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Copper: The end of surplus

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Tightening increments erase surplus prospects. Over the past year, copper investors have been consistently reminded that between 2022 and open-ended copper deficits in the middle of the decade lies a period of surplus as a final burst of mine supply temporarily softens fundamentals. Yet today, this soft patch is failing to materialise - the cathode market has remained in clear deficit through 2022 (GSe 210kt deficit vs. 131kt deficit previously), with global visible stocks falling to the lowest level in 14 years, both critical factors curtailing downside risk to price, in our view. Moreover, the surplus we previously expected for 2023 (169kt surplus) has also now disappeared in our latest balance iteration (GSe 178kt deficit). The tightening increment primarily reflects a sharp downgrade in global mine supply expectations for next year (-434kt vs Oct-22 balance), with the projected growth rate falling by a third over the past quarter to just 3.6%, as well as significant upgrades to China's renewable related demand (+250kt vs Oct-22 balance). Moreover, with copper mine greenfield and brownfield project approvals having plunged to cycle lows this year, peak supply is now immovably fixed in mid-2024, reinforcing open-ended depletion generating deficits from that point. In this context, we now upgrade our average 2023 forecast to $9,750/t (from $8,325/t previously) and 2024 forecast to $12,000/t (from $10,750/t previously), as well as increasing our 3/6/12M targets to $9,500/10,000/11,000/t (from $6,700/7,600/9,000/t).

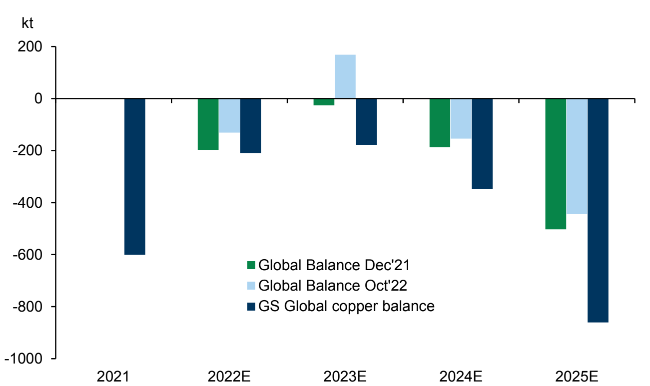
Return of China restock amplifies '23 upside. The copper market starts next year in a unique setup for the post-2000 era, with near depleted cathode stocks onshore. This means there is no left tail on the onshore stock cycle just as China moves towards its reopening alongside greater stabilisation focus on the property sector. With a similar asymmetry in supply chain forward demand confidence, we think there is a high risk that as the growth recovery gathers momentum restocking will also play out. If China were to return its copper stock to consumption ratio to pre-2020 levels, that would imply as much as a 500kt boost to physical demand. Based on our estimates, if China's monthly net refined import volumes rise above 280ktm, we think that would be a signal they are restocking and in turn, tilting the ex-China market towards an accelerated depletion path. Whilst the CNY seasonal surplus will typically act as a source of fresh buffer, the earlier a reopening is signalled, the greater the risk downstream restocking limits such visible builds. In the interim, if China were to temporarily revert to greater COVID related lockdowns, it is also important to note the diminished seasonal stock builds seen over the past two years (60% lower than pre COVID 2016-19 period) show during the Q1 period that lockdowns actually correlate positively with copper tightness.

Copper's economy is inflecting early. Persistent recession fears and related macro trends, most prominently dollar strength, have been key to industrial commodity price headwinds this year. Moreover, for copper, with China at the epicentre of both this growth slowdown and the dominant metal consumer, the deceleration in the copper demand weighted global economy has been outsized. This was particularly evident in Q2 this year, where copper demand weighted GDP growth was significantly lower (2.3%) than market FX weighted GDP growth (3%). Conversely, with a clear sequential recovery path now expected for China in 2023, we believe we are near the trough in the copper economic cycle, with a return to relatively healthy copper weighted GDP growth trend in H1-23 (+2.6%) versus continued pressures on market FX weighted GDP (1.7% growth in H1-23). For copper at least, 2022 was the year of growth deceleration and a more supportive macro backdrop is expected next year. Alongside a continued metal deficit, the positive orientation in both macro and micro suggests strong price support ahead. Indeed, since 2000 during the 8 years when such factor alignment has occurred in copper, that has generated an annual average return of 27%. Yet investor positioning remains extremely light but with broad interest in the upside trade, suggesting that a participation surge could trigger a significant increase in flat price. We also continue to think that the LME curve is under-priced versus micro conditions, with historical average spreads for current tightness suggesting the cash to 15m spread is undervalued by 88%. We continue to recommend investors hold a long position in copper via the long GSCI Copper Sub Index and also recommend the initiation of a long Jun-Dec'23 LME spread trade.

Copper: The end of surplus

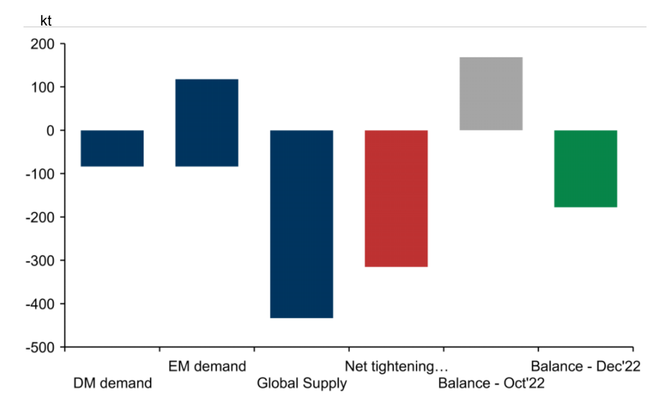
1. Tightening pivot in 2023 copper balance expectations. Over the past year, copper prices have been pressured in part by a persistent expectation for a surplus inflection in the metal market, based on a combination of demand headwinds from slower global growth as well as an acceleration in mine supply. That the cathode market has remained in clear deficit through 2022 (GSe 210kt deficit vs. 131kt previously), with global visible stocks falling to the lowest level in 14 years, has been a critical factor curtailing downside risk to price, in our view. Equally important, the surplus we previously expected for 2023 (169kt surplus) has also now disappeared in our latest balance iteration (GSe 178kt deficit). This tightening in balance reflects three key adjustments to fundamental expectations for next year versus our last published balance. First, we have cut 434kt from our global mine supply forecasts, mostly related to lower guidance on operations in Chile. Second, we have increased our China green demand forecasts by 250kt, following our analysts' updated 23' expectations of installations of solar PV's (150GW vs 100GW previously), driven by a softening price for solar PV materials. Thirdly, we have marginally reduced our China non green demand for next year (-47kt), primarily related to lower assumed infrastructure investment next year, whilst also lowering EU and US demand (-84kt) due to a worsening construction sector. With global visible inventories set to end 2022 at below 200kt, we think that another deficit in the market next year will take fundamental conditions to an unprecedented extreme in terms of tightness. In this context, we now upgrade our average 2023 forecast to $9,750/t (from $8,325/t previously) and 2024 forecast to $12,000/t (from $10,750/t previously), as well as increasing our 3/6/12M targets to $9,500/10,000/11,000/t (from $6,700/7,600/9,000/t).

