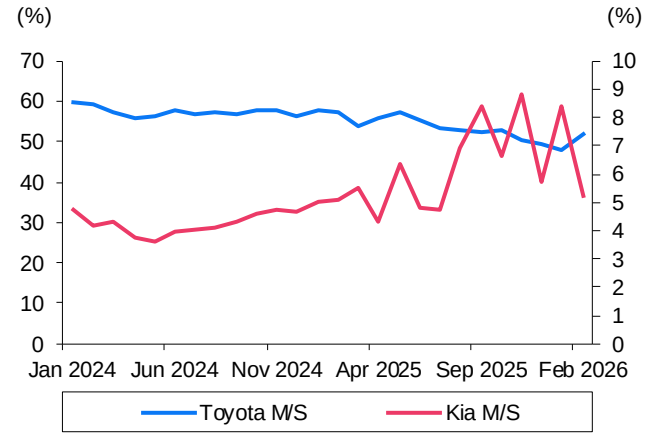
Source: Bloomberg, Samsung Securities

US market: Jan-Feb retail sales growth (y-y)



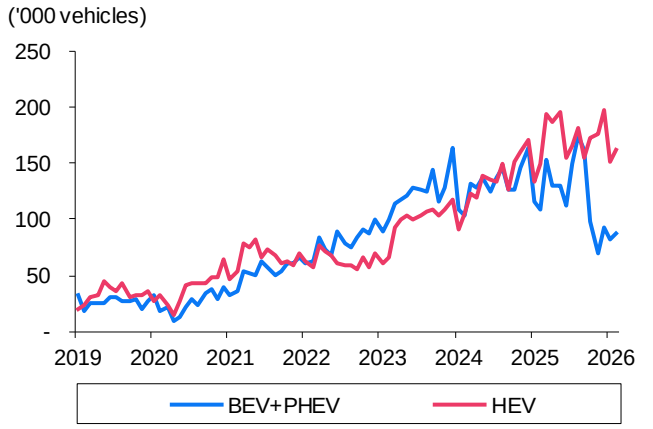
Source: Wards, Samsung Securities

US: Hybrid market shares



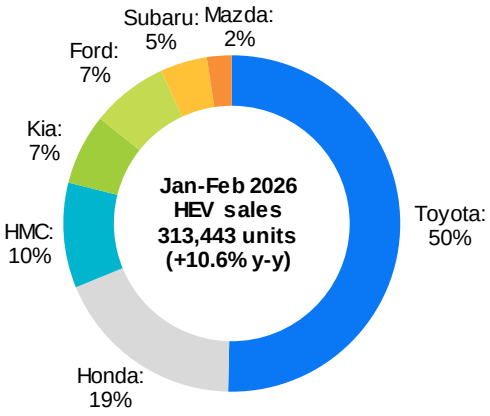
Source: Wards, Samsung Securities

US: Auto demand - HEVs vs BEVs+PHEVs



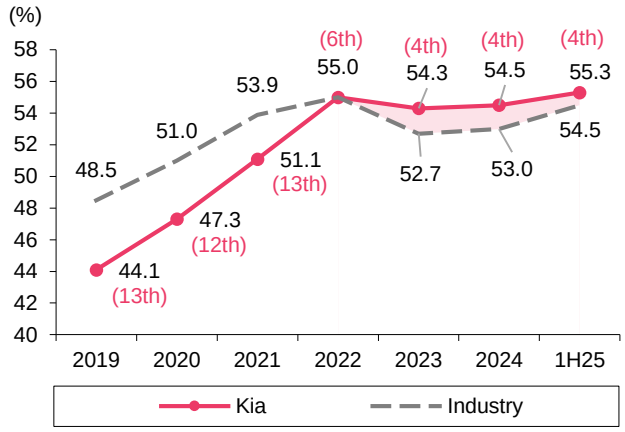
Source: Wards, Samsung Securities

US: HEV portion of sales volume, by automaker



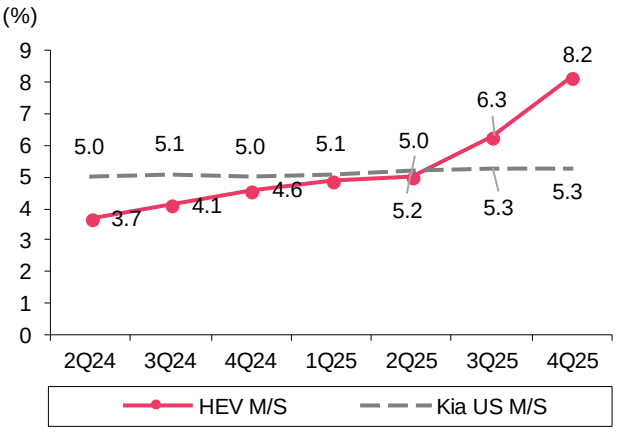
Source: Wards, Samsung Securities

Residual value and ranking



Source: U.S. ALG Residual Value, Company data, Samsung Securities

Kia: Hybrid market share in US



Source: Company data, Samsung Securities

Telluride profitability analysis

	Telluride 1st gen	Telluride 2nd gen
Selling price (USD)	46,453	55,743
Wholesale price (USD)	41,807	50,169
Sales volume (units)	127,000	177,000
Revenue (USDm)	5,309	8,880
Profitability (%)	20%	22%
Operating profit (USDm)	**1,062**	**1,954**
Operating profit (KRWb)	**1,529**	**2,813**

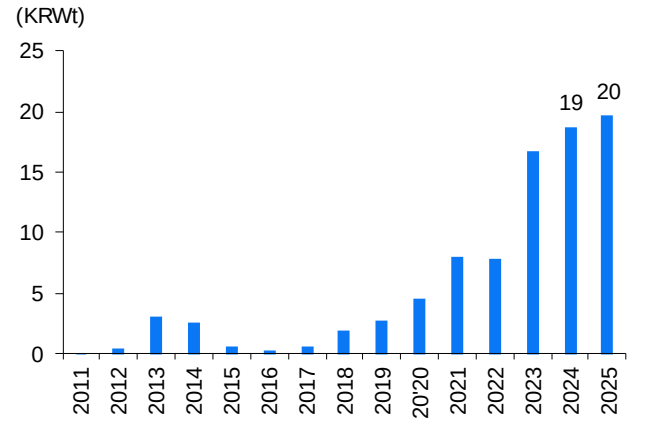
Source: Samsung Securities estimates

HMG: USD sensitivity estimation

	HMC	Kia	Mobis
USD revenue	106,070	62,403	29,869
USD COGS and SG&A	61,739	24,234	23,071
USD Exposure	44,331	38,169	6,798
Hedge (5%)	2,217	1,908	340
Net Exposure	**42,114**	**36,261**	**6,458**
1% movement	421	363	65
2025E operating profit	12,672	10,773	3,457
OP impact	**3.3%**	**3.4%**	**1.9%**

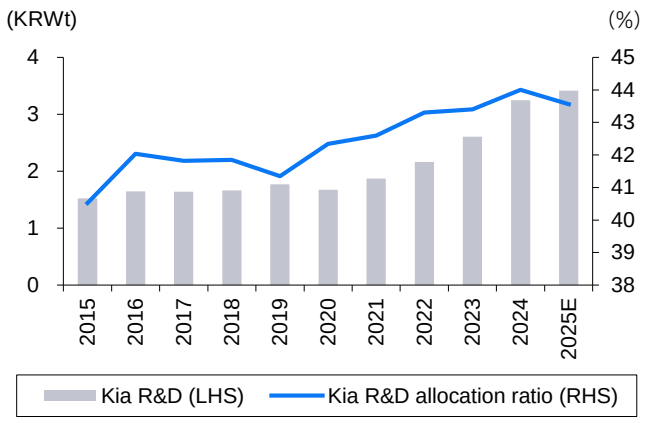
Source: Company data, Samsung Securities estimates

