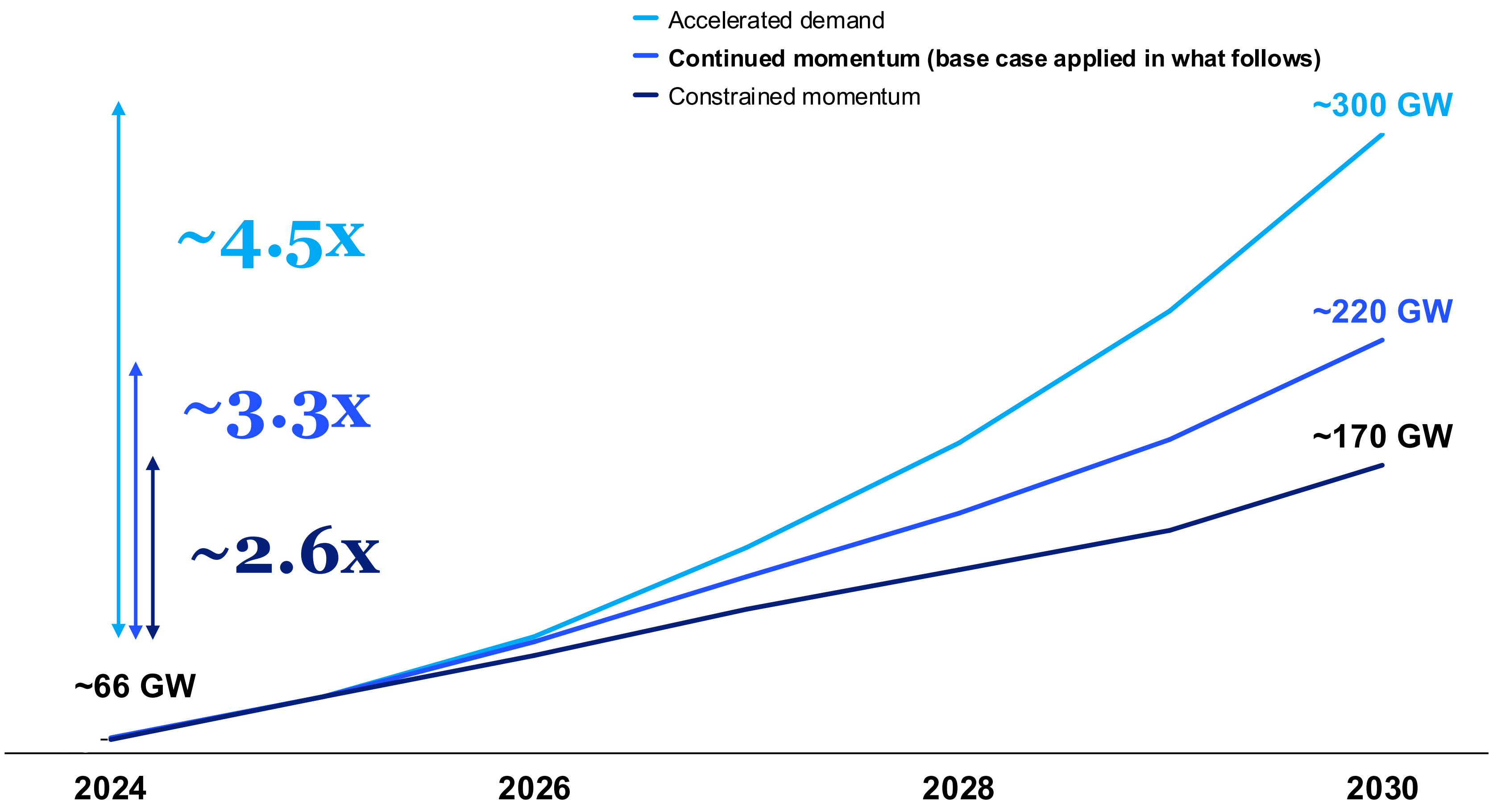
Critical raw materials for Data Centers

World Materials Forum

4 September 2026

Global Data Center demand more than tripling by 2030

Estimated Global Data Center Demand, in GW IT compute



Source: McKinsey Cloud Infra & Data Center Service Line AI forecast (based on bottom-up shipment data and triangulated with LLM demand and IT decision makers (Updated January 2025)

US accounts for 50% of this growth, Asia 35%, Europe 15%

In 2025-30, **AI from 50% to 70% of Data Center workload** (GenAI from 15% to 40%)

