Note: The following is a redacted version of the original report published April 13, 2021. [31 pgs].

Green Metals

Copper is the new oil

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No decarbonisation without copper. After a year of the global pandemic, with its supply chain disruptions, race for PPE, testing kits and vaccines, the critical importance of securing sufficient raw materials in combating society's problems has never been more in focus. This importance extends to the next greatest challenge of our time: climate change. The critical role copper will play in achieving the Paris climate goals cannot be overstated. Without serious advancements in carbon capture and storage technology in the coming years, the entire path to net zero emissions will have to come from abatement - electrification and renewable energy. As the most cost-effective conductive material, copper sits at the heart of capturing, storing and transporting these new sources of energy. In fact, discussions of peak oil demand overlook the fact that without a surge in the use of copper and other key metals, the substitution of renewables for oil will not happen. Though much ink has been spilled discussing the stranding of hydrocarbon assets, in our view there has been insufficient focus on securing the resources required to build new, sustainable, energy infrastructure. As we have long argued, moving the global economy toward net zero emissions remains a core driver of the structural bull market in commodities demand, in which green metals – copper in particular – are critical.

The green transition will support a surge in copper demand. At the core of copper's carbonomics is the need for the world to shift away from a production system based on the chemical energy of hydrocarbons (oil and gas), to one based on a range of sustainable sources – electromagnetic (solar), kinetic (wind) and geothermal. Copper has the necessary physical properties to transform and transmit these sources of energy to their useful final state, such as moving a vehicle or heating a home. Leveraging our equity analysts' carbonomics analysis across EVs, wind, solar, and battery technology, we quantify this demand in a bottom-up model, estimating that by 2030, copper demand from the transition will grow nearly 600% to 5.4Mt in our base case and 900% to 8.7Mt in the case of hyper adoption of green technologies. We estimate that by-mid decade this growth in green demand alone will match, and then quickly surpass, the incremental demand China generated during the 2000s.Ripple effects into non-green channels mean the 2020s are expected to be the strongest phase of volume growth in global copper demand in history.

The copper market is unprepared for this critical role. Crucially, the copper market as it currently stands is not prepared for this demand environment. The market is already tight as pandemic stimulus (particularly in China) have supported a resurgence in demand, set against stagnant supply conditions. Moreover, a decade of poor returns and ESG concerns have curtailed investment in future supply growth, bringing the market the closest it's ever been to peak supply. Indeed, we see the copper market sleepwalking to a classic case of the "Revenge of the old economy", just as oil did during the 2000s commodity boom. The mining sector remains wary of a pivot towards growth after the price collapse in the mid-2010s severely punished any front-footed producers. Even as copper prices have rallied 80% over the last 12 months, there have been no material greenfield project approvals. Coronavirus has only compounded this dynamic, creating enough uncertainty to freeze companies' investment decisions. This combination of surging demand and sticky supply has reinforced current deficit conditions and foreshadows large open-ended deficits from mid-decade. We now estimate a long-term supply gap of 8.2Mt by 2030, twice the size of the gap that triggered the bull market in copper in the early 2000s.

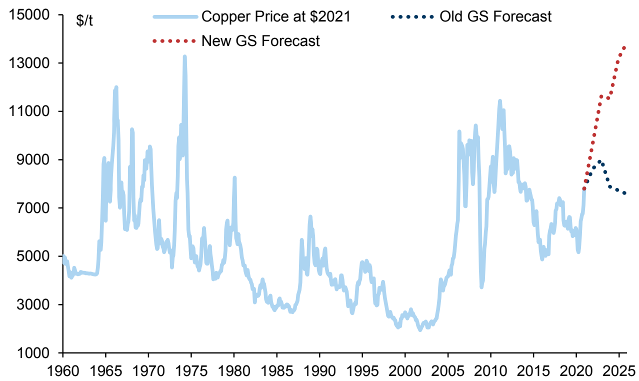
Sticky supply threatens to deplete copper stocks by mid-decade. Copper is a predominantly long-cycle commodity – it takes 2-3 years to extend an existing mine and as long as 8 years to establish a new greenfield project. This long lead time for the majority of copper supply, combined with the mining sector's resistance towards new capex, leaves the copper market running out of runway to secure the necessary supply to meet demand in the second half of the decade. Perversely, this means copper prices must rise now to incentivise enough supply to solve prospective deficits, or risk chronic scarcity pricing in the second half of the decade. Copper is so integral to the green transition – a global effort underpinned by government support – that the supply requirements necessitate a spike in copper prices. History has seen many examples of commodities solving similar mid-term depletion risks with extreme nearer-dated price spikes, not least US natural gas and nickel in the early 2000s where projections for severe shortages were countered by significant increases in price, and followed by the required supply innovation. Copper, lacking any obvious productivity innovations on the horizon, needs higher prices to stimulate a record set of established short cycle (scrap, demand substitution) and long cycle (mine investment) responses.

Copper on a necessary path to $15,000. To capture the precise dynamics of this process we construct long-run models of scrap supply and substitution, as well as extend our balance out to 2030. The immediate conclusion is that current copper prices ($9,000/t) are too low to prevent a near-term risk of inventory depletion, while our current long-term copper ($8,200/t) is not high enough to incentivise enough greenfield projects to solve the long-term gap. If copper remains at $9,000/t through the next two years, then we estimate the resultant deficits would generate a depletion of market inventories by early 2023. Based on our scrap and demand modelling, we believe that the most probable path for copper price from here – that both avoids depletion risk and as well as a sharp surplus swing – is to trend into the mid-teens by mid-decade.

The metal research team would like to thank Annalisa Schiavon, an intern on the Metals team, for her contribution to this report.

Exhibit 1: Copper prices will be forced materially higher in coming years...

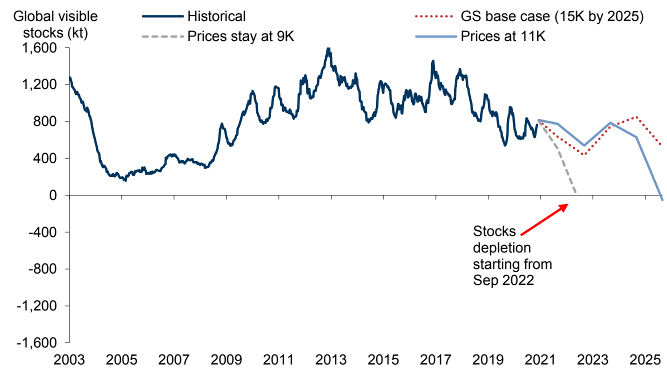
Historical and forecasted copper price at $2021



Source: World Bank, Goldman Sachs Global Investment Research

Exhibit 2: ...to prevent the depletion of copper stocks as green demand surge coincides with a current peak in mine supply

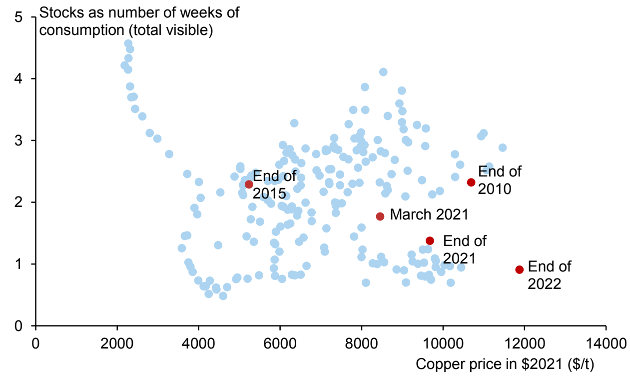
Historical and forecasted copper global visible stocks



Source: Wind, Woodmac, Goldman Sachs Global Investment Research

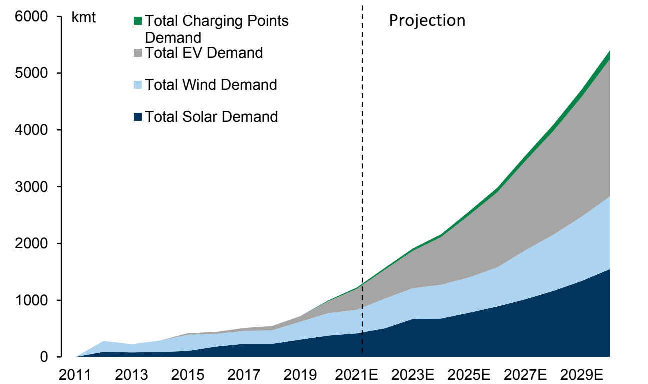
Copper's path to $15,000 in 6 charts

Exhibit 3: Copper market starts the 2020s in an already tight state on post-pandemic demand resurgence set against a stagnant and disrupted supply dynamic
Stocks to consumption ratio



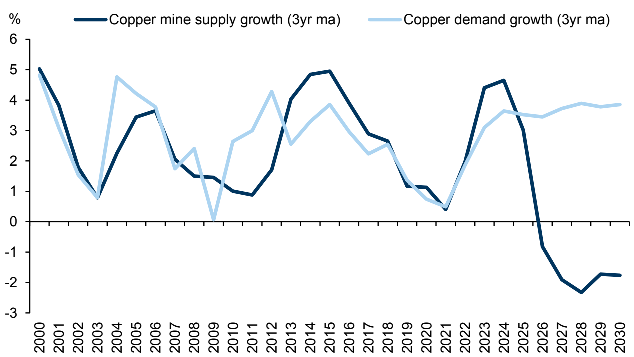
Source: Woodmac, Wind, Goldman Sachs Global Investment Research

Exhibit 4: Acceleration in green electrification trends is set to drive strongest decade in copper demand growth post-2000
Copper demand, per year, from green sectors



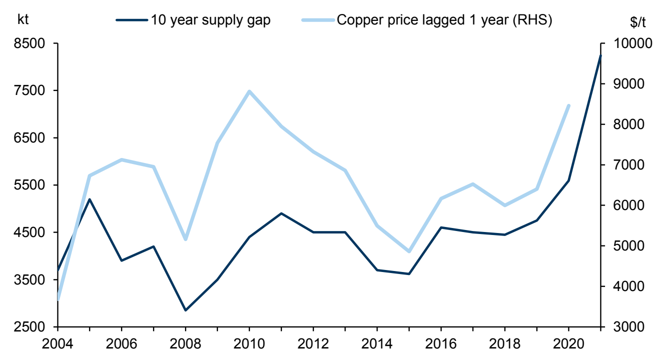
Source: Goldman Sachs Global Investment Research

Exhibit 5: Mine supply will fall well below demand after 2024...
Copper mine supply growth vs copper demand growth, yoy %



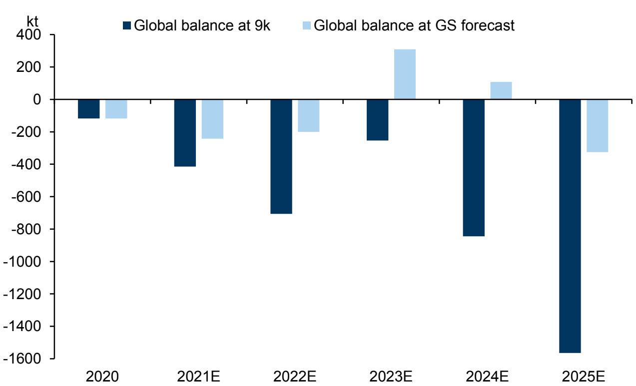
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 6: ...driving largest long-term supply gap on record
LT supply gap and copper price



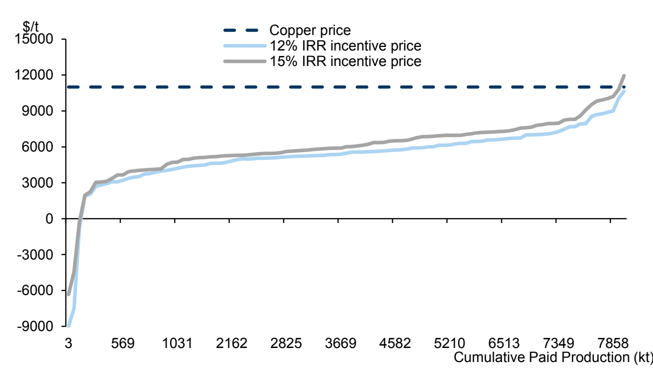
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 7: With these trends at play, if copper prices stay at current levels, depletion risk is real by 2023; a sustained rally is needed now to mitigate that risk into mid-decade
Global copper balance



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 8: We believe a long-term copper price near $10,000/t is needed to incentivise necessary volume of probable projects to solve deficits towards end of 2020s
Risk-adjusted PIP curves



Source: Woodmac, Goldman Sachs Global Investment Research

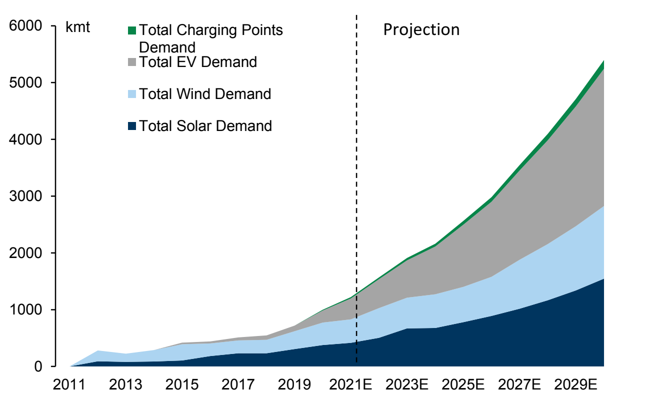
Quantifying the green copper demand revolution

Metals are at the heart of the new commodity super cycle, and green demand is at the heart of the metals price rally. As we detail in Box 1 below for copper, the physical properties of transition metals (aluminum, copper, lithium, cobalt) make them critical to transforming the basis of our energy system away from hydrocarbons toward sustainable sources. However, the precise implications of this transition to net zero emissions has not yet been explicitly mapped into metal's demand more broadly. In the first of the **Green Demand** series, we conduct a bottom-up analysis of the demand from green channels, using our sector expert projections for each copper-containing green technology as well as institutional estimates for the precise copper intensity of each technology, and how this intensity will likely change over time.

