

Copper opportunities in low carbon megatrends

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October 2017



Legal Statement

Cu

The purpose of the information in the following presentations is to guide ICA programs and provide members with information to make independent business decisions.

Antitrust Guidelines for Copper Industry Trade Association Meetings

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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.



This report analyses copper demand from three sectors linked to decarbonisation trends

The report has been compiled by Wood Mackenzie and MetalsPlus



Renewable Energy

1. Solar
2. Wind



Electromobility

1. Electric vehicles
2. Charging Infrastructure



Energy Efficiency

1. Electric motors
2. Distribution Transformers
3. Air conditioners

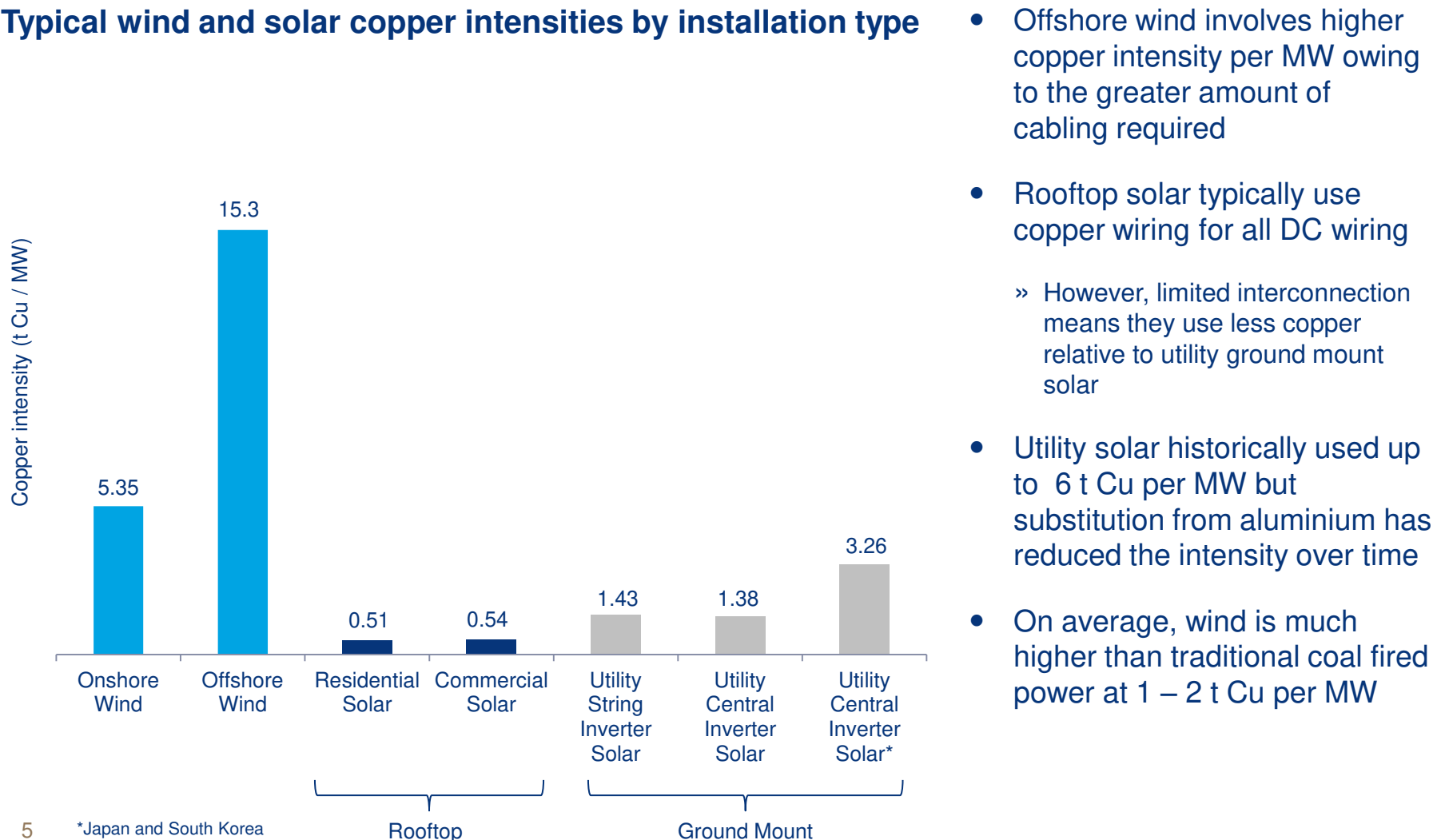




Wind power notably involves high levels of copper intensity of use with the transformer and cabling

Ground mounted utility solar uses more copper roof mounted types, but has also experienced more substitution from aluminium

