

AI/data centers' global power surge

Five drivers of upside/downside and the Reliability investment tailwind



We continue to see data center power demand adding the equivalent of a top 10 power-consuming country by the end of the decade. As data center and broader electricity demand growth accelerates, we see five potential constraints that could drive upside or downside risk to our updated base case of more than 160% global data center power demand growth in 2030 vs. 2023 levels:

- Data center capacity additions
- Power capacity/infrastructure
- 'Green' data centers: Low-carbon lead times/incentives/cost
- Data center power intensity efficiency gains
- AI results/innovations

In this report, we provide our latest analysis of expected growth in data center capacity, power infrastructure and Green Reliability Premiums, frame upside/downside implications from customer responses to chip efficiency gains and highlight key metrics to consider the ultimate breadth of AI's potential innovations that could advance Sustainable Development Goals.

Reiterate Reliability as a multi-year investment theme

We reiterate our bullish view on the [multi-year theme of Reliability and resulting Green Capex](#) driven by the confluence of: (a) power demand growth accelerating to levels not seen in the US and Europe in more than 20 years; (b) Big Tech's long-term low-carbon prioritization/ability to support Green Reliability Premiums; and (c) Adaptation needs to mitigate risk of aging infrastructure, wider summer/winter temperatures and extreme weather events. We remain bullish on stocks of companies in the data center power supply chain that will see investment tailwinds to advance Reliability of power and water.

Brian Singer, CFA

+1 (212) 902-8259
brian.singer@gs.com
Goldman Sachs & Co. LLC

Brendan Corbett

+1(415)249-7440
brendan.corbett@gs.com
Goldman Sachs & Co. LLC

Carly Davenport

+1(212)357-1914
carly.davenport@gs.com
Goldman Sachs & Co. LLC

Alberto Gandolfi

+39(02)8022-0157
alberto.gandolfi@gs.com
Goldman Sachs Bank Europe SE -
Milan branch

James Schneider, Ph.D.

+1(212)357-2929
jim.schneider@gs.com
Goldman Sachs & Co. LLC

Goldman Sachs does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision. For Reg AC certification and other important disclosures, see the Disclosure Appendix, or go to www.gs.com/research/hedge.html. Analysts employed by non-US affiliates are not registered/qualified as research analysts with FINRA in the U.S.



Contributing Authors

Brian Singer, CFA

+1 (212) 902-8259
brian.singer@gs.com
Goldman Sachs & Co. LLC

Eric Sheridan

+1 (917) 343-8683
eric.sheridan@gs.com
Goldman Sachs & Co. LLC

Grace Chen

+44 20 7774-5119
grace.j.chen@gs.com
Goldman Sachs International

Brendan Corbett

+1(415)249-7440
brendan.corbett@gs.com
Goldman Sachs & Co. LLC

Kash Rangan

+1(415)249-7318
kash.rangan@gs.com
Goldman Sachs & Co. LLC

Xavier Zhang

+852 2978-6681
xavier.zhang@gs.com
Goldman Sachs (Asia) L.L.C.

Carly Davenport

+1 (212) 357-1914
carly.davenport@gs.com
Goldman Sachs & Co. LLC

Toshiya Hari

+1(646)446-1759
toshiya.hari@gs.com
Goldman Sachs & Co. LLC

Joshua M. Frantz, CFA

+1(917)343-4384
joshua.frantz@gs.com
Goldman Sachs & Co. LLC

Alberto Gandolfi

+39(02)8022-0157
alberto.gandolfi@gs.com
Goldman Sachs Bank Europe
SE - Milan branch

Derek R. Bingham

+1(415)249-7435
derek.bingham@gs.com
Goldman Sachs & Co. LLC

Michael Smith

+1 (212) 357-2136
michael.s.smith@gs.com
Goldman Sachs & Co. LLC

James Schneider, Ph.D.

+1(212)357-2929
jim.schneider@gs.com
Goldman Sachs & Co. LLC

Evan Tylanda, CFA

+44(20)7774-1153 |
evan.tylanda@gs.com
Goldman Sachs International

John Miller

+1(646)446-0292
john.y.miller@gs.com
Goldman Sachs & Co. LLC

Brian Lee, CFA

+1(917)343-3110
brian.k.lee@gs.com
Goldman Sachs & Co. LLC

Emma Jones

+61(2)9320-1041
emma.jones@gs.com
Goldman Sachs Australia Pty Ltd

Tyler Bisset, CFA

+1 212 357-5510
tyler.bisset@gs.com
Goldman Sachs & Co. LLC

Neil Mehta

+1(212)357-4042
neil.mehta@gs.com
Goldman Sachs & Co. LLC

Madeline Meyer

+44(20)7774-4593
madeline.r.meyer@gs.com
Goldman Sachs International

Jaskaran Jaiya

+1 332 245-7709
jaskaran.jaiya@gs.com
Goldman Sachs India SPL

Adam Wijaya

+1(212)357-1575
adam.wijaya@gs.com
Goldman Sachs & Co. LLC

Varsha Venugopal

+1(415)393-7554
varsha.venugopal@gs.com
Goldman Sachs & Co. LLC

John Mackay

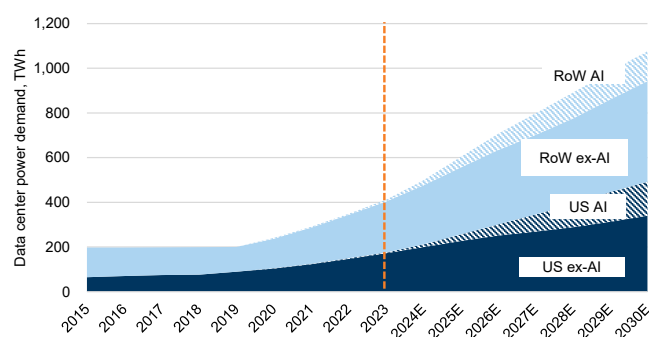
+1(212)357-5379
john.mackay@gs.com
Goldman Sachs & Co. LLC

Five key drivers of upside/downside risk to our data center power demand outlook

- 1. Will AI server shipments be constrained by data center capacity?** Our analysis led by our Telecom Infrastructure team suggests a tightening market for data center real estate in the coming years but sufficient capacity for our base case expectations for power demand.
- 2. Will data center capacity be constrained by power infrastructure?** Our analysis led by our Utilities team suggests a combination of new generation additions and greater utilization of existing capacity will be sufficient to meet data center power demand with transmission/interconnection the greatest risk.
- 3. Will power infrastructure be constrained by low-carbon optionality/cost?** We believe Big Tech will continue to take an all-in approach to data center power sourcing, with continued willingness to pay Green Reliability Premiums while at the same time prioritizing time-to-market.
- 4. Will new-gen AI chips drive lower or higher aggregate power demand?** We assume Big Tech cash flow/budgets will be the key constraint, leaving upside risk if there are no constraints and downside risk if compute speed demand is finite.
- 5. Will AI server demand be constrained by AI results/innovations?** This will remain key to watch, particularly from a Sustainability perspective whether we see accelerated efficiency solutions in the health care, energy, agriculture and education sectors.

Exhibit 1: After being flat for 2015-19, we have seen data center power demand accelerate in 2020-23 and expect a >160% increase through the rest of the decade

Global data center electricity consumption, TWh; includes AI and excludes cryptocurrency



Source: Cisco, IEA, Goldman Sachs Global Investment Research, Masanet et al. (2020)

AI/data center power demand key driver of Reliability as multi-year investment theme

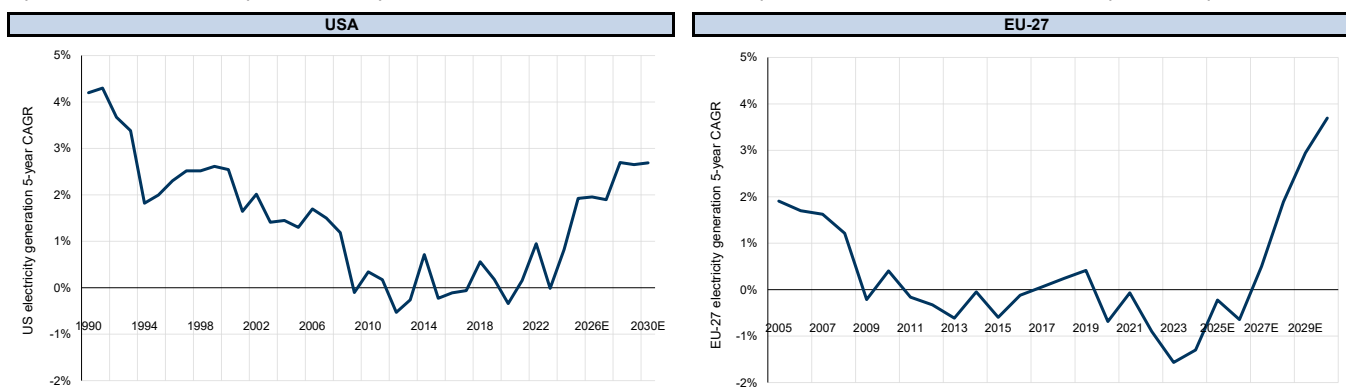
We believe the confluence of rising power demand, historical underinvestment in infrastructure, AI investment and rising temperatures/more extreme weather events will continue to drive rising tailwinds for investments in Reliability, i.e., products that help maintain resiliency, particularly for water and power. We continue to see opportunity for investment in stocks levered to the theme globally, which we believe will be a priority for both policymakers and corporate/residential consumers.