This analysis has produced a green demand balance (see Exhibit 25), which is then incorporated into our broader balance. It is important to note that this estimate forms a first-pass for estimating green demand, as both the rate of adoption of new technologies will likely be revised in coming years as the transition accelerates. Our analysis shows that in aggregate 'green' copper amounted to 1Mt in 2020, just 3% of total global copper. However, our modeling suggests under our base case, a rapid acceleration in green demand growth from here rising to 2.6Mt by 2025 (9% total global demand) and then 5.4Mt in 2030 (16% of total global demand). We estimate that green demand will grow at average annual growth rate of 20% y/y in the 2020s, generating just under 500kt per year of growth in demand volumes.

Exhibit 9: We project a surge in green-related copper demand from just under 1Mt in 2020 to 5.4Mt in 2030

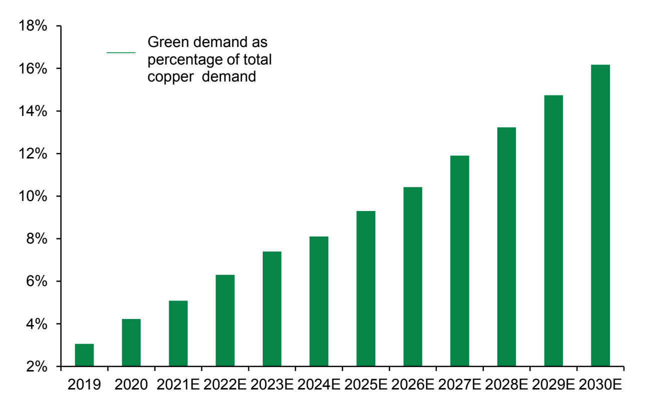
Copper demand, per year, by green sector



Source: IEA, IRENA, ICA, CDA, Goldman Sachs Global Investment Research

Exhibit 10: Green demand will rise from just 3% of total global demand in 2020 to close to 16% by 2030

Green copper demand as percentage of total copper demand



Source: Woodmac, Goldman Sachs Global Investment Research

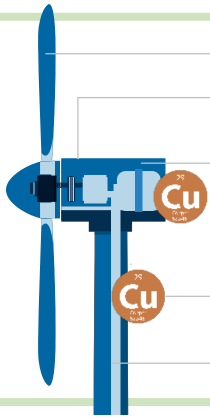
Why Copper Is Key for Electrification

In order to understand the central role copper will play in the coming green revolution, it is important to understand how its unique chemical structure gives it a range of useful properties. Copper is a transition metal with a single valence election, giving it the following three properties that make copper the first-best affordable material for use in cables, batteries, transistors and inverters – all key technologies on the path to net zero.

1. **Ductility.** Copper is a ductile metal – that is, it can be rolled into sheets and *pulled into wires without breaking*. When solid, copper is an array of positive ions surrounded by a sea of mobile valence electrons. When a force is applied to the metal, the free-flowing electrons can slip in between the stationary cations and prevent them from coming in contact, shattering the metal. Other elements with a single valence electron – such as silver and gold – have similar properties, but are not available in industrial quantities.
2. **Electrical conductivity.** The delocalised electrons in copper are free to move throughout the ion array in 3-dimensions and, crucially, can cross grain boundaries, allowing charge to flow across the metal easily. Moreover, the transfer of electromagnetic energy is strongest when there is little resistance. The most effective conductors of electricity are metals that have a single valence electron that is free to move and causes a strong repelling reaction in other electrons. This is the case in the most conductive metals, such as silver, gold, and copper.
3. **Thermal conductivity.** Heat energy is picked up by the electrons as additional kinetic energy is passed along the material. As a result, the best conductors have free electrons that can carry this energy along their length. The energy is transferred throughout the rest of the metal by the moving electrons. Apart from silver, copper is the best.
4. **Low reactivity.** Copper is low in the reactivity series, with minimal corrosion of the metal due to a natural protective coating that forms during oxidisation – similar to stainless steel. However, stainless steel is substantially less ductile and its thermal conductivity is 30 times worse than that of copper.

How Cu Will Power the Next Generation of Clean Tech

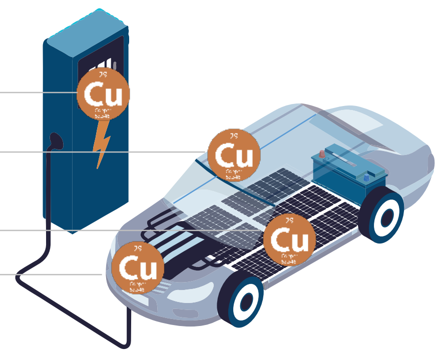
WIND TURBINES



Copper demand from wind energy will account for 20% of green demand, with copper intensity expected to grow as offshore projects that require twice as much copper become more prevalent.

ELECTRIC VEHICLES

Electric vehicles have more than 5 times the copper of ICE vehicles and by the end of decade they will account for around 40% of the green copper demand.

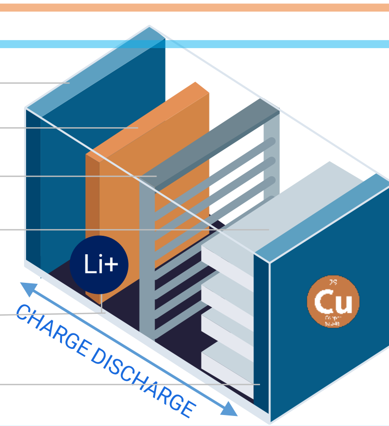


SOLAR PANELS

Copper is key for efficiency and performance of PV panels and thanks to their fast declining cost and deployment they will be the second driver of green demand after EVs.

ENERGY STORAGE

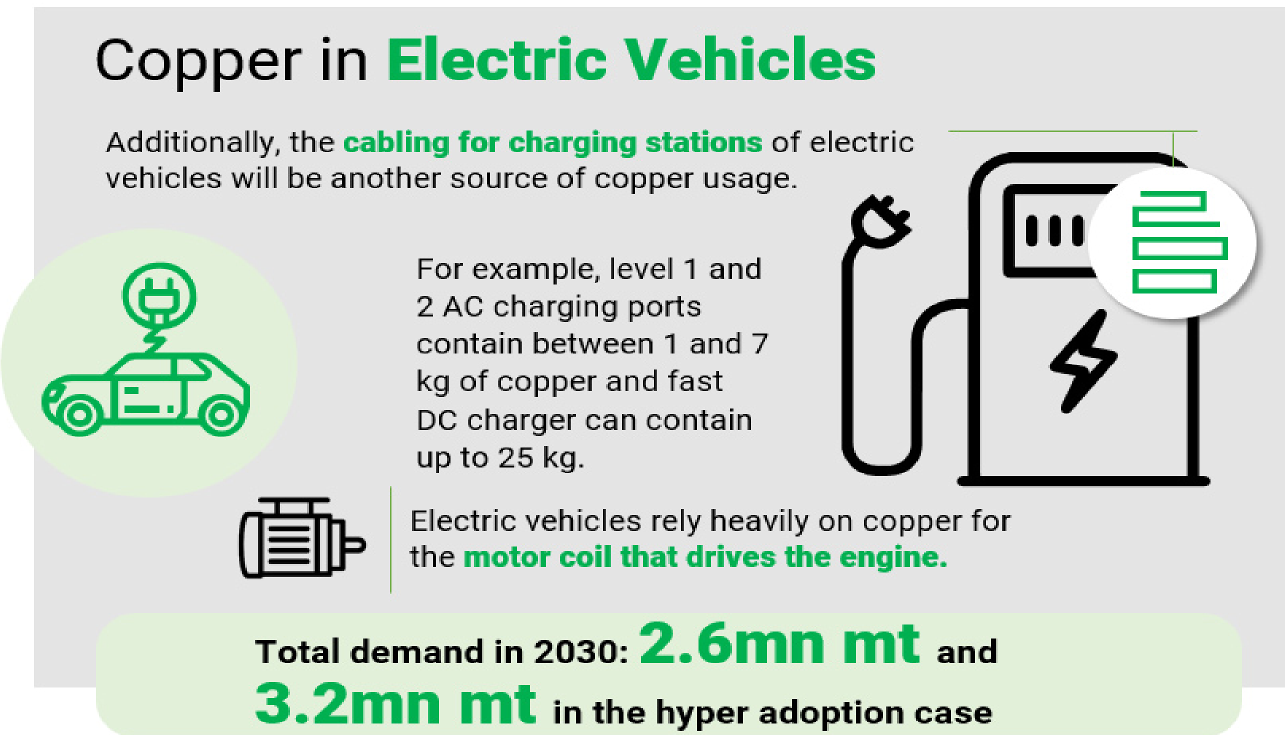
In EVs copper is mostly used for batteries and in the future the development of grid energy storage systems will represent a key upside risk for green copper demand.



Source: World Bank, ICA, Copper Alliance, Goldman Sachs Global Investment Research

Electric Vehicles - Surge in adoption to support most significant green boost to copper demand

Of the three drivers of green copper demand in the coming decade, electric vehicles (EVs) will be the item most salient to households, and the source of demand that is most likely to face volatile revisions to adoption rates, based on consumer demand trends rather than long-run utility scale investments in wind and solar. We see copper demand from EVs accelerating throughout this decade, with GS equity analysts projecting this year 5.1mn EVs to be sold (vs a stock of more than 1.2bn vehicles), rising to peak at 31.51mn EVs a year in 2030 (see **Exhibit 13**). To forecast the annual installations of charging units we map their growth to GS EVs sales forecast, implying that 30mn charging units will be installed in 2030. We forecast EV-related demand-to amount to 2.4Mt of copper by 2030 (vs. 210kt in 2020) with an additional 153kt of copper demand coming from charging stations (vs 14kt in 2020). We expect this demand to grow at a rate of 31% a year for the remainder of the decade.

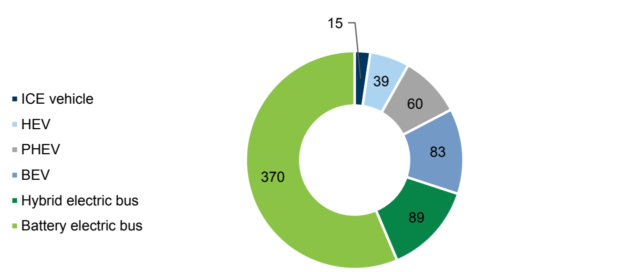


Source: Copper Alliance, Goldman Sachs Global Investment Research

A standard EV's copper content (on average 60-83 kg per car) is four times larger than that of an ICE (on average 15-20 kg per car), with total wiring length of c.1km. Copper is found inside EV batteries, motor coils, inverters and wiring. The copper content inside Lithium-ion batteries (the most used for EVs) ranges between 0.5 kg/kWh for a NCA battery type to 0.7 kg/kWh for a NMC 811 type. The remaining vehicle components, mainly the electric motor and the wiring system that carries the current to all the electronic parts of the car, account for around 40 kg/unit of copper. In addition, copper is a crucial component for EV infrastructure, required for the cabling of charging poles. The metal intensity ranges from 2 kg for an AC level 1 charger, 7 kg for an AC level 2 charger to 25 kg for a DC fast charger. In Exhibit 12, we decompose copper demand from EVs by technology type, based on our auto analyst's sector forecasts and by-technology intensity table.

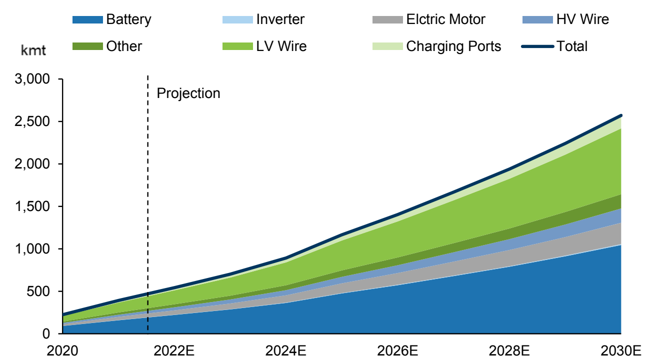
This acceleration is being driven by increasingly supportive regulation in both Europe and China. In fact, our auto analysts now calculate that the cost economics of a BEV on a like-for-like basis are €5-6k worse per unit than a comparable ICE vehicle. While the outlook is not as sharp in the US, President Biden's recent commitment to transition the federal vehicle fleet to EVs signals a shift in US policy toward the sector, with the Biden administration also proposing a large EV charging infrastructure investment and reinstating EV tax credits in their latest $2.2trn infrastructure package.