Typical wind and solar copper intensities by installation type

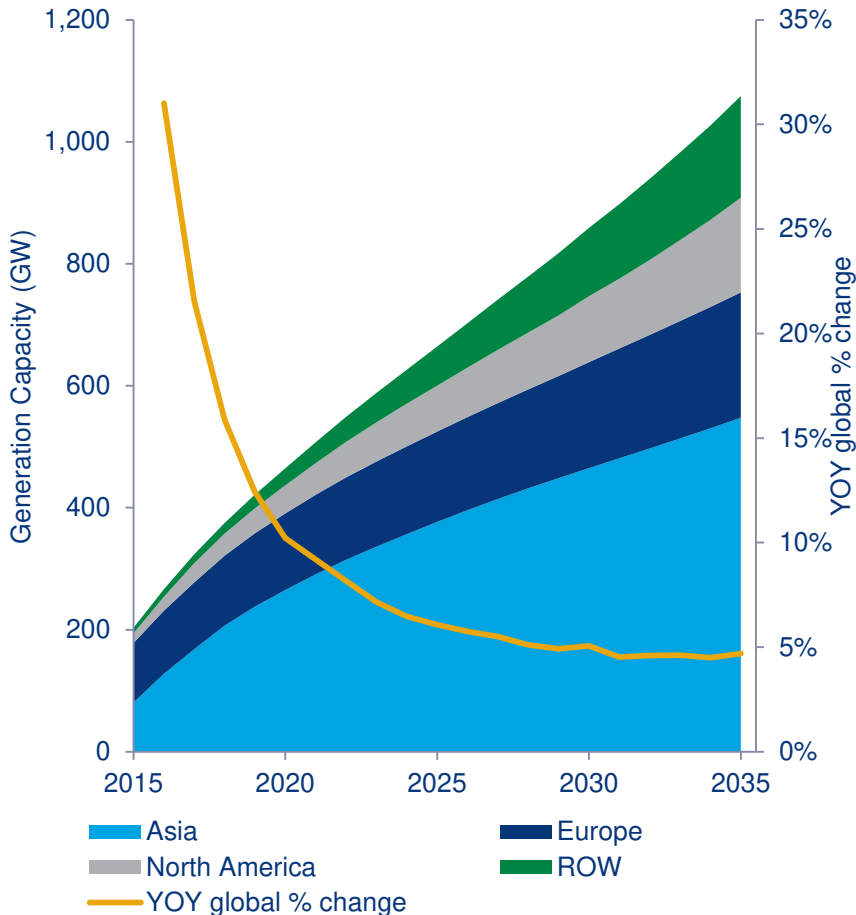


- Offshore wind involves higher copper intensity per MW owing to the greater amount of cabling required
- Rooftop solar typically use copper wiring for all DC wiring
 - » However, limited interconnection means they use less copper relative to utility ground mount solar
- Utility solar historically used up to 6 t Cu per MW but substitution from aluminium has reduced the intensity over time
- On average, wind is much higher than traditional coal fired power at 1 – 2 t Cu per MW

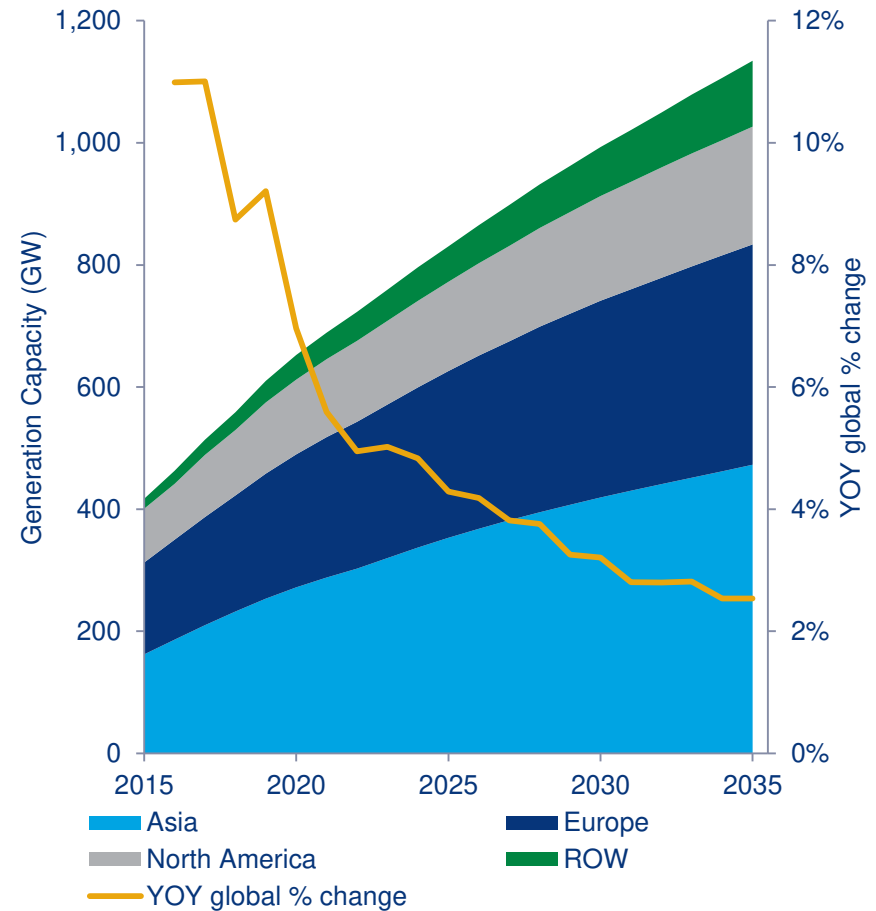
Global solar and wind power will each account for over 1 TW of capacity by 2035