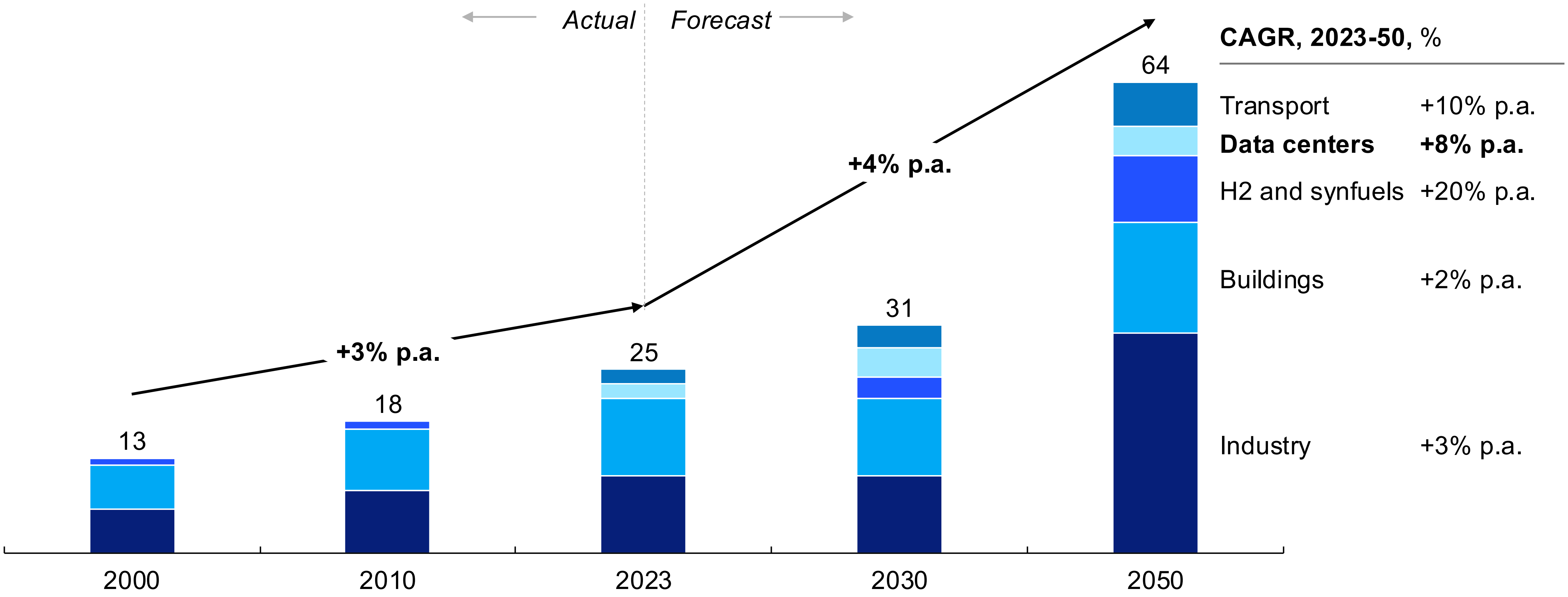
Testing/ Inference from 60/40 to 40/60

Cumulative 2025-30 capex >7 TUSD (builders, energizers, designers/ manufacturers; excluding end-users)

Data Centers projected to consume 10-15% of global power by 2030

Continued momentum case

Global power consumption by sector, thousand TWh



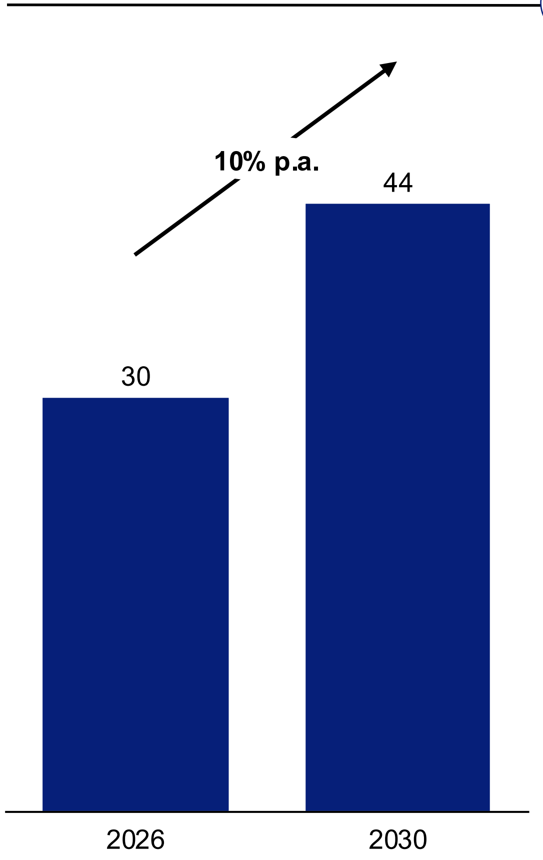
Source: McKinsey Global Energy Perspective 2024