Infrastructure replacement and hardening both necessitate Reliability investment.

Our meetings with corporates, regulators and policymakers in 2024 and at our 2025 Global Energy, Utilities and Clean Tech Conference indicated increased recognition of the need for grid/water infrastructure hardening and modernization. This is due to both underinvestment in recent years as well as a wider range of expected temperatures between summer and winter. We believe both policymakers and regulators will look to reduce risk of outages and as such prioritize measures that would improve Reliability and Resiliency. This multi-stakeholder focus on Reliability combined with Big Tech's support for low-carbon technologies should provide tailwinds for exposed stocks at the confluence of Adaptation, Decarbonization and AI/Data Center Power Demand that also show strong financial fundamentals, in our view.

Exhibit 2: Generational Growth: Our Utilities Research teams expect USA and EU-27 electricity consumption accelerating through the end of the decade to levels not seen in 20+ years

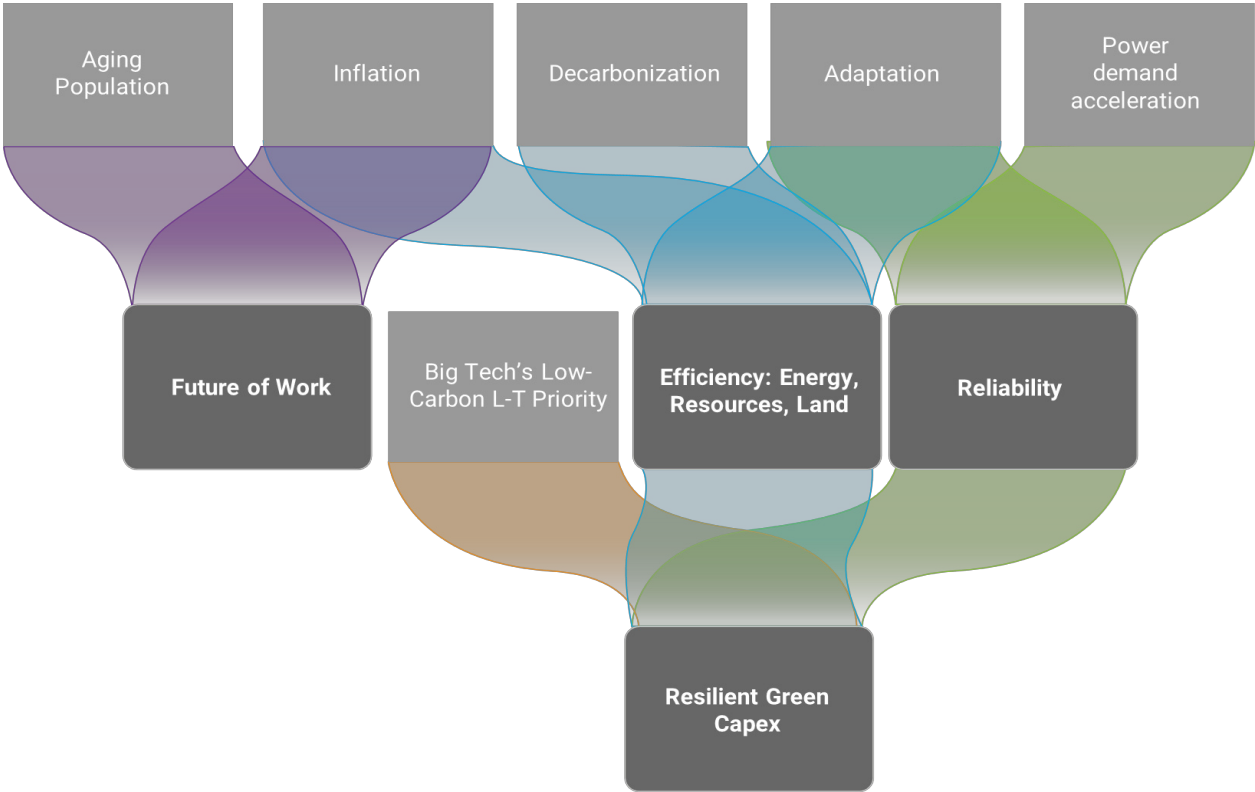
5-yr CAGR for US and European electricity demand; forecasts from our US and Europe Utilities Research teams from our April 2024 reports



Source: EIA, EMBER, Goldman Sachs Global Investment Research

Exhibit 3: The confluence of power demand acceleration with Adaptation to aging infrastructure, extreme weather events and wider/higher temperature ranges is helping to drive significant investment towards energy/water Reliability

Where we see the confluence of various macro trends into Sustainability-related mega-themes we believe will drive investment tailwinds



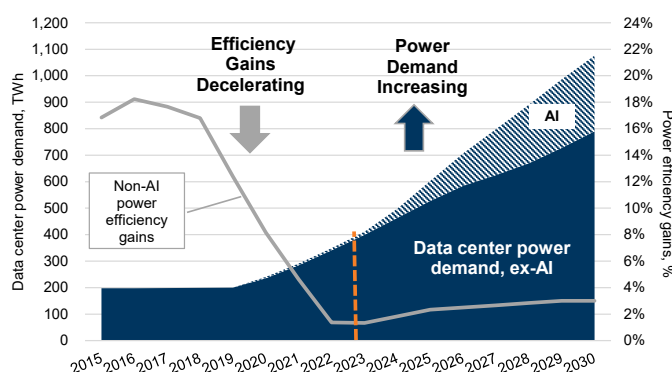
Source: Goldman Sachs Global Investment Research

Latest outlook on data center power demand and emissions

We believe data demand — driven in part by AI and in part from deceleration in non-AI efficiency gains — will catalyze generational growth in global power demand. Our analysis suggests a 160%-165% increase in data center power demand by 2030 vs. 2023 levels. In the US, this implies that data centers will contribute a ~1% CAGR to overall US power demand; our Utilities team in its April 2024 report expects overall US power demand CAGR of 2.4% through 2030. We see data centers adding a 0.3% CAGR to overall global power demand. Our base case implies data center power demand moves from 1%-2% of overall global power demand to 3%-4% by 2030. In the US, the pace of mix increase is even greater, more than doubling by 2030 from 4% in 2023. If global data center growth in 2030 vs. 2023 levels were its own country, it would be a top 10 global power consumer.

Exhibit 4: As efficiency gains have decelerated, data demand growth is driving a surge in datacenter power use, with AI acceleration expected to continue

Datacenter electricity consumption, TWh (LHS) and power efficiency gains ex-AI, % (RHS)



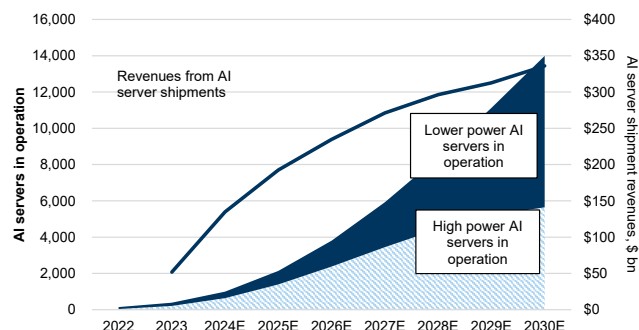
Source: Masanet et al. (2020), IEA, Cisco, Goldman Sachs Global Investment Research

In our updated estimates, we reflect:

- Greater contribution from AI driven by a greater weighting on our server shipment supply-based analysis.
- Narrower contribution ex-AI based on some of the additional demand we assume from AI to cannibalize a portion of what would otherwise be non-AI demand. We assume about 12% annual growth in ex-AI workload by decade-end, decelerating from a historical 20%-25%.
- Greater global weighting of power demand in the US based on recent reporting of US historicals for data center power use by a study commissioned by the US DOE.
- Integration of our Telecom Infrastructure team's outlook for data center capacity buildout. We look at the expected utilization of data center capacity after adjusting for power usage effectiveness (PUE) and our Telecom Infrastructure team's outlook for data center vacancy rates.