Exhibit 1: Copper market is set to remain in deficit next year, with no surplus now anticipated on the forward fundamental horizon
GS global copper balance (current, Oct'22 & Dec'21)



Source: Goldman Sachs Global Investment Research

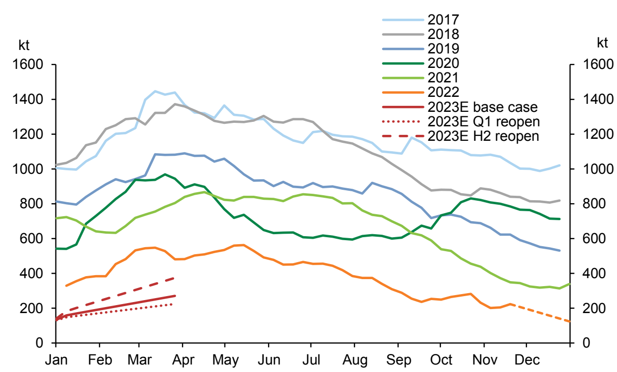
Exhibit 2: Upgrade in green demand and reduced mine supply growth have been key to adjusting the 2023 balance to a deficit
2023 copper balance adjustments



Source: Goldman Sachs Global Investment Research

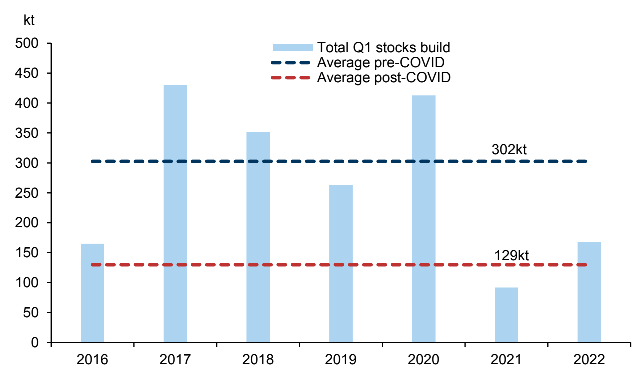
2. Reopening skews risk towards diminished seasonal stock build. The copper market starts next year in a fairly unique setup for the post-2000 era, with near depleted cathode stocks onshore. This means there is no left tail on the onshore stock cycle just as China moves towards its reopening alongside a greater stabilisation focus on the property sector. With a similar asymmetry in supply chain forward demand confidence, there is a high risk that as the growth recovery gathers momentum, restocking will also play out. If China were to return its copper stock to consumption ratio to pre-2020 levels, that would imply as much as a 500kt boost to physical demand. Based on our estimates, if China's monthly net refined import volumes rise above 280ktm, we think that would be a signal they are trending towards restocking. In that context, we would note that our latest estimate on ex-China refined balance points to 3.25Mt surplus in 2023. This means that if China's monthly net refined imports are above 270ktm, this will generate a deficit in metal ex-China, drawing Western exchange and off warrant stocks. Whilst the CNY seasonal surplus will typically act as a source of fresh buffer, the earlier a reopening is signaled by Beijing, the greater the risk downstream restocking limits visible builds. In the interim, if China were to revert to greater COVID related lockdowns through winter, it is also important to note the diminished seasonal stock builds over the past two years (60% lower than pre COVID 2016-19 period) show at this point in the year that lockdowns actually correlate positively with tightness for copper. Scrap market conditions are already extremely tight in China, with high grade scrap trading at close to parity with refined and semi fabricators consuming higher cathode volumes than normal. Equally with limited new smelting capacity being added in China, there is limited flex in onshore supply to solve the domestic tightness.

Exhibit 3: An earlier reopening and related downstream restocking effects could significantly curtail the potential visible seasonal stock build in Q1
Global visible copper cathode stocks (kt)



Source: Wind, Goldman Sachs Global Investment Research

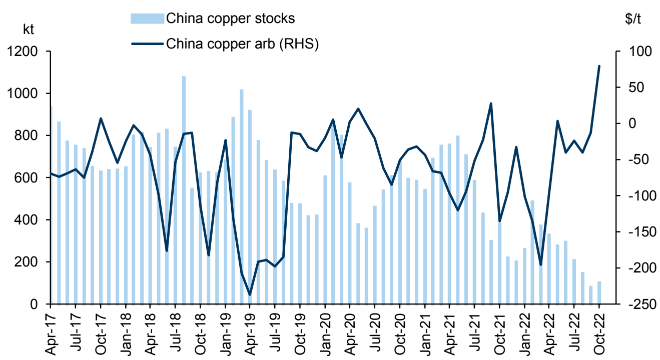
Exhibit 4: Seasonal stock builds in both 2021 and 2022 were limited by lockdown effects onshore
Q1 visible copper cathode stock trends