Asia, particularly China, drives rapid near and mid term growth due to falling technology costs, policy incentives and development of transmission infrastructure

Solar power generation capacity by region



Wind power generation capacity by region

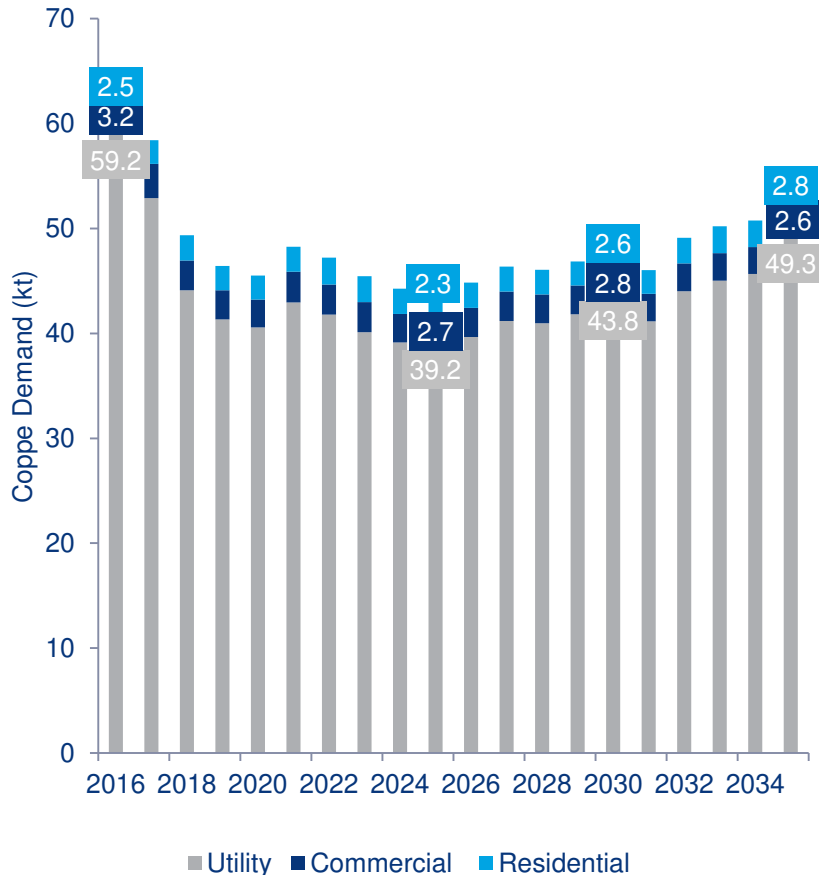




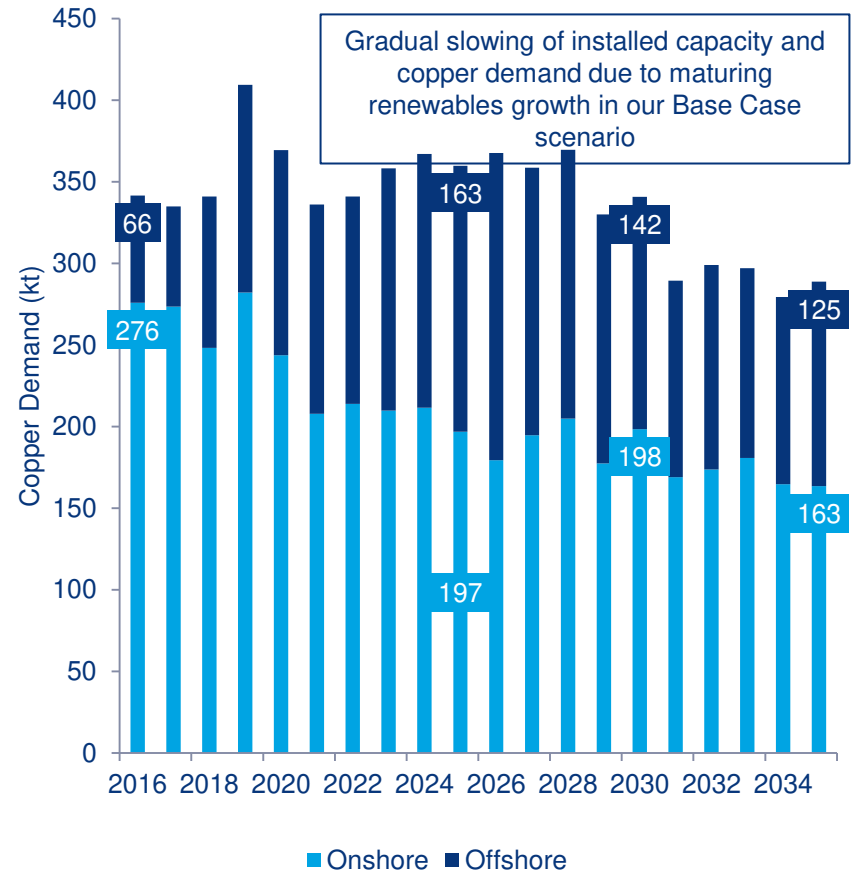
Rapid growth of wind power installations consume on average 359 ktpa of copper up to 2020 and 339 ktpa to 2025