Exhibit 5: We expect AI servers in operation will grow sharply through 2030 even as revenues from AI server shipments decelerate in 2027-30

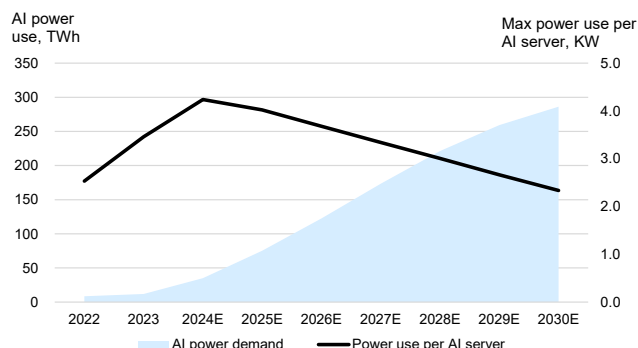
AI servers in operation implied by our global TMT team forecasts and implied annual AI server revenues



Source: Goldman Sachs Global Investment Research

Exhibit 6: We see AI power demand growing rapidly even as power use per AI server falls later in the decade due to mix shift and expected efficiencies

AI power use, TWh (LHS); max power use per AI server, KW (RHS)

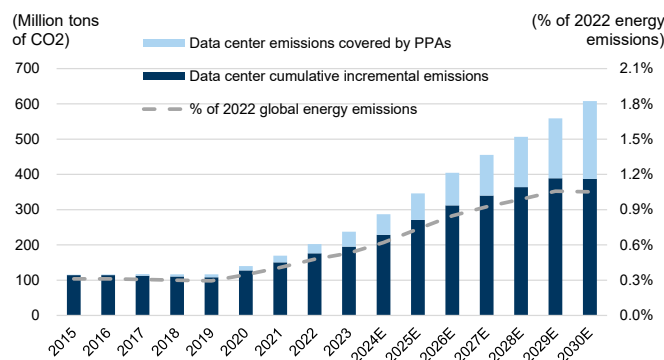


Source: Goldman Sachs Global Investment Research

Emissions outlook: We continue to assume about 40% of data center power growth is sourced by renewables, much of which we expect to come from power purchase agreements. We assume modest additional nuclear capacity online globally by the end of the decade to support data center demand, but we expect to see acceleration of added capacity in the 2030s. We continue to see rising carbon dioxide emissions from data centers by decade-end — about 100% vs. 2023 levels.

Exhibit 7: We see data center emissions doubling in 2030 vs. 2023 levels, net of impact of power purchase agreements (PPAs) from technology companies

Carbon dioxide emissions in millions of tons (LHS); percent of 2022 energy emissions (RHS)



Source: IEA, Goldman Sachs Global Investment Research

Key learnings from the January 6-8 Global Energy, Utilities and Clean Tech Conference

Bullish on appetite for data center growth. Takeaways from our Global Energy, Utilities and Clean Tech Conference suggest pent-up interest from data center customers and conservatism by utilities in base-casing data center power demand growth into longer-term growth guidance. Utilities highlighted much greater magnitude of generation demand being discussed with data center customers than managements are willing to base case. There appears to be mutual interest among utilities, regulators and hyperscalers in ensuring rising data center demand does not drive reliability or affordability issues to broader power customers. This is partly a driver of the conservative approach by utilities until contracts are signed that underpins investment towards further acceleration in power demand.

Energy companies at the conference highlighted diversity of drivers of the power surge. Utilities continue to highlight that AI is not the sole driver of power demand growth. Non-AI cloud-related demand continues to be strong, complemented by reshoring in the US and electrification globally. Our Utilities teams continue to expect Generational Growth in overall power demand — 5-year CAGRs of US and European power demand not seen in 20+ years.

Sourcing power in near, medium and longer term: Existing gas capacity, renewables, natural gas, nuclear. Commentary at the Global Energy, Utilities and Clean Tech Conference suggested that sourcing new power capacity not already in queue is easiest for renewables (particularly solar), given long lead times for combined natural gas turbines (2028+) and the very long lead time for nuclear generation. Utilities continued to highlight the relative cost competitiveness of renewables even as there is uncertainty on the sustainability of federal incentives. Overall, we expect greater weighting on flexing existing natural gas capacity and adding renewables (augmented with battery storage and natural gas peaking plants) in the near term, a pickup in natural gas combined cycle additions in the medium term and a rising focus on nuclear capacity additions for the 2030s.

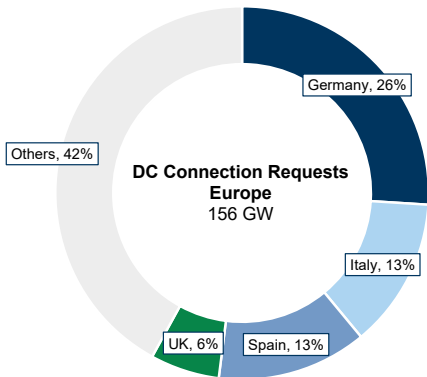
For additional details please also see our US Utilities team's takeaways report.

New survey of European utilities suggests European power demand set to inflect

Following 15 years of declining power demand (consumption in Germany is equivalent to 1990, the year of reunification), the strong increase in connection requests (Data Centers, manufacturing, charging points, etc.) should lead to an inflection in power demand on a 2-3 year basis, bringing major tailwinds to power utilities. Our European Utilities team assumes 1%-2% annual increases in 2025-27, gradually rising to +3% by later in the decade. Our European Utilities team surveyed power utilities in our coverage, concluding that the number of connection requests received by power distribution operators (a leading indicator of future demand) has risen exponentially, mostly driven by Data Centers (DC). We estimate a DC pipeline of c.170 GW, equivalent to about 1/3 of European power consumption. Although only a portion may be

converted, we estimate a potential 10%-15% boost to power demand over the coming 10-15 years.

Exhibit 8: Our European Utilities team’s recent survey suggests covered European Utilities have received more than 150 GW of connection requests from data centers
European data center connection requests split by geographic region (GW, %)



Source: Company data, Goldman Sachs Global Investment Research

For additional details please also see our European Utilities team’s report, Data Centers and AI: the time is now for Europe.

Will new-gen AI chips drive lower or higher aggregate power demand?

Data center power demand was flattish in 2015-19 even as workload demand nearly tripled.

This largely results from efficiency gains as: (a) data center workload has shifted from higher energy-intensity traditional data centers to more efficient cloud and hyperscale data centers; and (b) cloud/hyperscale data centers have separately become more energy efficient, which we attribute in part to innovation and hyperscale/cloud consolidation. But starting in 2020, efficiency gains have significantly decelerated, which we attribute to more limited than prior period opportunities for mix shift away from traditional centers and cloud/hyperscale consolidation.

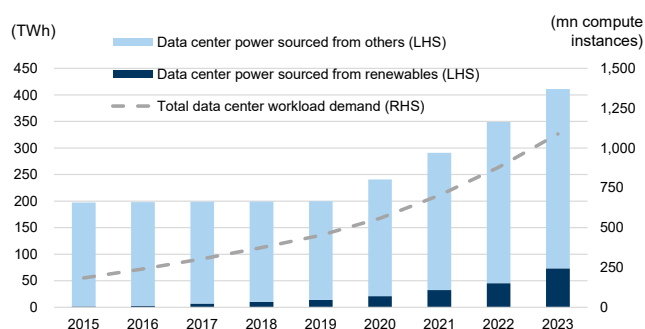
We continue to expect innovations that can drive efficiency gains that lower power intensity.

We have already see new generations of AI servers that increase computing speed at a much greater pace than max power consumption, thus representing meaningful reductions in power intensity. However, as demand for AI training grows in the medium term and for inference longer term, we see demand growth well exceeding the efficiency improvements that are leading to meaningful reductions in high power AI server power intensity.

We assume non-AI server power efficiency gains — which averaged around 15% annually in 2015-19 but decelerated to around low single digits in 2020-22 — **will remain relatively low**. We do model a slight re-acceleration to an average of 3% in our base case in 2024-30 as industry discussions suggest continued efforts towards innovation efficiencies, especially around the power intensity given the prospects for significant power needs ahead.

