



Copper Substitution Survey 2021 World Copper Conference

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Antitrust Guidelines for Copper Industry Trade Association Meetings

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community¹ are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

Price: Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

Competitive Information: Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

New Products: Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance. In addition, proposed methods for and results of field and laboratory testing can be considered.

The Role of Legal Counsel: Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled 'Copper Industry Trade Associations and Antitrust Laws' is available upon request.

10/92, 5/93, 10/10

1. Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.

Impact of COVID19

Neutral Impact

Utility Power Cables/ Winding Wire in Transformers /Busbars The upgrade of the electricity network continues to be an important objective and COVID19 has not significantly influenced utility investments. Some even restocked at low copper price.

Equipment wire, Winding Wire in Motors, Industrial Tubes, Electronic PSSF

The production of home, household and consumer appliances was remarkably stable during the pandemic. For example, the residential A/C market was growing in 2020 as people installed A/Cs not only in the bedroom but also in other rooms where they worked. However, as consumers' available income might decline, price-driven substitution might increase in near future.

External and Internal Telecommunication and Data Cables

Covid19 has only limited impact on the telecommunication network, substitution by optical fibre and 5G continues. Installations of optical fibre in the homes might slowed down in 2020.

Slightly Negative

Industry Power Cables/ Winding Wire in Transformers/Other Winding Wires / Busbars / Industrial Motors / Casting
COVID19 has impacted industrial demand based on limited demand/supply/labour but it quickly rebounded. If negative economic climate and budget pressure continue, these can lead to delayed projects and increased substitution.

Negative

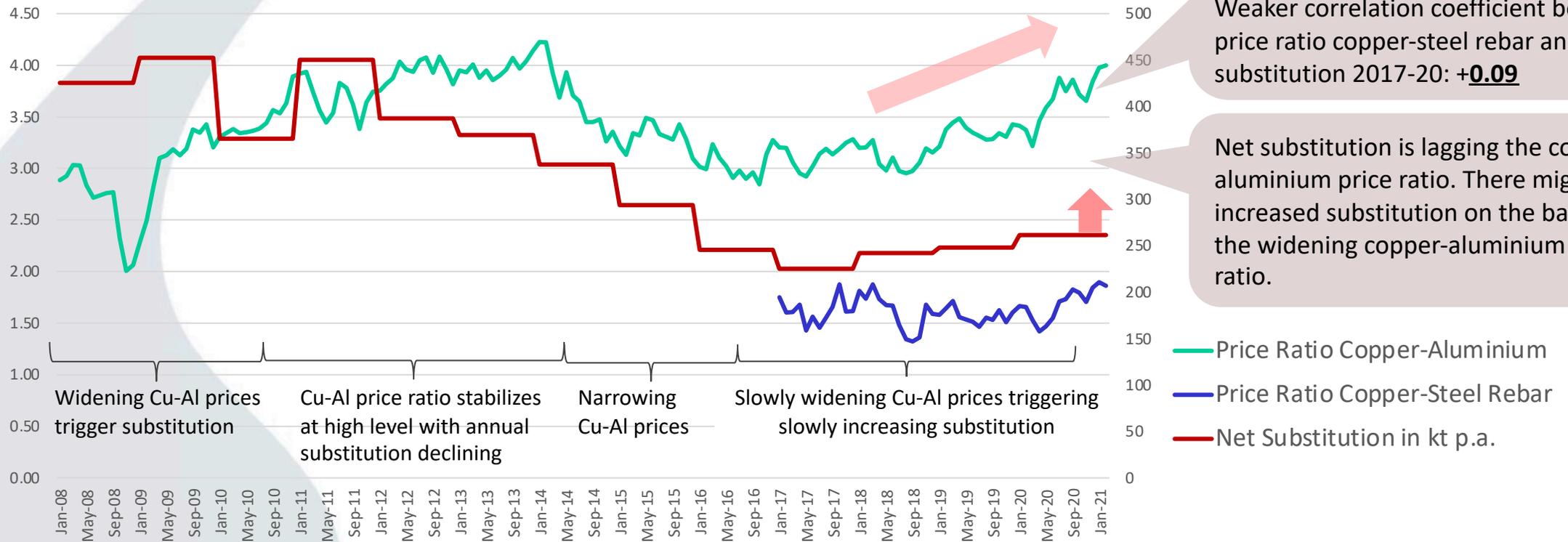
Architectural PSSF, Bare Wire, Bare Wire, Plumbing tube
Commercial construction was seriously impacted by Covid19 leading to budget pressure and increased value engineering. This has and continues to have an impact on demand and substitution of copper products.