Source: Wind, Goldman Sachs Global Investment Research

3. Lower property drag and green demand underpin solid China demand trend. Constrained between ZCP and the property deleveraging, the traditional channels of China copper demand, property, home appliances and industrial machinery, have been underperforming for most of 2022. Yet China copper apparent demand is up 4% y/y, supported by higher than expected EV sales (+110% y/y YTD) and continued strength in renewables installations (+53% y/y YTD), equal to +668kt of copper demand YTD. Into 2023 we expect this trend to continue with 68% (420kt) of growth driven by green sectors. Namely, following our analysts upgrade of China solar installations by 50GW, driven by a sharp decline in poly prices, we now expect China green demand at 1.44Mt next year, up by 249kt vs our previous expectation, with growth from solar PVs accounting for 52% (220kt) of total green demand growth, followed by wind growth (+100kt) and EVs (+83kt). The upward revision in the green sectors more than offset the marginal downgrade in the non-green cyclical sectors (-47kt), driven by expected lower infrastructure investments, following the strong stimulus in 2022. While we believe China green demand will remain the main driver to 2023 growth, upside risks remain from property demand, in our view. Indeed China policy makers have been sequentially easing the policy stance on property, signalling an increased focus on stabilising the sector to correct the '22 overtightening. While our base case entails a continuation of the deleveraging process, our analysts recently highlighted potential upside paths for the 2023 property industry that would reduce materially the completion risk. Leveraging the analysts scenarios we estimate that an improvement of the late property cycle (completions up by 8% vs base case 5%) would translate into an additional 135kt of demand from property and home appliances (see Exhibit 8), further tightening our 2023 balances.

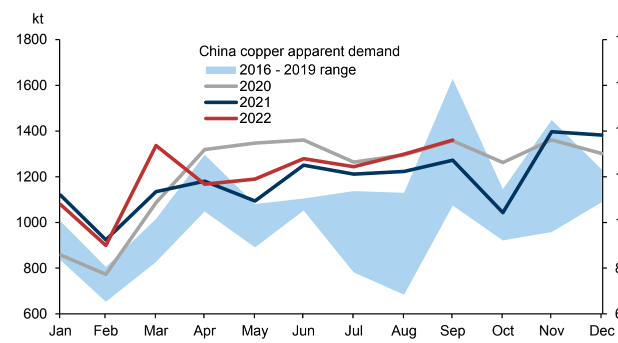
Exhibit 5: With the onshore market fully destocked, imports are likely to be well supported by solid end demand growth and any additional restocking impulse



Source: Bloomberg, Wind, Goldman Sachs Global Investment Research

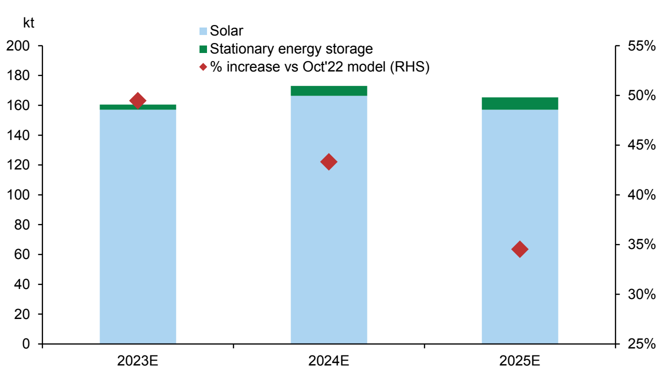
Exhibit 6: Despite ZCP and the property drag China demand has remained healthy through 2022 and that trend is expected to continue into next year

Copper China apparent demand



Source: Goldman Sachs Global Investment Research, Haver Analytics

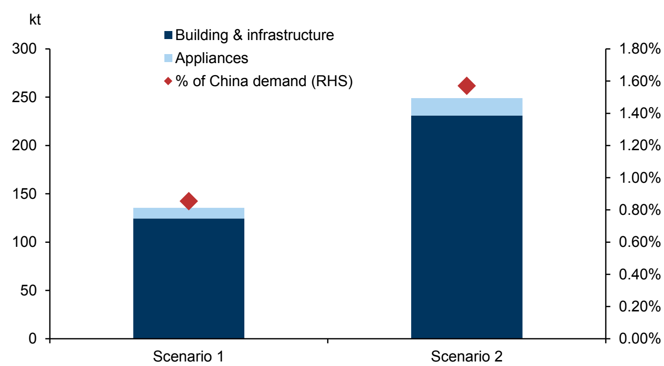
Exhibit 7: Latest upgrade to our onshore solar installations assumption for next year will drive 160kt additional demand in 2023



Source: Wind, Goldman Sachs Global Investment Research

Exhibit 8: Further upgrades to China property trajectory into next year could add as much as an additional 250kt to demand in 2023

2023 additional China copper demand from property scenarios



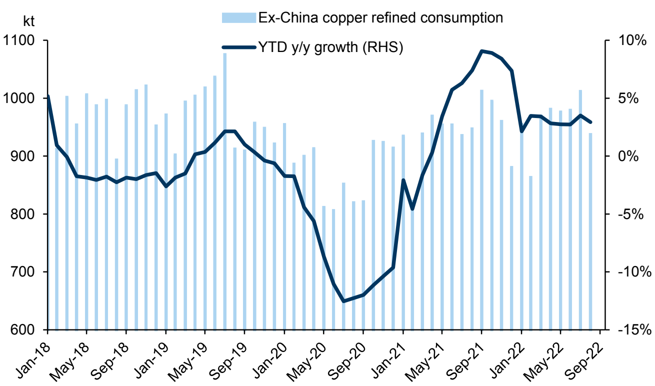
Scenario 1: 2023 Property completions +8%y/y; Scenario2: 2023 Property completions +10% y/y

Source: Goldman Sachs Global Investment Research

4. Green demand and only modest deceleration limit DM drag. The energy shock in Europe and the continued FCI tightening in the US are the two main factors of the slowdown in ex-China copper demand into 2023, in our view. Despite ex-China demand remaining strong in the first three quarters of 2022, growing by 3% y/y YTD (see Exhibit