Exhibit 11: Electric vehicles contain substantially more copper than traditional ICEs
Copper content by type of vehicle (kg)



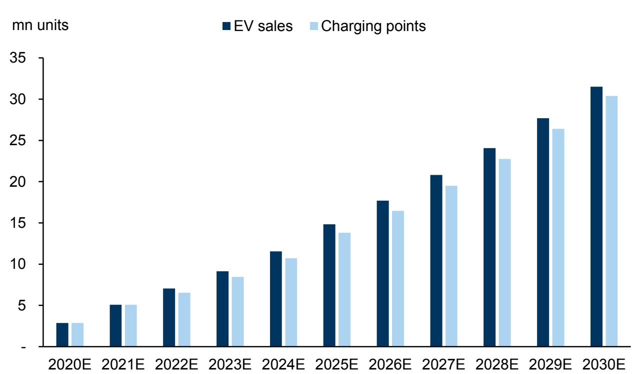
Source: ICA, Goldman Sachs Global Investment Research

Exhibit 12: We see copper demand from EVs growing to c.2.4Mt by the end of the decade
Copper demand by EVs components



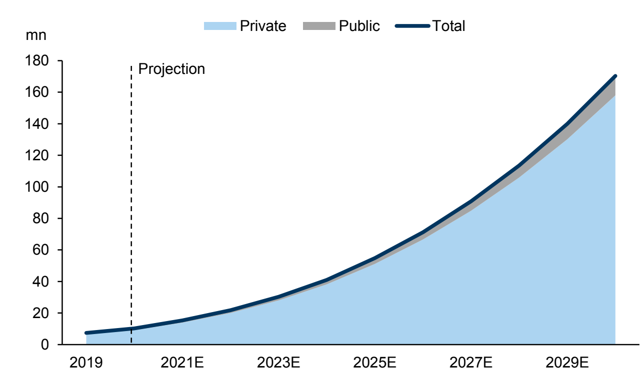
Source: ICA, IEA, Goldman Sachs Global Investment Research

Exhibit 13: Charging point infrastructure will lag the adoption of EVs
Annual EVs sales and charging points installations (mn units)



Source: IEA, Goldman Sachs Global Investment Research

Exhibit 14: While some EV stations will be government provided, the majority will remain private investments
Charging points by source



Source: IEA, Goldman Sachs Global Investment Research

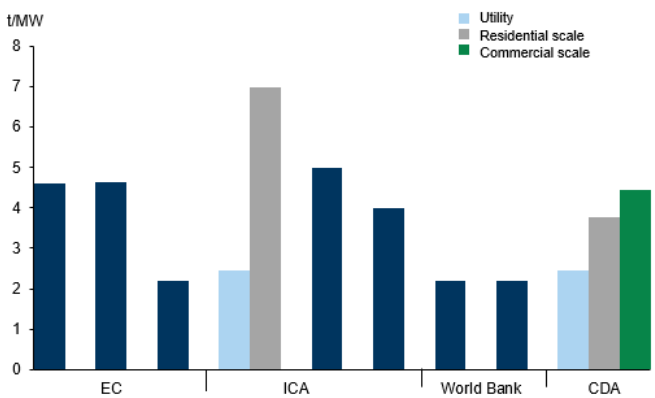
Solar - Sharp acceleration from mid decade, 400kt in 2021 to 1.6Mt by 2030

Of all the core copper-containing green technologies, solar remains the one with the largest potential upside, as the ultimate power distribution method leads to a wide range of copper intensity across different production methods (see Exhibit 15). Taking a weighted average of different technologies, solar contains around 2.4kt of copper per GW of capacity with 66% of this demand coming from China, 20% from Europe and

17% from the US. Over the next decade, we see solar demand rising to 1.6Mt at a rate of c.15% a year. Epitomising the transfer of power from oil to renewables, the Middle East will account for a large share of this growth. Copper is an essential element in solar PV technologies owing to its high conductivity and cost, giving it a higher conductivity per $/t than silver or gold, critical to maximising the conversion ratio of photovolatic to electrical energy. Moreover, its durability is crucial for a technology that has an average life cycle of 25 to 30 years. Higher copper-intensity, "thin-film" technologies like CIGS have achieved some market penetration to date (c.15% of total MW installed), and have the potential to increase future market share if production inefficiencies are reduced in coming years.

Exhibit 15: Solar intensities by source and project type

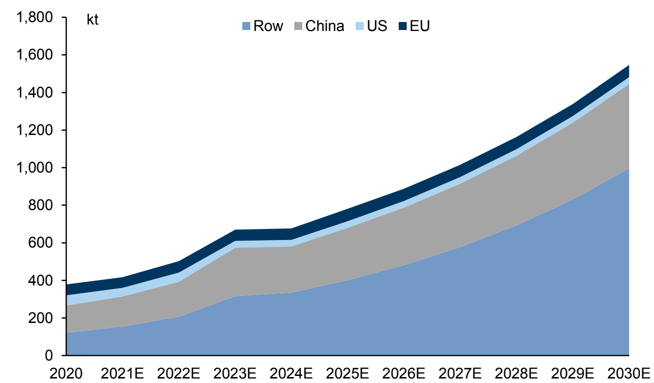
Copper intensity of use in sola PV panels



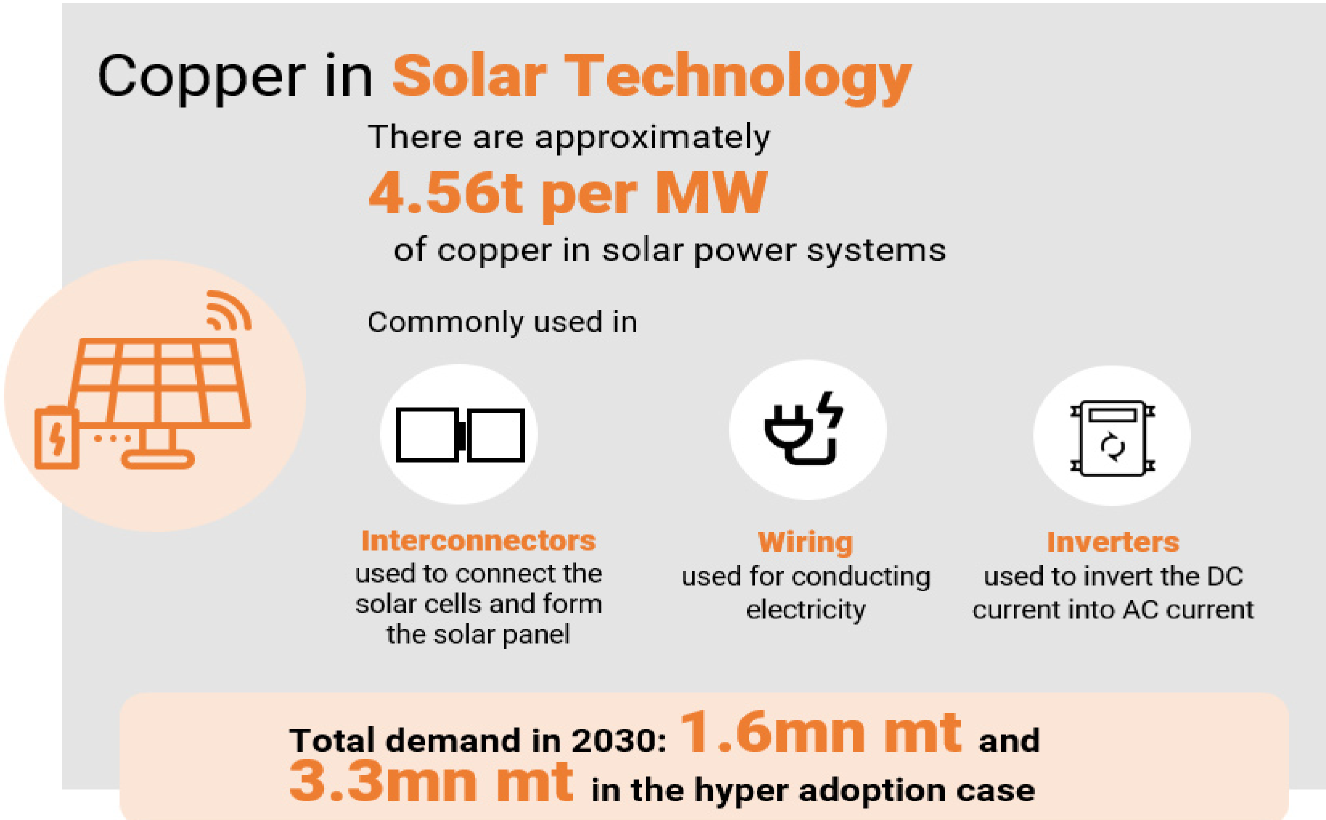
Source: ICA, European Commission, World Bank, CDA, Goldman Sachs Global Investment Research

Exhibit 16: Copper solar demand to reach 1.6Mt in 2030

Copper demand coming from solar PV systems by country



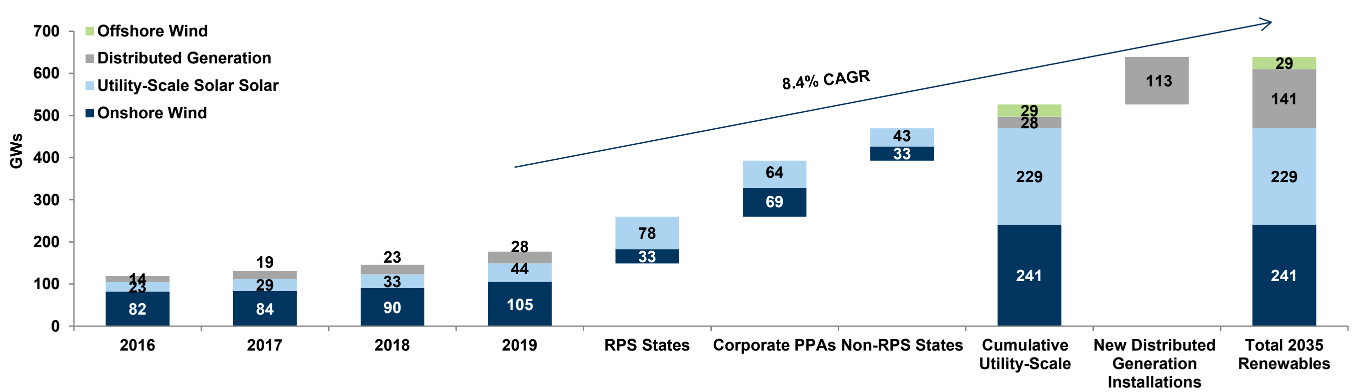
Source: IRENA, ICA, Goldman Sachs Global Investment Research



Source: Copper Alliance, Goldman Sachs Global Investment Research

Outside the solar panel, copper is used extensively in all the other elements that contribute to the functioning of the system and that are generally called balance of system (BOS). The current produced by the solar PV panels is transported with cables to the inverter (in distributed scale installation) or transported to a transformer that will step up the voltage for the transmission to the grid (in a utility scale installation). Our sector experts see total solar capacity reaching 370 GW in 2035 with 60% of that coming from utility scale installation and 40% from DG.

Exhibit 17: We now expect wind and solar capacity additions in the US of over 280 GWs by 2030
Revised GS renewable forecast, 2018YE-2030

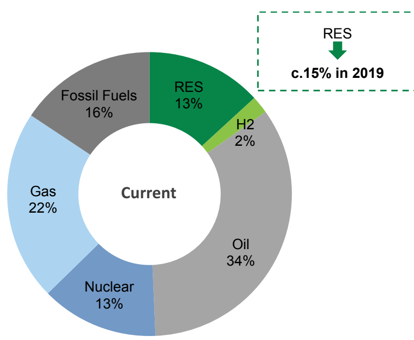


Source: DSIRE, SNL, Goldman Sachs Global Investment Research

Wind - Copper demand from turbines set to triple from 400kty currently to 1.3Mt by 2030

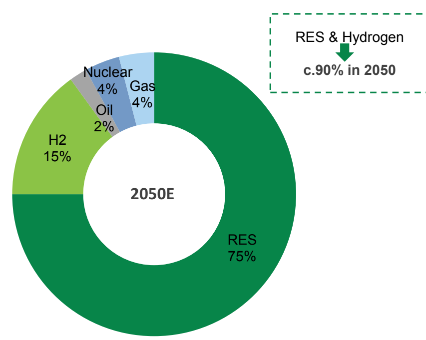
Energy is the largest emitter of carbon globally, accounting for 73% of emissions in 2017, and with the electrification of transport and the growing computing demands of AI, energy consumption globally is expected to rise 26% over the next 30 years, requiring a growing renewable energy capacity that will drive wind farm growth in the coming decade. Indeed, we see wind-related copper demand reaching 1.3Mt a year by 2030, growing at a rate of 12.4% annually. The end use demand for copper varies widely across all turbine models, ranging from 8t to 48t per tower. Wind turbines demand copper primarily for generators, power cable conductors and earthing cables. These cables are on average 15cm thick and weigh around 60-80kg/m. Copper intensity depends on two factors, the turbine generator (geared/direct drive) and the type of installation (on shore/offshore), with copper use per GW ranging from 4kt/GW in onshore installations up to 13.5kt/GW for offshore. The main use of copper in offshore windfarms is for the ultra-high voltage cables used to transport the power back onshore, leading them to be the largest source of copper demand in wind power (Exhibit 22).

