

Digital AI to Physical AI – *The Next Chapter in Electricity Demand*

October 2026

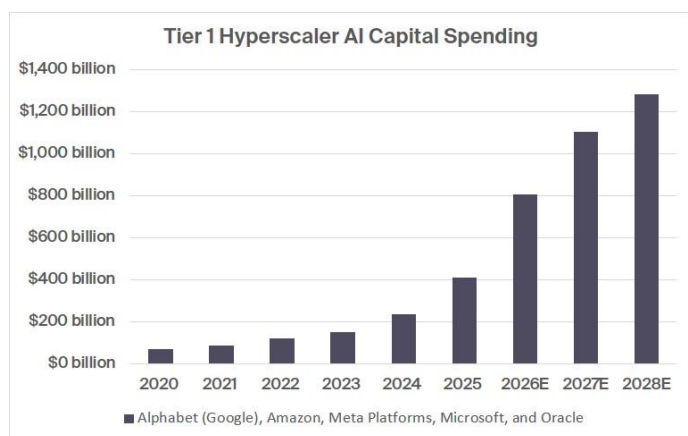
David L. LaBonte, Managing Director

Executive Summary

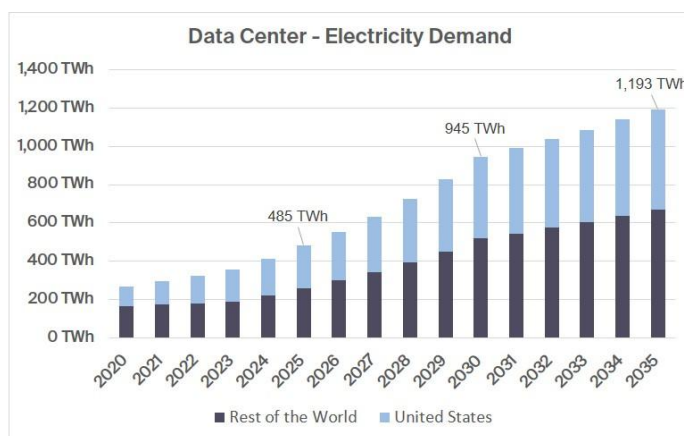
Artificial intelligence (AI) and the rapid buildout of data centers have captured the attention of the business community, financial markets and policymakers. Goldman Sachs projects that Tier 1 hyperscalers—the world’s largest cloud computing, storage and networking services companies—will spend almost \$3.2 trillion on AI-related infrastructure from 2026 through 2028, close to three times the \$1.1 trillion deployed over the previous six years. This cycle has been a powerful catalyst for suppliers of transformers, switchgear, power management systems and other critical electrical infrastructure. The question we expect investors to increasingly ask is: What comes next? We estimate that physical AI and the electrification it could accelerate may add ~1,555 TWh of electricity demand in 2035 in our central case (range: ~700–2,700 TWh), beyond what the International Energy Agency’s (IEA) Current Policies Scenario (CPS) assumes. That is about 4% of the IEA’s 2035 global electricity demand and about 30% above its data center estimate of 1,193 TWh. Less than one-fifth comes from robots and robotaxis themselves; the rest depends on automation accelerating industrial fuel switching and truck and mining electrification. This paper explores how the evolution from digital to physical AI could broaden and extend the electrical investment cycle.

Digital AI: Electricity Demand Baseline

Tier 1 hyperscalers like Alphabet (Google), Amazon, Meta Platforms, Microsoft, and Oracle are projected to spend more than a trillion dollars annually by 2027 on AI and data center expansions. This amount of investment is on track to become the largest economic bet in U.S. history, dwarfing investments made to fund other big infrastructure projects, including the railroads and interstate highway system.¹ The implications for the power sector are significant: AI is fundamentally dependent on electricity, and the infrastructure required to support its growth is extraordinarily power intensive. The U.S., Europe and China account for ~85% of global electricity consumption from data centers today.^{2,3} Data centers accounted for 224 TWh of electricity demand in the U.S. in 2025, representing about 46% of global data center electricity consumption and >5% of total U.S. electricity demand.^{3,4} Globally, that demand is expected to increase substantially over the next decade, with the IEA forecasting data center electricity consumption to nearly double from 485 TWh in 2025 to 945 TWh by 2030, before reaching 1,193 TWh by 2035.^{2,3} In the U.S., data centers are expected to account for nearly half of total electricity demand growth through 2030.²