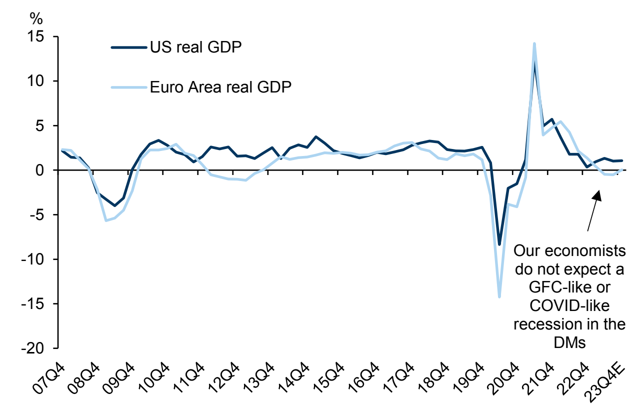
9) thanks to COVID-related pent-up demand and a downstream restocking, we now expect a deceleration into year-end, reinforced in Europe by consumers destocking. Nevertheless, demand weakness in the DMs will remain limited in our view, with Europe demand decreasing by 1.4% y/y (72kt) and US consumption remaining flat y/y (-7kt). This reflects our economists view of a shallow recession in Europe, on the back of better than expected gas supply and fiscal support, with FY GDP expected to decrease by only 0.1%y/y, and only a modest slowdown in the US (+1.2% y/y) (see Exhibit 10). The slowdown will affect mostly the demand from non-green cyclical sectors, highly sensitive to growth and consumers' expenditure. As such, we expect demand from building and infrastructure, appliances and industrial machinery to contract by 5% in Europe and US (-250kt). However, we also expect transition related demand growth (renewables, EVs & power grid) to partly offset the construction centered demand decrease, thanks to an acceleration in EVs and renewable demand in the US, driven by the Inflation Reduction Act and a renewed commitment in Europe to electrification, as countries try to shy away from Russian gas and secure energy supplies. In this context we see green transition related demand growing by 3% (42kt) in Europe and 17% (92kt) in the US, offsetting 53% of the cyclical sector slowdown.

Exhibit 9: Modest deceleration in ex-China copper demand growth since mid-22' but no collapse into broad contraction evident so far
Ex-China copper refined consumption



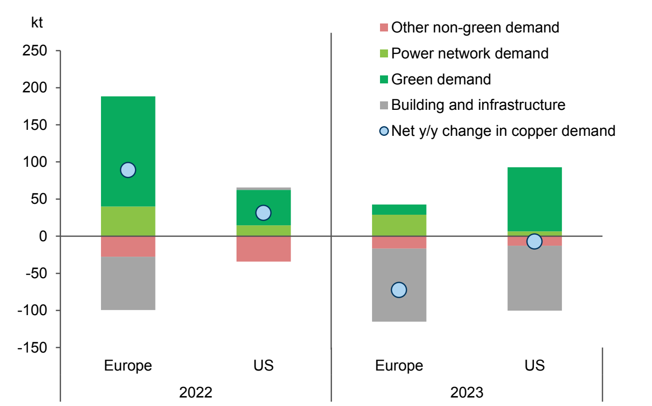
Source: Wind, ICSG, Goldman Sachs Global Investment Research

Exhibit 10: US growth and shallow recession in Europe to limit downside impact on copper demand



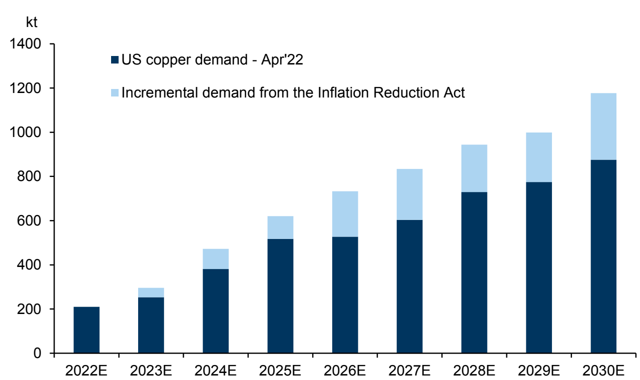
Source: Goldman Sachs Global Investment Research

Exhibit 11: Green demand is set to offset most of cyclical sectors' drag
Europe and US copper demand



Source: Goldman Sachs Global Investment Research

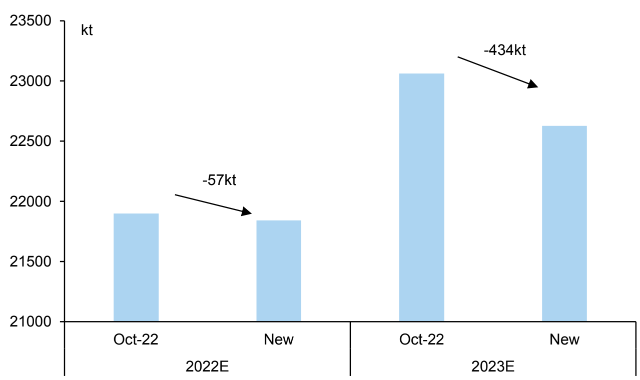
Exhibit 12: We estimate increasing incentives for green transition will lead to 1.4Mt additional US copper demand by 2030



Source: Goldman Sachs Global Investment Research

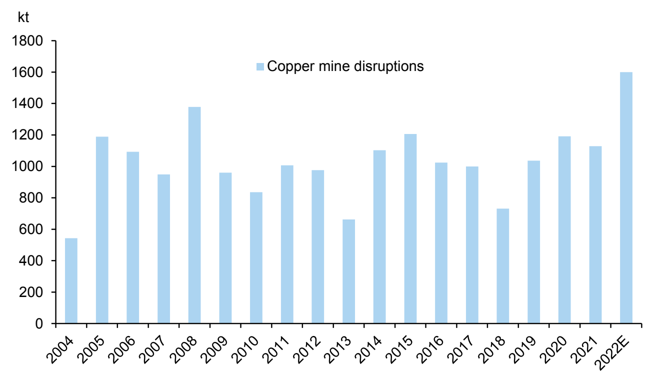
5. Disruptions and delays mean no surge in mine supply now or next year. One of the other key pressures to copper prices this year has been the expectation of a sharp acceleration in mine supply over the 2022-23 period. At the beginning of this year we forecast global mine supply to grow just under 6% this year. Mine supply growth is set to end the year closer to 4%, nearly 450kt below our initial estimate. This underperformance has reflected significantly weaker out-turn versus expectations in Chile and Peru, where there have been an extremely high level of mine disruptions. In fact, we now estimate that mine disruption losses are on track to reach 1.6Mt in 2022, owing to a combination of poor grade quality, water issues and slower ramp ups at new projects. This compares to our initial disruption allowance close to 1.1Mt, close to 6% of base case supply, which we determine as a 3 year rolling average of disruption rate. Into 2023, we also now project a lower supply growth rate than even mid-year, with the global growth rate now just 3.6%, down from 6% mid-year and 5.3% previously. This reflects a number of downgrades across copper operations over the past quarter, as producers increasingly signal the factors that have generated underperformance this year - such as delayed maintenance from COVID lockdowns, water issues and cost inflation - are set to remain as headwinds into next year. We would note that Chile accounts for 49% of these downgrades, followed by Peru (28%).