Data Center expansion requiring increasing amounts of raw materials – Ga and Cu most critical; Sn, REE, Ge next

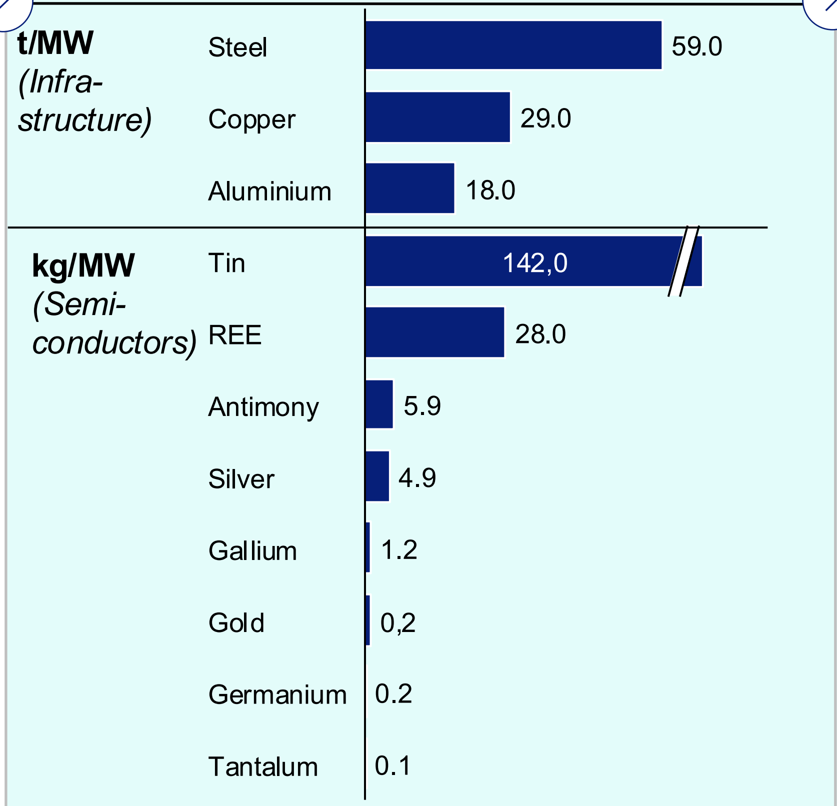
Continued momentum case

Share of global demand <1% 1-3% >3%

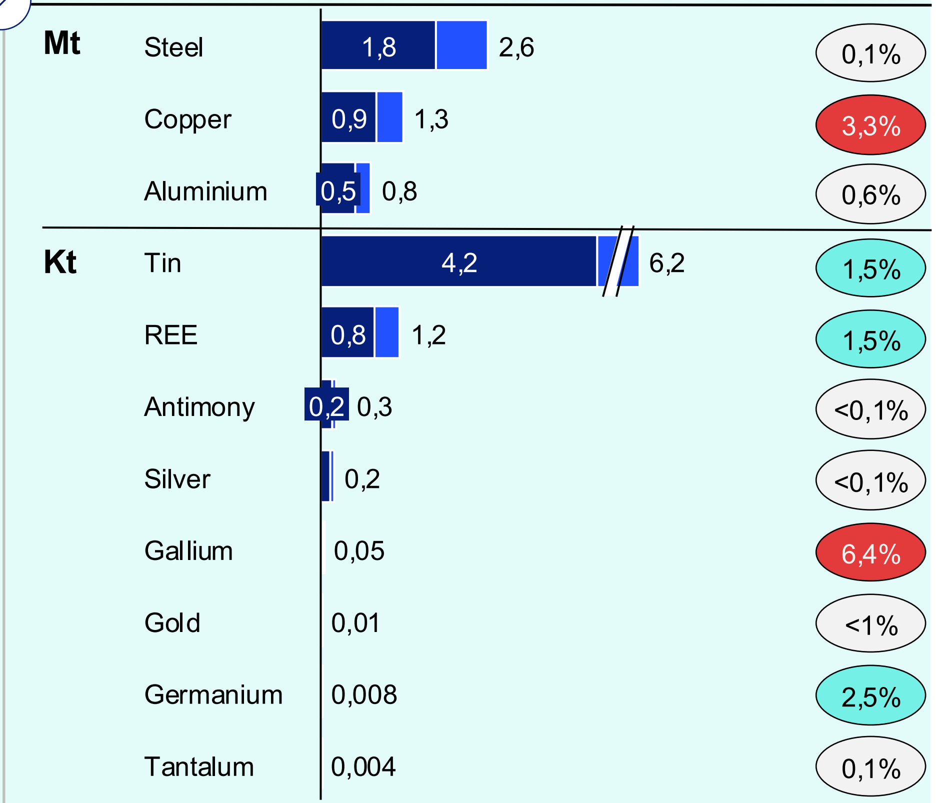
Global Data Center incremental yearly workload demand, GW/year