Kia: Net cash



Source: Company data, Samsung Securities

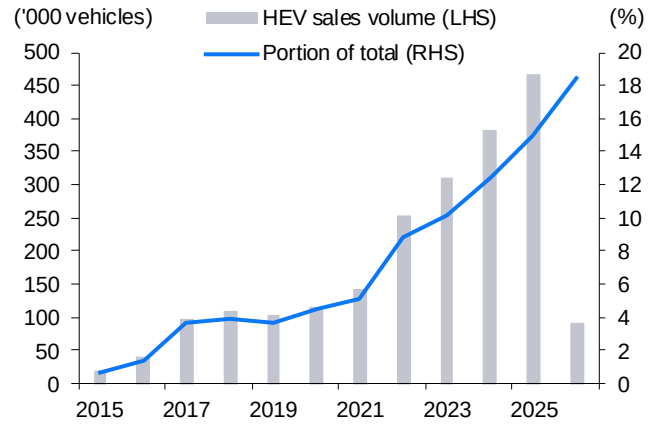
Kia: R&D expense and allocation ratio



Note: Kia's R&D allocation ratio is based on its share of the total R&D costs combined with HMC

Source: Company data, Samsung Securities

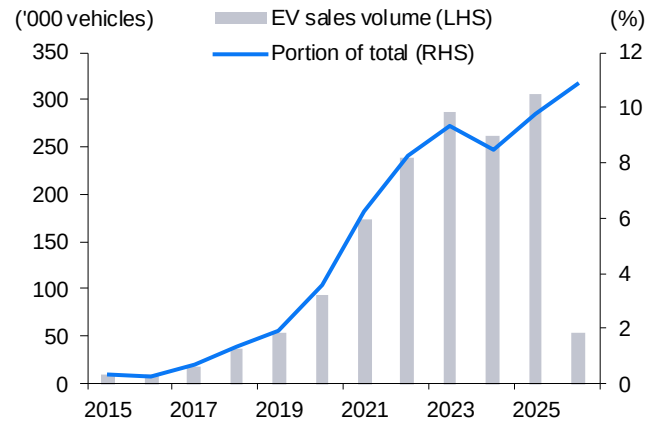
Kia: Hybrid sales volume



Note: Cumulative sales through Feb 2026

Source: Company data, Samsung Securities

Kia: EV sales volume



Note: Cumulative sales through Feb 2026

Source: Company data, Samsung Securities

Income statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Sales	**99,808**	**107,449**	**114,141**	**123,663**	**128,983**
Cost of goods sold	77,180	82,678	91,633	99,652	103,876
Gross profit	**22,629**	**24,771**	**22,508**	**24,011**	**25,106**
Gross margin (%)	22.7	23.1	19.7	19.4	19.5
SG&A expenses	11,021	12,104	13,430	13,372	13,573
Operating profit	**11,608**	**12,667**	**9,078**	**10,639**	**11,533**
Operating margin (%)	11.6	11.8	8.0	8.6	8.9
Non-operating gains (losses)	**1,069**	**833**	**1,163**	**1,484**	**1,519**
Financial profit	1,263	1,351	1,117	1,320	1,637
Financial costs	392	610	97	99	99
Equity-method gains (losses)	684	395	415	714	749
Other	-485	-304	-272	-451	-768
Pre-tax profit	**12,677**	**13,500**	**10,242**	**12,124**	**13,052**
Taxes	3,900	3,725	2,687	3,152	3,394
Effective tax rate (%)	30.8	27.6	26.2	26.0	26.0
Profit from continuing operations	8,778	9,775	7,554	8,972	9,659
Profit from discontinued operations	0	0	0	0	0
Net profit	**8,778**	**9,775**	**7,554**	**8,972**	**9,659**
Net margin (%)	8.8	9.1	6.6	7.3	7.5
Net profit (controlling interests)	8,777	9,773	7,561	8,980	9,667
Net profit (non-controlling interests)	1	2	-7	-8	-9
EBITDA	13,961	15,216	11,969	13,405	14,106
EBITDA margin (%)	14.0	14.2	10.5	10.8	10.9
EPS (parent-based) (KRW)	21,770	24,413	19,111	23,000	24,762
EPS (consolidated) (KRW)	21,772	24,418	19,094	22,980	24,740
Adjusted EPS (KRW)*	21,770	24,413	19,111	23,000	24,762

Balance sheet

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Current assets	**37,466**	**41,797**	**45,624**	**53,321**	**61,669**
Cash & equivalents	14,353	13,567	15,829	21,301	28,406
Accounts receivable	2,475	3,561	3,783	4,099	4,275
Inventories	11,273	12,419	13,193	14,293	14,908
Other current assets	9,365	12,251	12,819	13,628	14,080
Fixed assets	**43,162**	**50,958**	**54,223**	**55,811**	**56,054**
Investment assets	22,205	27,223	28,878	31,232	32,547
Tangible assets	16,104	18,279	19,924	19,630	18,975
Intangible assets	3,310	4,094	4,059	3,587	3,170
Other long-term assets	1,542	1,362	1,362	1,362	1,362
Total assets	**80,628**	**92,756**	**99,846**	**109,133**	**117,723**
Current liabilities	**25,674**	**26,977**	**28,254**	**30,551**	**31,834**
Accounts payable	10,369	10,455	11,106	12,032	12,550
Short-term debt	129	221	721	721	721
Other current liabilities	15,176	16,302	16,427	17,798	18,563
Long-term liabilities	**8,395**	**9,938**	**10,902**	**11,562**	**11,931**
Bonds & long-term debt	2,702	2,176	2,676	2,676	2,676
Other long-term liabilities	5,693	7,763	8,227	8,887	9,255
Total liabilities	**34,070**	**36,916**	**39,156**	**42,113**	**43,765**
Owners of parent equity	**46,552**	**55,831**	**60,688**	**67,025**	**73,972**
Capital stock	2,139	2,139	2,139	2,139	2,139
Capital surplus	1,758	1,760	1,760	1,760	1,760
Retained earnings	43,271	50,241	55,243	61,580	68,527
Other	-616	1,691	1,546	1,546	1,546
Non-controlling interests' equity	**6**	**9**	**2**	**-6**	**-14**
Total equity	**46,558**	**55,840**	**60,690**	**67,020**	**73,958**
Net debt	-12,718	-15,303	-17,733	-23,674	-31,040

Cash flow statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Cash flow from operations	**11,297**	**12,564**	**10,873**	**12,223**	**12,153**
Net profit	8,778	9,775	7,554	8,972	9,659
Non-cash profit and expenses	8,836	9,666	3,961	3,802	3,498
Depreciation	1,846	2,010	2,355	2,294	2,156
Amortization	507	540	535	472	417
Other	6,483	7,116	1,071	1,036	926
Changes in A/L from operating activities	-4,247	-4,287	844	1,200	671
Cash flow from investments	**-3,107**	**-10,153**	**-5,003**	**-2,716**	**-1,900**
Change in tangible assets	-2,230	-3,424	-4,000	-2,000	-1,500
Change in financial assets	-541	-4,788	-503	-716	-400
Other	-336	-1,941	-500	0	0
Cash flow from financing	**-5,596**	**-3,570**	**-2,391**	**-2,634**	**-2,716**
Change in debt	-3,622	-525	168	8	4
Change in equity	21	2	0	0	0
Dividends	-1,403	-2,194	-2,559	-2,642	-2,720
Other	-592	-853	0	0	0
Change in cash	2,799	-787	2,262	5,472	7,105
Cash at beginning of year	11,554	14,353	13,567	15,829	21,301
Cash at end of year	14,353	13,567	15,829	21,301	28,406
Gross cash flow	**17,614**	**19,441**	**11,516**	**12,773**	**13,157**
Free cash flow	**8,961**	**9,079**	**6,873**	**10,223**	**10,653**