Exhibit 13: Versus our previous balance (October 22'), we have revised down 2023 mine production by 300kt (1.5% global mine supply)
Global copper mine production GSe



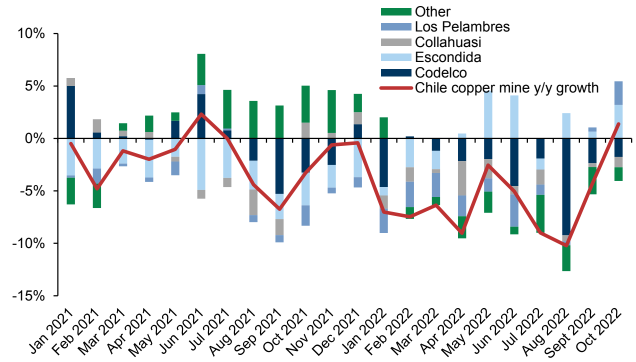
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 14: 2022 has seen a record high level of mine disruptions, particularly concentrated in Chile and Peru
Copper mine disruptions



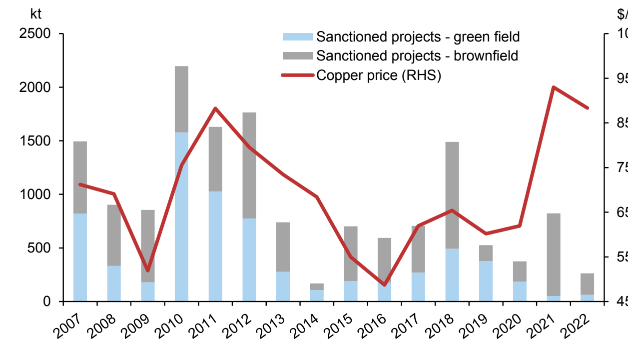
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 15: Chile remains the main driver of underperformance on the mine supply-side, with no obvious catalyst for substantive improvement in the near term



Source: Cochilco, Goldman Sachs Global Investment Research

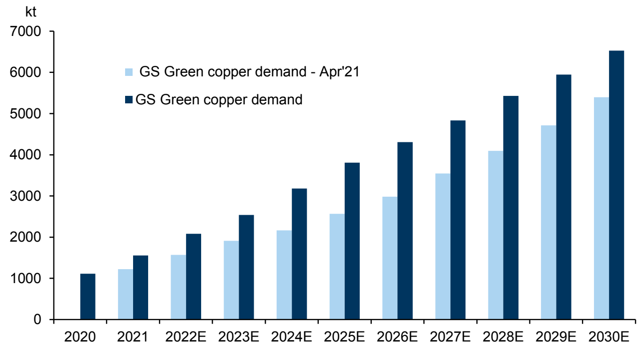
Exhibit 16: Sanctioned copper projects - both greenfield and brownfield - were at 15 years lows in 2022



Source: Woodmac, Goldman Sachs Global Investment Research

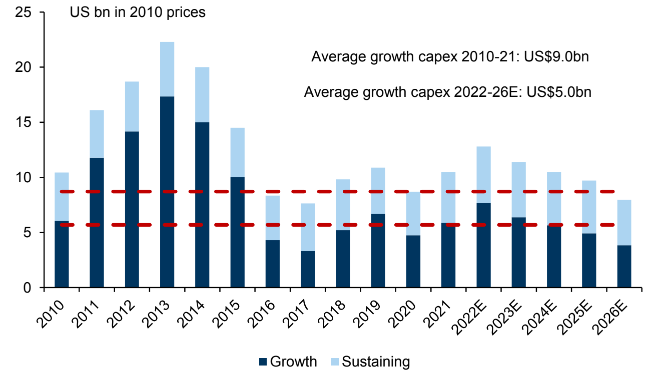
6. Structural bullish story unchanged. In the mid term we retain high conviction in our copper structural bullish view, forecasting increasing sized deficits into mid-decade and higher prices (see Exhibit 28). Most crucial in this regard is the sequential increase in policy targets and commitments to green transition, alongside a minimal supply response so far, which have resulted in earlier and larger open-ended deficit conditions that essentially are already here not beginning at some point in the future. The green transition will continue to be the main driver of copper consumption growth post 2023, in our view, with green demand expected to grow on average by 580kty in the period between 2024 to 2030, reaching 6.6Mt in 2030, accounting for 16% of global demand versus just 4% in 2021. This entails an increase of 4Mt over the same period (see Exhibit 17), with new policies such as the Inflation Reduction Act and RePowerEU setting the stage for a renewables and EVs adoption acceleration. The supply side response to this increase in forward demand expectations has been extremely limited, such that we expect the supply gap at the end of this decade (7.8Mt, see Exhibit 20) essentially unchanged over the past two years. This is best demonstrated by the collapse in approvals for both greenfield and brownfield copper mine projects over the past year. We estimate in 2022 the aggregate design capacity of sanctioned mine projects will amount to only 263kt, essentially the lowest approval volume in the last 15 years (see Exhibit 16). This only reinforces the prospect of peak supply fast approaching on the horizon, which is now just 18 months away (see Exhibit 19). Moreover, there is no indication in miners' spending plans that the higher price environment is shifting capex momentum, with current guidance pointing toward 34% less growth capex deployed in nominal terms between 2022-2026 than was deployed over the same time frame during the early-mid 2000's (see Exhibit 18).