The contributions from solar installations is more modest, owing to the lower copper intensity, averaging ~50 ktpa through the Base Case forecast period

Forecast global copper demand from installed solar power



Forecast global copper demand from installed wind power



Copper use in batteries increases copper intensity for electric vehicles over internal combustion engine vehicles

The use of copper in electric motors is another notable contribution to increased intensity of use

Copper intensity per vehicle (kg) by type

Component	Passenger				Light Commercial Vehicles				Heavy Commercial Vehicles	
	ICE	HEV	PHEV	BEV	ICE	HEV	PHEV	BEV	ICE	BEV Bus
Battery ¹		1	15	38		5	32	60		173
Rest of Vehicle	22	39	40	42	26	47	48	50	42	80
Total	22	40	55	80	26	52	80	110	42	253

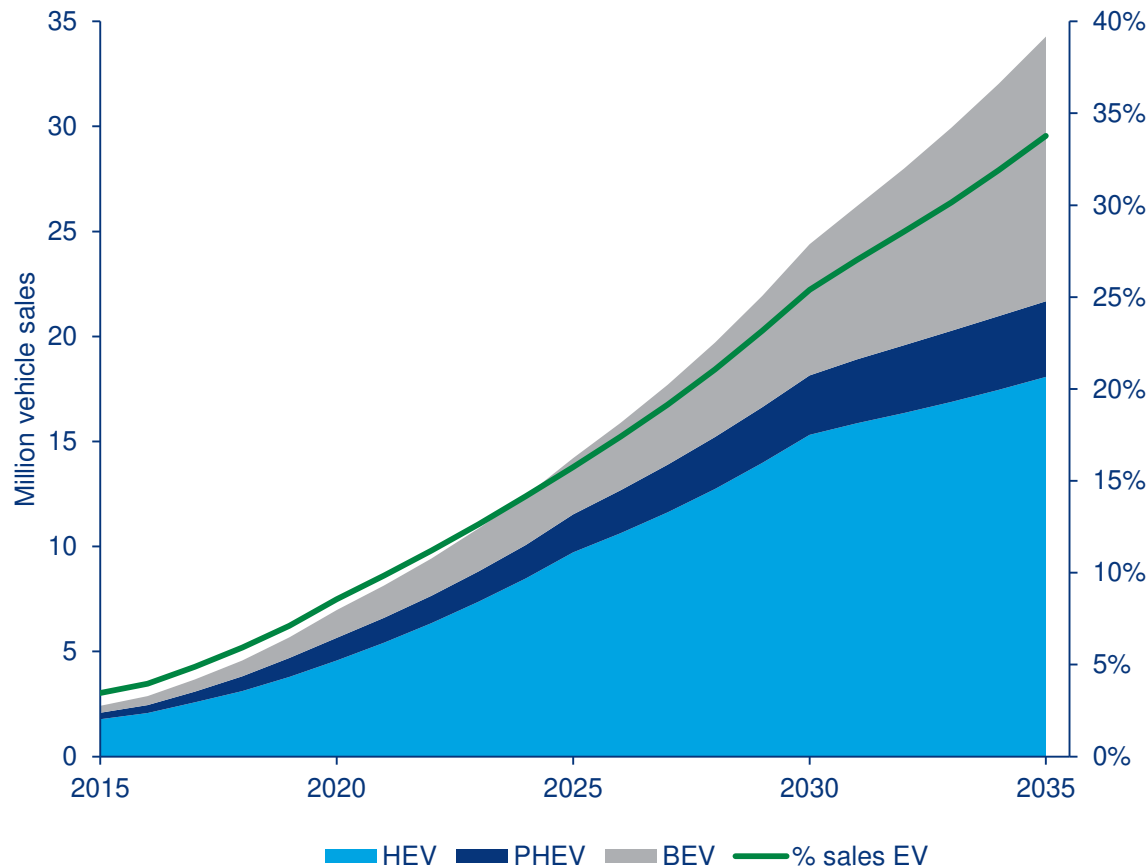
- Battery contributes significantly to higher copper intensity moving from ICE through to EV
- Higher the copper usage within the rest of the vehicle are largely attributable to the electric motor windings and the wiring harness/electrical distribution system (to accommodate higher voltages)
- Aside from additional electrical components, the need for improved heat exchanger equipment to deal with higher running temperatures also serves to boost copper consumption in xEV
- There are some losses in engine hardware in BEV versus ICE/HEV/PHEV as no combusting engine is incorporated, however these are small overall and comfortably outweighed by gains elsewhere