Source: Goldman Sachs



Source: IEA; Rithm Capital estimates

1. Konrad Putzier and Justin Lahart, "The AI Build-Out Is Becoming the Biggest Economic Bet in U.S. History," *The Wall Street Journal*, September 24, 2026.
2. International Energy Agency (IEA), *Energy and AI*, April 2025.
3. IEA, *Key Questions on Energy and AI*, April 2026.
4. IEA, "Data Centre Electricity Consumption, 2015-2025," June 2026.

Physical AI: Electricity Demand Beyond the Data Center

The next phase of AI development is extending beyond the digital world and into the physical one. Physical AI pairs machine intelligence with systems that perceive their surroundings, reason and act autonomously in real-world environments—not only the humanoid robots that attract the headlines, but industrial robots, autonomous mobile robots, autonomous vehicles and drones. What separates these systems from conventional automation is not just capability but how they draw power. A fixed industrial robot performs a predefined task on a predictable schedule using its host facility’s electrical infrastructure. An autonomous machine can be untethered: it may run on batteries, recharge throughout the day and carry on-board computing and sensing. In autonomous vehicles, the IEA cites estimates spanning several hundred watts to more than 1 kW for on-board computation and sensors, and notes that this power draw needs to be very stable.⁵ Much of this computing load is tied to the time a machine is in service rather than the work it completes. These applications introduce different load profiles in different locations. Alongside continued demand from large data centers, electricity demand expands in factories, warehouses, transportation networks, businesses and homes where these machines operate.

Digital AI — vs. — Physical AI



Text Chat



Code



Image Generation



Data Centers



Sensors



Robots



Autonomous Vehicles



Factory & Medical

Physical AI remains in the early stages of adoption, but the potential addressable market is considerably broader than the industrial automation market that preceded it. More than 600,000 industrial robots were installed globally in 2025, taking the operational fleet to about five million units—more than double the level of seven years ago.⁶ Historically, industrial robots have performed repetitive tasks in highly structured manufacturing environments. What AI changes is the range of work a machine can do: as systems learn, adapt, and operate with less supervision, the set of automatable tasks widens from the factory floor into logistics, transportation, and commercial settings where conditions are far less controlled. Real barriers remain—cost, reliability, safety outside structured environments and battery life. Battery life deserves particular attention because it constrains operating time and shapes the frequency, timing and infrastructure requirements of charging.

Quantifying Incremental Electricity Demand

The electricity requirements of physical AI will vary considerably by application. For machine-based applications, we estimate consumption using fleet size, average power draw and utilization, or vehicle mileage and electricity consumption per mile, including charging losses where applicable. For industrial fuel switching, we estimate the share of fossil-fuel consumption exposed to automation-related capital renewal, the portion subsequently electrified, and the electricity required after accounting for equipment efficiency. We model six areas in two groups: the physical AI load (industrial robots, humanoid robots, and robotaxis) and electrification that automation may accelerate (industrial fuel switching, accelerated truck electrification including autonomous trucking, and mining haul trucks). Autonomous mobile robots and drones are not modeled. Our objective is to estimate demand additional to the IEA's CPS, rather than electricity consumption already reflected in that outlook. Because CPS incorporates electric vehicle (EV) adoption and industrial electrification, we apply explicit baseline or overlap assumptions to trucking, robotaxis, mining and fuel switching. For industrial robots, we deduct the roughly five million units already operating. We treat humanoid robot demand as additional, an author assumption reflecting limited visibility into its treatment in published forecasts.