Exhibit 9: Data center workload demand nearly tripled between 2015-2019 but electricity consumption from data centers was flat

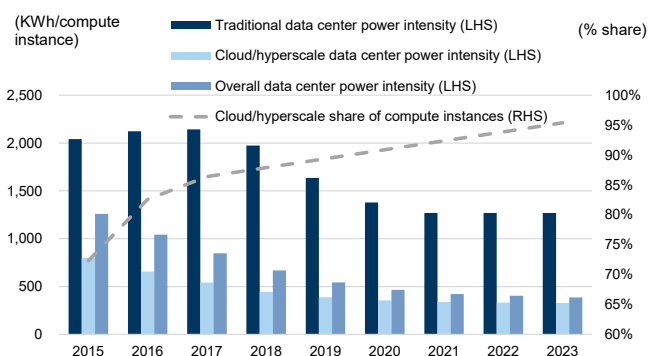
Data center workload demand (RHS) in million compute instances; data center power demand (LHS) in TWh



Source: Masanet et al. (2020), Cisco, IEA, Goldman Sachs Global Investment Research

Exhibit 10: Data center efficiency gains and the shift to cloud/hyperscale have been critical drivers of the moderate increase in data center power demand, but decelerating efficiency gains have helped to drive a pickup in power demand from data centers in recent years

Data center power intensity (LHS) in KWh per compute instance; share of cloud/hyperscale data centers (RHS) as % of workload



Source: Masanet et al. (2020), Cisco, IEA, Goldman Sachs Global Investment Research

We see greater potential for efficiency gains from AI servers and assume 8% annualized gains for high-power servers through the end of the decade. We assume 5%-8% annual power efficiency gains per year to reflect expected future server

innovation — relative to demand-based energy intensities where saw higher annual efficiencies early in life cycle, we assume slower pace in a supply-based approach to reflect timing of adoption.

Will AI chip power intensity reduction lead to higher power consumption or lower power consumption?

We have seen new AI innovations increase both computing speed and max power consumption per server but increase computing speed at a much greater pace, representing meaningful reduction in power intensity. As demand for GPUs grows, there is still notable company-projected intensity reductions. As an example of how innovations have reduced power intensity per server but increased overall power per server:

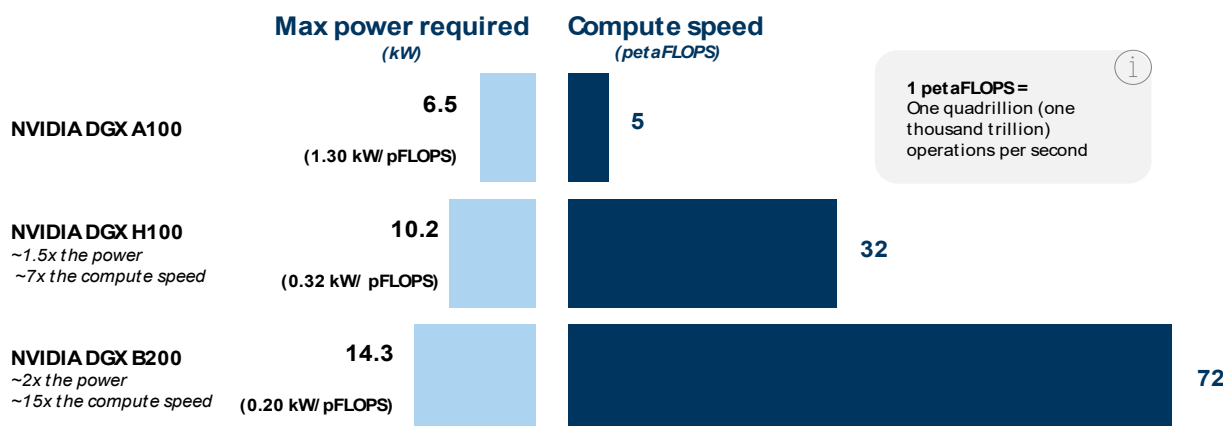
- The NVIDIA DGX A100 system is listed to net 5 petaFLOPS and consuming 6.5 kW max, or 1.30 kW per pFLOPS.
- The more recent NVIDIA DGX H100 system is listed at 32 petaFLOPS and consuming 10.2 kW max, or 0.32 kW per pFLOPS.
- The new generation NVIDIA DGX B200 system using the new Blackwell chips is listed to net 72 petaFLOPS (training) and consuming 14.3 kW max, or 0.20 kW per pFLOPS.

Our global TMT team expects AI server units shipped to grow at a 76% CAGR in 2024-26; whether demand, budgets or neither is the constraint to growth is critical for energy use forecasting. A key question impacting compute demand is whether that demand is pent-up (i.e., available new servers will be bought regardless of budget), not pent-up and constrained by demand itself, or constrained by customer budgets. In other words, will customers buy equal amounts of the more powerful servers as they would the less powerful ones? If in a scenario in which a customer initially desires to buy 10 AI servers, and a new generation is announced with 10x the compute speed for 5x the price, will the customer:

1. Buy the same number of servers (10), spend more money (5x) and substantially increase its compute speed as a result of the innovation (10x)? This would represent no constraints (i.e., unlimited budgets, so demand dictated by available supply).
2. Buy 1/10 the number of servers (1), maintaining the same level of compute power as prior to the innovation and spending less money (0.5x)? This would represent demand as the constraint.
3. Buy 1/5 the number of servers (2), thereby maintaining budget allocated for server purchases but getting a greater compute speed (2x)? This would represent budget as the constraint.

Exhibit 11: We have seen new AI innovations increase max power consumption per server but increase computing speed per server by an even greater level, representing a meaningful reduction in power intensity

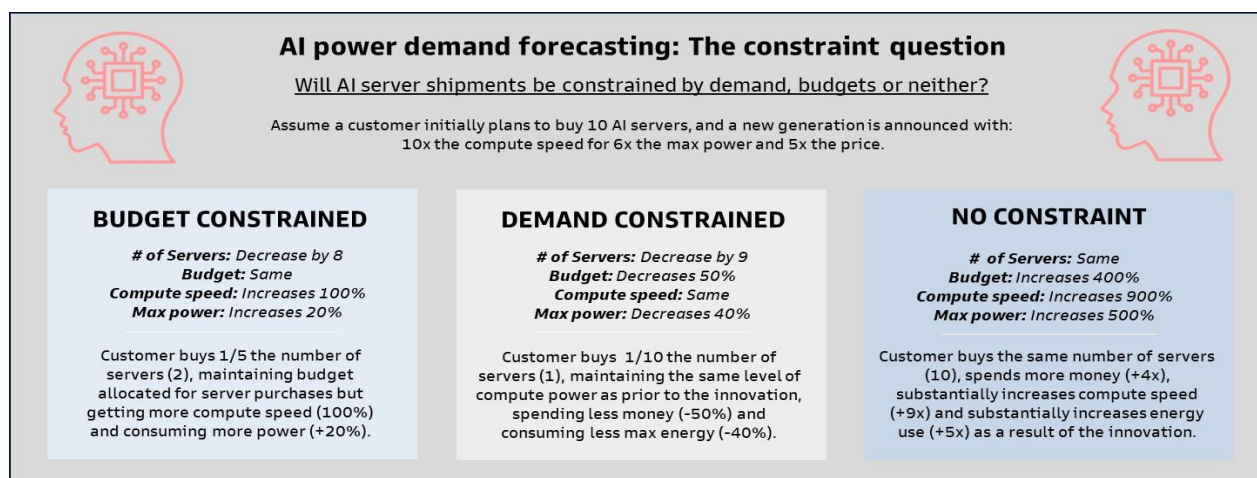
Recent evolution of NVIDIA server system specifications is indicative of increasing max power per server but with lower power intensity relative to computing speed (for training)



Source: NVIDIA, Goldman Sachs Global Investment Research

Exhibit 12: Extent of pent-up demand for AI server supply and voraciousness of technology capex budgets will be critical for pace of AI power consumption

Indicative scenario analysis of how demand vs. budget constraints could impact AI compute speed and power use



Assumes power generation, transmission and interconnection are not a constraint for indicative purposes

Source: Goldman Sachs Global Investment Research

Confidence in the above question is key to whether forecasting methodology should be weighted towards server-based (requiring nuance given varied and dynamic power consumption intensity and compute intensity) vs. demand based (forecasting compute power and power intensity per unit of compute power). New generation AI servers consume more power and provide more compute speed, even as the power intensity has fallen meaningfully. There could be meaningful upside to our base case if appetite for purchase and utilization of servers is unconstrained. There could be downside to our base case if power efficiency is higher than expected or if power/compute speed efficiencies lead to fewer servers purchased than expected. We note corporate optimism that AI innovations can drive significant efficiencies to ultimately mitigate power demand and emissions growth. **Overall, it does not appear from our recent**

corporate dialogues that efficiency gains are leading to a reduced need for data center infrastructure and rack space. Rather, we think the risk is to the unconstrained side until there is greater clarity on the impact/demand of AI solutions.

Will AI server shipments be constrained by data center capacity?