Material intensity[1], t(or kg)/MW



Global materials demand, Kt/year, 2026/30 ■ 2026 ■ 2030



1. Material intensity for both AI as convential data centers, assumed flat evolution over time

Source: McKinsey proprietary data center demand model (2026Q2), Minespans, Press search

Cu, Ga, Ge, REEs, Sn facing increased risks from supply concentration and S/D tightness

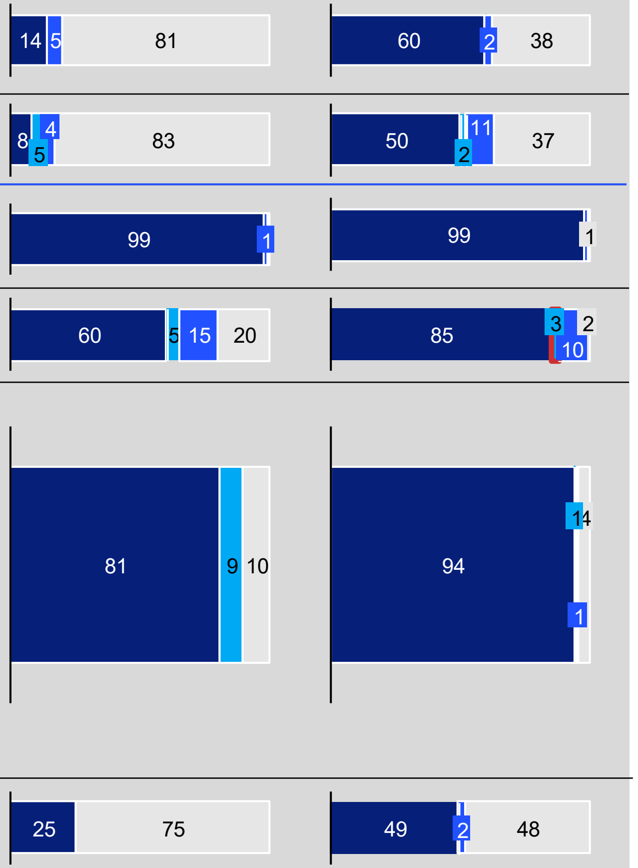
Critical raw materials for Data Centers; Continued momentum case

Data Centers

Global market

■ China ■ USA ■ Europe ■ Rest of World

Critical raw materials			**Application in Data Centers**	**Share of DC in demand 2030, %**	**Global Demand 2030,** Mt - t	**CAGR (2025-30),%**	**Base case S/D balance** 2030	**Supply concentrations** Upstream	**Midstream**
Infra-structure	**Aluminum**		Power distribution at every scale from substation to VRM	0,6%	116 Mt	2%	Balanced	14, 5, 81	60, 2, 38
	Copper		Conductors, cooling systems, racks, structural components	3,3%	32 Mt	2%	**Deficit**	8, 5, 4, 83	50, 2, 11, 37
Semi-conductors	**Gallium**		GaN power electronics, GaAs networking chips scaling with AI GPU deployment	6,4%	1,118 t	6,5%	**Deficit**	99, 1	99, 1
	Germanium		Fiber-optic buildout for DC interconnects	2,5%	270 t	4.6%	Balanced	60, 5, 15, 20	85, 3, 10, 2
	REEs	Neodymium	High-efficiency PM motors in cooling; Backup power generators	1,5%	99 t	6%	**Deficit**	81, 9, 10	94, 14, 1
		Praseodymium		1,4%	22 t	6.1%	**Deficit**		
		Terbium		1,7%	4 t	7.2%	**Deficit**		
		Dysprosium		2,2%	15 t	9.6%	**Deficit**		
	Tin		Solder for components joint to circuit boards, GPU boards, solder bumps	1,5%	0,4 Mt	1%	**Deficit**	25, 75	49, 2, 48