Automotive wire / Casting

Automotive sales plummeted during 2020 and OEMs do not expect any sharp recovery in 2021. Also the restricted supply of semiconductors from China impacts automotive production. We expect further substitution to reduce costs, especially in India, China and USA.

Price ratios and net substitution

Price Ratios (Cu-Al, Cu-Steel Rebar) and Net Substitution - in kt



Correlation coefficient between Net Substitution and copper - aluminium price ratio 2010-20: **+0.79**

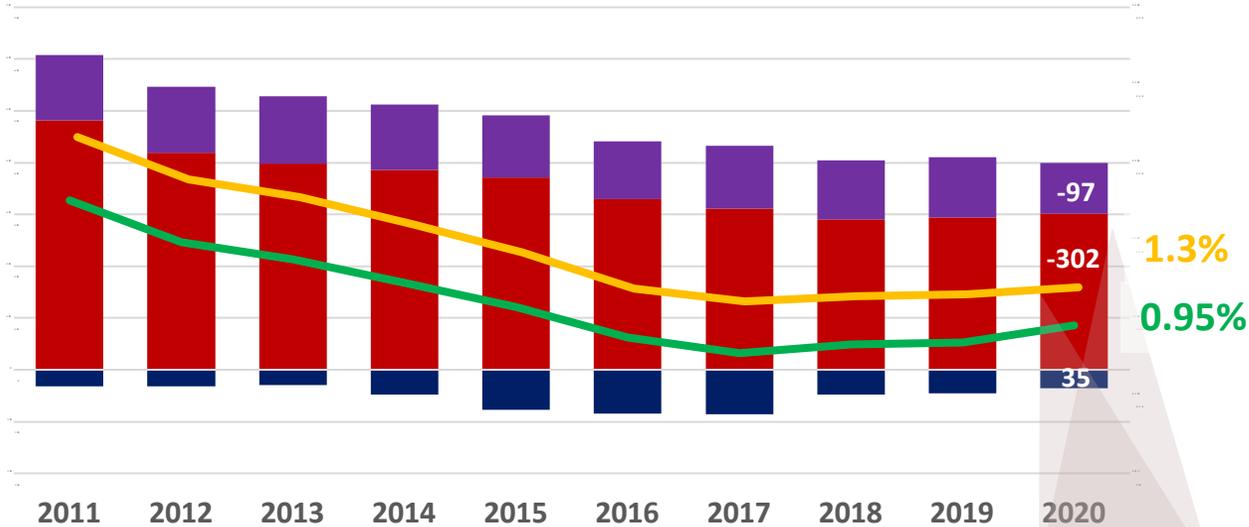
Weaker correlation coefficient between price ratio copper-steel rebar and net substitution 2017-20: **+0.09**

Net substitution is lagging the copper-aluminium price ratio. There might be increased substitution on the back of the widening copper-aluminium price ratio.

Prices used: Monthly average LME Copper and Aluminium Cash-Settlement Price, Price of Steel Rebar according to Trading Economics