5. IEA, *Global EV Outlook 2026*, "Autonomous Vehicles," May 2026.

6. International Federation of Robotics (IFR), "Five Million Robots Now Operate in Factories Globally," September 2026.

Estimated Demand from Physical AI and Associated Electrification

Category	Demand	Percent	Key Assumptions
Physical AI Load			
Industrial Robots - Net Fleet (a)	188 TWh	12%	Global fleet = 16m by 2035, net of 5m operating today
Humanoid Robots - Gross Fleet (b)	54 TWh	3%	Global fleet = 10m at commercial duty cycles
Robotaxis (c)	48 TWh	3%	Global fleet = 2m and includes on-board computing
Subtotal	289 TWh	19%	
Associated Electrification			
Industrial Fuel Switching (d)	598 TWh	38%	Effective fuel switching rate = 5% vs. IEA CPS at <1%
Accelerated Truck Electrification (e)	610 TWh	39%	Electric share of truck travel = 20% vs. IEA CPS at 10%
Mining Haul Trucks (f)	57 TWh	4%	Electric share of haul fleet = 35% vs. 15% baseline
Subtotal	1,265 TWh	81%	
Net Incremental Demand	1,555 TWh	100%	

(a) Global fleet of 16 million by 2035 per Wood Mackenzie (August 2026); power draw and utilization are author assumptions. Net of the roughly five million units operating today, which removes current consumption but may not fully exclude future adoption embedded in CPS.

(b) Global fleet of 10 million by 2035 per Wood Mackenzie (August 2026), which estimates humanoid demand of ~6 TWh; our lower case (5 TWh) is close to that estimate. Power draw and utilization are author assumptions.

(c) On-board computing and sensors account for ~10% of vehicle energy and are not separately identified in the published demand forecasts we reviewed.

(d) The IEA's CPS adds roughly 100 TWh of industrial electrification by 2035 (IEA, *World Energy Outlook 2025*); our central case assumes about six times that amount.

(e) The 10% baseline in the IEA's *Global EV Outlook 2026* refers to vehicle stock rather than distance travelled; our assumption treats electric and other trucks as having equal annual mileage. The 20% accelerated share is an author assumption.

(f) Full electrification of the global haul fleet would require ~284 TWh; we count only the portion autonomy brings forward. Baseline and accelerated electric shares are author assumptions.

Source: Rithm Capital estimates. Central case; scenario ranges and full build-up in the Appendix. Figures may not sum due to rounding.

Associated electrification that automation may accelerate accounts for ~1,265 TWh, or ~81% of the modeled increase, led by industrial fuel switching and accelerated truck electrification (~1,208 TWh). Physical AI load accounts for ~289 TWh (19%); humanoid robots and robotaxis, the examples that get the most attention, account for under 7%. Our analysis suggests the electricity impact of physical AI extends beyond the power consumed by robots, sensors and on-board computers, and depends on whether automation accelerates the replacement of fossil-fuel equipment with electric alternatives. That relationship is not automatic since a factory can install robots without electrifying its process heat, and an autonomous truck need not be electric. These two factors may nevertheless reinforce each other: autonomous operation removes the shift patterns and refueling constraints that have favored combustion. An electric truck's charging time competes with its driver's regulated hours; an autonomous one has none to protect. In mining, where autonomous haulage already operates at scale, that convergence is visible today.

Implications for Electrical Infrastructure

The data center buildout concentrates substantial electricity demand at large sites. Physical AI and associated electrification could spread new loads across a broader base of factories, warehouses, vehicle depots and mines—changing not only the equipment required, but who buys it and when. Much of this investment would arise through facility upgrades and fleet replacement programs, creating requirements at local distribution networks and within customer sites. Where electrification pushes a site beyond its existing capacity, the first requirements are at the connection: new or expanded substations, higher-capacity transformers, medium-voltage switchgear and additional feeders. Inside the facility, the investment extends to low-voltage switchboards, circuit breakers, busway, cable and protective relays to distribute electricity and isolate faults. Industrial robots and electric production equipment add motor drives, power conversion equipment and controls, while electric process heat brings electric boilers, industrial heat pumps and their associated electrical systems. Truck depots and mining sites introduce a further set: high-power chargers, rectifiers, connectors and dedicated distribution infrastructure capable of serving multiple vehicles. Energy management systems—and, where economical, battery storage—can coordinate those loads and limit peak demand. The mix varies by application, but transformers and switchgear recur across these investments, with charging infrastructure adding a further opportunity in EV transportation and mining. For suppliers, this broadens demand beyond hyperscalers and data center developers to industrial companies and fleet operators investing on different replacement and expansion cycles.