WM expects EVs to account for 34% of global passenger vehicle sales by 2035 with over 50% being hybrid types

The split of EV type is heavily dependent on region – a BEV is not currently viable in regions with limited charging infrastructure

WM passenger EV forecast (base case), 2015 - 2035



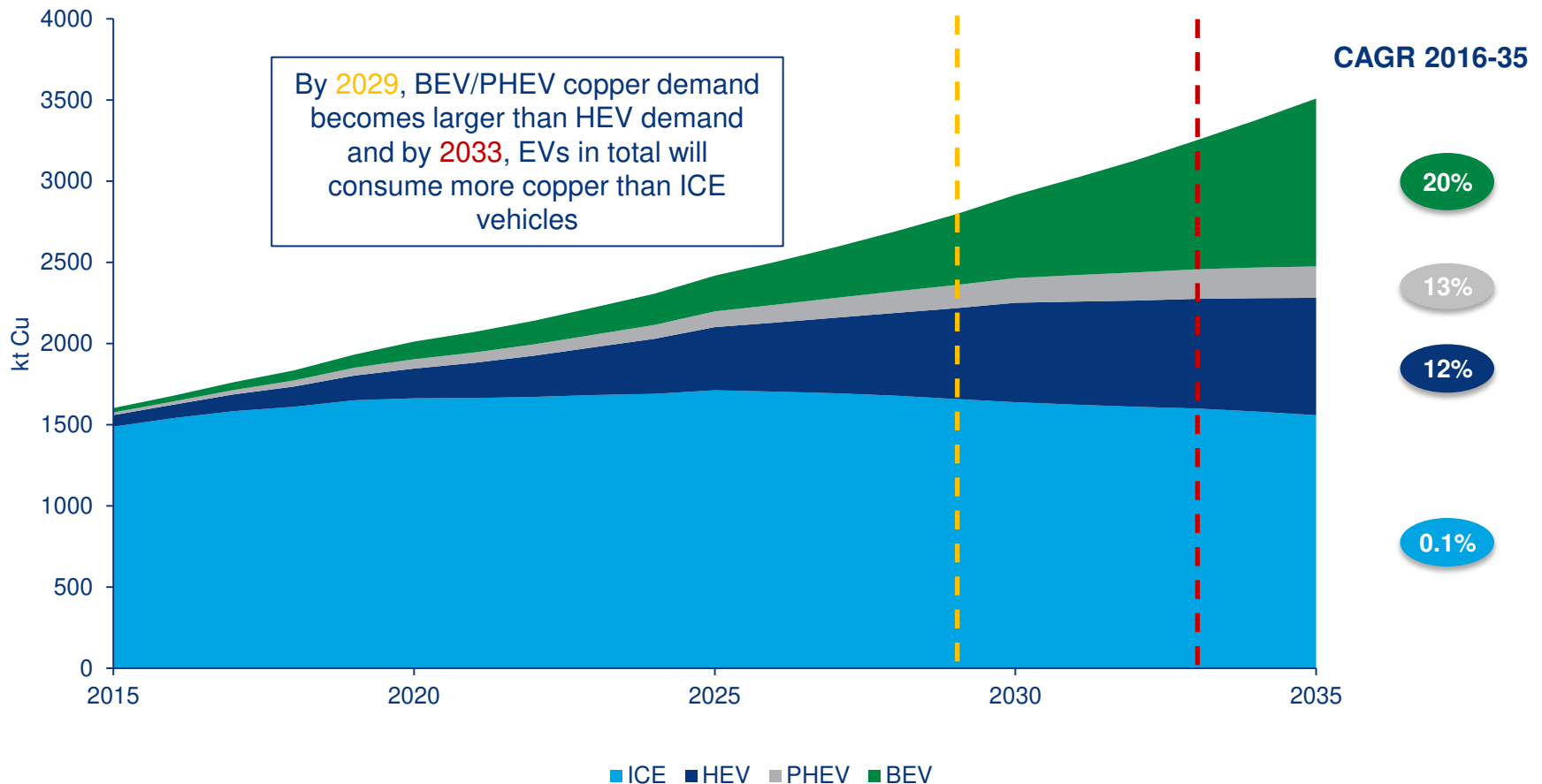
- Uptake of EVs is dependent on:
 - » Regional policy & subsidies
 - » Battery, oil & electricity prices
 - » Vehicle range and cost
 - » Infrastructure
 - » Vehicle stock saturation
- China has had the latest surge in electric vehicle sales with strong government subsidies
 - » Growth will continue to come from Europe, US and developed Asian markets
- Overall HEVs are the preferred vehicle type as they do not have the price tag of a BEV/PHEV and do not require infrastructure, while offering the consumer a more efficient, environmentally friendly option