Financial ratios

Year-end Dec 31	2023	2024	2025E	2026E	2027E
Growth (%)					
Sales	15.3	7.7	6.2	8.3	4.3
Operating profit	60.5	9.1	-28.3	17.2	8.4
Net profit	62.3	11.4	-22.7	18.8	7.7
Adjusted EPS**	63.1	12.1	-21.7	20.3	7.7
Per-share data (KRW)					
EPS (parent-based)	21,770	24,413	19,111	23,000	24,762
EPS (consolidated)	21,772	24,418	19,094	22,980	24,740
Adjusted EPS**	21,770	24,413	19,111	23,000	24,762
BVPS	117,495	141,812	156,170	172,478	190,355
DPS (common)	5,600	6,500	6,800	7,000	7,500
Valuations (x)					
P/E***	4.6	4.1	6.4	7.0	6.5
P/B***	0.9	0.7	0.8	0.9	0.9
EV/EBITDA	2.0	1.6	2.5	3.0	2.3
Ratios (%)					
ROE	20.4	19.1	13.0	14.1	13.7
ROA	11.4	11.3	7.8	8.6	8.5
ROIC	45.7	45.2	28.7	33.2	37.5
Payout ratio	25.0	26.2	34.9	30.3	30.1
Dividend yield (common)	5.6	6.5	5.6	4.3	4.6
Net debt to equity	-27.3	-27.4	-29.2	-35.3	-42.0
Interest coverage (x)	63.8	124.8	93.7	107.3	116.2

Note: *Excluding one-off items;
**Fully diluted, excluding one-off items;
***From companies subject to equity-method valuation

Source: Company data, Samsung Securities estimates

COMPANY UPDATE

2026. 3. 20

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LG Energy Solution (373220)

Market leader also excels in robotics

- LG Energy Solution (LGES) has already secured orders from six humanoid makers, with deliveries underway or under discussion for next-generation models. It is likely planning to supply batteries for use in Boston Dynamics' Atlas robot.
- Mirroring its position in the EV and ESS markets, LGES is likely to emerge as the strongest competitor against Chinese firms in the humanoid robotics industry. We maintain our 12-month target price and BUY rating.

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AT A GLANCE

BUY

Target price	KRW510,000 32.8%
Current price	KRW384,000 (3/12 close)
Market cap	KRW89.9t/USD60.7b
Shares (float)	234,000,000 (20.2%)
52-week high/low	KRW514,000/KRW268,000
Avg daily trading value (60-day)	KRW161.2b/ USD108.8m

ONE-YEAR PERFORMANCE

	1M	6M	12M
LG Energy Solution (%)	-6.3	8.0	10.2
Vs Kospi (%pts)	-7.4	-34.3	-49.2

KEY CHANGES

(KRW)	New	Old	Diff
Recommend.	BUY	BUY	
Target price	510,000	510,000	0.0%
2025E EPS	-4,352	-4,352	0.0%
2026E EPS	1,234	1,234	0.0%

SAMSUNG vs THE STREET

No of estimates	23
Target price	528,227
Recommendation	3.9

※ Rating: 4 < → BUY, 3 = HOLD, 2 > → SELL

WHAT'S THE STORY?

Already secured orders from six humanoid companies: During its 4Q25 earnings presentation, LG Energy Solution (LGES) disclosed its progress in the humanoid robot battery space. The company is currently recognized as a preferred partner by top-tier humanoid firms across the US, Korea, and China. It has already secured orders from six customers, with deliveries underway or under discussion for next-generation models. The product being supplied is high-energy-density, high-power 2170 cylindrical batteries. Notably, it is believed to be planning to supply batteries for use in Boston Dynamics' next-generation humanoid robot Atlas.

(Continued on the next page)

SUMMARY FINANCIAL DATA

	2024	2025E	2026E	2027E
Revenue (KRWb)	25,620	23,672	27,346	37,153
Operating profit (KRWb)	575	1,346	1,269	5,237
Net profit (adj) (KRWb)	339	81	777	4,105
EPS (adj) (KRW)	-4,354	-4,352	1,234	11,877
EPS (adj) growth (% y-y)	nm	nm	nm	862.8
EBITDA margin (%)	14.1	21.3	20.0	29.1
ROE (%)	-4.9	-4.9	1.4	12.8
P/E (adj) (x)	n/a	n/a	311.3	32.3
P/B (x)	3.9	4.3	4.4	3.9
EV/EBITDA (x)	28.4	23.0	22.2	10.9
Dividend yield (%)	0.0	0.0	0.0	0.0

Source: Company data, Samsung Securities estimates

Cylindrical battery production capacity around the globe: LGES currently operates 2170 or 46-series cylindrical battery manufacturing facilities in China and Korea. By end-2026, it plans to complete a new 46-series cylindrical battery plant in Arizona, US (44 GWh). In Europe, it intends to convert part of its existing pouch-type production line to 46-series cylindrical production, aiming to start the line (12 GWh) by 2028. Both the US and European facilities will initially supply batteries for EVs—contracts have already been signed. However, with Tesla leading the trend towards integrating 46-series batteries into humanoid robots, the company's expansion of cylindrical battery production capacity across its global manufacturing network means that LGES should be well positioned to meet battery demand from a wide range of humanoid companies.

View—Leading EV/ESS battery maker also excels in robotics: Even though the humanoid robot market is still in its very early stage, LGES has already managed to sign up six customers, suggesting that it is best positioned to challenge Chinese firms in this space—just as it has been challenging them in the EV and ESS markets. We maintain our 12-month target price and BUY rating.

LG Energy Solution: Three key batteries for humanoid robots

	2170 cylindrical battery		
	H51	**H52A**	**M58**
Energy Capacity (Wh)	18.2	18.5	20.3
Energy Density (Wh/L)	743	749	801
Weight (g)	69.6	64.5	70.9
Max Charging C-rate	1C	3C	0.47C
Max Discharging C-rate	5C	8C	2.2C
Fast Charging Support	30 min	15 min	-
Key Features	**High energy density, high power output, lightweight**	**Ultra-high-power output, suitable for applications requiring high power for short durations**	**Prioritizes energy density and capacity, suitable for long-duration operations**

Source: LG Energy Solution, Samsung Securities

LG Energy Solution: Cylindrical battery production capacity plan, by region

(GWh)	Product Type	Customers*	2025	2026E	2027E	2028E
Korea	2170/46 series	Tesla, Rivian, Chery Automobile	10	10	10	10
China	2170	Tesla	65	65	65	65
US	46 series	Tesla, Rivian, Ford, Mercedes Benz		44	44	44
Europe	46 series	Mercedes Benz, Chery Automobile				12
Global			**75**	**119**	**119**	**131**

Note: Production capacity is based on year-end nominal capacity.
* Based on Samsung Securities estimates.
Source: LG Energy Solution, Samsung Securities