Risks to Our Estimates

1. **Attribution:** Automation and electrification may advance independently rather than together. A facility can deploy robots without electrifying its process heat, and an autonomous truck need not be electric. Associated electrification represents ~81% of our estimate, and all of it depends on that linkage playing out.
2. **Adoption:** Fleet projections may prove optimistic. Cost, reliability, battery life and the difficulty of operating safely outside structured environments could slow deployment materially, and our estimates scale directly with installed base.
3. **Scope:** Our estimate covers six applications. Warehouse and logistics robots, agricultural machinery, delivery fleets, port and terminal equipment, autonomous buses, drones and air taxis are not modeled. Some of that demand is likely already embedded in CPS—delivery vans and buses are explicitly projected to electrify—while other categories may not be. The net effect is not quantified.
4. **Baseline Overlap:** The IEA's CPS may already embed more of this demand than we deduct. Our robot adjustment removes today's installed fleet but may not fully exclude future adoption, and EV adoption and industrial electrification are projected explicitly, making the incremental share difficult to isolate.
5. **Relative Energy Costs:** Industrial electrification depends on the price of electricity against natural gas and diesel. Automation does not change that spread, and a widening gap could delay fuel switching irrespective of how quickly facilities modernize.
6. **Efficiency Gains:** Improvements in motor, battery and computing efficiency could reduce consumption per unit of work. The IEA's own high-efficiency case for data centers sits roughly 15% below its base case,³ and comparable gains in physical AI applications would lower these estimates.

Final Thoughts

The data center buildout has been the visible face of AI's electricity demand, and we expect it to remain the dominant source through the remainder of this decade. Physical AI, however, should be the next chapter in electricity demand. If physical AI adoption approaches our central case, and if automation and electrification advance together, the incremental demand could exceed the entire global data center load the IEA projects for 2035, arriving across a broader range of locations, customers, applications and voltage levels. For electrical equipment manufacturers, this extends our investment thesis that electricity's importance to the global economy is growing. The case we made two years ago⁷—that grid and electrical infrastructure provide exposure to electrification without requiring investors to pick the winning end-use technologies—does not change. That thesis also answers the question investors are likely to ask next: what happens if hyperscaler spending slows? Digital AI has been a powerful catalyst, but in our earlier paper data centers were one part of one of four megatrends, alongside energy transition, electrification and reindustrialization, with an aging grid that must be replaced regardless. Physical AI could prove another catalyst. We therefore see little reason to expect a material slowdown in equipment orders. What changes is the customer base and the length of the runway: beyond hyperscaler-driven projects to industrial facilities, depots and mines upgrading on their own replacement cycles. We would not underwrite the 2035 figure as a forecast but rather the direction. The more useful question is not whether physical AI arrives, but how quickly it scales and whether the electrical infrastructure to support it is built ahead of that demand or behind it.

7. Rithm Capital, *Investment Opportunities Amid the Electric Revolution*, November 2024.

APPENDIX

A1: Industrial Fuel Switching - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Industrial Fuel Switching			
Fossil Fuel Usage, 2035 CPS (a)	26,389 TWh	26,389 TWh	26,389 TWh
Automation-Driven Capital Renewal by 2035 (b)	25%	25%	25%
Incremental Fuel Switching (within those facilities)	10%	20%	30%
Effective Fuel Switching Rate	2.5%	5.0%	7.5%
Fossil Fuel Energy Displaced	660 TWh	1,319 TWh	1,979 TWh
Displaced Equipment Efficiency	80%	80%	80%
Heat Pump Share of Replacement	70%	70%	70%
Heat Pump Coefficient of Performance (3 kWh heat / 1 kWh electricity)	3	3	3
Direct Electric Share of Replacement	30%	30%	30%
Direct Electric Heating Efficiency	90%	90%	90%
Incremental Annual Electricity Demand	299 TWh	598 TWh	897 TWh

(a) Projected global industrial final consumption of coal, natural gas and oil for energy use in 2035 under the IEA's Current Policies Scenario, excluding oil used as feedstock. We apply the incremental fuel-switching assumptions below to this remaining fossil-fuel consumption. Source: IEA, *World Energy Outlook 2025*; author calculations.