Net substitution slightly increased to 0.95% of copper use

Copper Substitution and Miniaturization
- in kt and % of Copper Use in 2011-2020



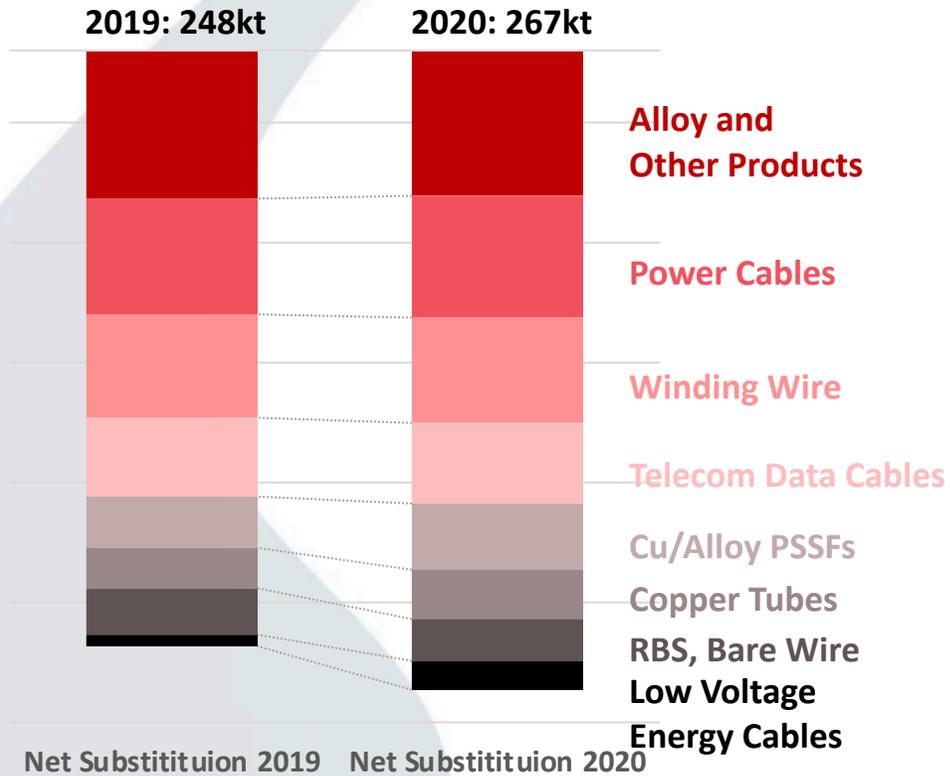
- Substitution
- Substitution Gain
- Miniaturization
- Net Substitution as % of Copper Use
- Substitution & Miniaturization as % of Copper Use

Net Substitution as 0.95 % of Copper Use
Substitution & Miniaturization 1.3 % of Copper Use

- 2020 was dominated by Covid19 and the impact on demand, supply and labour markets. These circumstances were not ideal for changing production and materials strategy beyond what was already under way.
- In 2020 copper material costs were relatively low and this has not triggered significant substitution. Since then, cost rose above the threshold that might motivate substitution in some applications.
- Net substitution as a % of copper use has risen slowly in 2020 as substitution losses slightly rose and gains declined.
 - Substitution losses rose as OEMs and end users are more experienced with using alternative materials.
 - Substitution gains declined as initiatives that are positive for copper, like energy efficiency regulations, undergrounding, environmental regulations were slow in 2020.
- Miniaturization, viewed as a positive for copper, also slowed in 2020 as existing innovations allowing the use of less material reached their technical or cost reduction limits.
- Many copper applications have limited exposure to substitution as copper and alloys still provide the best cost-performance combinations, especially where conductivity, heat, corrosion or friction resistance is required.

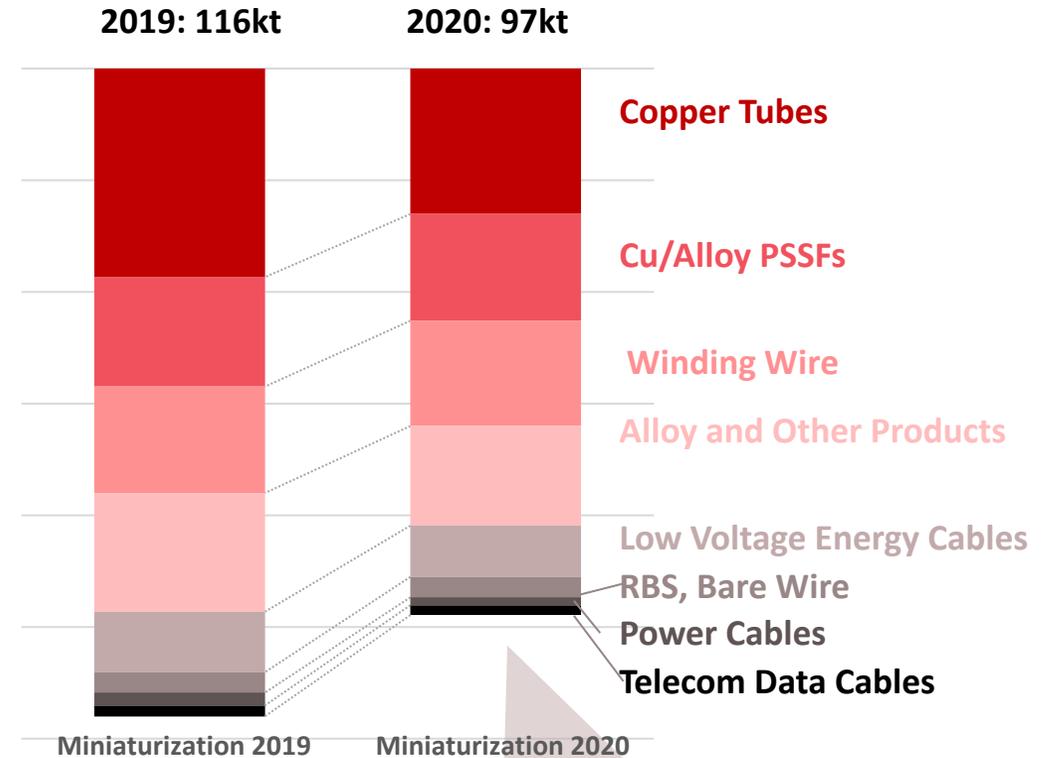
Product substitution slightly increased while miniaturization declined