LG Energy Solution: Results and forecasts

(KRWb)	1Q25	2Q25	3Q25	4Q25	1Q26E	2Q26E	3Q26E	4Q26E	2024	2025	2026E	2027E
KRW/USD (average)	1,453	1,401	1,387	1,449	1,450	1,400	1,350	1,315	1,365	1,422	1,379	1,315
Sales	**6,265**	**5,565**	**5,700**	**6,142**	**5,762**	**6,390**	**7,244**	**7,950**	**25,620**	**23,672**	**27,346**	**37,153**
Growth (% q-q)	-2.9	-11.2	2.4	7.7	-6.2	10.9	13.4	9.8				
Growth (% y-y)	2.2	-9.7	-17.1	-4.8	-8.0	14.8	27.1	29.4	-24.1	-7.6	15.5	35.9
Small batteries	1,710	1,553	1,653	1,935	1,855	2,005	2,270	2,271	7,363	6,851	8,401	8,443
Growth (% q-q)	5.6	-9.2	6.5	17.0	-4.1	8.1	13.2	0.1				
Growth (% y-y)	-21.4	-16.0	-3.9	19.5	8.4	29.1	37.3	17.4	-22.9	-7.0	22.6	0.5
EV batteries	4,110	3,623	3,466	2,856	2,142	2,434	2,716	3,019	16,408	14,054	10,311	14,878
Growth (% q-q)	-2.0	-11.8	-4.3	-17.6	-25.0	13.6	11.6	11.2				
Growth (% y-y)	9.9	-9.5	-22.5	-31.9	-47.9	-32.8	-21.6	5.7	-24.5	-14.3	-26.6	44.3
ESS	445	390	581	1,351	1,766	1,951	2,258	2,659	1,849	2,767	8,634	13,832
Growth (% q-q)	-30.4	-12.4	49.2	132.4	30.7	10.5	15.7	17.8				
Growth (% y-y)	107.4	26.4	-15.5	111.6	296.9	400.8	288.4	96.8	-24.5	49.6	212.0	60.2
EBITDA	**1,231**	**1,375**	**1,519**	**913**	**696**	**1,207**	**1,674**	**1,887**	**3,621**	**5,038**	**5,463**	**10,825**
Growth (% q-q)	94.3	11.7	10.5	-39.9	-23.8	73.4	38.7	12.7				
Growth (% y-y)	50.8	47.8	22.4	44.1	-43.5	-12.2	10.2	106.7	-18.6	39.1	8.5	98.1
Operating profit	**375**	**492**	**601**	**-122**	**-226**	**210**	**573**	**711**	**575**	**1,346**	**1,269**	**5,237**
Growth (% q-q)	Turned pos	31.4	22.2	Turned neg	To remain neg	To turn pos	172.5	24.1				
Growth (% y-y)	138.1	152.0	34.1	Remained neg	To turn neg	-57.3	-4.7	To turn pos	-73.4	134.0	-5.8	312.8
Small batteries	117	92	115	129	91	118	202	111	195	453	522	524
Growth (% q-q)	Turned pos	-21.7	25.2	12.7	-29.9	30.2	70.9	-44.9				
Growth (% y-y)	49.1	41.9	48.9	Turned pos	-22.6	28.7	75.7	-14.2	-74.3	133.0	15.1	0.4
EV batteries	-107	-91	87	-488	-538	-246	-139	-3	-880	-599	-925	123
Growth (% q-q)	Remained neg	Remained neg	Turned pos	Turned neg	To remain neg	To remain neg	To remain neg	To remain neg				
Growth (% y-y)	Remained neg	Remained neg	Turned pos	Remained neg	To remain neg	To remain neg	To turn neg	To remain neg	Turned neg	Remained neg	To remain neg	To turn pos
ESS	-93	0	34	-96	46	55	70	77	-219	-155	248	415
Growth (% q-q)	Remained neg	Turned pos	17,509.7	Turned neg	To turn pos	19.0	28.1	10.2				
Growth (% y-y)	Remained neg	Turned pos	49,773.0	Remained neg	To turn pos	27,946.1	104.1	To turn pos	Turned neg	Remained neg	To turn pos	67.6
AMPC	458	491	365	333	175	283	440	526	1,480	1,647	1,424	4,176
Growth (% q-q)	21.3	7.2	-25.5	-8.9	-47.4	61.8	55.2	19.6				
Growth (% y-y)	142.2	9.6	-21.6	-11.8	-61.7	-42.2	20.3	58.0	118.7	11.3	-13.5	193.2
Pre-tax profit	**365**	**-27**	**553**	**-476**	**-447**	**177**	**531**	**620**	**349**	**414**	**882**	**4,553**
Growth (% q-q)	4.5	Turned neg	Turned pos	Turned neg	To turn neg	To turn pos	199.9	16.7				
Growth (% y-y)	63.7	Turned neg	63.0	Remained neg	To turn neg	To turn pos	-3.9	To turn pos	-82.9	18.7	112.9	416.4
Net profit	**227**	**91**	**536**	**-772**	**-394**	**156**	**468**	**546**	**339**	**81**	**777**	**4,105**
Growth (% q-q)	-33.1	-60.0	491.7	Turned neg	To turn neg	To turn pos	199.9	16.7				
Growth (% y-y)	6.8	Turned pos	-4.5	Remained neg	To turn neg	72.4	-12.6	To turn pos	-79.3	-76.1	862.1	428.1
Attributable to parent	-146	-297	247	-822	-339	75	253	299	-1,019	-1,018	289	2,779
Margins (%)												
EBITDA	19.6	24.7	26.6	14.9	12.1	18.9	23.1	23.7	14.1	21.3	20.0	29.1
Operating profit	6.0	8.8	10.5	-2.0	-3.9	3.3	7.9	8.9	2.2	5.7	4.6	14.1
Small batteries	6.9	5.9	6.9	6.7	4.9	5.9	8.9	4.9	2.6	6.6	6.2	6.2
EV batteries	-2.6	-2.5	2.5	-17.1	-25.1	-10.1	-5.1	-0.1	-5.4	-4.3	-9.0	0.8
ESS	-21.0	0.1	5.9	-7.1	2.6	2.8	3.1	2.9	-11.9	-5.6	2.9	3.0
Pre-tax profit	5.8	-0.5	9.7	-7.8	-7.8	2.8	7.3	7.8	1.4	1.7	3.2	12.3
Net profit	3.6	1.6	9.4	-12.6	-6.8	2.4	6.5	6.9	1.3	0.3	2.8	11.0

Source: Company data, Samsung Securities estimates

Income statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Sales	**33,745**	**25,620**	**23,672**	**27,346**	**37,153**
Cost of goods sold	28,802	22,214	19,440	22,400	29,070
Gross profit	**4,943**	**3,406**	**4,232**	**4,945**	**8,084**
Gross margin (%)	14.6	13.3	17.9	18.1	21.8
SG&A expenses	3,457	4,311	4,533	5,101	7,022
Operating profit	**2,163**	**575**	**1,346**	**1,269**	**5,237**
Operating margin (%)	6.4	2.2	5.7	4.6	14.1
Non-operating gains (losses)	**-120**	**-227**	**-932**	**-387**	**-683**
Financial profit	985	1,048	63	428	279
Financial costs	857	1,261	739	852	924
Equity-method gains (losses)	-32	-49	-6	-6	-6
Other	-215	35	-250	42	-33
Pre-tax profit	**2,043**	**349**	**414**	**882**	**4,553**
Taxes	405	10	333	104	448
Effective tax rate (%)	19.8	2.9	80.5	11.8	9.8
Profit from continuing operations	1,638	339	81	777	4,105
Profit from discontinued operations	0	0	0	0	0
Net profit	**1,638**	**339**	**81**	**777**	**4,105**
Net margin (%)	4.9	1.3	0.3	2.8	11.0
Net profit (controlling interests)	1,237	-1,019	-1,018	289	2,779
Net profit (non-controlling interests)	401	1,357	1,099	489	1,326
EBITDA	4,450	3,621	5,038	5,463	10,825
EBITDA margin (%)	13.2	14.1	21.3	20.0	29.1
EPS (parent-based) (KRW)	5,287	-4,354	-4,352	1,234	11,877
EPS (consolidated) (KRW)	7,000	1,447	345	3,322	17,544
Adjusted EPS (KRW)*	5,287	-4,354	-4,352	1,234	11,877