Exhibit 18: Renewable energy will go from 15% of total energy production in 2019...
Energy production by source



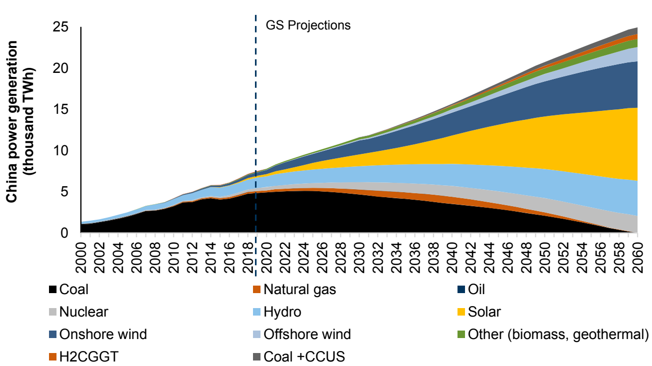
Source: Goldman Sachs Global Investment Research

Exhibit 19: ...to 90% in 2050
Energy production by source



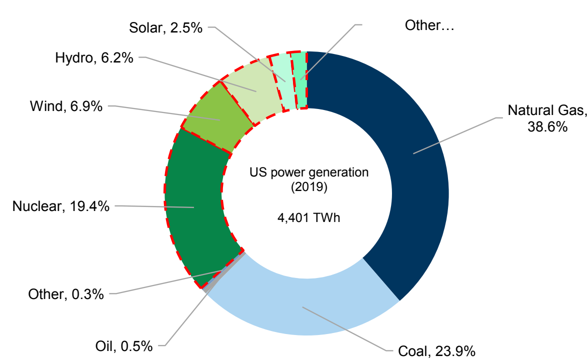
Source: Goldman Sachs Global Investment Research

Exhibit 20: We expect China's power generation to triple by 2060, driven by solar, wind, nuclear and hydro power generation
China electricity generation (thousand TWh)



Source: BP Statistical Review, Goldman Sachs Global Investment Research

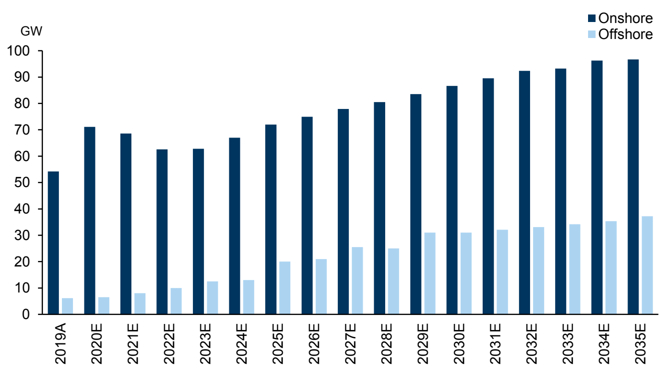
Exhibit 21: c.37% of US power generation is carbon free
2019 US power generation mix (TWh)



Source: BP, Goldman Sachs Global Investment Research

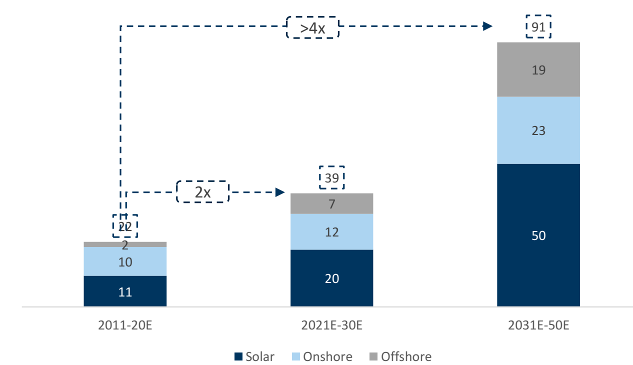
As turbine distance from shore is set to grow – particularly in Europe, in the coming decade, we see near 400kt additional copper demand from offshore wind farm cables in the EU alone by 2030. The distance these cables need to travel requires higher density copper rather than aluminum, which is traditionally used in overhead grid networks due to its lightweight nature. Support for these offshore projects is only set to grow, with the European Commission publishing EU Strategy on Offshore Renewable Energy, with a 2030 objective of 60 GW of installed offshore capacity. Moreover, in December 2020 the US Congress extended credits on wind (and solar) power with the Consolidated Appropriations Act, while China's 2060 goal translates to a $16trn investment over the next 40 years. Of the total investment, $2trn will go into onshore installations and $0.7trn for offshore projects.

Exhibit 22: Wind installations out to 2035
GW

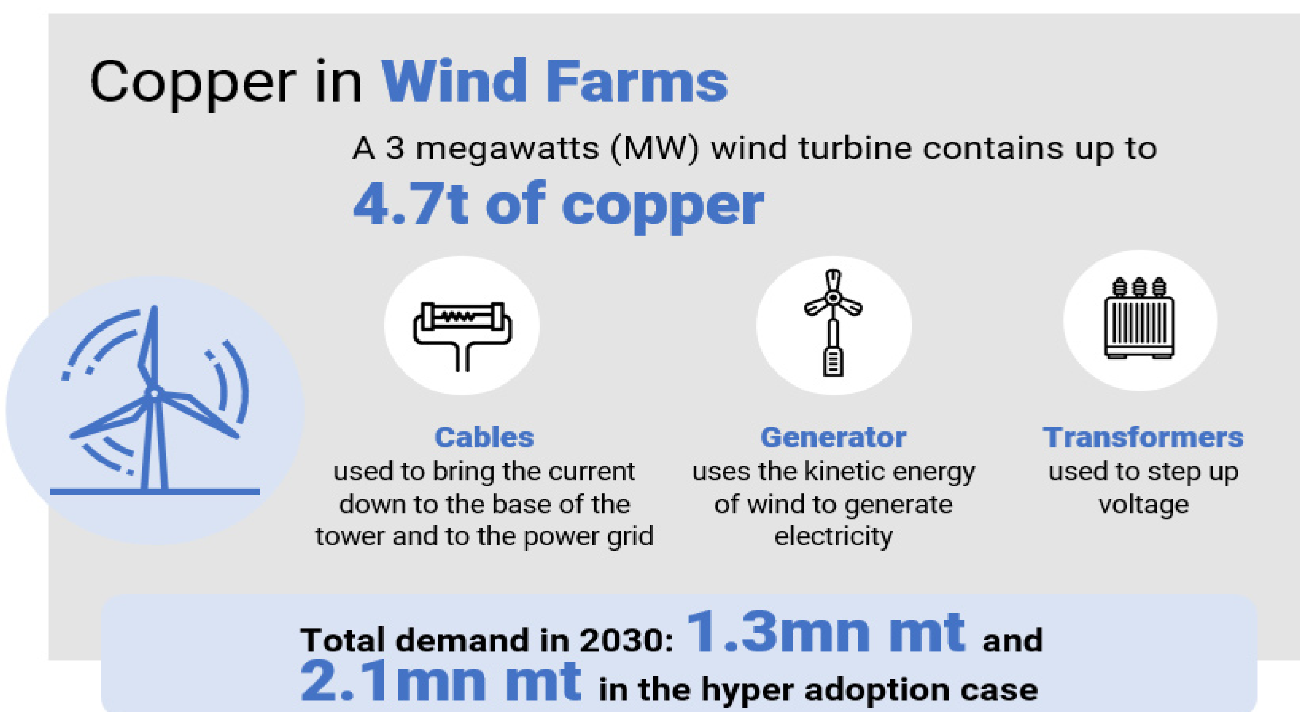


Source: Goldman Sachs Global Investment Research

Exhibit 23: Sharp increase expected in EU wind generation capacity over the next decade



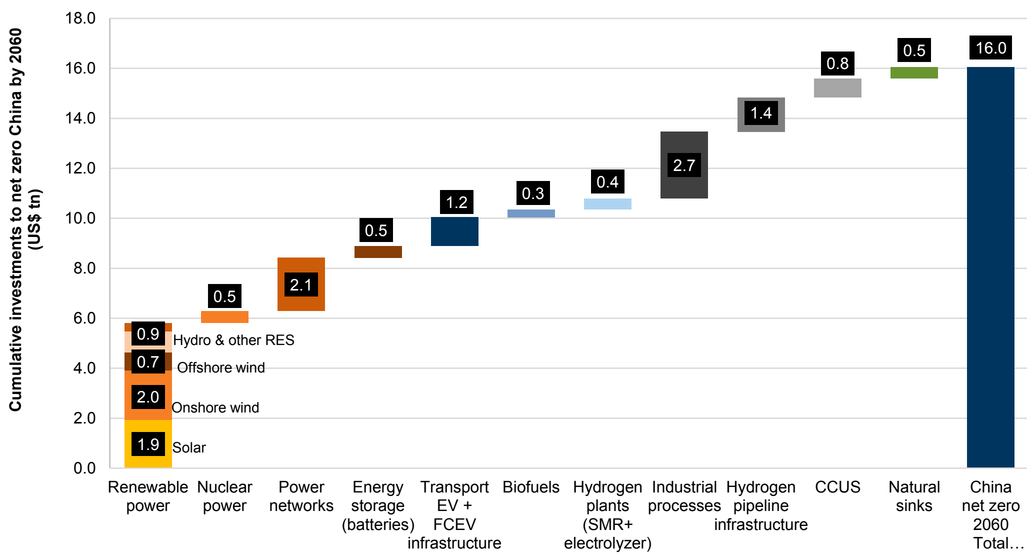
Source: Goldman Sachs Global Investment Research



Source: Copper Alliance, Goldman Sachs Global Investment Research

Even though the absolute consumption of copper is set to increase with the size of the turbines, the relative content per MW generated will decrease as designs will be more resource efficient. According to JRC this decrease will be of only 5% by assuming an increase turbine capacity (for off shore wind turbines) of 1.5MW by 2030. However offshore wind farms may become more copper intensive if floating foundation become a viable solution. This type of foundation could be deployed for wind farms at greater distances from the shore than the ones with fixed foundations, therefore the length of transmission cables (usually made with copper) would be greater.

Exhibit 24: China's net zero path implies a $16trn clean tech infrastructure investment opportunity by 2060
Cumulative investment opportunity across sectors for China net zero by 2060 (US$ tn)



Source: Company data, Goldman Sachs Global Investment Research

Assessing the dilution risks to copper in the green demand outlook

Given the relative immaturity of the wind, solar and EV sectors, all remain in phases of constant improvement to achieve better performances and higher material efficiency. Although this process will affect copper use, we think that it is unlikely to change the bigger picture. In wind and solar systems, copper is not a technology-specific material, rather it is used for the structure that usually is not deeply affected by material efficiency improvements. In EVs the lower intensity of usage can potentially come from the substitution of copper with aluminium; however, this comes at a cost of lower energy efficiency and reliability. The potential, yet moderate, fall of intensity of use in the examined technologies is counter balanced by the new green copper uses, that are not modelled but should be taken into account as an upside risk for the future decades as our analysts see them as key in the path to net zero.

In that context, in e-hydrogen fuel cells, copper is used in alloy with nickel to form the anode catalyst in solid oxide fuel cell type and then in wires and other conductive parts. Furthermore, our analysts see an increase of the demand of renewable energy coming from green hydrogen starting from 2030 as the electrolysis requires a great amount of renewable energy. Copper will also play a role in batteries for grid storage, another important piece that will allow renewable energy sources to be widely used in the future. Copper is used both inside the battery in the current collector and outside for the wiring, cabling and switches that connect the renewable energy system to the energy storage device. Finally, copper is also considered among the key materials for the carbon capture and storage technologies that, according to our analysts, are complementary to carbon conservation ones to achieve affordable net zero emissions.