Exhibit 17: Increasing policy commitment and improving economies of scale have added a net increase of 580kty in our green estimates
Green demand from solar, wind & EVs



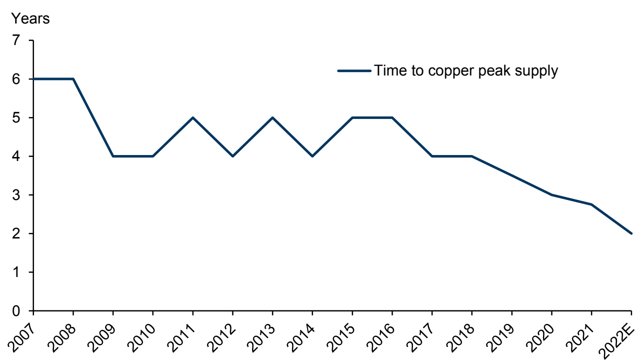
Source: Goldman Sachs Global Investment Research

Exhibit 18: Growth capex remains well below the needed levels



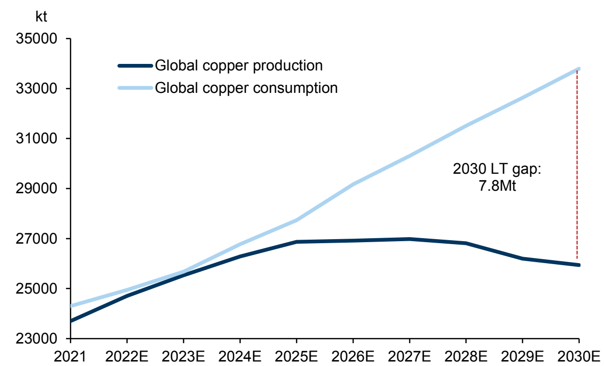
Source: Company data, Goldman Sachs Global Investment Research

Exhibit 19: Peak supply is now just 18 months away, never closer to current year in the post-2000 era
Time to copper peak supply



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 20: Upgrades to green demand and lack of supply investments have increased the size of the long term supply gap from earlier in the year

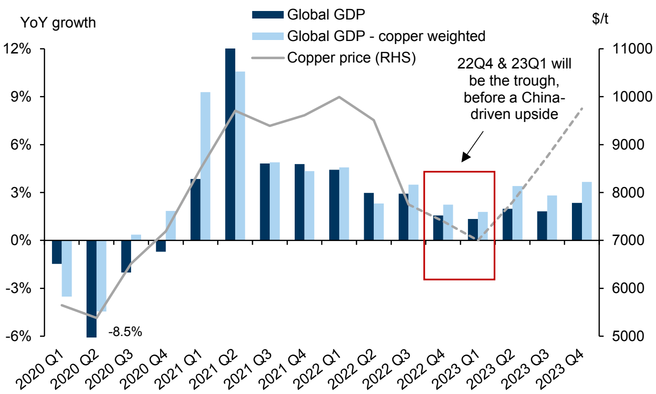


Source: Woodmac, Goldman Sachs Global Investment Research

7. Macro shifts set to refuel upside flat price momentum. Persistent recession fears and related macro trends, most prominently dollar strength, have been key to industrial commodity price headwinds this year. Moreover, for copper, with China at the epicentre of both this growth slowdown and the dominant metal consumer, the deceleration in the copper demand weighted global economy has been outsized. This was particularly evident in Q2 this year, where copper demand weighted GDP growth was significantly lower (2.3%) than market FX weighted GDP growth (3%). Conversely, with a clear sequential recovery path now expected for China in 2023, we believe we are near the trough in the copper economic cycle, with a return to relatively healthy copper weighted GDP growth trend in H1-23 (+2.6%) versus continued pressures on market FX weighted GDP (1.7% growth in H1-23). For copper at least, 2022 was the year of growth deceleration and a more supportive macro backdrop for the metal is expected ahead. With another metal deficit now expected over the year ahead, the positive orientation in both macro and micro factors suggests a setup for significant upside in price. Indeed, since 2000 during the 8 years when such positive macro and micro alignment has occurred in copper, that has generated an annual average return of 27%. Investor positioning still remains extremely light but with broad interest in the upside trade, suggesting just as in early 2021 that a participation surge could trigger a further significant increase in flat price. We also continue to think that the LME curve is under-priced versus micro spot and forward conditions, with historical average spreads for current tightness suggesting the cash to 15m spread is undervalued by 88%. We continue to recommend investors hold a long position in copper via the long GSCI Copper Sub Index and also recommend the initiation of a long Jun-Dec'23 LME spread trade.

Exhibit 21: Copper demand weighted global growth is already at a trough and should be in a recovery trend over 2023

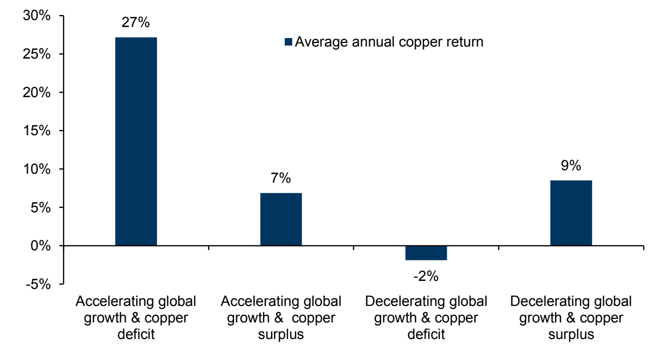
Global GDP (market exchange rate weighted & copper demand weighted) & copper price (GSe from 2022 Q4)



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 22: In year's when both macro and micro factors have aligned to support, since 2000 copper has achieved an annual average return of 30%

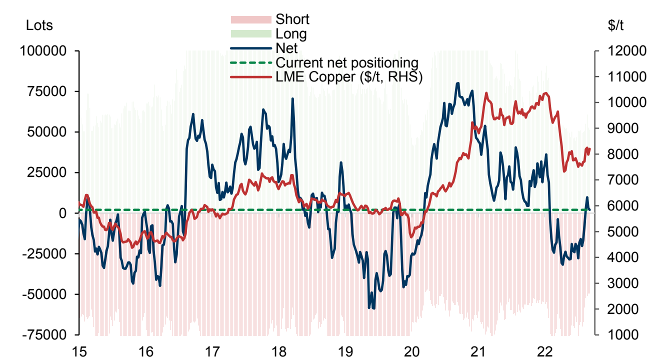
Average annual copper return



Global growth is copper-consumption weighted

Source: Haver Analytics, Goldman Sachs Global Investment Research

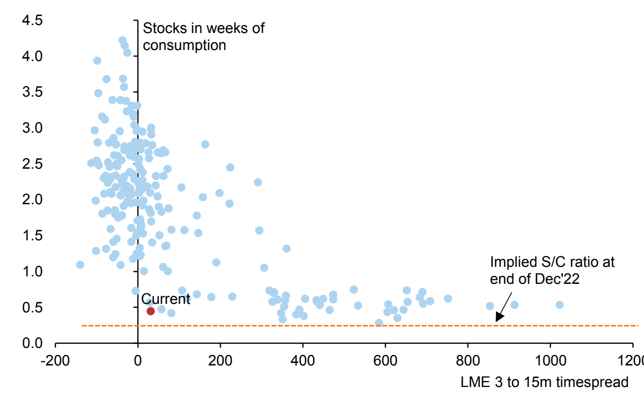
Exhibit 23: CFTC data points to essentially flat copper positioning currently, with short covering the key adjustment so far in Q4