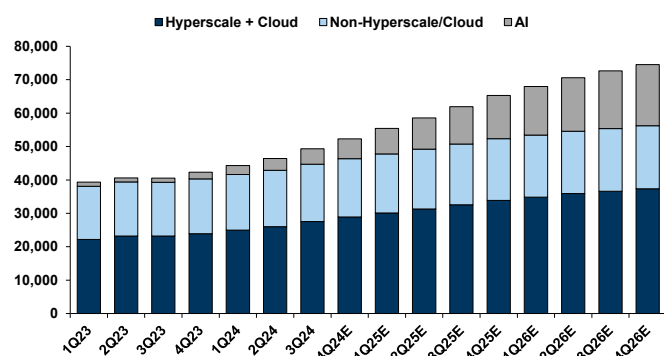
New analysis from our Telecom Infrastructure team implies a tight market for data centers (DC) through 2026, then potential for modest loosening thereafter. Part of this growth will be fueled by a substantial shift in workload mix due to the rapid expansion of Generative AI, which our Telecom Infrastructure team expects to grow from 9% of workloads (7.7 GW) in 1Q25 to 31% (35 GW) by 4Q2030. Overall DC workload demand is estimated to be 110 GW by 2030. Nonetheless, our Telecom Infrastructure team expects DC supply will meet these needs and that by the end of 2030 there will be 122 GW of capacity online, implying a 13% 6-year CAGR. DC supply mix will skew even further to cloud workloads in 2030 (70% vs ~60% today) given then ongoing shift to higher compute workloads.

The sustainability of AI workload demand growth and cannibalization of legacy DC workloads remain some of the largest variables impacting overall data center power demand estimates. Our Telecom Infrastructure team estimates these factors can drive as much as 25 GW of demand variance vs. their base case, even by the end of 2027. The DC operator landscape outlook appears more clear as our Telecom Infrastructure team has highlighted that seven of the top ten companies with the most operational UPS power are also in the top ten companies with the most planned UPS power coming online over the next five years. In effect, the companies which currently lead the datacenter market are already invested heavily in maintaining their lead.

For more details, please see our Telecom Infrastructure team's January 2025 report, *We see a tightening market through 2026*.

Exhibit 13: AI will see the largest share of DC demand growth over the next two years

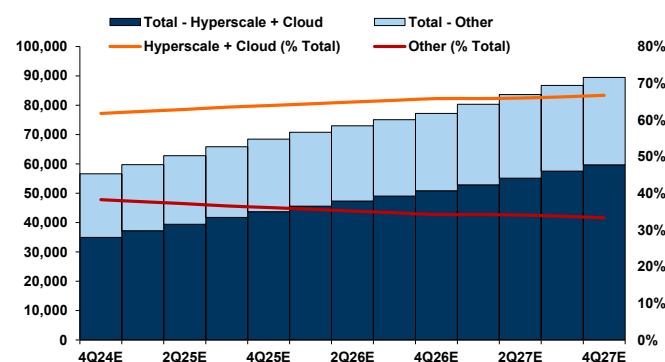
GS US DC baseline demand forecast - hyperscale + cloud, traditional, AI



Source: 451, Goldman Sachs Global Investment Research

Exhibit 14: Cloud compute will continue to gain share of overall DC workload capacity

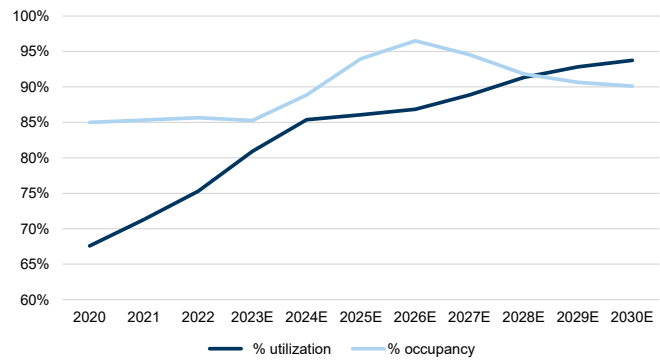
Forecast datacenter supply by workload type, 2024-30



Source: Goldman Sachs Global Investment Research

Overall, this suggests that data center capacity growth we expect can accommodate our base case for power demand outlook. We incorporate power usage effectiveness (PUE) estimates based on US DOE historical data/outlook and apply our Telecom Infrastructure team's views on data center vacancy rates. Based on this, our power demand estimates imply a rising utilization of what we expect will be contracted capacity for data centers — to around 90%-95% by decade end globally.

Exhibit 15: Our power demand base case implies rising utilization of contracted data center capacity based on our Telecom Infrastructure team’s outlook for data center capacity growth and vacancy rates
Implied capacity utilization and occupancy rates of global contracted data center capacity



Source: 451, US DOE, Goldman Sachs Global Investment Research

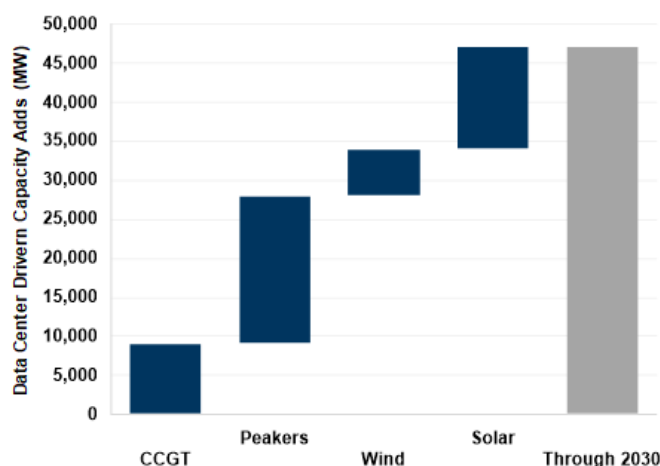
Will data center capacity be constrained by power infrastructure?

We continue to expect an all-in approach in sourcing power demand. Our conversations with renewable developers indicated that wind and solar could serve roughly 80% of a data center's power demand if paired with storage, but some sort of baseload generation is needed to meet the 24/7 demand. Nuclear is the preferred option to step in as the baseload generation, but given both the scarcity of existing unregulated nuclear plants and the difficulty of building a new one, we view natural gas as the more realistic option for most data centers. This creates a potential bottleneck for data centers, with many utilities estimating that you would have to wait until 2029 to receive a large gas turbine if you entered the queue now, shifting the focus to smaller scale natural gas peakers.

Our US Utilities team sees almost 50 GW of incremental US generation capacity likely through 2030. In our original note discussing the rising power demand from data centers, we laid out our framework for identifying how much of the power demand from data centers needs to be met with incremental capacity vs existing capacity. Our methodology remains the same, with the conclusion that roughly 50% of data center demand needing to be met with new capacity, and that the generation capacity that is added will likely be 40% natural gas CCGTs, 20% natural gas peakers, 25% solar, and 15% wind. Applying this to our demand estimates, it implies roughly 47 GWs of incremental generation capacity through 2030.

Exhibit 16: We forecast roughly 47 GWs of incremental capacity related to data center power demand, with the bulk being natural gas capacity

Overall net capacity additions through 2030 by source, MW



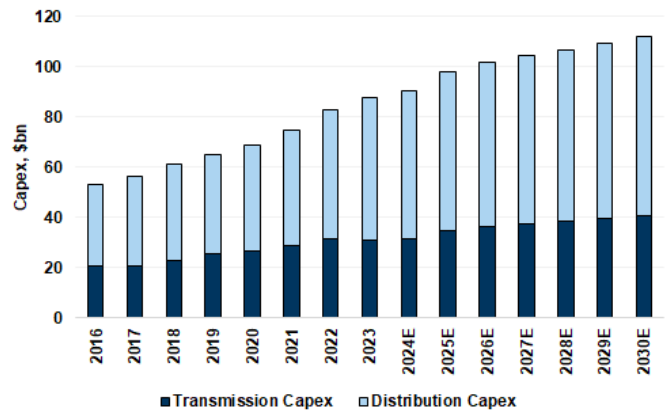
Source: Goldman Sachs Global Investment Research

In the US, we expect more than \$700 bn of grid investment through 2030 in the US. The grid will also require significant investment, not solely related to data centers but the rise in power demand does further accelerate the need for grid upgrades and grid expansion. Our US Utilities team's estimates imply roughly \$720 bn of grid spend through 2030, with the bulk of the spend focused on distribution. However, we expect transmission spend to grow at a slightly faster rate than distribution as a significant

amount of high voltage transmission is needed to supply regions where data centers are being built out with sufficient power to distribute. These transmission projects can take several years to permit, and then several more to build out, creating another potential bottleneck for data center growth if the regions are not proactive about this given the lead time.