GS Global green copper demand model

Exhibit 25: Quantifying green copper demand by sector and region

('000's tonnes)	2020	2021E	2022E	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E
Solar											
EU	57.8	56.6	60.9	60.5	60.8	65.7	64.7	65.5	64.7	64.7	65.5
% change	*15%*	*-2%*	*8%*	*-1%*	*1%*	*8%*	*-2%*	*1%*	*-1%*	*0%*	*1%*
US	53.7	46.6	49.8	35.6	35.6	35.5	35.5	35.5	35.4	35.4	35.4
% change	25%	-13%	7%	-29%	0%	0%	0%	0%	0%	0%	0%
China	145.3	159.7	185.7	258.4	245.6	278.9	306.8	337.4	371.2	408.3	449.1
% change	60%	10%	16%	39%	-5%	14%	10%	10%	10%	10%	10%
Row	121.5	154.5	206.5	315.9	334.9	400.6	480.7	576.8	692.2	830.6	996.8
% change	-1%	27%	34%	53%	6%	20%	20%	20%	20%	20%	20%
Total Solar Demand	**378**	**417**	**503**	**670**	**677**	**781**	**888**	**1,015**	**1,163**	**1,339**	**1,547**
Wind											
EU	89	129	179	129	108	127	141	202	204	204	234
% change	9%	46%	38%	-28%	-16%	18%	10%	44%	1%	0%	15%
US	42	38	42	66	96	52	52	76	76	76	76
% change	26%	-10%	11%	57%	47%	-46%	0%	46%	0%	0%	0%
China	184	141	182	202	222	242	265	308	383	459	504
% change	64%	-23%	29%	11%	10%	9%	9%	16%	24%	20%	10%
Row	81	103	121	143	168	199	235	278	330	393	467
% change	-7%	27%	17%	18%	18%	18%	18%	18%	19%	19%	19%
Total Wind Demand	**396**	**412**	**523**	**539**	**594**	**620**	**692**	**864**	**993**	**1,131**	**1,280**
Electric Vehicles											
EU	95	174	228	276	330	402	518	627	730	832	944
% change	124%	83%	31%	21%	19%	22%	29%	21%	16%	14%	13%
US	28	63	102	141	203	304	342	381	432	496	560
% change	13%	126%	63%	38%	44%	50%	13%	11%	13%	15%	13%
China	77	116	155	203	253	319	373	429	486	547	608
% change	228%	50%	33%	31%	24%	26%	17%	15%	13%	12%	11%
Row	9	14	26	41	54	73	88	135	178	236	307
% change	31%	54%	77%	58%	33%	34%	22%	53%	32%	32%	30%
Total EV Demand	**210**	**368**	**511**	**661**	**840**	**1,098**	**1,322**	**1,572**	**1,826**	**2,110**	**2,419**
Charging Points											
EU	3.5	6.1	8.6	11.4	14.8	17.8	24.1	30.8	37.3	42.9	50.1
% change		76%	40%	33%	29%	20%	35%	28%	21%	15%	17%
US	3.1	5.7	6.8	8.9	12.1	16.8	18.5	20.8	24.0	28.6	34.3
% change		83%	19%	32%	36%	38%	11%	12%	15%	19%	20%
China	6.1	10.2	13.0	16.3	19.9	25.7	29.5	34.3	39.7	46.3	54.8
% change		67%	26%	26%	22%	29%	15%	16%	16%	17%	18%
Row	2	3	3	4	5	7	8	10	12	14	14
% change		71%	31%	27%	20%	27%	21%	21%	20%	20%	-3%
Total Charging Points Demand	**14**	**25**	**32**	**41**	**52**	**67**	**80**	**96**	**113**	**132**	**153**
By Region											
EU Renewable Demand	246	366	476	477	513	613	748	926	1,036	1,143	1,293
US Renewable Demand	127	153	200	251	347	408	448	513	567	636	706
China Renewable Demand	412	427	535	679	740	866	974	1,108	1,280	1,460	1,615
RoW Renewable Demand	214	275	357	503	562	679	812	1,000	1,212	1,473	1,784
Global Copper Demand	**998**	**1,221**	**1,569**	**1,911**	**2,163**	**2,566**	**2,982**	**3,547**	**4,095**	**4,712**	**5,398**
% change	*39%*	*22%*	*28%*	*22%*	*13%*	*19%*	*16%*	*19%*	*15%*	*15%*	*15%*

Source: ICA, IRENA, IEA, Goldman Sachs Global Investment Research

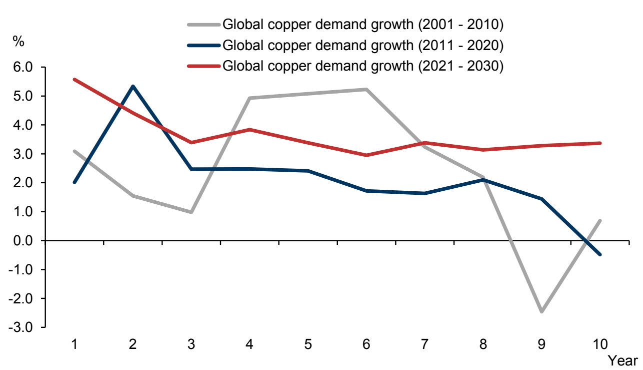
Green demand driving the tightest forward copper balances in history

Green electrification related demand will have a significant tightening effect on the global copper balance over the next decade (see Exhibit 51). On our base case green projections, global copper demand growth will trend at a materially higher rate this decade than in either of the previous decades. Moreover, we expect the annual average demand growth volumes from green sources alone to be on a par with that from China during the 2000s. Set against a current peak in base case mine supply timed for 2024 and open-ended contraction thereafter (given current projects), this steers the copper market on a clear tightening path through the course of the decade. The copper market already faces a clear metal deficit in both 2021 and 2022, which we expect to lower the market exchange stock to consumption ratio to a near record low by H2-22. While we project a softening window in metal fundamentals to occur in 2023/24, the current peak in global mine supply during that period will sow the seeds for the beginning of large deficits from the second half of 2024 onward. The consequence of these fundamental trends it that by the end of the decade the long-term supply gap stands at 8.2Mt. This is the highest long-term supply gap on record and nearly double where the peaks in long-term supply gap stood in both the 2000s and 2010s, when real copper prices hit $10,420/t and $11,440/t respectively.

Green electrification to support strongest decade for global copper demand growth in the post-2000 era

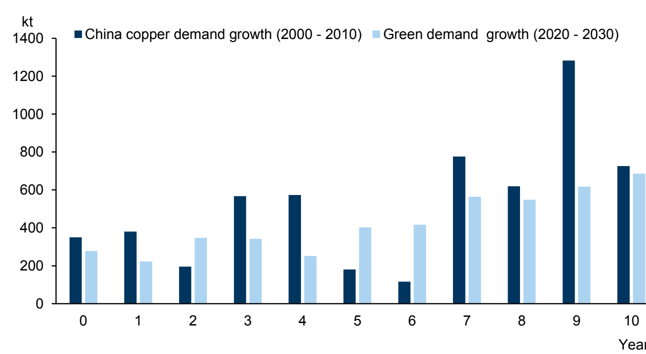
The most obvious conclusion from integrating green demand into the broader global balance context is that we project the global copper demand trend growth to be significantly higher in the 2020s (3.1%) versus both the 2000s (1.2%) and 2010s (2.5%). In volume terms, global refined copper demand will grow on average nearly 1Mty in the 2020s, which compares to just over 400kty in the 2010s. Over the course of the decade that additional growth in demand converts into an additional 65Mt refined copper requirement in this decade versus the previous. The addition of green electrification related demand provides a significant accelerator to global copper demand dynamics. On non-green demand areas, after a phase of above-trend growth rates in 2021/22 related to the post-pandemic cyclical recovery (~4% average annual growth rate), we see this portion of aggregate consumption decelerating to a trend close to a 2% annual growth rate over the remainder of the decade, in line with the equivalent growth rate in the 2010s. This masks some differentiation between sector, largely related to green trends. We expect grid-related demand to benefit most given the accelerated investments related to distribution requirements around renewables and EV infrastructure, while conversely traditional (ICE) transportation related demand will face a sustained phase of contraction given demand diversion towards EV.

Exhibit 26: Global copper demand growth is set to trend at a matterially higher rate in the 2020s versus the 2000/10s
Global copper demand growth, by decade



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 27: Green demand growth volumes will start to surpass previous bull cycle China demand growth from mid-decade
China and green copper demand growth



Source: Woodmac, Goldman Sachs Global Investment Research

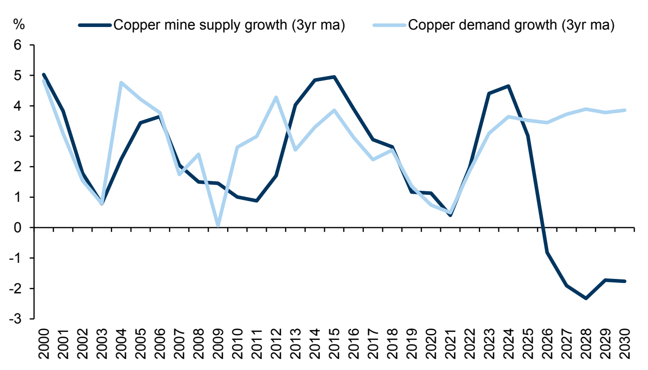
Mine supply peaks in 2024, open-ended contraction thereafter just as green demand accelerates

The other defining feature of expected copper fundamental trends in the 2020s pertains to the peak in base case mine supply in 2024 and (current) open-ended contraction thereafter. After a 5-year period of essentially no growth in mine supply up to and including 2021 (GSe 21Mt, +1.1% yoy), we expect a brief but strong phase of mine supply growth in 2022-23 (~6% average annual growth). This would, however, represent a final window for mine supply growth given global mine supply then peaks in 2024 at close to 24Mty before falling to 23Mt by 2026 and 21.5Mt by 2030 on our estimates. These production projections reflect our base case mine projections plus additional assumed supply from a proportion of known probable brownfield (70%) and greenfield (50%) projects. Probable projects are classified by Woodmac as (1) high-quality but not advanced projects operated by established producers and (2) projects owned by single asset operators with robust technical and economic qualities (but as yet not financed).

Without the inclusion of this portion of probable projects (which essentially represent a pre-approval of some likely but still unapproved projects), global mine supply would peak in 2023. How has the copper market got into this position? There's not an absolute shortage of copper deposits; rather it is a reflection of the mining sector's focus on deleveraging and balance sheet conservatism after the 2014-15 metals price collapse. This came after a surge in supply investment following the copper price rally in 2010-11. Committed copper related growth capex is on a downward path from 2021. There has been no indication of a pivot towards growth yet from the mining sector despite the stronger copper price environment. Given the lead times on copper projects – 2-4 years for brownfield additions (at existing mines) and 6-8 years for greenfield projects – we would note that the earliest mine level responses can emerge is into mid-decade. Given the size of deficits starting from the same point, approvals and investments in mine projects have to start now.

Exhibit 28: Mine copper supply growth decelerates sharply from peak timing in 2024, contrasting with green underpin to demand trend growth

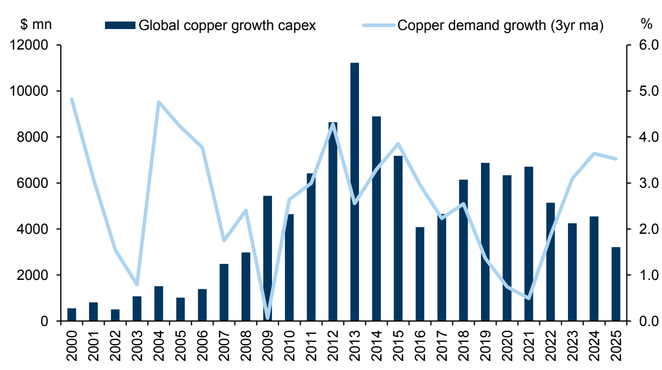
Mine copper supply and demand growth



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 29: Copper growth capex currently fades into mid-decade just demand accelerates on green channel

Global copper capex and demand growth

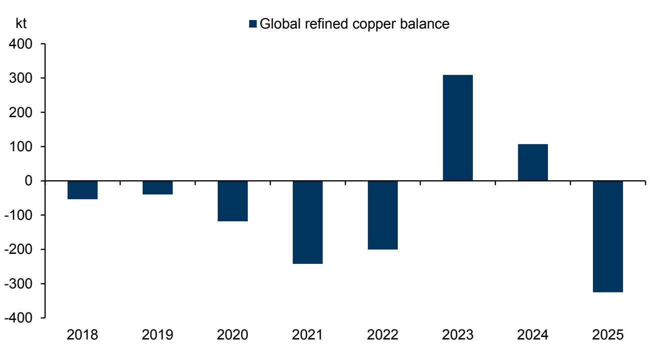


Source: Woodmac, Goldman Sachs Global Investment Research

Cumulative metals deficits into mid-decade present elevated risk of stock depletion

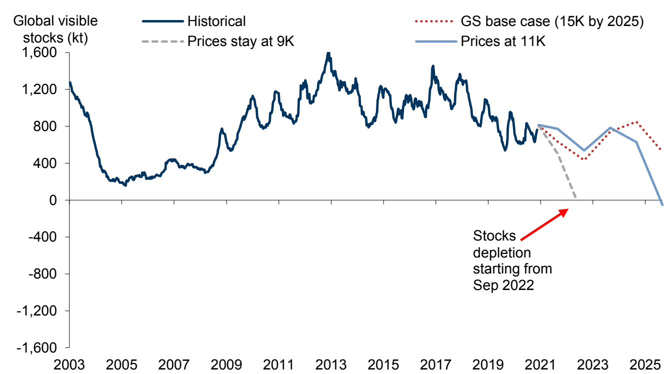
The combination of the green transition based demand acceleration and peak in mine supply by mid-decade underpins a tightening path in copper fundamentals over the course of this decade. However even before these trends start to materially influence the balance, we project sizeable market deficits both this year (242kt) and then in 2022 (201kt). As we have laid out previously, these deficits reflect the tightening influence from a robust cyclical and policy driven demand environment and at least initially COVID restraining supply dynamic. The net impact of these twin metal deficits will be to reduce market inventories to the lowest level since the mid-2000s, and in turn the tightest market conditions since the same point. There will then follow a softening window in metal fundamentals in 2023 (309kt surplus) as strong mine supply supports increased metal supply, while the cyclical support recovery in demand post pandemic starts to fade. This will only be a brief softening phase as the refined market then moves back to close to balanced in 2024 (107kt surplus) before a phase of increasingly large deficits play out from 2025 (325kt deficit). On this base case path, inventories fall sharply into mid-decade but avoid depletion. However, we would note that thereafter mega sized deficits begin (2Mt in 2026, 3.6Mt in 2027) which as per the next comment, feed into the record sized long-term gap. The deficits from 2026 will have to be predominantly solved by growth in mine supply from as yet unidentified sources.