Source: Wind, Goldman Sachs Global Investment Research

Exhibit 24: Historical relationship between copper stocks and spreads points to a significant underpricing in the curve currently

LME 3 to 15m timespread vs visible copper stocks in weeks of consumption



Source: Wind, Woodmac, Goldman Sachs Global Investment Research

Appendix

Exhibit 25: We expect weak property demand to be partially offset by strong grid and green demand in China

China Copper Demand Model	2021	2022E	2023E	2024E	2025E
China non-Green Demand					
Building and Infrastructure	**4370**	**4189**	**4204**	**4127**	**4078**
YoY growth		***-4%***	***0%***	***-2%***	***-1%***
Property	2535	2095	2128	2109	2093
YoY growth		*-17.4%*	*1.6%*	*-0.9%*	*-0.8%*
Infrastructure (ex-grid)	1835	2095	2076	2018	1985
YoY growth		*14.1%*	*-0.9%*	*-2.8%*	*-1.6%*
Transport	**604**	**562**	**494**	**477**	**467**
YoY growth		***-7%***	***-12%***	***-3%***	***-2%***
ICE Light and Heavy vehicles	564	456	351	305	262
YoY growth		*-19%*	*-23%*	*-13%*	*-14%*
Hybrid EV	40	106	143	172	205
YoY growth		*166%*	*35%*	*20%*	*19%*
Power Network	**3980**	**4192**	**4245**	**4310**	**4385**
YoY growth		***5%***	***1%***	***2%***	***2%***
Power grid infrastructure	2559	2598	2634	2667	2709
YoY growth		*1.5%*	*1.4%*	*1.2%*	*1.6%*
End-user distribution	1421	1595	1610	1643	1676
YoY growth		*12.2%*	*1.0%*	*2.0%*	*2.0%*
Appliances	**3448**	**3566**	**3695**	**3843**	**3902**
YoY growth		***3.4%***	***3.6%***	***4.0%***	***1.5%***
Industrial Machinery	**1868**	**1897**	**1980**	**2128**	**2242**
YoY growth		***2%***	***4%***	***7%***	***5%***
Total non-Green Demand	**14270**	**14406**	**14618**	**14885**	**15074**
		1%	***1%***	***2%***	***1%***
China Green Demand					
Solar	**166**	**251**	**471**	**550**	**612**
YoY growth		**51%**	**88%**	**17%**	**11%**
Wind	**366**	**251**	**356**	**467**	**579**
YoY growth		**-31%**	**41%**	**31%**	**24%**
Energy storage	**2**	**6**	**14**	**23**	**32**
YoY growth		**165%**	**147%**	**66%**	**40%**
EV	**231**	**498**	**581**	**660**	**719**
YoY growth		**116%**	**17%**	**14%**	**9%**
Charging infrastructure	**10**	**15**	**20**	**26**	**31**
YoY growth		**46%**	**33%**	**26%**	**21%**
Total Green Demand	**776**	**1022**	**1442**	**1725**	**1974**
		32%	**41%**	**20%**	**14%**
Total Demand	**15046**	**15428**	**16060**	**16610**	**17048**
		2.5%	***4.1%***	***3.4%***	***2.6%***

Source: Goldman Sachs Global Investment Research

Exhibit 26: We forecast strong demand from the power network and transport sectors

GS global non-green copper demand

Global non-Green Copper Demand Model										
'000 tonnes	2021	2022E	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E
EU	**4642**	**4582**	**4496**	**4483**	**4598**	**4666**	**4744**	**4789**	**4815**	**4846**
Building and Infrastructure	1840	1769	1670	1639	1672	1722	1757	1792	1819	1837
Transport	300	304	324	319	344	300	284	235	175	130
Power Network	928	968	997	1034	1073	1115	1156	1197	1239	1281
Industrial Machinery	575	571	548	536	544	555	566	575	582	588
Appliances	999	971	958	955	963	973	981	991	1000	1009
US	**2063**	**2046**	**1952**	**1889**	**1879**	**1860**	**1853**	**1852**	**1851**	**1830**
Building and Infrastructure	932	935	848	802	810	818	831	835	843	849
Transport	439	410	423	411	378	334	295	273	251	208
Power Network	316	330	337	344	356	370	385	400	412	424
Industrial Machinery	152	153	141	137	138	139	141	142	143	144
Appliances	224	218	204	195	197	199	201	202	203	204
China	**14270**	**14419**	**14618**	**14884**	**15073**	**15544**	**15974**	**16408**	**16750**	**17014**
Building and Infrastructure	4370	4189	4204	4126	4077	4199	4325	4429	4536	4581
Transport	604	562	494	477	467	482	466	452	436	410
Power Network	3980	4205	4245	4310	4384	4538	4674	4814	4910	5009
Industrial Machinery	1868	1897	1980	2128	2242	2306	2369	2449	2519	2578
Appliances	3448	3566	3695	3843	3902	4019	4139	4264	4349	4436
RoW	**7856**	**7955**	**8093**	**8352**	**8616**	**8864**	**9116**	**9385**	**9691**	**9983**
Building and Infrastructure	2457	2494	2531	2607	2694	2766	2849	2935	3023	3114
Transport	920	907	954	1000	1044	1079	1094	1109	1125	1137
Power Network	1595	1629	1660	1720	1778	1836	1900	1977	2056	2117
Industrial Machinery	1040	1050	1056	1090	1120	1148	1177	1207	1243	1281
Appliances	1844	1875	1891	1935	1981	2034	2095	2158	2244	2334
Global non green copper demand	**28830**	**29002**	**29160**	**29607**	**30165**	**30935**	**31686**	**32434**	**33107**	**33671**