Net Material Substitution by products
2019-2020 - in kt



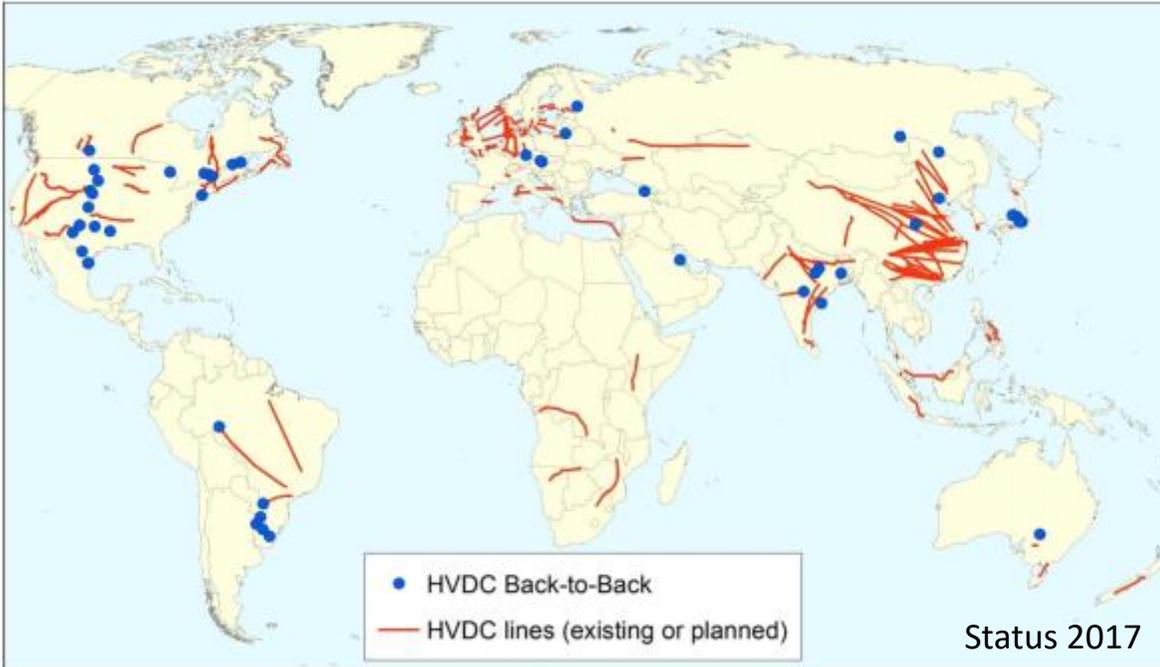
Net Substitution increased mainly due to underlying substitution trends

Miniaturization by products
2019-2020 - in kt



Miniaturization declined as it reached technical limitations and the price incentive was weak.