Balance sheet

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Current assets	**17,208**	**15,327**	**10,626**	**13,269**	**23,671**
Cash & equivalents	5,069	3,899	66	1,070	7,098
Accounts receivable	5,128	4,944	4,568	5,277	7,170
Inventories	5,396	4,552	4,206	4,859	6,602
Other current assets	1,615	1,932	1,785	2,063	2,802
Fixed assets	**28,229**	**44,979**	**51,897**	**54,230**	**54,039**
Investment assets	648	1,272	1,231	1,309	1,516
Tangible assets	23,655	38,350	45,343	47,628	47,256
Intangible assets	876	1,285	1,250	1,220	1,193
Other long-term assets	3,050	4,073	4,073	4,073	4,073
Total assets	**45,437**	**60,307**	**62,523**	**67,498**	**77,710**
Current liabilities	**10,937**	**12,055**	**10,469**	**12,021**	**15,751**
Accounts payable	3,094	2,705	2,500	2,888	3,923
Short-term debt	1,576	1,291	1,291	1,291	1,291
Other current liabilities	6,267	8,058	6,678	7,842	10,536
Long-term liabilities	**10,126**	**17,285**	**21,007**	**23,652**	**26,030**
Bonds & long-term debt	7,628	12,641	16,620	18,780	19,862
Other long-term liabilities	2,498	4,644	4,387	4,872	6,168
Total liabilities	**21,064**	**29,340**	**31,476**	**35,674**	**41,780**
Owners of parent equity	**20,201**	**21,116**	**20,098**	**20,387**	**23,166**
Capital stock	117	117	117	117	117
Capital surplus	17,165	17,165	17,165	17,165	17,165
Retained earnings	2,364	1,397	379	667	3,447
Other	555	2,437	2,437	2,437	2,437
Non-controlling interests' equity	**4,173**	**9,850**	**10,949**	**11,438**	**12,764**
Total equity	**24,374**	**30,967**	**31,047**	**31,825**	**35,930**
Net debt	5,870	11,493	18,445	19,783	14,905

Cash flow statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Cash flow from operations	**4,444**	**5,112**	**3,408**	**4,846**	**10,258**
Net profit	1,638	339	81	777	4,105
Non-cash profit and expenses	3,607	4,984	4,417	4,779	6,741
Depreciation	2,150	2,856	3,507	4,015	5,412
Amortization	137	190	185	180	176
Other	1,320	1,939	726	584	1,153
Changes in A/L from operating activities	-277	691	-116	218	582
Cash flow from investments	**-9,719**	**-12,065**	**-10,359**	**-6,169**	**-5,351**
Change in tangible assets	-9,821	-12,324	-10,500	-6,300	-5,040
Change in financial assets	-114	-277	36	-69	-183
Other	215	536	104	199	-127
Cash flow from financing	**4,355**	**5,382**	**3,120**	**2,341**	**1,150**
Change in debt	2,895	4,383	3,120	2,341	1,150
Change in equity	0	0	0	0	0
Dividends	0	0	0	0	0
Other	1,460	998	0	0	-0
Change in cash	-869	-1,170	-3,832	1,004	6,028
Cash at beginning of year	5,938	5,069	3,899	66	1,070
Cash at end of year	5,069	3,899	66	1,070	7,098
Gross cash flow	**5,245**	**5,323**	**4,498**	**5,556**	**10,846**
Free cash flow	**-5,479**	**-7,287**	**-7,092**	**-1,454**	**5,218**

Financial ratios

Year-end Dec 31	2023	2024	2025E	2026E	2027E
Growth (%)					
Sales	31.8	-24.1	-7.6	15.5	35.9
Operating profit	78.2	-73.4	134.0	-5.8	312.8
Net profit	110.0	-79.3	-76.1	862.1	428.1
Adjusted EPS**	60.0	nm	nm	nm	862.8
Per-share data (KRW)					
EPS (parent-based)	5,287	-4,354	-4,352	1,234	11,877
EPS (consolidated)	7,000	1,447	345	3,322	17,544
Adjusted EPS**	5,287	-4,354	-4,352	1,234	11,877
BVPS	86,328	90,240	85,888	87,122	98,999
DPS (common)	0	0	0	0	0
Valuations (x)					
P/E***	80.9	n/a	n/a	311.3	32.3
P/B***	5.0	3.9	4.3	4.4	3.9
EV/EBITDA	24.7	28.4	23.0	22.2	10.9
Ratios (%)					
ROE	6.4	-4.9	-4.9	1.4	12.8
ROA	3.9	0.6	0.1	1.2	5.7
ROIC	6.7	1.5	0.6	2.2	8.8
Payout ratio	0.0	0.0	0.0	0.0	0.0
Dividend yield (common)	0.0	0.0	0.0	0.0	0.0
Net debt to equity	24.1	37.1	59.4	62.2	41.5
Interest coverage (x)	6.9	1.0	1.8	1.5	5.7

Note: *Excluding one-off items
**Fully diluted, excluding one-off items
***From companies subject to equity-method valuation

Source: Company data, Samsung Securities estimates

COMPANY UPDATE

2026. 3. 20

EV/Mobility Team

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Samsung SDI (006400)

To turn profitable in full-year 2026

- Samsung SDI reported in-line 4Q25 results.
- The company should turn profitable y-y in 2026 led by improved performance in ESS and small- and large-sized batteries.
- We raise out target price for the stock to KRW420,000 and maintain BUY.

WHAT'S THE STORY?

4Q review: Samsung SDI announced its 4Q25 results showing sales of KRW3.8t and an operating loss of KRW299.2b, the latter in line with FnGuide consensus (of an operating loss of KRW301.4b). The large-battery division saw a smaller-than-expected loss, mainly due to increased compensation from existing customers for sales underperformance, which positively impacted both sales and operating margin. Meanwhile, advanced manufacturing production credit (AMPC) reached KRW79.8b, exceeding our estimate of KRW60.7b, driven by the North American JV, where ESS shipments were in line with expectations (estimated at 1.1 GWh), while the hike in the KRW/USD exchange rate had a significant positive impact.

2026 outlook--Annual profitability still in sight: We slightly raise our 2026 sales and operating profit forecasts for the company to KRW15.5t and KRW352b, respectively. We believe that: 1) EV shipments will grow in the mid-to-high single digits as new models from key customers enter production; 2) ESS shipments will surge by 50% y-y, driven by the expansion of AI data centers, with margins improving meaningfully in 2H as added capacity in North America comes online, reducing tariff exposure and enabling the company to win more tax credits; and 3) the small-battery segment will see reduced losses in 2H, supported by rising demand for power tool-use batteries and battery backup units (BBUs) amid data center expansion.