Exhibit 17: Our US Utilities team’s forecasts imply \$720 bn of grid capex through 2030, with transmission growing at a slightly faster rate than distribution

Grid capex, \$ bn



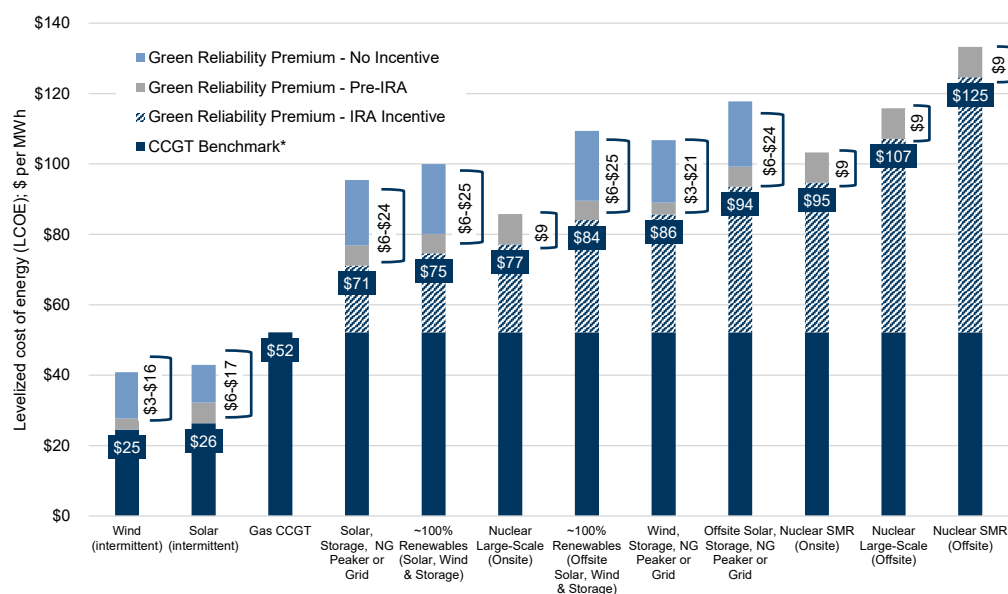
Source: Company data, EEI, Goldman Sachs Global Investment Research

Will power infrastructure be constrained by low-carbon optionality/cost?

While we do not see a Green Premium for intermittent power in the US, our analysis suggests a Green Reliability Premium for low-carbon round-the-clock power solutions vs natural gas combined cycle in the US. We expect the Green Reliability Premium to be greater in the US vs. other developed markets in part due to lower-cost natural gas in the US, even before taking into account country-level carbon prices in some other markets.

Exhibit 18: We see a Green Reliability Premium to source round-the-clock low-carbon solutions, even as intermittent solar/wind have lower levelized energy cost vs. combined cycle natural gas in the US; renewables and nuclear options would see higher levelized costs of energy if IRA incentives are diluted/ended












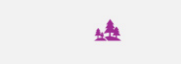











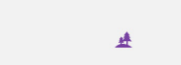








Levelized cost of energy of various fuel & technology combinations to power new data centers, inclusive of assumed transmission and distribution (except intermittent solar/wind); call out boxes show LCOE under current IRA incentives; bracketed ranges reflect incremental LCOE in scenarios of pre-IRA/no-IRA incentives



*Wind and Solar (Intermittent) assume no transmission; Wind is assumed to be offsite, solar/gas/nuclear is assumed onsite unless noted; ~100% renewables assumes ~5% power sourced from natural gas peakers or grid due to day-to-day intermittency variability

Source: Goldman Sachs Global Investment Research

Exhibit 19: Relative tradeoffs of various technologies which can all provide capacity for new data center-driven power demand

		Capacity Factor	Emissions Intensity	Land Footprint Intensity	Advantages / Challenges
	Solar				Advantages: carbon footprint Challenges: land requirements, intermittent power
	Onshore Wind				Advantages: carbon footprint Challenges: land requirements, intermittent power
	Nuclear Large Scale				Advantages: small land footprint, reliable, carbon footprint Challenges: waste, labor, enriched uranium supply, lead time
	Nuclear SMR				Advantages: small land footprint, reliable, carbon footprint Challenges: waste, labor, enriched uranium supply, lead time
	Battery Storage				Advantages: enables greater clean energy reliability Challenges: capacity limits
	Natural Gas CCGT				Advantages: reliable, small land footprint Challenges: carbon footprint
	Natural Gas Peaker				Advantages: reliable, small land footprint Challenges: carbon footprint; less carbon efficient than CCGT
	Grid (natural gas)				Advantages: reliable, land footprint Challenges: carbon footprint, interconnection wait times

Source: Goldman Sachs Global Investment Research

We expect hyperscalers will remain committed to pursuing low-carbon power solutions based on our analysis of Green Reliability Premiums, industry discussions and recent contracts. Our analysis — updated for our latest data center power demand outlook and analyst expectations for hyperscaler EBITDA — suggests that the capital requirements for Green Reliability Premiums to source data center power demand to be modest relative to the EBITDA (2%-3%) and corporate returns of key hyperscalers (1 percentage point impact vs. 32% average baseline estimates; median across all sectors is about 12%-13%).

Exhibit 20: The Green Reliability Premium in the US, conservatively applied to global data center power demand growth in 2030 vs. 2023, is modest in comparison to hyperscalers' EBITDA and corporate returns
 US Green Reliability Premium applied to global data center power demand growth in 2030 vs. 2023 relative to 2026E and 2030E EBITDA and 2026E cash return on cash invested

	Average
Baseline levelized cost of energy, US, \$/MWh	\$52
Green Reliable levelized cost of energy average, US, \$/MWh	\$91
Average US Green Reliability Premium, \$/MWh	\$39
Global data center power demand (TWh)	
2023	411
2030E	1,076
Increase, 2030E vs. 2023	665
Required 2030E industry outlay if applying US Green Reliability Premium, \$ bn	\$26
Hyperscaler total company EBITDA, 2026E, \$ bn	\$764
% of hyperscaler 2026E EBITDA	3%
Hyperscaler 2030E EBITDA (at 10% CAGR vs. 2026E)	\$1,119
% of hyperscaler 2030E EBITDA	2%
Hyperscaler average CROCI, 2026E	32%
CROCI impact from industry 2030E Green Reliability Premium	-1%
Adj. CROCI if hyperscalers cover industry Green Reliability Premium	31%

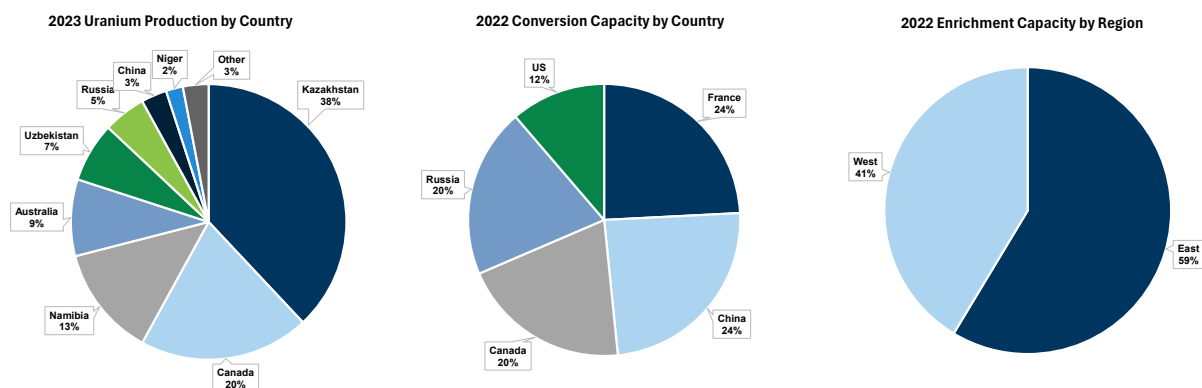
Baseline source is combined cycle natural gas; Green Reliable sources are large nuclear, SMR nuclear, solar + storage + gas peaker, solar + offsite wind + storage. Please see the section later in the report for more details on our global data center power demand forecasts.

Source: Goldman Sachs Global Investment Research

We are in the early stages of nuclear renaissance in US and globally. Recent contracts for small modular reactors (SMRs) and larger-scale nuclear to source data center power demand growth, combined with increased country-level embrace of nuclear power appears poised to drive a significant rampup of investment in the next 5 years and power in the 2030s. Lowering the capital costs of SMRs and accommodating nuclear expansion while minimizing impact to reliability/pricing elsewhere in the grid will be key for long-term competitiveness, in our view.

Confidence in enriched uranium supply is a key challenge. Our Energy equity research team highlighted the three processes needed to supply nuclear plant feedstock: Uranium production, Uranium Conversion and Uranium Enrichment. Each is not done in the same place so could also require transportation. As shown in the below exhibit, Europe and the Americas source about 30% of uranium production, hold 56% of uranium conversion capacity, and hold 41% of uranium enrichment capacity. The key participants outside these countries are China/Russia/Kazakhstan, together representing about 46% of uranium supply, 44% of uranium conversion capacity and 59% of uranium enrichment capacity.

Exhibit 21: As momentum builds for nuclear capacity expansion, we expect greater focus on geographical exposure to Uranium — not just production but conversion and enrichment as well



Source: World Nuclear Association, UxC, Goldman Sachs Global Investment Research

We expect Big Tech's all-in approach to low-carbon technology deployment will continue, supportive of upside for Green Capex. Our analysis suggests less variability in levelized cost of energy among low-carbon power solutions such as large-scale nuclear and solar/wind/energy storage. We also expect continued hyperscaler support for carbon capture and carbon removal.