HVDC networks are battleground for conductor materials but create gains for copper



Source: EU JRC Science for Policy Report: A China-EU electricity transmission link

HVDC electricity distribution networks

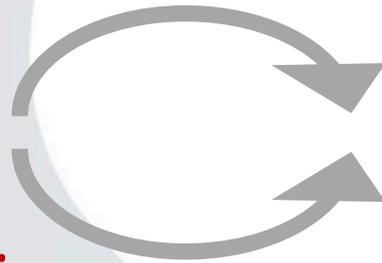
- As part of achieving carbon neutrality, utilities implement HVDC networks bringing renewable energy from the generation (often offshore windfarms) to inland consumption.
- These HVDC networks are seen as a tool in carbon footprint reduction as intended to partially replace traditional distribution networks connecting thermal and nuclear energy generation.
- HVDC networks use new technology, require less transformers and minimise electrical losses.
- HVDC lines, especially if underground, tend to use copper and can provide substitution gains for copper against overhead aluminium lines.
- For example, SuedLink and SuedOstLink underground HVCD distribution networks in Germany use copper. Also HVDC networks in China tend to use copper conductors.
- However, the existence of reliable aluminium conductor DC cables might reduce copper's gains.

Impact of 5G on telecommunications wiring

Broad View 2020:

Copper wires ca. 30% of connections in EU (50% in USA)

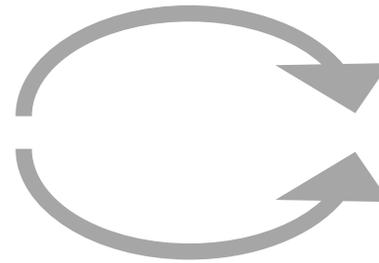
Optical fibre ca. 70% of connections in EU (50% USA)



Distribution point /
5G Cell drop point

**Copper wires EU 90%
of connections (USA 85%)**

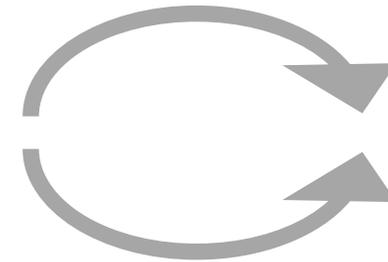
The last 100-300m from the pole to the home is still copper as bringing optical fibre into the homes is costly (new conduits) and requires the owners' collaboration.



Home access

Copper wires 99%

WiFi generally is a parallel system for mobile and non-critical applications while copper wires are used for security and speed of transfer.



User

Future with 5G:

Physical connection will remain to the 5G cell drop points but optical fibre will further penetrate this part of the network based on fibre's bandwidth and scalability.

5G network

5G requires specific equipment/antenna but will substitute a significant share of the mainly copper physical connections within 5G cells.

Very slow substitution of copper wires inside building by WiFi/5G as walls significantly deteriorate 5G connections and WiFi has limited bandwidth

5G networks work best for mobile applications, outside of buildings, in an environment with low humidity and low air pollution

Substitution of brass in high friction applications is limited

Cost reduction in friction applications

Traditional brass-brass friction applications



- Brass remains the main material for high friction applications e.g., aerospace, oil, gas (fracking etc.)
- Focus is more on improving the composition of copper alloys.
- Copper alloys are also the main materials for low-tolerance precision casting.

Brass-steel for friction applications (machines etc.)



- Steel wears out quickly, therefore steel-steel connecting components are difficult.
- Here, brass will remain as one part of the connecting components.