(Continued on the next page)

AT A GLANCE

BUY

Target price	KRW420,000 18%
Current price	**KRW356,000 (2/2 close)**
Market cap	KRW28.7t/USD19.6b
Shares (float)	80,585,530 (72.6%)
52-week high/low	KRW396,500/KRW160,200
Avg daily trading value (60-day)	KRW262.8b/ USD179.5m

ONE-YEAR PERFORMANCE

	1M	6M	12M
Samsung SDI (%)	35.6	87.4	63.8
Vs Kospi (%pts)	18.1	18.1	-16.7

KEY CHANGES

(KRW)	New	Old	Diff
Recommend.	BUY	BUY	
Target price	420,000	320,000	31.3%
2025E EPS	-4,157	-4,157	0.0%
2026E EPS	3,197	3,197	0.0%

SAMSUNG vs THE STREET

No of estimates	17
Target price	377,500
Recommendation	3.9

※ Rating: 4 < → BUY, 3 = HOLD, 2 > → SELL

SUMMARY 4Q RESULTS

(KRWb)	4Q25	Chg		Diff (%)	
		(% y-y)	(% q-q)	Samsung	Consensus
Sales	3,858.6	2.8	26.4	-0.0	10.2
Operating profit	-299.2	nm	nm	nm	nm
Pre-tax profit	524.7	nm	nm	-0.0	nm
Net profit	169.2	nm	2,887.1	-0.0	957.5
Margins (%)					
Operating profit	-7.8				
Pre-tax profit	13.6				
Net profit	4.4				

Source: Company data, Fnguide, Samsung Securities estimates

VALUATION SUMMARY

	2024	2025E	2026E
Valuation (x)			
P/E	29.2	n/a	111.4
P/B	0.8	1.0	1.3
EV/EBITDA	13.4	84.0	15.4
Div yield (%)	0.4	0.4	0.3
EPS growth (% y-y)	-70.2	nm	nm
ROE (%)	3.1	-1.6	1.2
Per-share data (KRW)			
EPS	8,288	-4,157	3,197
BVPS	287,707	273,706	276,071
DPS	973	973	973

Raising target price to KRW420,000; maintaining BUY: We raise our target price for the stock by 31% from KRW320,000 to KRW420,000 (based on a SOTP valuation), as: 1) we change our EBITDA valuation basis from 2026 to 2027 to better capture long-term EV and ESS market dynamics; and 2) we apply an EV/EBITDA multiple of 10.7x to the battery business (the average of industry peers). We maintain BUY in light of: 1) the high visibility of annual profitability, driven by rapid capacity expansion in ESS to meet strong demand growth; and 2) ongoing expectations for a hike in LFP prismatic battery adoption in North America (due to capacity expansion there) and solid-state battery development for robotics applications.

4Q review

(KRWb)	4Q25P	4Q24	3Q25	Chg	
				(% y-y)	(% q-q)
Sales	3,858.6	3,754.5	3,051.8	2.8	26.4
Operating profit	-299.2	-256.7	-591.3	Remained neg	Remained neg
Pre-tax profit	524.7	-304.2	-347.2	Remained neg	Remained neg
Net profit	169.2	-242.7	5.7	Remained neg	Turned neg
Margins (%)					
Operating profit	-7.8	-6.8	-19.4		
Pre-tax profit	13.6	-8.1	-11.4		
Net profit	4.4	-6.5	0.2		

Source: Company data, Samsung Securities

Revisions to full-year forecasts

(KRWb)	2025P			2026E		
	Old	New	Diff (%)	Old	New	Diff (%)
Sales	12,840.4	13,266.7	3.3	14,839.8	15,542.1	4.7
Operating profit	-1,797.7	-1,722.4	nm	329.1	352.0	7.0
Pre-tax profit	-989.9	-319.7	nm	497.6	547.5	10.0
Net profit	-574.2	-207.8	nm	398.0	438.0	10.0

Source: Samsung Securities estimates

Results and forecasts

(KRWb)	1Q24	2Q24	3Q24	4Q24	1Q25	2Q25	3Q25	4Q25P	1Q26E	2Q26E	3Q26E	4Q26E	2024	2025P	2026E
Sales	4,816.2	4,085.9	3,935.6	3,754.5	3,176.8	3,179.4	3,051.8	3,858.6	3,467.8	3,710.0	3,921.7	4,442.6	16,592.1	13,266.7	15,542.1
Batteries	4,581.8	3,872.9	3,672.0	3,564.6	2,980.9	2,961.2	2,820.0	3,622.0	3,211.2	3,414.6	3,580.3	4,126.5	15,691.3	12,384.1	14,332.6
LiB (IT)	1,613.5	1,228.1	863.4	690.3	641.6	833.7	875.2	869.6	895.1	939.5	986.3	1,035.6	4,395.3	3,220.1	3,856.6
LiB (EV+ESS)	2,968.3	2,644.8	2,808.6	2,874.3	2,339.3	2,127.5	1,944.8	2,752.4	2,316.1	2,475.1	2,594.0	3,090.8	11,296.0	9,163.9	10,476.0
Electronic materials	234.4	213.0	263.5	190.0	195.9	218.2	231.8	236.7	256.6	295.3	341.4	316.1	900.8	882.6	1,209.5
Operating profit	249.1	240.9	129.9	-256.7	-434.1	-397.8	-591.3	-299.2	-57.5	-0.8	46.1	364.2	363.2	-1,722.4	352.0
Batteries	214.5	208.0	63.5	-268.3	-452.4	-430.8	-630.1	-338.5	-99.3	-49.4	-13.7	320.5	217.6	-1,851.8	158.1
LIB (IT)	72.6	86.0	-19.0	-138.1	-224.6	-72.9	-48.1	-95.6	-44.8	-65.8	-29.6	0.0	1.5	-441.2	-140.1
LIB (EV+ESS)	95.1	112.3	73.0	106.2	-337.3	-424.3	-601.5	-322.6	-147.8	-79.8	-83.3	-10.6	386.6	-1,685.7	-321.5
IRA (AMPC)	46.8	9.6	9.4	13.9	109.4	66.4	19.5	79.8	93.3	96.1	99.2	331.0	79.8	275.1	619.7
Electronic materials	34.6	32.9	66.4	11.6	18.3	33.0	38.8	39.3	41.8	48.7	59.8	43.7	145.5	129.4	193.9
Operating margin (%)	5.2	5.9	3.3	-6.8	-13.7	-12.5	-19.4	-7.8	-1.7	0.0	1.2	8.2	2.2	-13.0	2.3
Batteries	4.7	5.4	1.7	-7.5	-15.2	-14.5	-22.3	-9.3	-3.1	-1.4	-0.4	7.8	1.4	-15.0	1.1
Electronic materials	14.8	15.5	25.2	6.1	9.3	15.1	16.7	16.6	16.3	16.5	17.5		16.2	14.7	16.0

Source: Company data, Samsung Securities estimates

Target-price calculation

(KRWb)		Note
Operating value	36,895	
Established business*	8,241	
LIB (IT)	5,163	2027E EBITDA weighted avg
ECM*	3,078	2027E EBITDA weighted avg
New growth business	28,654	
LIB (EV, ESS)**	28,654	2027E EBITDA weighted avg
Non-operating value	6,340	
Listed subsidiaries	1,083	As of Dec 18 close
Unlisted subsidiaries	420	30% discount to 2024 book value
Samsung Display	4,837	2024 book value
Net debt	6,489	End-2025
Net asset value	36,747	
Discount (%)	20%	Risk of slowdown in market (20%)
NAVPS	427,507	
Target price (KRW)	420,000	
Current price (KRW)	356,000	As of Feb 2, 2026 close
Upside (%)	18.0	

Note: *Calculated by applying peer average EV/EBITDA multiples (10.7x for the LIB (IT) unit, and 8.3x for ECM) to our 2027 weighted average EBITDA forecasts for each division;
**Calculated by applying the peer average EV/EBITDA multiple (10.7x) to our 2027 weighted average EBITDA forecast
Source: Bloomberg, Samsung Securities estimates

AMPC estimates and reflection on net profit (non-controlling interests)