We expect natural gas-fired power use by data centers to rise with 60% of data center power demand from thermal sources (largely gas). Policy, technology and equipment lead times will likely help guide the split between combined cycle and peaker unit deployment.

Will AI server demand be constrained by AI results?

As Artificial Intelligence investment increases, we expect the investment community will look to measure the impact of AI solutions.

We see interest from Sustainable investors in understanding how AI can accelerate progress across a range of sustainability objectives, comparing corporate value creation relative to investment and social value of potential AI solutions relative to the social cost of emissions. In a previous report, **AI's Sustainable Solutions**, frames AI-related opportunities across key sectors, including Human Capital, Healthcare, Education, Agriculture, and Climate (Exhibit 22). We identify SDGs in which we see the greatest potential for AI-impact and propose metrics that may help investors assess the value of AI-benefits relative to the negative value caused by higher emissions and social risks.

Exhibit 22: We see AI accelerating progress across a range of Sustainable Development Goals (SDGs)

AI's Sustainability opportunities: Where to watch, SDG crossover, and how to measure



Healthcare: Accelerating discovery and care (SDG 3)

Metrics: Value for new drug/vaccine/therapeutic products linked to AI acceleration, value for efficiency gains for swifter drug development timeline to market, value for efficiency



Agriculture: Improving yields and reducing waste (SDG 2).

Metrics: Value of improved crop yield, value of reduced resource usage (water, fertilizer)



Climate Solutions: Optimization and efficiency in power generation and physical assets (SDG 7, 9).

Metrics: Value of linked power generation/utilization efficiency, value/level of reduction in emissions and emissions intensity



Human Capital: The opportunity and need for reskilling and upskilling (SDG 8).

Metrics: Economic productivity, value of employees re-skilled/re-purposed for different roles, value of certifications earned



Education: A step change in interactivity and personalization (SDG 4).

Metrics: Value of linked improvement to student test scores, value of linked enablement of certifications / degrees earned



Source: Goldman Sachs Global Investment Research

- **Healthcare: Accelerating discovery and care (SDG 3).** Massive amounts of healthcare data are produced every day from a range of diverse sources, providing a rich opportunity for the application of AI-based technologies to drive innovation across drug discovery & design, clinical trials, healthcare analytics, tools & diagnostics, and personalized care.
 - **Metrics:** Value for new drug/vaccine/therapeutic products linked to AI acceleration, value for efficiency gains for swifter drug development timeline to market, value for efficiency

- **Agriculture: Improving yields and reducing waste (SDG 2).** AI-enabled applications stand to improve agricultural outcomes all the way from enhanced insights into what to plant and when to improve logistics that reduce time-to-market for perishable goods. Precision agriculture — data driven approaches to farming (crops & livestock), is the broadest category where leveraging AI can help to improve yields and reduce waste. However, beyond the myriad of AI applications that fall under the precision ag umbrella, AI also stands to help improve agricultural supply chain safety, speed and transparency.
 - Metrics: Value of improved crop yield, value of reduced resource usage (water, fertilizer)
- **Climate Solutions: Optimization and efficiency in power generation and physical assets (SDG 7, 9).** AI holds promise for being a contributor in mitigating the impact of climate change in a wide range of applications, including renewable energy optimization (e.g., weather forecasting, operational scheduling, battery storage optimization); physical asset and power use optimization (e.g., dynamic heating/cooling, data center efficiency, manufacturing efficiencies); and climate modeling.
 - Metrics: Value of linked power generation/utilization efficiency, value/level of reduction in emissions and emissions intensity
- **Human Capital: The opportunity and need for reskilling and upskilling (SDG 8).** Increasing adoption of advanced technologies such as AI create a growing need for educational platforms that enable 'reskilling' and 'upskilling.' We also anticipate greater demand for human capital management tools that can help identify and match rapidly shifting worker competencies with organizational needs ('skills matching').
 - Metrics: Economic productivity, value of employees re-skilled/re-purposed for different roles, value of certifications earned
- **Education: A step change in interactivity and personalization (SDG 4).** AI is complementing e-learning effectiveness through leaps forward in personalization and interactivity. Software-based e-learning platforms can leverage AI to create cost-effective custom study sequences to fit an individual's needs, track progress, and enable self-directed learning, while AI-powered chatbots are making the future of interactivity a reality. Education is especially relevant in periods of technological acceleration in which workers must upskill, and job seekers must gain new skills.
 - Metrics: Value of linked improvement to student test scores, value of linked enablement of certifications / degrees earned

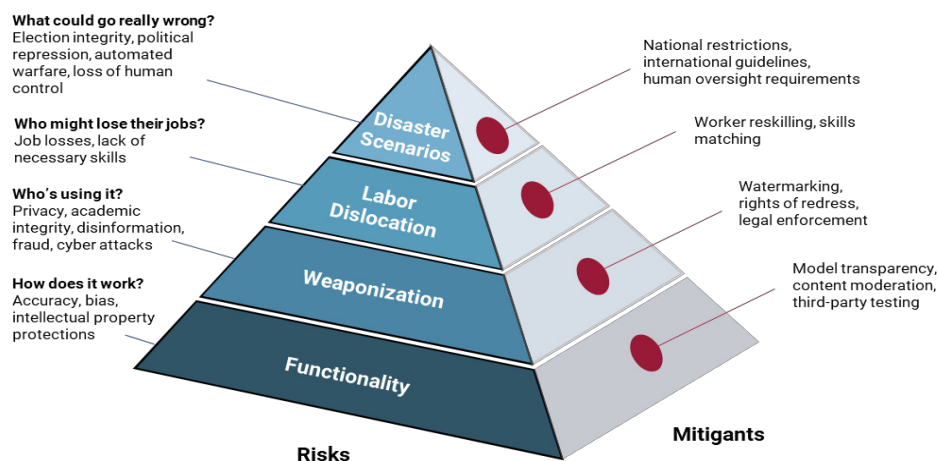
Key risks include both how AI models work and how they're likely to be used. The first order of concerns related to AI center on how the models work, including informational accuracy, transparency, potential algorithmic bias, and intellectual property protections. A next order of risk encompasses the 'weaponization' of AI models, and includes privacy, academic integrity, disinformation, fraud and cyber attacks. In each of these cases, AI enables potential threats to be propagated at new levels of speed, scale and customization. Potential impact on jobs is perhaps a less immediate, but

overarching concern. Our economists estimate that roughly two-thirds of current jobs are exposed to some degree of AI automation, and that generative AI could substitute up to one-fourth of current work. The highest order of potential impacts includes more extreme tail risks of societal destabilization and disaster scenarios, such as the manipulation of elections, political repression, or automated warfare ([Exhibit 23](#)).

What can be done to mitigate key risks? Creators of AI models will be pressed for transparency and accountability. This would include mechanisms to alert users to AI-generated content and authorship ('watermarking'), warning labels, and disclosures of how the systems are trained and how they work. Voluntary commitments from creators are already being made including the enablement of independent audits and third-party testing, while corporate users are putting into place frameworks for ethical use of AI. Regulations will also play a central role in mitigating AI risks. With the EU AI Act, Europe was the first to pass a comprehensive AI-related legal framework. The AI Act proposes a risk-based framework that classifies AI systems in four tiers of risk and lists prohibited technologies, disclosures and obligations of AI systems operators, and penalties for non-compliance. The US, UK, and China are among other nations that have proposed their own AI-focused rules and regulations.

Exhibit 23: We frame four principal tiers of risks, ordered by time horizon and potential impact, and mitigants for each

AI-related risks and mitigants



Source: Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Brian Singer, CFA, Brendan Corbett, Carly Davenport, Alberto Gandolfi, James Schneider, Ph.D., Brian Lee, CFA, Neil Mehta, Adam Wijaya, John Mackay, Eric Sheridan, Kash Rangan, Toshiya Hari, Derek R. Bingham, Evan Tylanda, CFA, Emma Jones, Madeline Meyer, Varsha Venugopal, Grace Chen, Xavier Zhang, Joshua M. Frantz, CFA, Michael Smith, John Miller, Tyler Bisset, CFA and Jaskaran Jaiya, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

GS Factor Profile

The Goldman Sachs Factor Profile provides investment context for a stock by comparing key attributes to the market (i.e. our coverage universe) and its sector peers. The four key attributes depicted are: Growth, Financial Returns, Multiple (e.g. valuation) and Integrated (a composite of Growth, Financial Returns and Multiple). Growth, Financial Returns and Multiple are calculated by using normalized ranks for specific metrics for each stock. The normalized ranks for the metrics are then averaged and converted into percentiles for the relevant attribute. The precise calculation of each metric may vary depending on the fiscal year, industry and region, but the standard approach is as follows:

Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

Financial Returns and Multiple use the Goldman Sachs analyst forecasts at the fiscal year-end at least three quarters in the future. Growth uses inputs for the fiscal year at least seven quarters in the future compared with the year at least three quarters in the future (on a per-share basis for all metrics).