Copper demand from passenger car EVs overtakes ICE vehicles after 2033, accounting for over 1.9 million tonnes by 2035

The offset from fewer ICE sales through the forecast is minimised due to the much lower copper intensity

Passenger car copper demand by vehicle type, 2017 - 2035

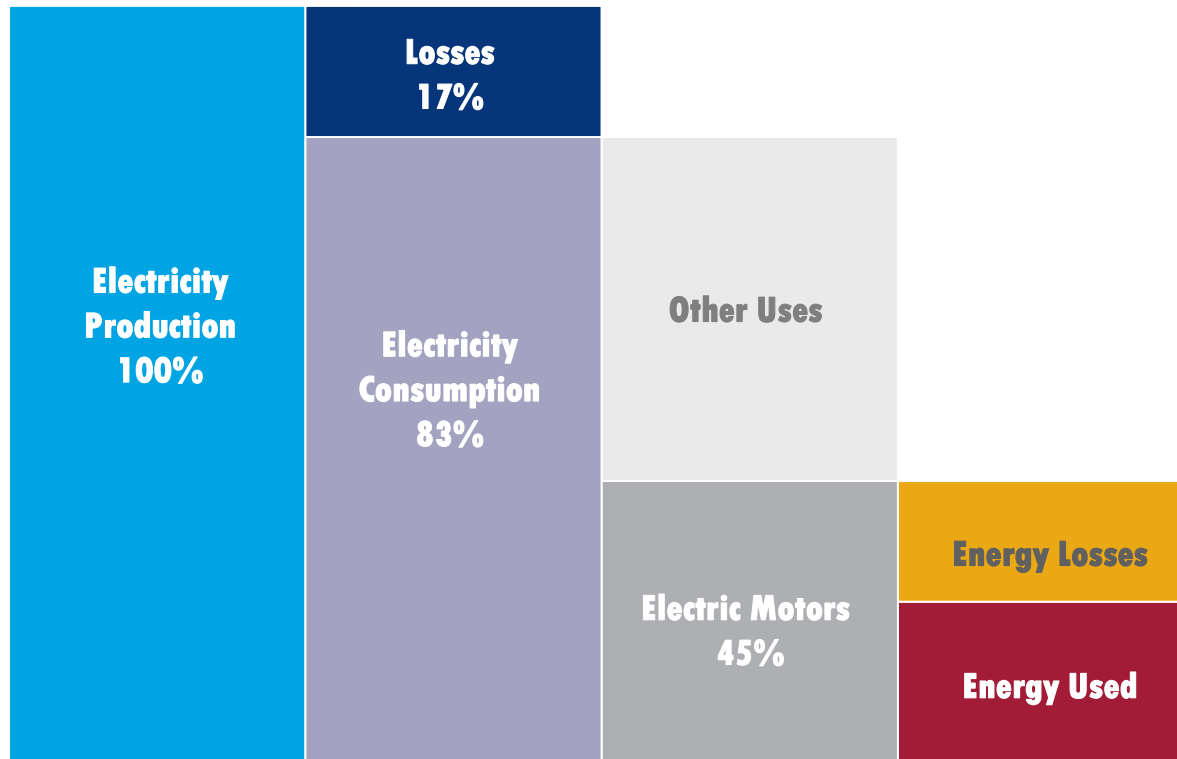




The three energy efficiency sectors are major sources of generated electricity loss

Reducing electricity loss in major consuming sectors is therefore a major area of importance for carbon emission reductions

Breakdown of Electricity Generation, Consumption and Losses



- From generation to use about 17% of electricity is lost, much of it from network transformers
- In use, motors and motor driven systems account for 45% of all electricity use, and a similar share of loss
- Air conditioners are a major application for electric motors



Energy efficiency is enforced through minimum energy performance standards (MEPS) which are present in most major markets