Exhibit 30: Copper market faces deficits in 2021-22, a brief surplus in 2023 before mega deficits from mid-decade
Global copper balance



Source: Woodmanc, Goldman Sachs Global Investment Research

Exhibit 31: Projected deficits could lead to a depletion in inventory unless prices follow a path into the mid-teens by 2025
Copper stocks by source

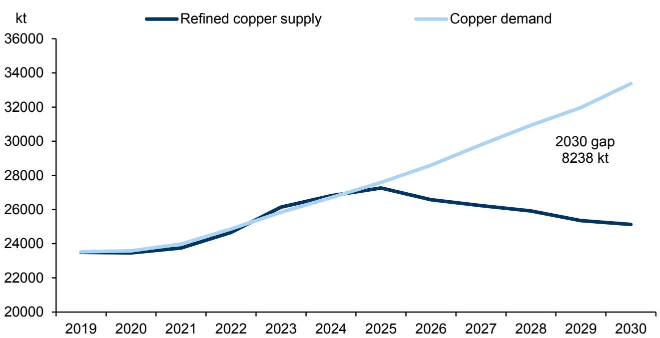


Source: Wind, Goldman Sachs Global Investment Research

Long-term supply gap now at a record 8.2Mt, nearly double the gap in the mid-2000s

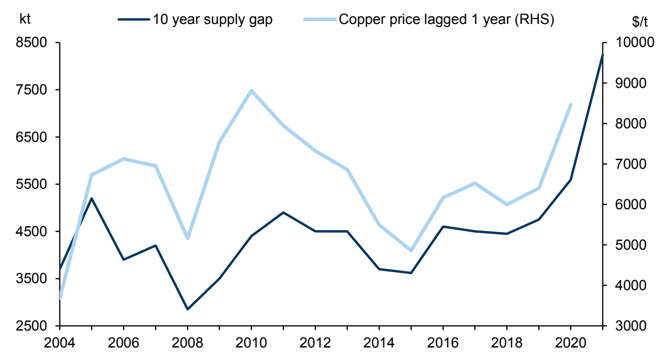
The final key conclusion for copper market fundamentals is with regard to the significant increase in long-term supply gap (10 year forward shortfall, 2030 for current year). We now see at a 8.2Mt shortfall, which compares 5.6Mt in Q4-20 and 4.5Mt in 2019. This is the highest long-term supply gap on record and 60% larger than the supply gap we projected in 2004/05 (for 2014/15), which we would view as comparable years to 2021 in terms of stage in bull cycle. The supply gap is essentially a 10-year forward balance, albeit with positive adjustments to mine supply projections to include a portion of probable projects (70% brownfield, 50% greenfield) as well as an extension to 20% of mine closure volume. The long-term supply gap will never be fully closed as there is an inherent lag in long dated supply responses relative to expected demand conditions on the same time frame. However, neither can the long-term gap sustainably rise to levels, which means those long-term deficit dynamics actually evolve into nearer dated deficit outcomes. That however is the current direction of travel for the copper market. In that context, as Exhibit 33 shows, whenever the supply gap spikes higher there is a strong positive correlation with the copper price. The key increment on reducing the gap size will come from the approval of possible brownfield and greenfield mine projects, which are not included in our base case projections.

Exhibit 32: Long-term supply gap now projected at over 8Mt by 2030
Refined copper supply and demand



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 33: Record long-term supply gap implies significant further upside to copper prices
LT supply gap and copper price



Source: Woodmac, Goldman Sachs Global Investment Research

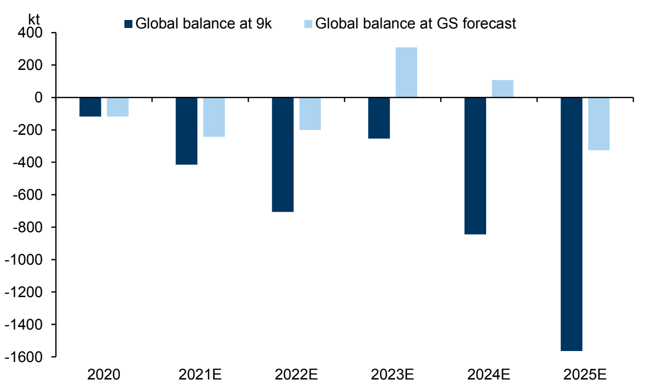
Solving the path to net zero for copper

We have established that on current trends, the copper market faces both a running inventories to critical levels – if not a depletion – in solving near-term metals deficits and shortage of approved mine projects to solve the current record (and expanding) long-terms supply gap. In order to prevent these extreme scenarios, a material softening response is required in the copper market. To prevent the risk of inventory depletion by mid-decade, we see a necessary combination of near-dated positive supply response (scrap, brownfield approvals) and negative demand adjustment (substitution) to soften the profile of deficits on that time horizon. On a longer dated balance basis – and focused on the large deficits in the second half of the decade – a substantial pivot to growth investment is needed now in terms of greenfield copper mine projects to materially lower the long-term supply gap. These adjustments have to happen to prevent copper being a constraint on the energy transition, and perhaps just as important, have to start now given the multi year time lags particularly in terms of mine response.

The copper price is ultimately the means for generating these fundamental adjustments. We have modelled both scrap and substitution effects into our supply-demand balance as a function primarily of our price forecasts and other economic variables, as well as reviewing the available greenfield project economics. The immediate conclusion in this context is that current copper prices ($9,000/t) are too low to prevent a risk of inventory depletion, while our current long-term copper ($8,200/t) is not high enough to incentivise enough greenfield projects to solve the long-term gap. If copper remains at

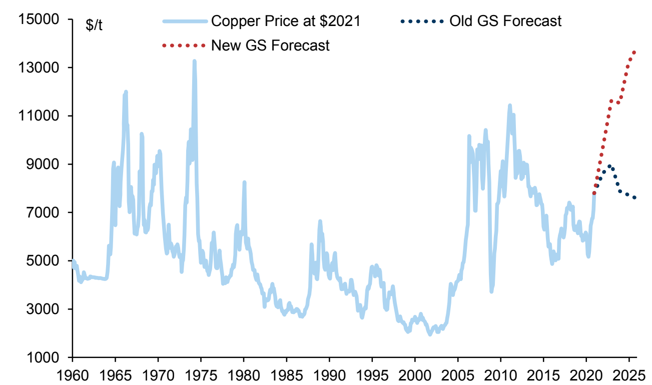
$9,000/t through the next three years, then the resultant deficits would generate a depletion of market inventories by early 2023 (Exhibit 34). Based on our scrap and demand modeling, we believe that the most probable path for copper price from here – that both avoids depletion risk and as well as a sharp surplus swing – is to trend into the mid-teens by mid decade. This means the metal balances into mid-decade remain manageable without depletion occurring. Whether prices need to rise further post-2025, will then depend on whether the price rally has supported enough mine supply response by that stage.

Exhibit 34: Copper balance would move into stock depletion level deficits if copper prices do not trend higher as we forecast
Global copper balance



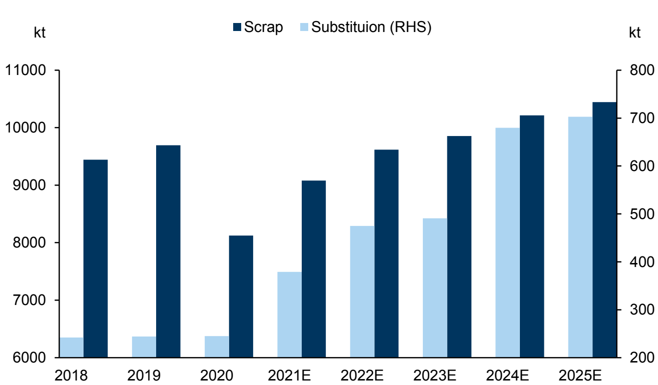
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 35: We now project copper to trade up to $15,000/t by mid-decade to mitigate depletion risks
Historical and forecasted copper price



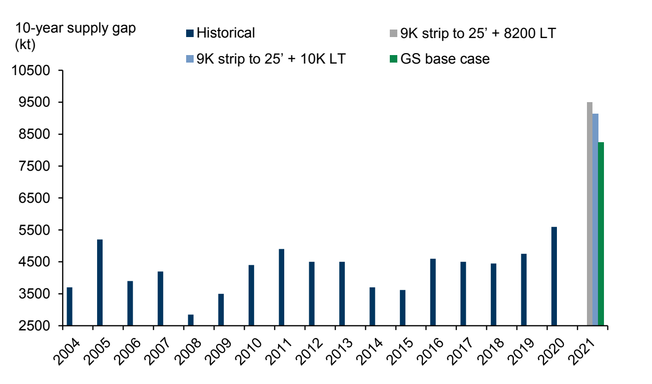
Source: World Bank, Goldman Sachs Global Investment Research

Exhibit 36: Scrap and substitution volumes under GS base case increase sharply into mid-decade
Scrap and substitution volumes



Source: ICA, Goldman Sachs Global Investment Research

Exhibit 37: Higher price profile modestly reduces the size of the LT supply gap, but sustained high prices key to solving via project approvals
Historical and forecasted LT supply gap



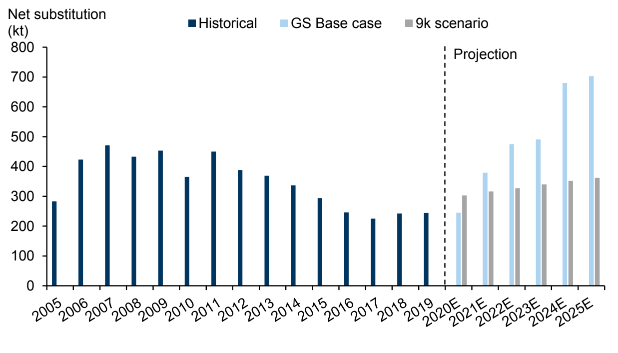
Source: Woodmac, Goldman Sachs Global Investment Research

Demand substitution: Record lost volumes by mid-decade on price extremes but limited aggregate impact

When a resource becomes scarce in an economy, profit-maximising firms naturally look to replace the scarce resource with a more plentiful substitute where technically possible, with copper no exception. Copper's main competitor – aluminium – has similar but inferior electrical and thermal properties, allowing for imperfect substitution across a range of goods, from power cable to wiring. Yet capturing the precise rate of substitution – as a function of the relative price of copper and aluminum –faces challenges of sparse data, underlying technological shifts and the endogenous relationship between new copper growth, price and aluminium demand that can create spurious correlations. To clean the data of these secular trends, we trim our data set to analyse the marginal increases in substitution during periods of a high copper-aluminium price ratio. Given the limited length of global data series, we restrict our analysis to the US copper/aluminum consumers only. We find that in those years when the copper-aluminium price ratio is more than two standard deviations above the mean, we see a substantial (but lagged) substitution effect emerging. For example, in 1966, 1974 and 2009 when the real copper-aluminium price ratio was at 3.50, 4 and 3.4 respectively, the years after the peak in (1967, 1975) saw copper demand growth decrease by 3% and 9%. However, emblematic of the inherent instability in substitution estimates, during the high copper prices of the 1970s, copper was losing c.3% of its market share of car radiator's a year – yet this was more driven by high oil prices incentivising manufacturers to look for ways to make car's lighter, rather than a direct result of high copper prices.