Source: Goldman Sachs Global Investment Research, Haver Analytics, BNEF, Woodmac

Exhibit 27: EVs and Solar are biggest drivers of green demand

GS global green copper demand model

Global Green Copper Demand Model '000 tonnes	2021	2022E	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E
EU	**306**	**452**	**462**	**564**	**720**	**951**	**1180**	**1424**	**1602**	**1674**
Solar	82	77	88	113	161	183	216	232	236	238
Wind	63	162	123	110	135	180	279	338	356	319
Stationary energy storage	2	3	4	5	6	7	8	9	10	10
Electric vehicles	153	201	234	317	393	550	639	799	943	1040
Charging infrastructure	6	9	13	18	24	31	39	47	57	67
US	**162**	**210**	**296**	**472**	**621**	**733**	**834**	**944**	**999**	**1177**
Solar	55	82	103	106	111	117	124	131	137	144
Wind	53	42	18	65	84	69	35	61	32	58
Stationary energy storage	5	7	11	14	17	20	23	26	31	35
Electric vehicles	46	76	160	281	399	514	634	702	770	904
Charging infrastructure	2	3	4	7	10	13	18	23	29	36
China	**776**	**1022**	**1442**	**1725**	**1974**	**2076**	**2201**	**2342**	**2492**	**2652**
Solar	166	251	471	550	612	644	675	707	738	769
Wind	366	251	356	467	579	637	701	757	817	858
Stationary energy storage	2	6	14	23	32	39	45	49	55	62
Electric vehicles	231	498	581	660	719	719	737	782	827	900
Charging infrastructure	10	15	20	26	31	37	43	49	55	62
RoW	**324**	**414**	**372**	**467**	**553**	**616**	**701**	**807**	**954**	**1139**
Solar	222	287	249	339	363	389	415	456	504	553
Wind	86	106	95	91	119	117	129	131	142	165
Stationary energy storage	1	1	3	3	4	4	5	5	6	7
Electric vehicles	14	18	24	32	63	101	145	206	290	400
Charging infrastructure	1	1	2	3	4	5	7	9	11	15
Global green copper demand	**1567**	**2097**	**2572**	**3228**	**3867**	**4376**	**4916**	**5517**	**6047**	**6642**

Source: BNEF, ICA, Goldman Sachs Global Investment Research

GS copper supply-demand balance

Exhibit 28: GS copper supply-demand balance

('000 tonnes)	2016	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E
Consumption - DM										
US	2107	2113	2127	2155	2047	2224	2256	2248	2361	2500
% change y/y	*0.1%*	*0.3%*	*0.7%*	*1.3%*	*-5.0%*	*8.6%*	*1.4%*	*-0.3%*	*5.0%*	*5.9%*
Europe	5040	5166	5259	5047	4668	4951	5040	4968	5059	5335
% change y/y	*0.3%*	*2.5%*	*1.8%*	*-4.0%*	*-7.5%*	*6.1%*	*1.8%*	*-1.4%*	*1.8%*	*5.5%*
Japan	1405	1458	1450	1392	1295	1403	1440	1403	1456	1508
% change y/y	*-2.0%*	*3.7%*	*-0.6%*	*-4.0%*	*-7.0%*	*8.4%*	*2.7%*	*-2.6%*	*3.7%*	*3.6%*
Other DM	2279	2328	2234	2089	1922	2026	2074	2068	2160	2251
% change y/y	*1.2%*	*2.2%*	*-4.1%*	*-6.5%*	*-8.0%*	*5.4%*	*2.4%*	*-0.3%*	*4.5%*	*4.2%*
Sub- DM	10831	11065	11069	10683	9933	10604	10810	10687	11036	11594
% change y/y	*0.1%*	*2.2%*	*0.0%*	*-3.5%*	*-7.0%*	*6.8%*	*1.9%*	*-1.1%*	*3.3%*	*5.1%*
Consumption - EM										
China	12816	13326	13710	13930	14251	15046	15441	16060	16609	17047
% change y/y	*3.1%*	*4.0%*	*2.9%*	*1.6%*	*2.3%*	*5.6%*	*2.6%*	*4.0%*	*3.4%*	*2.6%*
Other EM	4691	4769	4883	4963	4466	4751	4855	4994	5204	5409
% change y/y	*1.5%*	*1.7%*	*2.4%*	*1.6%*	*-10.0%*	*6.4%*	*2.2%*	*2.9%*	*4.2%*	*4.0%*
Sub- EM	17508	18095	18593	18893	18742	19797	20295	21055	21813	22456
% change y/y	*2.7%*	*3.4%*	*2.7%*	*1.6%*	*-0.8%*	*5.6%*	*2.5%*	*3.7%*	*3.6%*	*3.0%*
Global Consumption	28338	29160	29662	29576	28674	30401	31105	31742	32849	34050
% change y/y	*1.7%*	*2.9%*	*1.7%*	*-0.3%*	*-3.0%*	*6.0%*	*2.3%*	*2.0%*	*3.5%*	*3.7%*
Direct Global Scrap Use	*5756*	*6106*	*6136*	*6047*	*5140*	*5720*	*5733*	*5677*	*5710*	*5817*
Refined Global Consumption	22583	23054	23526	23529	23535	24301	24921	25605	26663	27757
% change y/y	*3.0%*	*2.1%*	*2.0%*	*0.0%*	*0.0%*	*3.3%*	*2.6%*	*2.7%*	*4.1%*	*4.1%*
Global Production										
Mine Production	20220	20118	20786	20929	20849	20956	21841	22627	23634	23846
% change y/y	*5.1%*	*-0.5%*	*3.3%*	*0.7%*	*-1.1%*	*0.5%*	*4.2%*	*3.6%*	*4.4%*	*0.9%*
Refined Production	22716	22958	23634	23692	23321	23700	24711	25427	26316	26896
% change y/y	*3.2%*	*1.1%*	*2.1%*	*-0.4%*	*-0.3%*	*1.6%*	*4.3%*	*2.9%*	*3.5%*	*2.2%*
Global Balance	**159**	**-62**	**-54**	**-152**	**-213**	**-601**	**-210**	**-178**	**-347**	**-861**
Cash Prices (annual average)										
Current Dollars ($/t)	4870	6192	6540	6017	6194	9300	8763	9750	12000	15000
Current Dollars (c/lb)	221	280	296	272	281	422	397	442	544	680

Source: Woodmac, Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

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