Source: MineSpans, Press search; Reference period: 2026Q1

Copper remains essential; substituting with Aluminium has limited applicability and brings minimal value

		Aluminium substitution		
Copper AI use cases	**Cu consumption %**	**Applicability**	**Value impact**	**Comments**
Power distribution bars	30-35%	Low	Low	Aluminum joints loosen under thermal cycling from variable AI/GPU loads, **incompatible with >99.9% uptime requirements**; 1.6x larger cross-section exceeds space in dense areas and configurations
Medium- and low-voltage power cables	20-25%	Low	Low	Constrained areas make **aluminum's larger bend radius impractical inside the building**; campus-level MV feeders can use aluminum but represent a minority of total facility copper
Grounding, bonding, and lightning protection	10-15%	Low	Low	Different **legislation mandates copper for equipment grounding in critical facilities**; aluminum corrodes at ground-rod interfaces and is prohibited for direct-burial grounding electrodes
Battery system conductors	5-10%	Low	Low	A single loose connection in a specific type of power path used in data centers can cascade to a full site outage costing USD 5-10k per minute; **failure economics overwhelm aluminum's 30-50% material cost saving,** making it impractical
Facility transformer windings	5-10%	Low	Low	Aluminum is impractical because data center transformers run at 60-80% load continuously, making **copper's 15-30% lower losses a compounding efficiency gain**
Cooling and liquid cooling systems	1-5%	Med	Low	Traditional heat exchangers already use some aluminum, but the **shift to direct-to-chip liquid cooling for AI racks introduces new copper demand in cold plates** and manifolds where leak prevention near electronics is critical

Source: Schneider Electric, Copper Development Association, Uptime Institute, NEC/NFPA 70 Article 250, IEC 60364-5, MineSpans; Reference period: 2026Q1

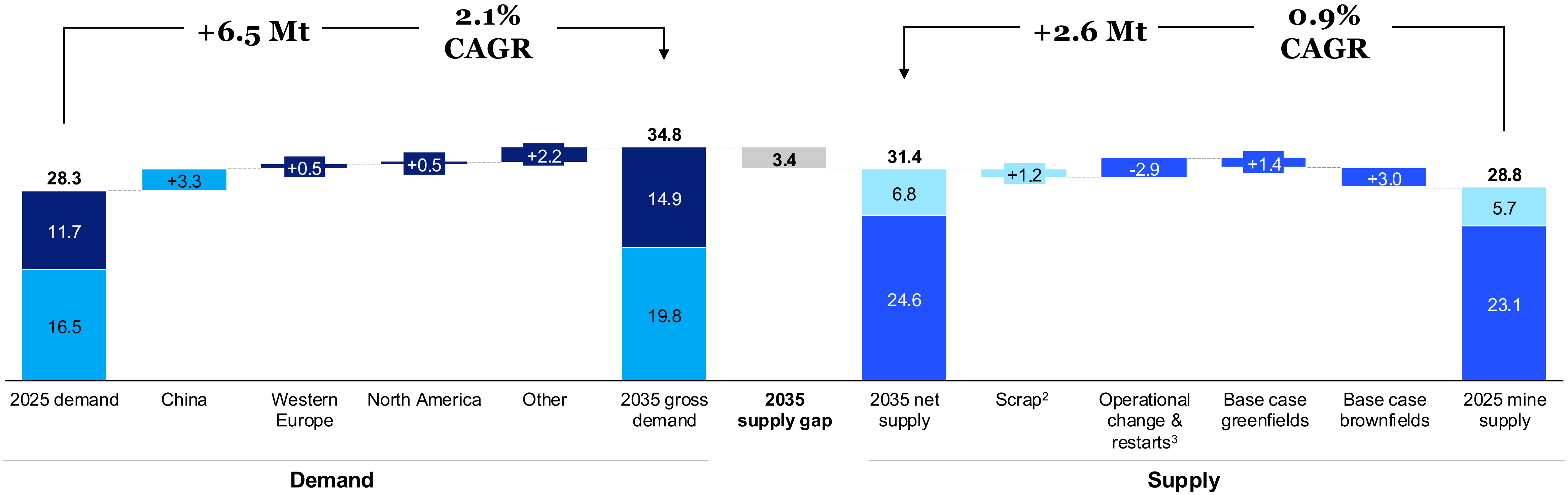
The world needs to incentivize additional Copper supply to meet demand over the next decade