(b) Automation-driven capital renewal is the share of industrial capacity replaced by 2035; incremental fuel switching is the share of that replaced capacity converting from fossil fuels to electricity. Their product is the effective fuel switching rate. These rates, the equipment efficiencies, the heat pump share and the coefficient of performance are all author assumptions. The incremental fuel switching share is drawn from applications suitable for heat pumps or direct electric heating; it does not treat these technologies as replacing coal's chemical-reduction role in steelmaking. On the same conversion factors, the roughly 100 TWh of industrial electrification in the IEA's CPS equates to an effective switching rate of about 0.8%. We have not found a published forecast that decomposes industrial electrification this way.

A2: Industrial Robots - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Industrial Robots			
Active Operating Power per Industrial Robot	2 kW	3 kW	4 kW
Annual Utilization	50.0%	65.0%	80.0%
Hours Per Day	24 hr	24 hr	24 hr
Annual Operating Hours	4,380 hr	5,694 hr	7,008 hr
Annual Electricity Usage per Robot	8,760 kWh	17,082 kWh	28,032 kWh
Global Industrial Fleet in 2035 (a)	12 m	16 m	20 m
Fleet Operating in 2025 (b)	5 m	5 m	5 m
Net Industrial Fleet in 2035	7 m	11 m	15 m
Gross Annual Electricity Consumption	105 TWh	273 TWh	561 TWh
Incremental Annual Electricity Demand	61 TWh	188 TWh	420 TWh

(a) Global industrial robot fleet, 2035. The central case of 16 million is per Wood Mackenzie, *Embodied AI: How Robotics Are Accelerating Global Power Demand*, August 2026, and assumes the current 12% annual growth continues; the lower and higher cases are author assumptions. Power draw and utilization are author assumptions.

(b) Installed base operating in 2025 (about 5 million units per the International Federation of Robotics, September 2026), held constant across cases and deducted at each scenario's power and utilization assumptions. Removes current consumption but may not fully exclude future adoption embedded in the IEA's CPS. The central-case deduction of about 85 TWh compares with Wood Mackenzie's estimate of 78 TWh for the current fleet; its 2035 estimate of 357 TWh is within our gross range.

A3: Humanoid Robots - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Humanoid Robots			
Humanoid Robots in 2035 (a)	8 m	10 m	12 m
Active Power per Humanoid	0.375 kW	1.100 kW	2.875 kW
Daily Utilization	17.5%	50.0%	80.0%
Hours Per Day	24 hr	24 hr	24 hr
Annual Operating Hours	1,533 hr	4,380 hr	7,008 hr
Annual Electricity Usage per Robot	575 kWh	4,818 kWh	20,148 kWh
Charging Efficiency (b)	90%	90%	90%
Incremental Annual Electricity Demand	5 TWh	54 TWh	269 TWh

(a) Global humanoid robot fleet, 2035. The central case of 10 million is per Wood Mackenzie, *Embodied AI: How Robotics Are Accelerating Global Power Demand*, August 2026, which estimates humanoid demand of about 6 TWh; our lower case (5 TWh) is close to that estimate. The lower and higher cases (8 and 12 million) are author assumptions, as are power draw and utilization. The central case assumes commercial duty cycles of about 12 hours of active operation per day at 1.1 kW.

(b) Annual usage per robot is shown before charging losses; demand is grossed up by dividing by charging efficiency. No baseline deduction is taken: humanoid demand is treated as additional (an author assumption), and the fleet operating today is immaterial.