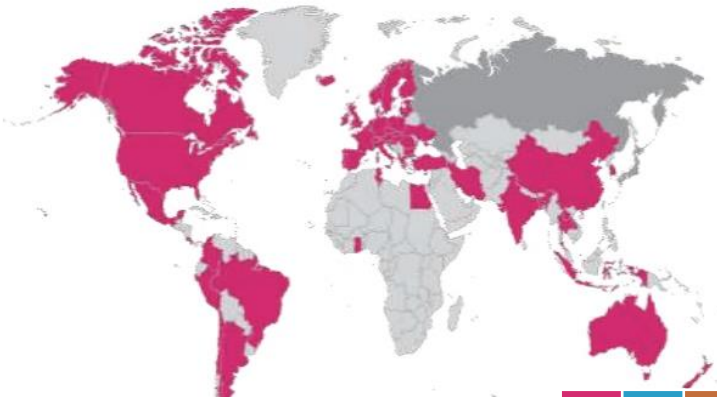
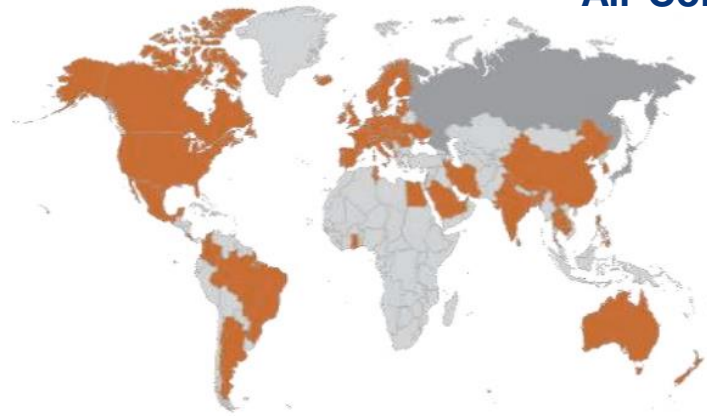
MEPS are the key to product upgrades and most developed regions have them in place, although developing markets are where the future gains will be made

MEP Presence by Country and Sector

Motors



Air Conditioners



Refrigerators



Transformers



Copper intensity per unit of capacity increases for all sectors, as efficiency gains require higher material intensity

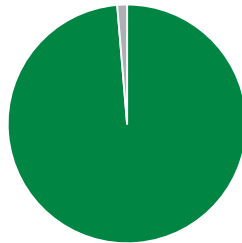
Copper in energy efficiency sectors is mainly present as winding wire and additional tubing for air conditioners, and more copper will be required per unit to achieve higher efficiency

Sectors

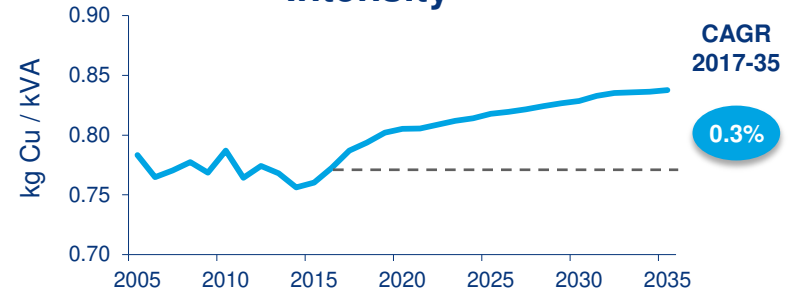
Distribution Transformers



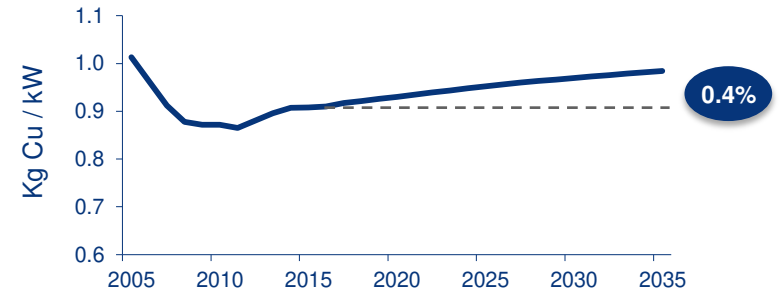
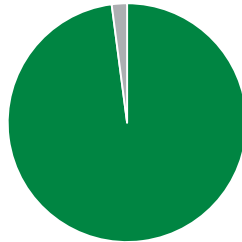
Copper forms



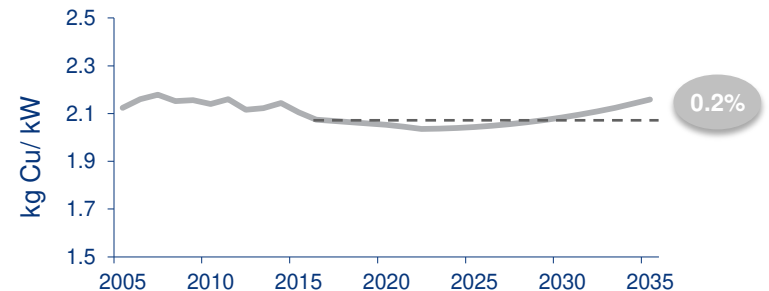
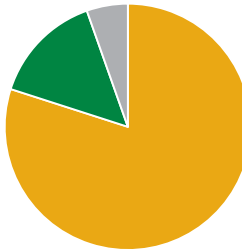
Copper Intensity