For a more detailed description of how we calculate the GS Factor Profile, please contact your GS representative.

M&A Rank

Across our global coverage, we examine stocks using an M&A framework, considering both qualitative factors and quantitative factors (which may vary across sectors and regions) to incorporate the potential that certain companies could be acquired. We then assign a M&A rank as a means of scoring companies under our rated coverage from 1 to 3, with 1 representing high (30%-50%) probability of the company becoming an acquisition target, 2 representing medium (15%-30%) probability and 3 representing low (0%-15%) probability. For companies ranked 1 or 2, in line with our standard departmental guidelines we incorporate an M&A component into our target price. M&A rank of 3 is considered immaterial and therefore does not factor into our price target, and may or may not be discussed in research.

Quantum

Quantum is Goldman Sachs' proprietary database providing access to detailed financial statement histories, forecasts and ratios. It can be used for in-depth analysis of a single company, or to make comparisons between companies in different sectors and markets.

Disclosures

Distribution of ratings/investment banking relationships

Goldman Sachs Investment Research global Equity coverage universe

	Rating Distribution			Investment Banking Relationships		
	Buy	Hold	Sell	Buy	Hold	Sell
Global	48%	34%	18%	64%	57%	43%

As of January 1, 2025, Goldman Sachs Global Investment Research had investment ratings on 3,021 equity securities. Goldman Sachs assigns stocks as Buys and Sells on various regional Investment Lists; stocks not so assigned are deemed Neutral. Such assignments equate to Buy, Hold and Sell for the purposes of the above disclosure required by the FINRA Rules. See 'Ratings, Coverage universe and related definitions' below. The Investment Banking Relationships chart reflects the percentage of subject companies within each rating category for whom Goldman Sachs has provided investment banking services within the previous twelve months.

Regulatory disclosures

Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage.

Analyst compensation: Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

Distribution of ratings: See the distribution of ratings disclosure above. **Price chart:** See the price chart, with changes of ratings and price targets in prior periods, above, or, if electronic format or if with respect to multiple companies which are the subject of this report, on the Goldman Sachs website at <https://www.gs.com/research/hedge.html>.

Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for “wholesale clients” within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of Global Investment Research of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client’s objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client’s own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs’ Australian Sell-Side Research Independence Policy Statement are available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Brazil:** Disclosure information in relation to CVM Resolution n. 20 is available at <https://www.gs.com/worldwide/brazil/area/gir/index.html>. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** This information is being provided to you for information purposes only and is not, and under no circumstances should be construed as, an advertisement, offering or solicitation by Goldman Sachs & Co. LLC for purchasers of securities in Canada to trade in any Canadian security. Goldman Sachs & Co. LLC is not registered as a dealer in any jurisdiction in Canada under applicable Canadian securities laws and generally is not permitted to trade in Canadian securities and may be prohibited from selling certain securities and products in certain jurisdictions in Canada. If you wish to trade in any Canadian securities or other products in Canada please contact Goldman Sachs Canada Inc., an affiliate of The Goldman Sachs Group Inc., or another registered Canadian dealer. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U7140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. Investment in securities market are subject to market risks. Read all the related documents carefully before investing. Registration granted by SEBI and certification from NISM in no way guarantee performance of the intermediary or provide any assurance of returns to investors. Goldman Sachs (India) Securities Private Limited Investor Grievance E-mail: india-client-support@gs.com. Compliance Officer: Anil Rajput | Tel: + 91 22 6616 9000 | Email: anil.m.rajput@gs.com. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for “professional investors” within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither “registered banks” nor “deposit takers” (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for “wholesale clients” (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

European Union and United Kingdom: Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom’s departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at <https://www.gs.com/disclosures/europeanpolicy.html> which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

Japan: Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan Type II Financial Instruments Firms Association, The Investment Trusts Association, Japan, and Japan Investment Advisers Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

Ratings, coverage universe and related definitions

Buy (B), Neutral (N), Sell (S) Analysts recommend stocks as Buys or Sells for inclusion on various regional Investment Lists. Being assigned a Buy or Sell on an Investment List is determined by a stock’s total return potential relative to its coverage universe. Any stock not assigned as a Buy or a Sell on an Investment List with an active rating (i.e., a stock that is not Rating Suspended, Not Rated, Coverage Suspended or Not Covered), is deemed Neutral. Each region manages Regional Conviction lists, which are selected from Buy rated stocks on the respective region’s Investment lists and represent investment recommendations focused on the size of the total return potential and/or the likelihood of the realization of the return across their respective areas of coverage. The addition or removal of stocks from such Conviction lists are managed by the Investment Review Committee or other designated committee in each respective region and do not represent a change in the analysts’ investment rating for such stocks.

Total return potential represents the upside or downside differential between the current share price and the price target, including all paid or anticipated dividends, expected during the time horizon associated with the price target. Price targets are required for all covered stocks. The total return potential, price target and associated time horizon are stated in each report adding or reiterating an Investment List membership.

Coverage Universe: A list of all stocks in each coverage universe is available by primary analyst, stock and coverage universe at <https://www.gs.com/research/hedge.html>.

Not Rated (NR). The investment rating, target price and earnings estimates (where relevant) are not provided or have been suspended pursuant to Goldman Sachs policy when Goldman Sachs is acting in an advisory capacity in a merger or in a strategic transaction involving this company, when

there are legal, regulatory or policy constraints due to Goldman Sachs' involvement in a transaction, when the company is an early-stage biotechnology company, and in certain other circumstances. **Rating Suspended (RS).** Goldman Sachs Research has suspended the investment rating and price target for this stock, because there is not a sufficient fundamental basis for determining an investment rating or target price. The previous investment rating and target price, if any, are no longer in effect for this stock and should not be relied upon. **Coverage Suspended (CS).** Goldman Sachs has suspended coverage of this company. **Not Covered (NC).** Goldman Sachs does not cover this company. **Not Available or Not Applicable (NA).** The information is not available for display or is not applicable. **Not Meaningful (NM).** The information is not meaningful and is therefore excluded.

Global product; distributing entities

Goldman Sachs Global Investment Research produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or contatogoldmanbrasil@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou contatogoldmanbrasil@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

European Economic Area: GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland and the Republic of Ireland; GSI - Succursale de Paris (Paris branch) which is authorised by the French Autorité de contrôle prudentiel et de résolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de résolution and the Autorité des marchés financiers ("AMF") disseminates research in France; GSI - Sucursal en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSA as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sv. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Sucursal en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinspektionen) disseminates research in the Kingdom of Sweden.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by Global Investment Research. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (<https://www.sipc.org>).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

The analysts named in this report may have from time to time discussed with our clients, including Goldman Sachs salespersons and traders, or may discuss in this report, trading strategies that reference catalysts or events that may have a near-term impact on the market price of the equity securities discussed in this report, which impact may be directionally counter to the analyst's published price target expectations for such stocks. Any such trading strategies are distinct from and do not affect the analyst's fundamental equity rating for such stocks, which rating reflects a stock's return potential relative to its coverage universe as described herein.

We and our affiliates, officers, directors, and employees will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research, unless otherwise prohibited by regulation or Goldman Sachs policy.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options and futures disclosure documents which are available from Goldman Sachs sales representatives or at <https://www.theocc.com/about/publications/character-risks.jsp> and

https://www.fiadocumentation.org/fia/regulatory-disclosures_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-pdf-version-2018.

Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

Differing Levels of Service provided by Global Investment Research: The level and types of services provided to you by Goldman Sachs Global Investment Research may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.

All research reports are disseminated and available to all clients simultaneously through electronic publication to our internal client websites. Not all research content is redistributed to our clients or available to third-party aggregators, nor is Goldman Sachs responsible for the redistribution of our research by third party aggregators. For research, models or other data related to one or more securities, markets or asset classes (including related services) that may be available to you, please contact your GS representative or go to <https://research.gs.com>.

Disclosure information is also available at <https://www.gs.com/research/hedge.html> or from Research Compliance, 200 West Street, New York, NY 10282.

© 2025 Goldman Sachs.

You are permitted to store, display, analyze, modify, reformat, and print the information made available to you via this service only for your own use. You may not resell or reverse engineer this information to calculate or develop any index for disclosure and/or marketing or create any other derivative works or commercial product(s), data or offering(s) without the express written consent of Goldman Sachs. You are not permitted to publish, transmit, or otherwise reproduce this information, in whole or in part, in any format to any third party without the express written consent of Goldman Sachs. This foregoing restriction includes, without limitation, using, extracting, downloading or retrieving this information, in whole or in part, to train or finetune a machine learning or artificial intelligence system, or to provide or reproduce this information, in whole or in part, as a prompt or input to any such system.