A4: Trucks - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Trucks			
Annual Freight Activity in Trillion Ton Miles (a)	32.1 TTM	32.1 TTM	32.1 TTM
Average Total Truck Operating Weight (b)	55,116 lb	55,116 lb	55,116 lb
Less: Tractor and Trailer Weight	(32,518)lb	(32,518)lb	(32,518)lb
Average Cargo Weight (Incl. Empty Travel)	22,597 lb	22,597 lb	22,597 lb
Assumed Average Cargo Carried Per Truck in Short Tons	11.3 ST	11.3 ST	11.3 ST
Annual Truck Travel in Trillion Miles	2.84 T mi	2.84 T mi	2.84 T mi
Operating Electricity Consumption - Whole Vehicle (c)	1.93 kWh/mi	1.93 kWh/mi	1.93 kWh/mi
Charging Efficiency	90.0%	90.0%	90.0%
Grid Electricity Consumption	2.15 kWh/mi	2.15 kWh/mi	2.15 kWh/mi
Assumed Electric Share of Trucking Travel (d)	10.0%	10.0%	10.0%
Electric Share in Accelerated-Adoption Scenario	15.0%	20.0%	25.0%
Truck Electricity - Baseline Share	610 TWh	610 TWh	610 TWh
Truck Electricity - Accelerated Share	916 TWh	1,221 TWh	1,526 TWh
Incremental Annual Electricity Demand	305 TWh	610 TWh	916 TWh

(a) Global road freight activity, 2035: 46.9 trillion tonne-km (32.1 trillion short ton-miles) under the IEA's CPS. Source: IEA, *World Energy Outlook 2025*, Annex A.

(b) Gross and tare weights of 25.0 and 14.75 tonnes are author assumptions. Cargo weight is averaged across loaded and empty miles.

(c) Whole-vehicle consumption of 1.2 kWh/km (1.93 kWh/mi) before charging losses; grid consumption divides by charging efficiency. Source: Our World in Data.

(d) We assume electric trucks account for 10% of global truck miles traveled in 2035, informed by the IEA's *Global EV Outlook 2026*, which projects roughly 10% of global truck stock electric under CPS. That projection refers to vehicle stock, not distance traveled; our assumption treats electric and other trucks as having equal average annual mileage. Accelerated-adoption shares are author assumptions.

A5: Robotaxis - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Robotaxis			
Robotaxis in 2035 (a)	700,000	2,000,000	3,000,000
Annual Miles Per Vehicle	80,000 mi	100,000 mi	120,000 mi
Average Operating Speed	20 mph	20 mph	20 mph
Implied Operating Hours Per Day	11 hours/day	14 hours/day	16 hours/day
Operating Electricity Consumption (b)	0.27 kWh/mi	0.32 kWh/mi	0.39 kWh/mi
Onboard Computing and Sensors (c)	0.50 kW	0.75 kW	1.00 kW
Computing Electricity	0.03 kWh/mi	0.04 kWh/mi	0.05 kWh/mi
Total Electricity at the Vehicle	0.30 kWh/mi	0.36 kWh/mi	0.44 kWh/mi
Charging Efficiency	90.0%	90.0%	90.0%
Annual Grid Electricity Per Vehicle	26,541 kWh	39,930 kWh	58,166 kWh
Gross Annual Electricity Demand	19 TWh	80 TWh	174 TWh
Share of Gross Demand additional to IEA (CPS) (d)	50.0%	60.0%	65.0%
Incremental Annual Electricity Demand	9 TWh	48 TWh	113 TWh

(a) Global robotaxi fleet, 2035. The IEA reports estimates of 700,000 to 3 million vehicles, likely concentrated in 40 to 80 cities; our lower and higher cases take those bounds and the central case of 2 million sits within them. Annual mileage and average operating speed are author assumptions; implied operating hours are derived as a plausibility check. No deduction is taken for today's fleet of about 8,000 vehicles. Source: IEA, *Global EV Outlook 2026*, "Autonomous Vehicles," May 2026.