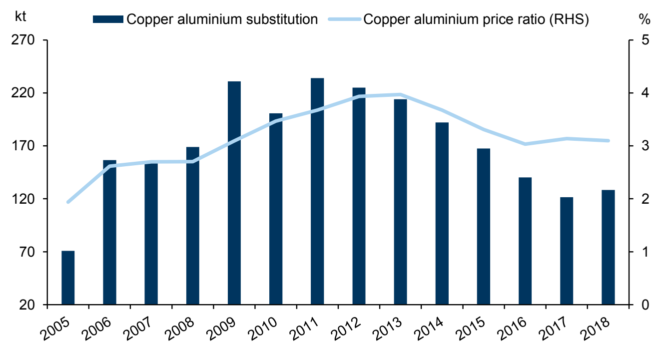
More recently, the copper market saw a lagged substitution effect as the copper aluminium price ratio reached new highs during China's commodity super cycle, reaching a peak of 471kt in 2007 and remaining at a high level until 2010. Going forward, we see substitution being driven in part by copper prices, but also by technological constraints. Indeed, we see substitution risk in green demand as low, partly because the physical properties of copper make substitution difficult. Although the aluminium winding wire in EVs can be used for electric motors due to its lighter weight, and similarly in wind turbines and solar, PV systems aluminium can used the transformer and transmission power cables. The lower conductivity reduces the engine efficiency and increase maintenance costs. Moreover, in almost all renewable technologies, the cost of copper is a fraction of the final cost. In construction, substituting building copper wire for aluminium, creates minimal cost savings to the overall project and stricter safety standards constrain the use of aluminium. For supply demand model, we have assumed that substitution volumes rise to new extremes given the record strength of price. We have used the peak substitution rate from previous peaks as the initial guide over 2021-23 (~500kty) before accelerated rate in 2024/25 (700kty). In other words, we assume in our model that the loss demand volumes to substitution ultimately trend to levels well above anything seen in history.

Exhibit 38: Under our base case we project a surge in substitution volumes to new record levels by the mid-2020s
Historical and forecasted net substitution volumes



Source: ICA, Goldman Sachs Global Investment Research

Exhibit 39: Substitution from copper to aluminium will be a key channel of losses though we also expect aluminium prices to trend higher into mid-decade
Copper aluminium substitution volumes and price ratio



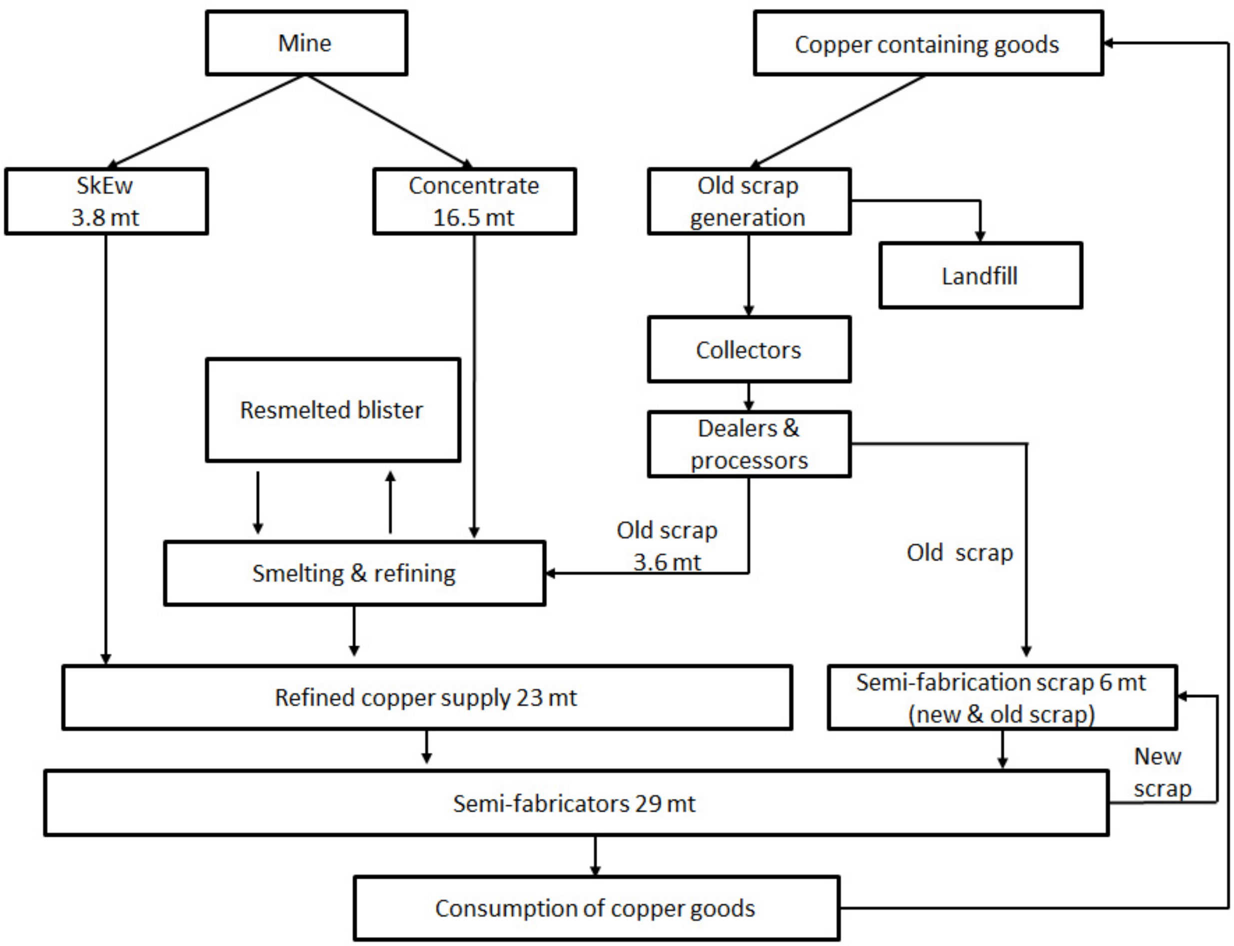
Source: ICA, Goldman Sachs Global Investment Research

Scrap supply: Unable to close long-term deficit

Scrap is often seen as the balancing residual of the copper market; able to plug deficits by incentivising short run supply surges, making the scrap response function of great concern to investors. However, it is important to distinguish the different sources of scrap, and the limits those sources have on tackling what are huge open ended deficits stretching out over half a decade. As Exhibit 40 shows, copper scrap flows from two sources: 1) 'new scrap' directly from the semi's manufactures, as offcuts (tailings) of piping and wiring can be immediately melted down to be reused in the semis production process and 2) 'old scrap' from recycling appliances, demolishing buildings and melting copper alloys like brass.

Exhibit 40: Copper scrap can be split into new scrap from semi-finished goods production and old scrap for the recycling of old copper containing goods

Scrap flow model (2019 data)



Source: Goldman Sachs Global Investment Research

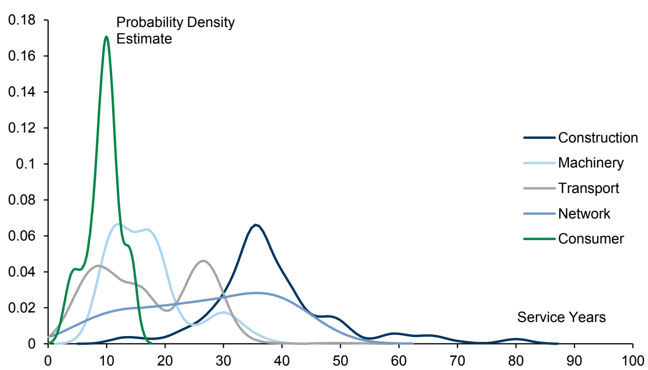
'New scrap' supply is relatively insensitive to price, with semi's manufacturers capturing the maximum amount of spare copper in their production process. Accordingly, this source of scrap grows only with actual copper demand and acts as a residual that reduces refined copper demand in the balance. The more important long-term driver is old copper scrap, whose supply response function can be decomposed into two parts.

First, old scrap generation from recycling copper-containing goods at the end of their life. This is a combination of the lifecycle-weighted sum of past copper consumption and the current discount rate used by households and firms when deciding whether to scrap their durable asset (car, plant, etc). Then, there is the scrap destocking effect – the pull on copper scrap inventory in scrapyards but not processed and sent to secondary copper smelters or brass mills.

An often cited argument by investors is that after the rapid growth of Chinese copper consumption in the 2000s, the world is headed for an onshore scrap surge that is likely to severely crimp primary refined copper demand. What this logic fails to take into account is that, while China's copper growth was exceptionally strong during the 2000s, ex-China demand stagnated. In other words, China was consuming metals on behalf of other countries and global copper consumption growth didn't jump when Chinese demand growth picked up. As a result, we expect global scrap generation growth to remain steady although we are likely to see China increasingly shift from using imported scrap to using domestically generated scrap.

Exhibit 41: To capture the potential future scrap supply, we take the life of copper-containing goods...

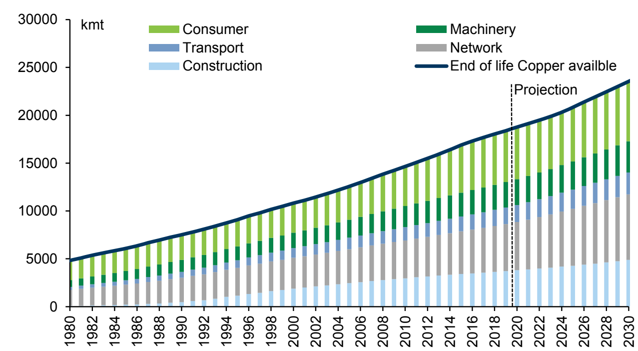
Probability density estimate of service life by sector



Source: US Bureau of Economic Analysis (BEA), OECD, Goldman Sachs Global Investment Research

Exhibit 42: ...and historical copper use, to capture available recyceable copper

Historical and projected copper use



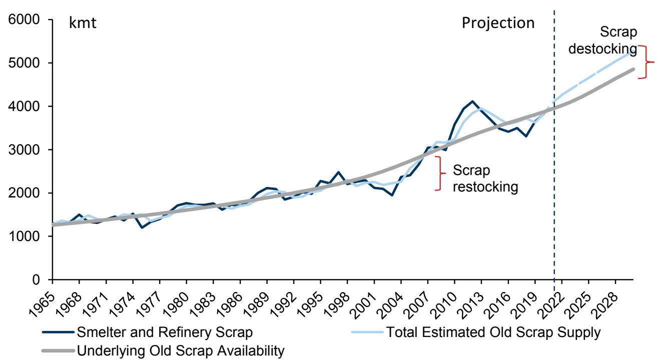
Source: ICA, US Bureau of Economic Analysis (BEA), OECD, Goldman Sachs Global Investment Research

A long-run model of scrap supply

To capture both these short- and long-run dynamics, we decompose total scrap supply into a structural or trend component, and a cyclical component. The structural component remains the convolution of by-sector non-parametric estimators of life-cycle distributions (see Exhibit 41) projected onto the history of by sector copper consumption, while the cyclical component (scrap supply minus trend) remains a function of the logarithim of real copper price moves and economic uncertainty (old scrap destocking) combined with new scrap supply modelled by global IP (new scrap from product tailings). Given the fact that the use of scrap can itself affect the price of copper, we construct an instrumental variable to isolate the moves in the refined copper price unrelated to scrap. Specifically, we model changes in the copper price using changes in the price of aluminium. We then use these predicted changes in the copper price in the scrap model instead of actual copper price changes.

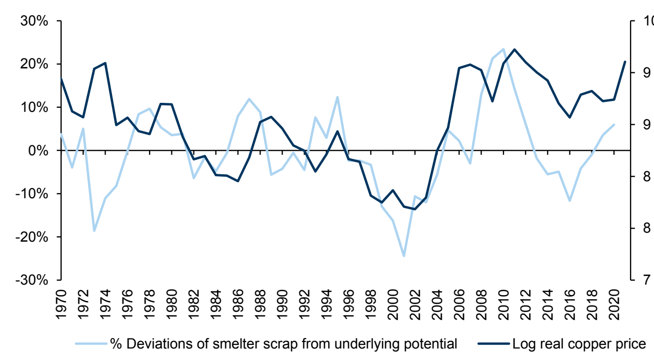
Our estimate then comprises a scrap trend (see Exhibit 43) and an old scrap destocking cycle driven by higher prices into this decade. We find for every $1,000 increase in the real copper price, we expect to see an additional 4% deviation from the underlying growth in scrap over the next decade, or equivalent to c. 174Kty. Crucially, our model explicitly captures the fact that despite persistently higher prices, scrap supply and scrap destocking remain constrained by physical logistics that limit the size of the positive output gap, yet account for the average growth in potential scrap over time. Moreover, we would expect scrap stocks to be run low should demand surprise to the upside and the open-ended deficit persist. Net, our scrap analysis shows how, even with short-cycle scrap supply aggressively responding to price action, green demand will have force prices substantially higher in order to drive sufficient greenfield expansion and demand destruction to balance the market by 2030.

Exhibit 43: We model copper scrap as a deviation from the latent potential scrap supply...
Scrap supply model



Source: Goldman Sachs Global Investment Research

Exhibit 44: ...as a function of prices and uncertainty



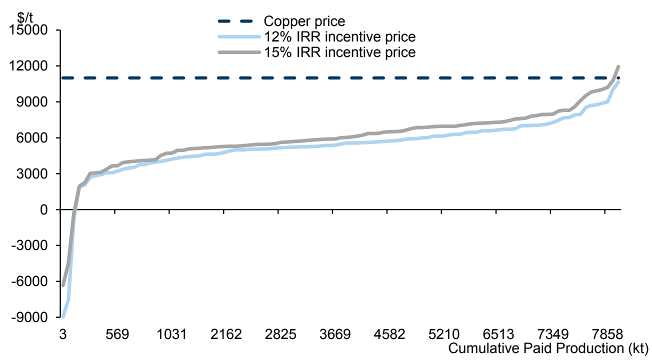
Source: Goldman Sachs Global Investment Research

Mine supply response: Incentive price of $10,000/t needed to support enough projects to solve LT gap

The argument for higher near-term copper prices has been underpinned by the need to limit inventory depletion risks into mid-decade via scrap and demand substitution responses. However, the copper market also faces a record long-term supply gap reflecting the impact of green electrification driving an accelerated trend in global demand contrasting with a peak in base case mine supply. One step towards reducing the LT supply gap relates to the knock on impact from the near-term upswing in price and softening adjustments into mid-decade. If there were to be no increase from current price levels, then the gap would be close to 9.5Mt. However,on our new price forecasts, the near-dated softening effects on the balance mean the LT supply gap falls to close 8.2Mt. Even with that reduction, this remains a record sized long-term gap and double the size of gap that triggered the bull market in the early 2000s.