		2024	2025E	2026E	2027E
AMPC estimates	**Capacity (cell) based on installations (at year-end)**				
	Michigan (pack)	3	3	3	3
	SPE 1	33	33	33	33
	GM JV			27	27
	Utilization rate				
	Michigan (pack)	88%	41%	76%	88%
	SPE 1	0%	12%	29%	30%
	GM JV				4%
	Output				
	Michigan (pack)	3	1	2	3
	SPE 1	0	4	10	10
	GM JV	-	-	-	1
	AMPC credit (USD/kWh)				
	Cell	35	35	35	35
	Module/pack	10	10	10	10
	AMPC reflection				
	AMPC (USDm)	59	192	460	1,024
	AMPC (KRWb)	80	275	620	1,346
Net profit (non-controlling interests) estimates	**Net profit (KRWb)**	576	-208	438	1,667
	Net profit (controlling interests)	599	-324	263	1,367
	Net profit (non-controlling interests)	-24	116	175	300
	AMPC net profit (non-controlling interests)	3	105	130	294

Source: Samsung SDI, Samsung Securities estimates

Income statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Sales	**21,437**	**16,592**	**13,267**	**15,542**	**19,532**
Cost of goods sold	17,655	13,499	12,717	12,539	14,048
Gross profit	**3,782**	**3,094**	**550**	**3,003**	**5,484**
Gross margin (%)	17.6	18.6	4.1	19.3	28.1
SG&A expenses	2,237	2,820	2,272	2,651	3,318
Operating profit	**1,545**	**363**	**-1,722**	**352**	**2,166**
Operating margin (%)	7.2	2.2	-13.0	2.3	11.1
Non-operating gains (losses)	**941**	**253**	**1,403**	**195**	**28**
Financial profit	958	1,129	107	159	167
Financial costs	1,157	1,603	1,265	514	608
Equity-method gains (losses)	1,017	801	2,444	651	570
Other	122	-74	118	-100	-100
Pre-tax profit	**2,486**	**616**	**-320**	**547**	**2,194**
Taxes	403	7	-83	109	527
Effective tax rate (%)	16.2	1.1	26.0	20.0	24.0
Profit from continuing operations	1,979	520	-154	438	1,667
Profit from discontinued operations	87	55	-54	0	0
Net profit	**2,066**	**576**	**-208**	**438**	**1,667**
Net margin (%)	9.6	3.5	-1.6	2.8	8.5
Net profit (controlling interests)	2,009	599	-324	263	1,367
Net profit (non-controlling interests)	57	-24	116	175	300
EBITDA	3,273	2,148	362	2,555	4,636
EBITDA margin (%)	15.3	12.9	2.7	16.4	23.7
EPS (parent-based) (KRW)	27,788	8,288	-4,157	3,197	16,633
EPS (consolidated) (KRW)	28,574	7,959	-2,664	5,328	20,285
Adjusted EPS (KRW)*	27,774	8,288	-4,157	3,197	16,633

Balance sheet

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Current assets	**9,187**	**10,334**	**12,935**	**13,956**	**16,702**
Cash & equivalents	1,524	1,885	5,953	5,777	6,424
Accounts receivable	2,875	2,729	2,240	2,624	3,298
Inventories	3,297	2,879	2,469	2,893	3,636
Other current assets	1,490	2,841	2,272	2,661	3,345
Fixed assets	**24,852**	**30,263**	**29,418**	**31,525**	**35,528**
Investment assets	11,394	11,187	9,127	10,537	13,009
Tangible assets	11,893	17,707	18,984	19,730	21,297
Intangible assets	859	668	606	558	520
Other long-term assets	705	701	701	701	701
Total assets	**34,039**	**40,597**	**42,353**	**45,482**	**52,230**
Current liabilities	**8,519**	**10,856**	**10,370**	**10,229**	**12,019**
Accounts payable	2,119	906	1,209	1,416	1,780
Short-term debt	2,298	5,394	5,394	5,594	6,194
Other current liabilities	4,103	4,557	3,768	3,219	4,045
Long-term liabilities	**5,613**	**8,174**	**8,526**	**11,436**	**14,803**
Bonds & long-term debt	2,850	5,064	6,014	8,514	11,164
Other long-term liabilities	2,763	3,111	2,512	2,922	3,640
Total liabilities	**14,132**	**19,030**	**18,897**	**21,664**	**26,822**
Owners of parent equity	**18,511**	**19,766**	**21,539**	**21,725**	**23,016**
Capital stock	357	357	416	416	416
Capital surplus	5,002	5,002	6,943	6,943	6,943
Retained earnings	12,336	12,780	12,389	12,575	13,865
Other	817	1,628	1,791	1,791	1,791
Non-controlling interests' equity	**1,396**	**1,801**	**1,917**	**2,093**	**2,393**
Total equity	**19,907**	**21,567**	**23,456**	**23,818**	**25,408**
Net debt	3,665	9,679	6,489	8,325	10,895

Cash flow statement

Year-end Dec 31 (KRWb)	2023	2024	2025E	2026E	2027E
Cash flow from operations	**2,104**	**-138**	**2,333**	**1,901**	**3,409**
Net profit	2,066	576	-208	438	1,667
Non-cash profit and expenses	1,498	2,397	2,317	2,004	2,856
Depreciation	1,660	1,795	2,022	2,155	2,433
Amortization	68	80	62	48	37
Other	-230	522	232	-198	386
Changes in A/L from operating activities	-938	-2,622	456	-90	-158
Cash flow from investments	**-4,105**	**-4,920**	**-4,046**	**-2,937**	**-4,065**
Change in tangible assets	-4,037	-6,263	-3,300	-2,900	-4,000
Change in financial assets	-77	428	54	-37	-65
Other	9	915	-800	-0	-0
Cash flow from financing	**903**	**5,544**	**2,776**	**1,608**	**3,182**
Change in debt	578	5,941	843	1,684	3,259
Change in equity	0	0	2,000	0	0
Dividends	-72	-70	-67	-77	-77
Other	396	-327	0	0	0
Change in cash	-1,090	361	4,068	-176	646
Cash at beginning of year	2,614	1,524	1,885	5,953	5,777
Cash at end of year	1,524	1,885	5,953	5,777	6,424
Gross cash flow	**3,564**	**2,972**	**2,109**	**2,442**	**4,524**
Free cash flow	**-1,945**	**-6,409**	**-967**	**-999**	**-591**

Financial ratios

Year-end Dec 31	2023	2024	2025E	2026E	2027E
Growth (%)					
Sales	6.5	-22.6	-20.0	17.2	25.7
Operating profit	-14.5	-76.5	nm	nm	515.3
Net profit	1.3	-72.1	nm	nm	280.7
Adjusted EPS**	2.9	-70.2	nm	nm	420.3
Per-share data (KRW)					
EPS (parent-based)	27,788	8,288	-4,157	3,197	16,633
EPS (consolidated)	28,574	7,959	-2,664	5,328	20,285
Adjusted EPS**	27,774	8,288	-4,157	3,197	16,633
BVPS	269,440	287,707	273,706	276,071	292,472
DPS (common)	973	973	973	973	973
Valuations (x)					
P/E***	16.6	29.2	n/a	111.4	21.4
P/B***	1.7	0.8	1.0	1.3	1.2
EV/EBITDA	11.6	13.4	84.0	15.4	9.1
Ratios (%)					
ROE	11.5	3.1	-1.6	1.2	6.1
ROA	6.4	1.5	-0.5	1.0	3.4
ROIC	9.6	1.9	-4.9	1.2	6.5
Payout ratio	3.3	10.9	-23.2	28.6	5.5
Dividend yield (common)	0.2	0.4	0.4	0.3	0.3
Net debt to equity	18.4	44.9	27.7	35.0	42.9
Interest coverage (x)	5.6	1.1	-3.7	0.7	3.6

Note: *Excluding one-off items
**Fully diluted, excluding one-off items
***From companies subject to equity-method valuation