Copper supply[1] and refined copper demand, 2025-2035
Mt refined metal

Demand: ■ Rest of World ■ China **Supply:** ■ Mine supply ■ Scrap

2035 mine supply high case (~ 33.2 Mt or +4.4 Mt additional mining supply vs. base case) and full potential (~ 35.4 Mt) scenarios would be **sufficient to close the supply gap**

However, despite knowing where the copper is to meet demand, there are financial, technical, regulatory constraints to overcome



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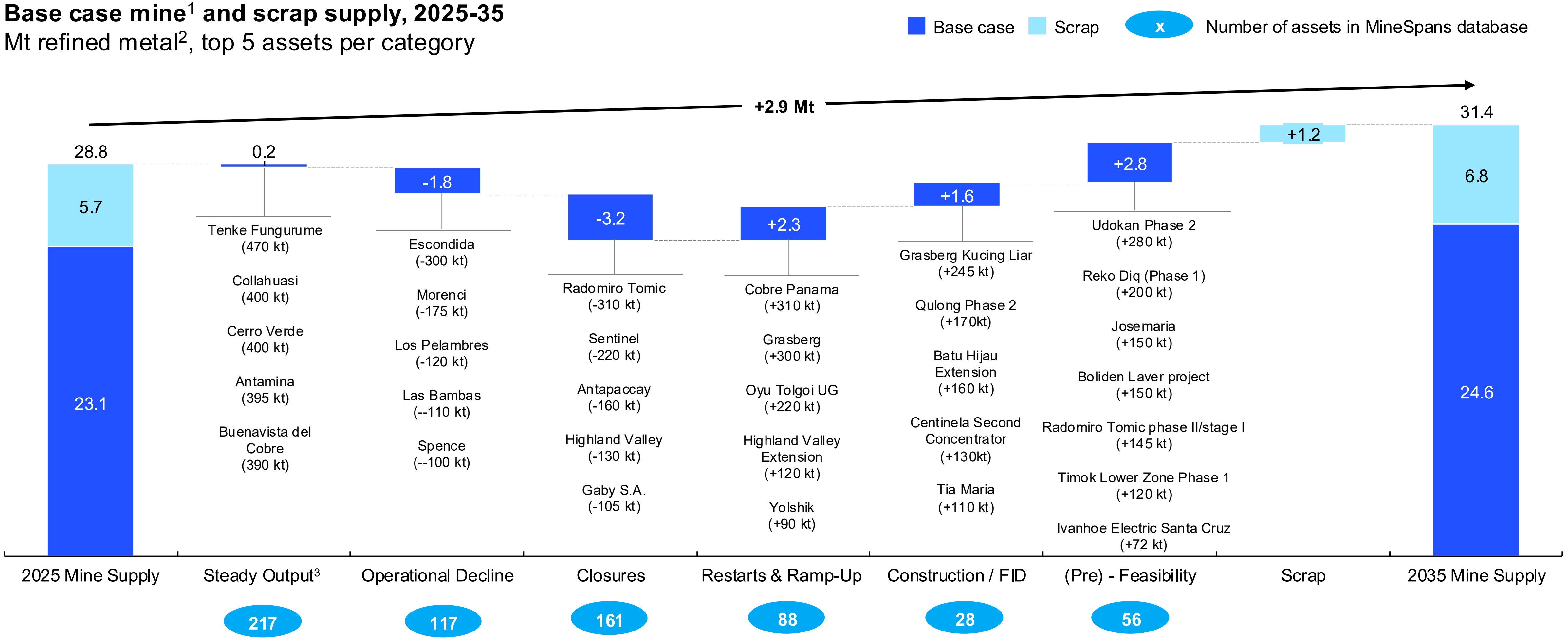
1. Base case
2. Scrap demand based on announced smelting & refining capacity
3. Net effect of operational improvements, new mine ramp-ups, restarts, closures, and operational decline

Source: MineSpans; Reference period: 2026Q1

Sanctioned Copper projects plus existing ramp-ups can surpass impact of operational declines and closures by 2035

Base case mine[1] and scrap supply, 2025-35
Mt refined metal[2], top 5 assets per category