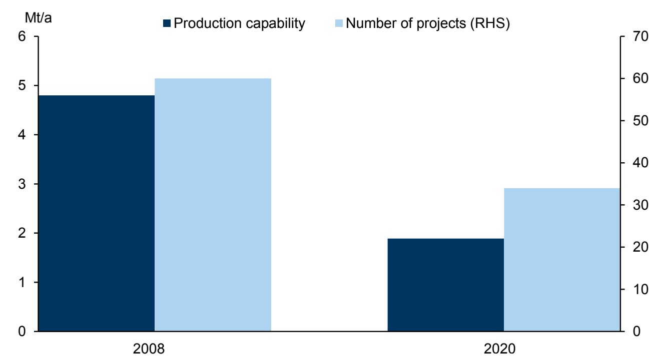
The second step is actually then solving that gap predominantly from what are classified as ‘possible’ brownfield and greenfield copper mine project. These are defined by Woodmac as current low priority development projects for established producers as well as projects owned by aspirant companies at a pre-feasibility stage with marginal economics. The total listed global possible brownfield and greenfield copper projects currently amount to 14.5Mt, which means that close to 60% of these low priority projects will ultimately need to be developed into commercial production. However, only 7Mt of that project capacity has been costed and the incentive price of the highest cost project (on an assumed 12% IRR) is just over $10,000/t. We would note that there has been a near complete absence of material copper project approvals from the mining sector so far in 2021.

Exhibit 45: Available project data suggests a long-term copper price near $10,000/t is needed to incentivise to enough approvals to mitigate the record LT gap
Risk-adjusted PIP curves



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 46: Cuts to exploration and early stage project development mean the size and number of copper projects is substantially lower than a decade ago
Production capability and number of copper projects



Source: Woodmac

New supply technology risk: Is there a shale or NPI equivalent risk for copper in the 2020s?

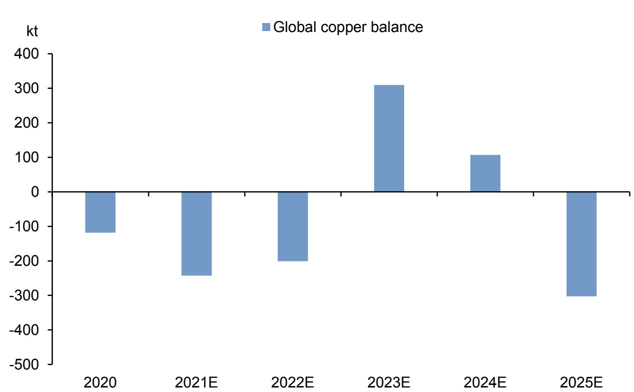
A final consideration for the copper markets path to solving the record forward deficits balances relates to the possibility for technology to generate a step change in production. As evidenced by shale oil, smart farming or nickel pig iron (NPI), new production technologies can have a critical influence on commodity fundamentals and price dynamics. From a historical perspective, the most obvious example of this in the copper market was the emergence of a new production path called leach-solvent extraction-electrowinning (SX/EW) in the early 1980s. Copper's dominant production path up to that point has been via a pyrometallurgical process, which starts with mining ore then concentrating and finally the smelting and refining stage to produce cathode. However, SX/EW enabled miners to produce copper from oxidised ore and waste materials, which was not possible via the conventional smelting process, while avoiding the smelting stage. SX/EW copper production amounted to 690kt in 1992 (7% global mine supply) but by 2015 had risen to 3.8Mt (20% global mine supply), though it is now expected to fall to 2.9Mt by 2025 as many operations taper volumes. Moving to the current backdrop, the evidence suggests there is no near-term equivalent to SX/EW's emergence in the 1980s, but rather a number of marginal innovations that will offer some improvement on efficiency, sustainability and cost without material aggregate impact on supply dynamics. More material supply innovation could yet emerge, though even if the anticipated price surge triggers an as yet unidentified substantive new technology, typical lags in mass adoption mean this is an improbable fundamental influence until at least well into the second half of the decade.

Assessing the possible copper price scenarios on a path to solving scarcity

Our analysis of green copper demand, its impact on the fundamental outlook and, ultimately, the path to preventing scarcity has resulted in a significant upgrade to our price forecast. This means the metal balances into mid-decade remain manageable without depletion occurring. Importantly, as knock on this then reduces the long-term supply gap to a level that we believe this higher price level can then solve on the known set of potential greenfield projects. However, we would accept there is an elevated margin of error regarding the precise price path over the next 5 years. We believe the critical point to make in this context is that copper prices cannot remain at current levels or a lack softening effects would mean the market depletes before it can solve the green demand surge via higher mine supply into the latter half of the decade.

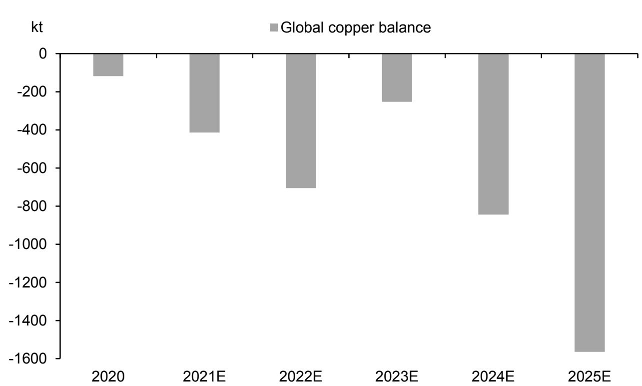
Modeling for a scenario where the copper remains a $9,000/t commodity(Exhibit 48) shows that the market would face inventory depletion risk by 2023. In other words, a lack of incremental softening effects from scrap supply increase and demand substitution mean that outcome is not realistic. However, where reality could differ from our base case is the timing on when the copper price works to solve the tightness. One alternative scenario could be that there is a late realisation of the scarcity risks and the next leg higher in price takes place closer to mid-decade than now (Exhibit 49). The problem with this scenario is that inventories will be drawn to critically low levels before that price spike plays, which suggests it is unlikely since prices are unlikely to remain unmoved with such an inventory trend. The other possible scenario is that copper prices spike over the next two years to the mid/high teens in preemption of the prospective deficits (Exhibit 50). The issue with this scenario is that the copper market will swing into very large surpluses over the next 3 years, which would be a material headwind to price and suggests that such price levels would then be challenged.

Exhibit 47: Under the GS base case near-term depletions risk are mitigated by a trend higher to $12,000/t by 2022 and then $15,000/t by 2025



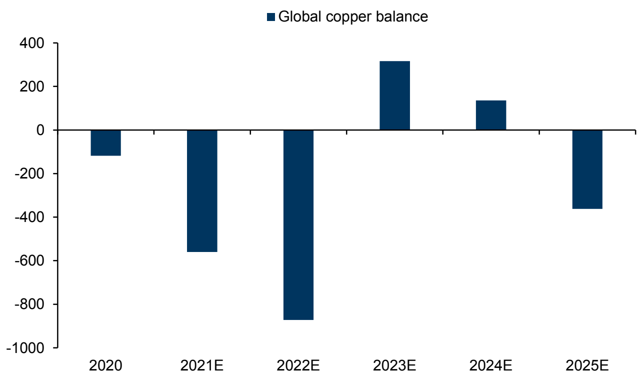
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 48: Copper balance if prices stay at $9,000/t - inventory depletion by 2022 means prices remaining at these levels is not feasible...



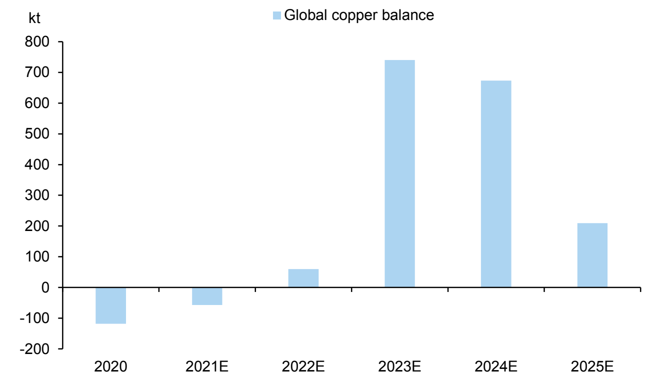
Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 49: Copper price drifts lower into 2022 ($8,000/t), then spikes to teens in 2023 - depletion occurs before price spike softens market



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 50: Market overshoots near term to $20,000/t by 2023 - no tightness and huge surpluses mean this price rally is unlikely to actually materialise



Source: Woodmac, Goldman Sachs Global Investment Research

GS Copper supply demand balance

Exhibit 51: Global supply demand copper balance out to 2025

('000 tonnes)	2016	2017	2018	2019	2020	2021E	2022E	2023E	2024E	2025E
Consumption - DM										
US	2107	2113	2127	2155	2026	2157	2265	2354	2474	2557
% change y/y	*0.1%*	*0.3%*	*0.7%*	*1.3%*	*-8.0%*	*6.5%*	*5.0%*	*3.9%*	*5.1%*	*3.4%*
Europe	5040	5166	5259	5047	4542	4815	5031	5137	5157	5627
% change y/y	*0.3%*	*2.5%*	*1.8%*	*-4.0%*	*-10.0%*	*6.0%*	*4.5%*	*2.1%*	*2.2%*	*3.7%*
Japan	1405	1458	1450	1392	1253	1328	1391	1433	1453	1589
% change y/y	*-2.0%*	*3.7%*	*-0.6%*	*-4.0%*	*-10.0%*	*6.0%*	*4.8%*	*3.0%*	*3.7%*	*3.5%*
Other DM	2279	2328	2234	2089	1880	2012	2083	2145	2052	2331
% change y/y	*1.2%*	*2.2%*	*-4.1%*	*-6.5%*	*-10.0%*	*7.0%*	*3.5%*	*3.0%*	*3.7%*	*3.5%*
Sub- DM	10831	11065	11069	10683	9701	10312	10770	11069	10930	12404
% change y/y	*0.1%*	*2.2%*	*0.0%*	*-3.5%*	*-9.2%*	*6.3%*	*4.4%*	*2.8%*	*1.7%*	*3.5%*
Consumption - EM										
China	12816	13326	13710	13930	14320	14979	15608	16154	16607	17171
% change y/y	*3.1%*	*4.0%*	*2.9%*	*0.5%*	*2.8%*	*4.6%*	*3.5%*	*3.5%*	*2.8%*	*3.4%*
Other EM	4691	4769	4883	4963	4466	4801	5041	5263	5395	5562
% change y/y	*1.5%*	*1.7%*	*2.4%*	*1.6%*	*-10.0%*	*7.5%*	*5.0%*	*4.4%*	*2.5%*	*3.1%*
Sub- EM	17508	18095	18593	18893	18787	19780	20650	21418	22002	22734
% change y/y	*2.7%*	*3.4%*	*2.7%*	*1.6%*	*-0.6%*	*5.3%*	*4.4%*	*3.7%*	*2.9%*	*3.3%*
Global Consumption	28338	29160	29662	29576	28723	30323	31660	32733	33988	35137
Direct Global Scrap Use	5756	6106	6136	6047	5140	5957	6320	6404	6606	6671
Refined Global Consumption	22583	23054	23526	23529	23583	23987	24865	25838	26702	27588
% change y/y	*3.0%*	*2.1%*	*2.0%*	*0.0%*	*0.2%*	*1.7%*	*3.7%*	*3.9%*	*3.3%*	*3.3%*
Global Production										
Mine Production	20220	20118	20786	20929	20799	21035	22176	23652	24094	24218
% change y/y	*5.1%*	*-0.5%*	*3.3%*	*0.7%*	*-0.6%*	*1.1%*	*5.4%*	*6.7%*	*1.9%*	*0.5%*
Refined Copper	22742	22992	23472	23490	23465	23744	24665	26147	26809	27263
% change y/y	*3.2%*	*1.1%*	*2.1%*	*-0.4%*	*-0.3%*	*1.2%*	*3.9%*	*6.0%*	*2.5%*	*1.7%*
Global Balance	**159**	**-62**	**-54**	**-152**	**-118**	**-242**	**-201**	**309**	**107**	**-325**
Cash Prices (annual average)										
Current Dollars ($/t)	4862	6166	6532	6000	6067	9675	11875	12000	14000	15000
Current Dollars (c/lb)	221	280	296	272	275	439	539	544	635	680

Source: Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

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