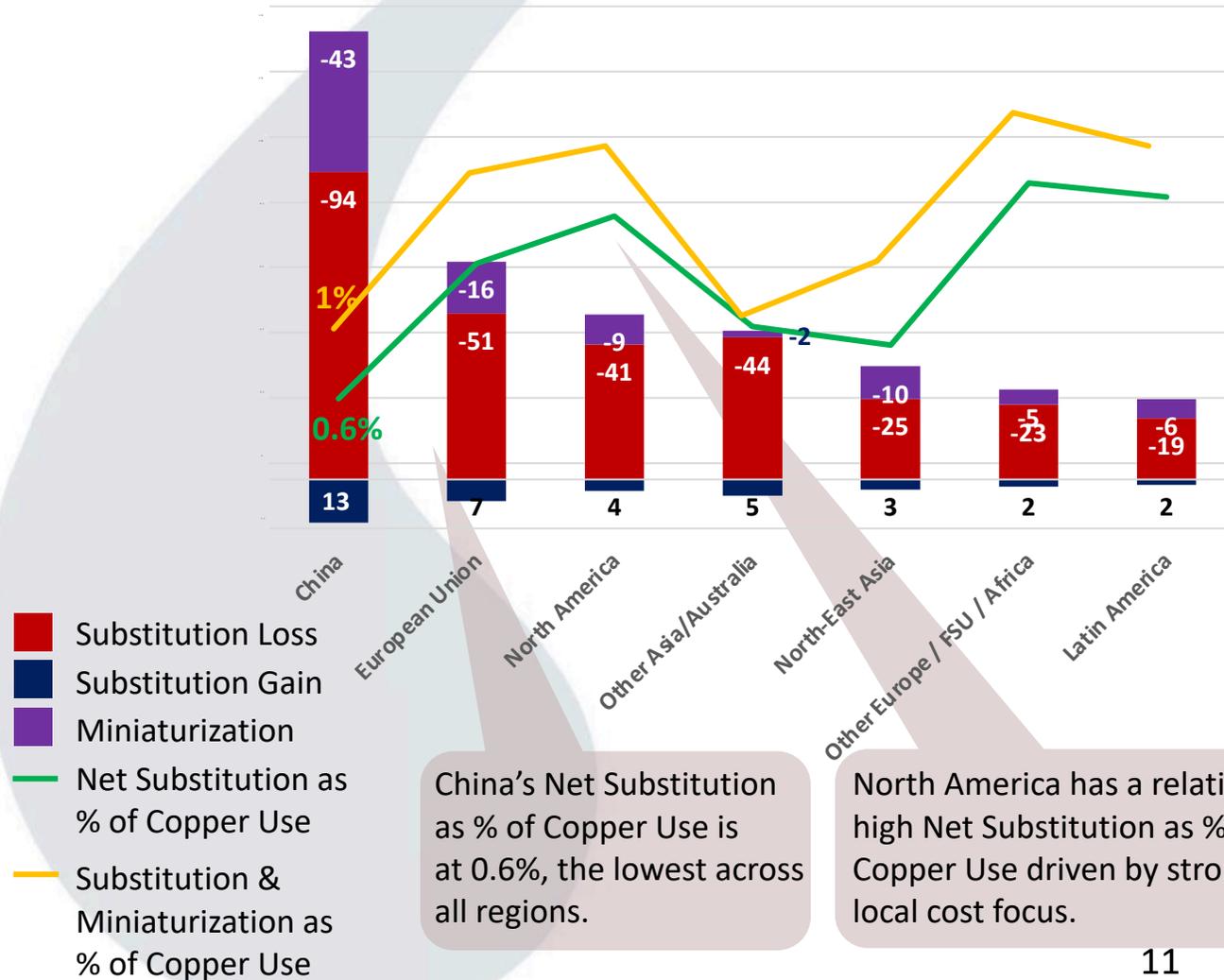
Engineered plastics withstanding only medium friction



- Used in machines, medium friction gears, automotive.
- Applications are still limited.

Regional Overview: China is still most loyal to copper, other regions' mainly influenced by local competitive situation and impact of COVID19

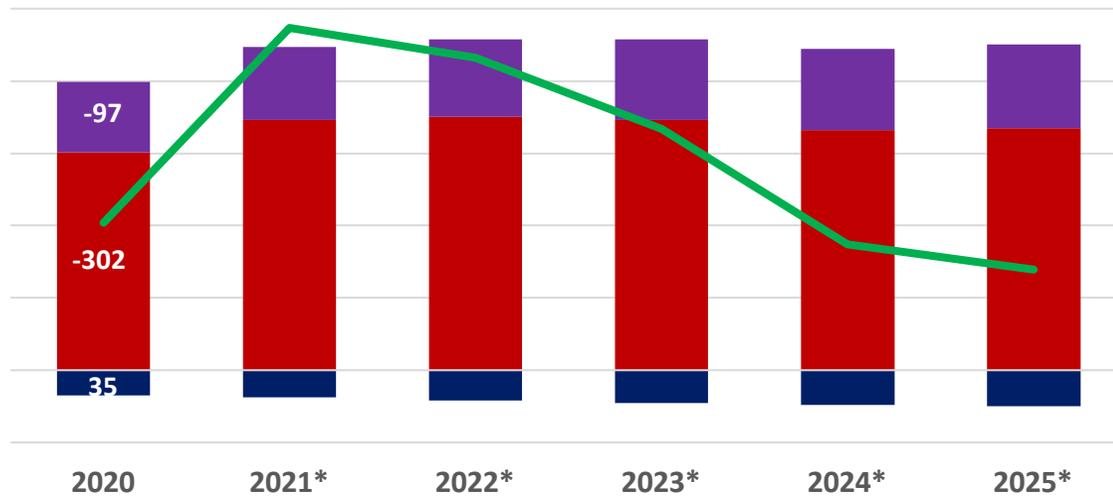
Substitution and Miniaturization by Geographic Regions 2020 – in kt and % of Copper Use