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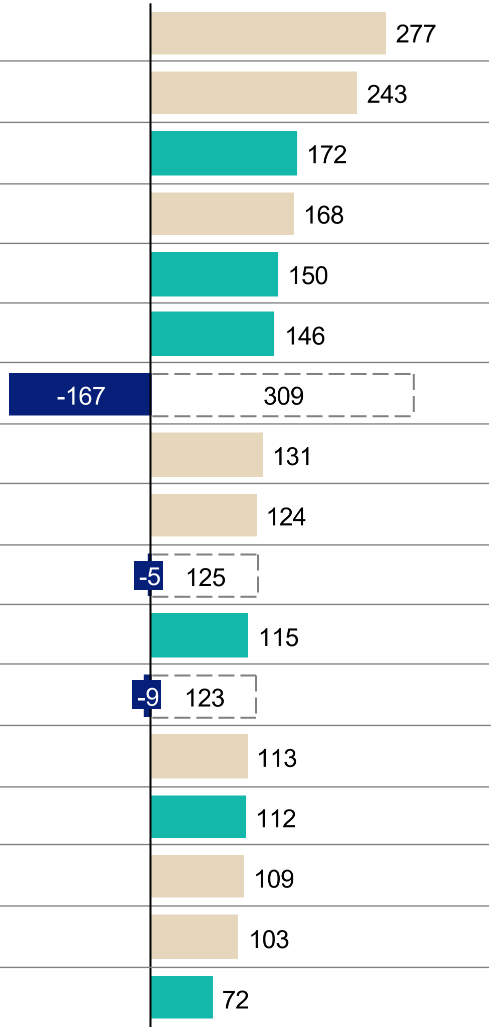
1. Sanctioned projects represent projects in construction or with final investment decision (FID); Restarts & Ramp-Ups represent the restart of idled operations as well as the ramp up of capacity at recently commissioned projects; Closures represent mines that are closing in the future due to depletion or other factors, mine LOM extensions covered under project categories (Construction/FID or (Pre) - Feasibility)
2. Refined metal supply equivalent = metal contained in concentrate * smelting recovery
3. Steady output refers to mining operations that do not see a significant increase or decrease in production levels

Source: MineSpans; Reference period: 2026Q1

Top 15 Copper projects add~1.6 Mt new supply, yet only ~30% Greenfields



Project	Country	Owner	Start year	Production 2035 vs 2025[3], kt
Udokan (Phase 2)	Russia	Baikal Mining	2030	277
Grasberg Kucing Liar	Indonesia	Freeport-McMoRan	2029	243
Reko Diq (Phase 1)	Pakistan	Barrick	2029	172
Qulong Phase 2	China	Zijin	2026	168
Boliden Laver project	Sweden	Boliden	2030+	150
Josemaria	Argentina	BHP Lundin Mining	2031	146
Radomiro Tomic sulphides phase II - stage I	Chile	Codelco	2029	-167 309
Centinela (Second Concentrator)	Chile	Antofagasta PLC	2027	131
Timok Lower Zone Phase 1	Serbia	Zijin	2026	124
Highland Valley Extension	Canada	Teck	2028	-5 125
Zafranal (flotation)	Peru	Teck	2029	115
Bingham Canyon Apex and East Tailings expansion	USA	RioTinto	2032	-9 123
Batu Hijau Expansion	Indonesia	Amman	2026	113
Tia Maria	Peru	Southern Copper Grupo Mexico	2027	112
Lumwana Super Pit	Zambia	Barrick	2028	109
Bagdad Concentrator Expansion	USA	Freeport-McMoRan	2029	103
Ivanhoe Electric Santa Cruz (Arizona)	USA	Ivanhoe Electric	2028	72

Copper project pipeline **increasingly reliant on organic growth, including mill expansions and LOM extension projects**, as producers look to **cut upfront costs and reduce geological, operational, ESG risks**

Average production size of projects has decreased, **with only 2 currently >200 ktpy in a base case scenario**

This contrasts with the largest new additions over the past 5 years such as Kamoa (400 kt), Quellaveco (340 kt), QB2 (280 kt), Oyu Tolgoi UG (250 kt)