(b) Operating assumption before on-board computing: 0.17, 0.20 and 0.24 kWh/km (0.27, 0.32 and 0.39 kWh/mi). The range spans purpose-built robotaxi platforms at the low end and retrofitted sport-utility platforms at the high end. Author assumptions.

(c) On-board computation and sensor load of 0.50, 0.75 and 1.00 kW are author assumptions within the range the IEA reports, which spans several hundred watts to over 1 kW. Load is charged to operating hours only and converted to a per-mile basis at the average operating speed. Source: IEA, *Global EV Outlook 2026*, "Autonomous Vehicles," May 2026.

(d) We assume 50%, 60% and 65% of gross robotaxi electricity demand, including on-board computing and charging losses, is additional to the IEA's CPS in the lower, central, and higher cases, respectively. The remaining demand is treated as overlapping with EV electricity consumption already embedded in CPS. These are author assumptions reflecting uncertainty over the travel robotaxis replace, additional vehicle mileage and baseline electrification; not IEA estimates.

A6: Mining Haul Trucks - Incremental Electricity Demand, 2035

	Lower	Central	Higher
Fleet and Current Diesel Assumption			
Global Mining Haul Truck Fleet (a)	52,200	52,200	52,200
Global Haul Truck CO2 Emissions (b)	174 Mt/Yr	174 Mt/Yr	174 Mt/Yr
Diesel Emissions Factor	2.68 kg CO2/L	2.68 kg CO2/L	2.68 kg CO2/L
Implied Fleet Diesel Consumption (Billion Liters per Year)	64.9 B L/Yr	64.9 B L/Yr	64.9 B L/Yr
Implied Per Truck	1,243,781 L/Yr	1,243,781 L/Yr	1,243,781 L/Yr
Diesel Energy Content	9.9 kWh/L	9.9 kWh/L	9.9 kWh/L
Fleet Diesel Energy	643 TWh/Yr	643 TWh/Yr	643 TWh/Yr
Electricity Required if That Work Were Done Electrically			
Diesel-Electric Drivetrain Efficiency (Fuel to Wheel) (c)	35.0%	35.0%	35.0%
Useful Work Delivered	225 TWh	225 TWh	225 TWh
Battery-Electric Drivetrain Efficiency (Battery to Wheel)	88.0%	88.0%	88.0%
Charging Efficiency	90.0%	90.0%	90.0%
Grid Electricity if Fleet Fully Electrified	284 TWh	284 TWh	284 TWh
Implied Per Truck	5,442 MWh/Yr	5,442 MWh/Yr	5,442 MWh/Yr
Baseline Electric Share of Haul Fleet, 2035 (d)	15.0%	15.0%	15.0%
Electric Share in Autonomy-Accelerated Scenario	25.0%	35.0%	45.0%
Incremental Share	10.0%	20.0%	30.0%
Incremental Annual Electricity Demand	28 TWh	57 TWh	85 TWh

(a) Global mining haul truck fleet of 52,200, held constant to 2035. Source: ABB / E&MJ, *Haul Truck Power Options*, May 2022.

(b) Global haul truck CO2 emissions. Source: IDTechEx, *Electric Vehicles in Mining 2024–2044*.

(c) Drivetrain efficiencies (35% diesel-electric, 88% battery-electric) and charging efficiency (90%) are author assumptions.

(d) Baseline (15%) and autonomy-accelerated (25%, 35% and 45%) electric shares are author assumptions; we are not aware of a published forecast of electric haul fleet share.

A7: Total Incremental Electricity Demand, 2035

	Lower	Central	Higher
A1: Industrial Fuel Switching	299 TWh	598 TWh	897 TWh
A2: Industrial Robots	61 TWh	188 TWh	420 TWh
A3: Humanoid Robots	5 TWh	54 TWh	269 TWh
A4: Trucks	305 TWh	610 TWh	916 TWh
A5: Robotaxis	9 TWh	48 TWh	113 TWh
A6: Mining Haul Trucks	28 TWh	57 TWh	85 TWh
Incremental Annual Electricity Demand	708 TWh	1,555 TWh	2,701 TWh

Figures may not sum due to rounding.