- In China substitution trends are changing as the economy moves to a different model. Cost focus and more openness to use alternative materials will be more relevant. Still, proportionally to the copper use, China's net substitution is below world average with 0.6% of copper use.
- Europe is characterized by low ongoing substitution and miniaturization driven by R&D and environmental regulations.
- Substitution in North America is driven by a strong focus on cost cutting and strong competitive pressure.
- North-East Asia has a traditional approach to material substitution and therefore, low net substitution proportionally to the region's copper use. However, the region is active in technology-driven miniaturization.
- Substitution in Latin America is impacted by Covid19 related disruptions.

Short-term substitution might peak on the back of increasing material costs subdued by technical and regulatory limitations

Copper Substitution and Miniaturization
- in kt and % of Copper Use in 2020-2025



* Forecast

- Substitution
- Substitution Gain
- Miniaturization
- Net Substitution as % of Copper Use

Substitution Loss

- In 2021-2022 copper might experience slightly accelerating substitution driven by material costs. Main areas might be select cable applications, select winding wire, industry tubes, some alloy applications, and to a certain extent specific brand automotive wire.
- After 2022 substitution is likely to reach technical and regulatory limitations and will slow down, unless material costs provide new impetus.

Substitution Gain

- After 2022 we expect to see more environmental and energy efficiency regulations, led by EU, China and increasingly the USA resulting in copper gains in electric motors, industry tube and some transformers.

Miniaturization

- From 2021 we might see increased R&D into miniaturization that might have an impact on copper use with a 1-2 year delay. Main markets for miniaturization are industrial tubes, electric PFFS, electric motors, automotive wires.

Note

- This forecast is based on information collected between November 2020 and January 2021 and assumes no significant barriers to trade, no unforeseeable political, economical, health-related and regulatory challenges over the next five years. Any forward-looking statements have been prepared on the basis of a number of assumptions, which may prove to be incorrect in the future. Forward looking statements, by nature, involve risk and uncertainty, and DMM Advisory Ltd. specifically warns against business decisions solely relied upon recommendation or forecasts DMM Advisory Ltd. Presents.

Summary

- **Main themes** of 2020 were **COVID19**, relatively **low copper material costs in H1/2020** and **carbon footprint reduction**.
 - COVID19 impacted copper demand, supply and labour availability. End users and OEMs focussed on solving these issues and new substitution and miniaturization initiatives were not priority.
 - Copper material costs were relatively low in May 2020 and therefore, there was no significant price incentive to substitution. However, copper material costs increased in H2/2020 possibly setting foundation for limited substitution in 2021.
 - Carbon footprint reduction, renewable energy, energy efficiency, fuel efficiency are key themes with long-term influence on OEMs and end users. However, their impact was limited on substitution and miniaturization in 2020.
- **Substitution trends**
 - Generally, substitution might occur where alternative materials bring additional benefits, in addition to material cost e.g., lighter weight, corrosion or friction resistance, aesthetics or reduction of theft.
 - 2020 was characterised by stable substitution with a net substitution at 0.95% of copper use, intense cost pressure in some industries led to immediately available material cost savings through substitution.
 - Factors reducing substitution such as the implementation of energy efficiency recommendations or new miniaturization technologies slowed down: the total impact of substitution and miniaturization was 1.3% of copper use in 2020.
- **Select market trends**
 - Increasingly popular **HVDC networks** (to carry renewable DC power from generation to consumption) and ongoing **undergrounding** (laying overhead lines underground for protection and for urban planning) offer potential gains for copper.
 - **Electrical mobility** is key but the current focus is less on EVs and more on two and three wheelers that are extremely popular in many countries. This has a positive impact on copper demand.