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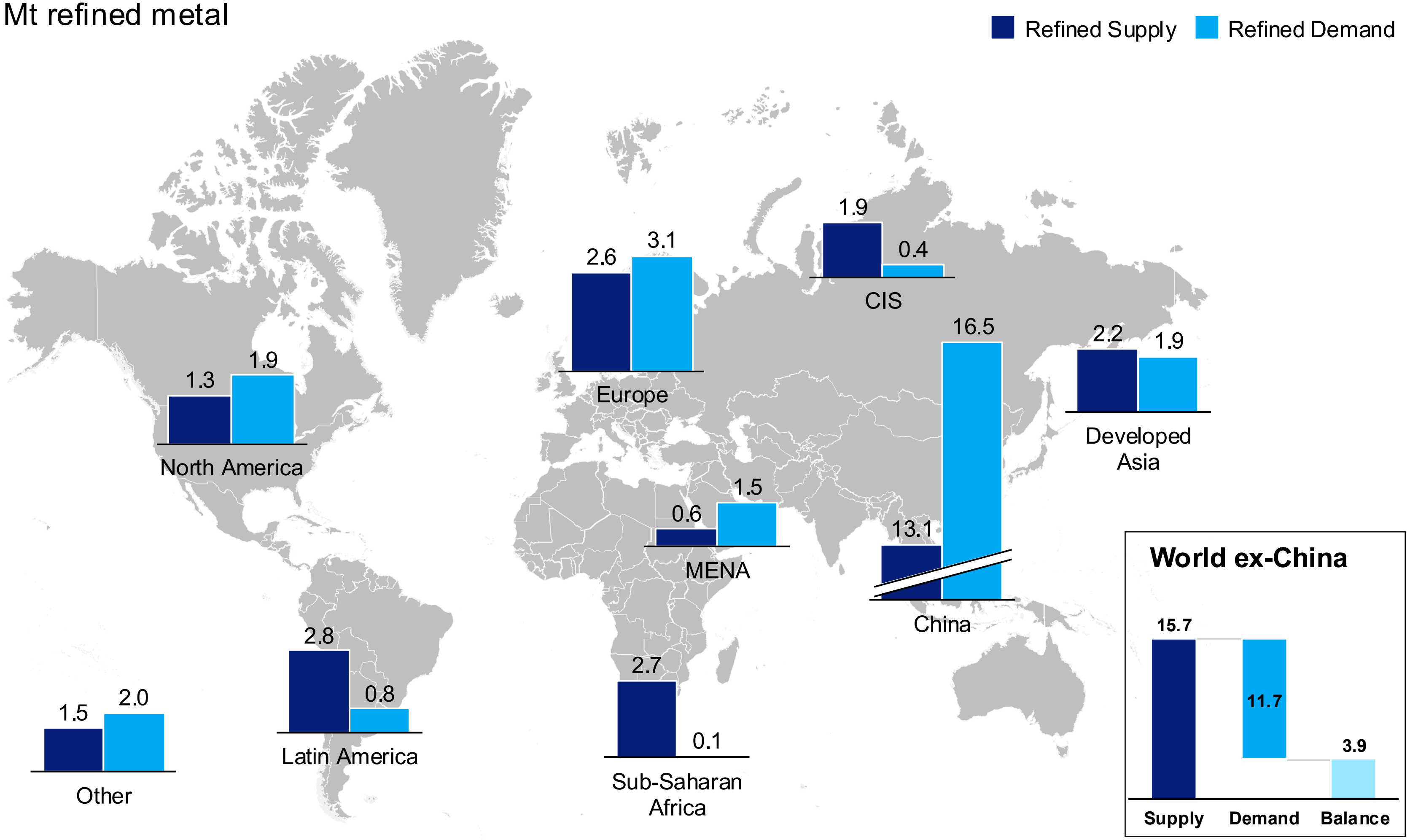
1. Expansions that will bring additional supply without closure of existing mining assets, e.g. mill capacity expansion 2. Net effect of an extension of LOM by getting extended permits/unlocking resources/processing method change. 3. Maximum expected refined metal annual production up to and including 2035 4. Increase vs existing mine capacity

Source: MineSpans; Reference period: 2026Q1

Emerging regionalization (‘near shoring’) of production would see increased competition for cathodes

Refined copper supply and demand by region, 2025

Mt refined metal



Source: MineSpans; Reference period: 2026Q1

‘Near shoring’ of downstream production facilities expected to **drive increased demand for cathode from surplus regions**, such as Latam and Sub-Saharan Africa, as cathode supply shifts away from China

North America and Europe are likely to face higher premiums from key supply regions to secure refined cathode for downstream processing

Higher shipping costs anticipated as **cathode flows are redirected to emerging markets**