Source: Company data, Samsung Securities estimates

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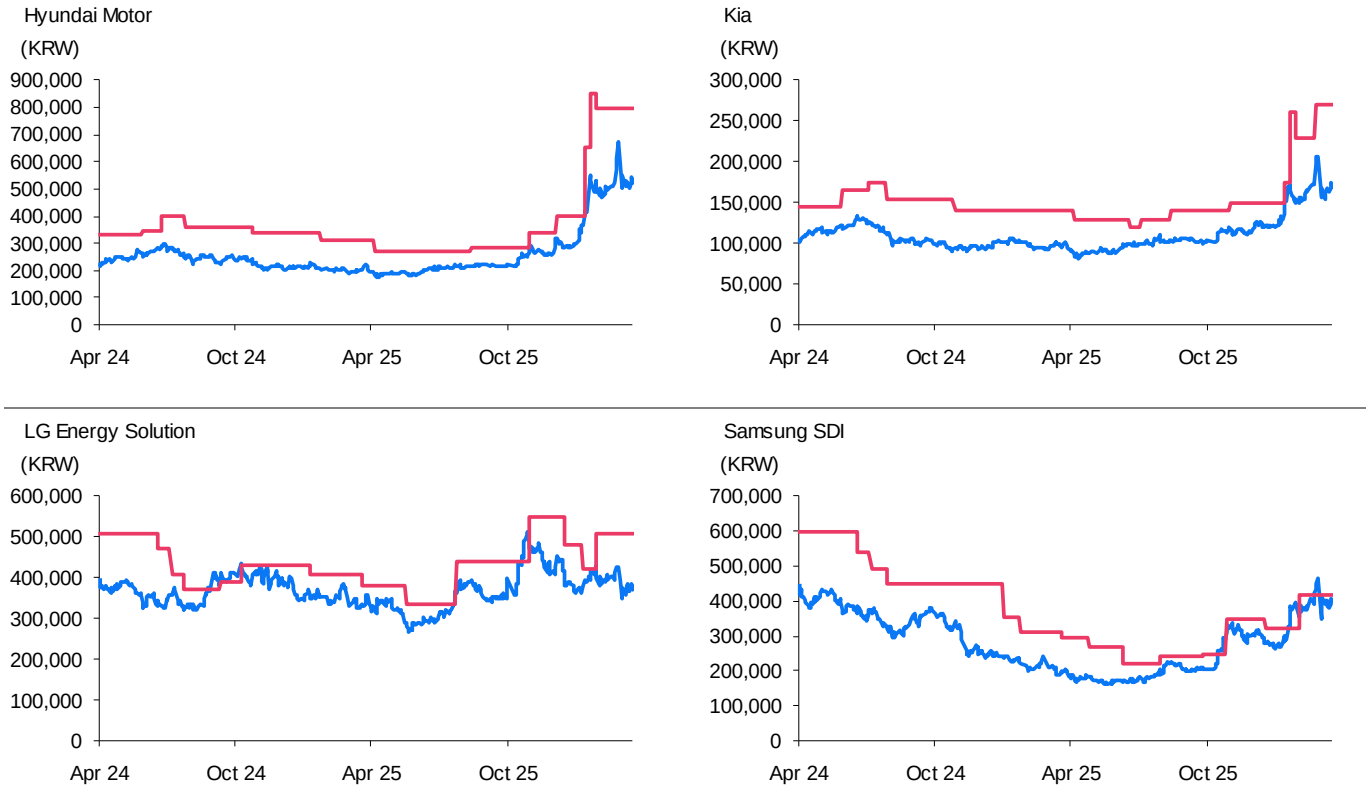
Target price changes in past two years



Rating changes over past two years (adjusted share prices)

Hyundai Motor												
Date	2024/3/20	5/29	6/25	7/26	10/25	2025/1/24	4/7	8/14	10/31	12/8	2026/1/14	1/22
Recommendation	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY
Target price (KRW)	330000	345000	400000	360000	340000	310000	270000	285000	340000	400000	650000	850000
Gap* (average)	-26.19	-21.52	-31.63	-32.30	-37.27	-34.90	-26.06	-20.49	-20.69	-22.55	-27.91	-40.91
(max or min)**	-16.06	-16.96	-25.50	-28.06	-33.38	-28.39	-17.41	-7.02	-7.35	1.50	-15.54	-37.88
Date	1/30											
Recommendation	BUY											
Target price (KRW)	800000											
Gap* (average)												
(max or min)**												
Kia												
Date	2024/2/5	5/29	7/4	7/29	10/28	2025/4/7	6/20	7/7	8/14	11/3	2026/1/14	1/22
Recommendation	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY
Target price (KRW)	145000	165000	175000	155000	140000	130000	120000	130000	140000	150000	175000	260000
Gap* (average)	-19.81	-24.20	-31.41	-34.54	-30.66	-30.49	-17.88	-21.50	-24.00	-20.38	-7.53	-40.63
(max or min)**	-11.38	-19.82	-27.83	-27.68	-23.79	-23.38	-15.75	-15.08	-14.36	-9.33	-1.66	-38.85
Date	1/29	2/25										
Recommendation	BUY	BUY										
Target price (KRW)	230000	270000										
Gap* (average)	-30.12											
(max or min)**	-24.35											
LG Energy Solution												
Date	2024/1/26	6/20	7/8	7/25	9/11	10/10	2025/1/10	3/21	5/19	7/25	10/31	12/18
Recommendation	BUY	BUY	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	BUY	HOLD	HOLD
Target price (KRW)	510000	470000	410000	370000	390000	430000	410000	380000	335000	440000	550000	480000
Gap* (average)	-25.18	-27.55	-15.22	-3.89	5.00	-9.14	-14.77	-12.67	-10.19	-12.74	-19.50	-21.65
(max or min)**	-17.75	-23.62	-8.54	11.35	0.38	-0.70	-5.98	-5.26	9.85	16.82	-11.91	-18.65
Date	2026/1/12	1/29										
Recommendation	HOLD	BUY										
Target price (KRW)	420000	510000										
Gap* (average)	-3.83											
(max or min)**	2.62											
Samsung SDI												
Date	2024/1/30	6/20	7/8	7/30	2025/1/2	1/24	3/21	4/28	6/11	8/1	9/26	10/28
Recommendation	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY	BUY
Target price (KRW)	597210	538468	489517	450355	352452	313291	293710	270000	220000	240000	250000	350000
Gap* (average)	-32.48	-32.88	-28.53	-31.99	-33.69	-32.91	-37.37	-37.02	-18.49	-12.36	-5.25	-11.76
(max or min)**	-20.33	-29.27	-22.10	-15.76	-30.69	-22.81	-30.50	-32.00	-6.36	-6.25	17.20	-3.57
Date	12/19	2026/2/3										
Recommendation	BUY	BUY										
Target price (KRW)	320000	420000										
Gap* (average)	-2.27											
(max or min)**	23.91											

Note: * [(average, maximum, or minimum share price over duration of target price minus target price) / target price] x 100%
** Maximum/minimum share price if new target is higher/lower than market close on the business day prior to target price change

Samsung Securities uses the following investment ratings*

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BUY	Expected to increase in value by 15% or more within 12 months and is highly attractive within sector
HOLD	Expected to increase/decrease in value by less than 15% within 12 months
SELL	Expected to decrease in value by 15% or more within 12 months

Industry

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UNDERWEIGHT	Expected to underperform market by 5% or more within 12 months

* Note: Effective Jul 27, 2023, BUY, HOLD, and SELL criteria are based on expectations of share-price moves of 15% or more within 12 months

Percentage of ratings in 12 months prior to 2025.12.31

BUY(85.8%)·HOLD(14.2%)·SELL(0%)

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