Electric motors



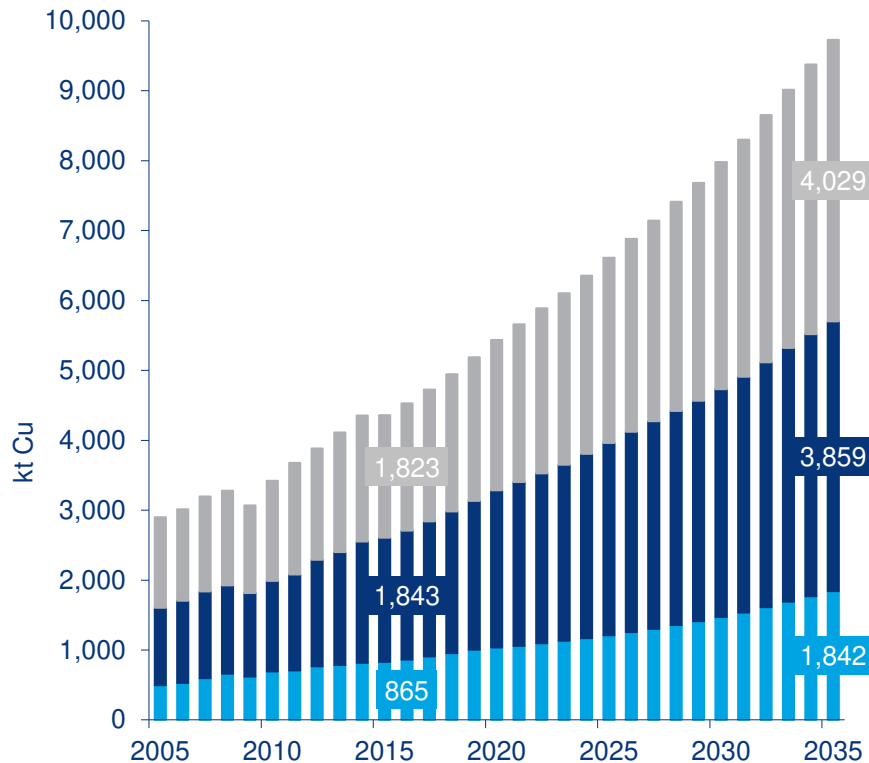
Air Conditioners



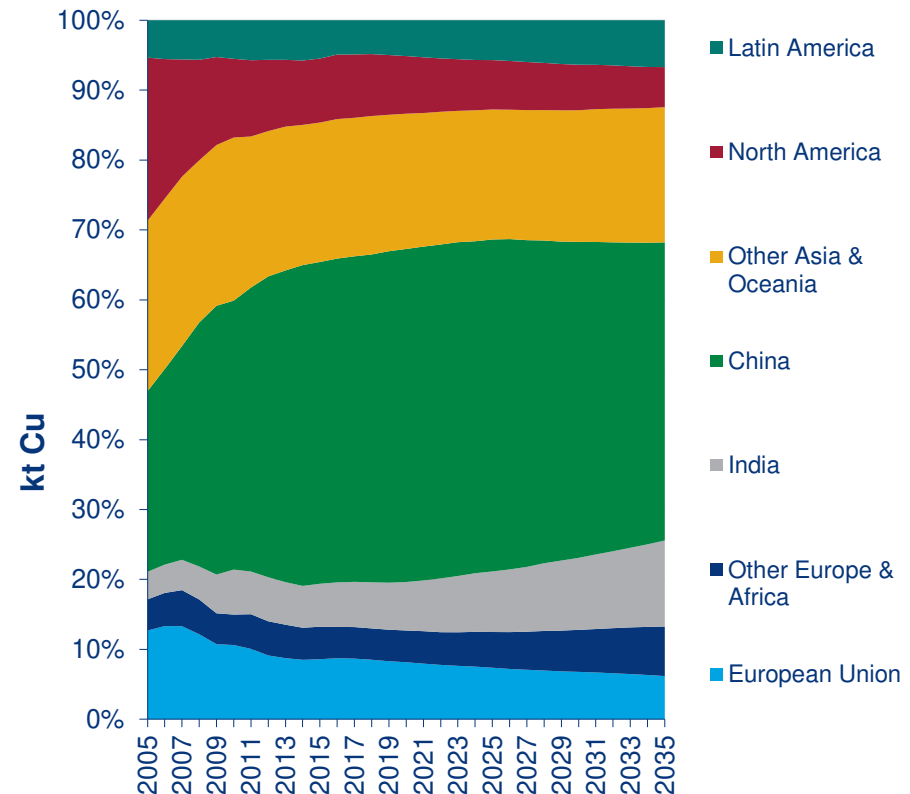
Copper demand in energy efficiency sectors almost doubles from 4.7 Mt in 2017 to reach 9.7 Mt by 2035

Increases in stock added and replacement, particularly in India and Other Asia, drives growth at CAGR of 4.0%, 3.9% and 4.3% for transformers, motors and AC respectively

Copper demand by energy efficiency sector



Global distribution of copper demand for energy efficiency sectors



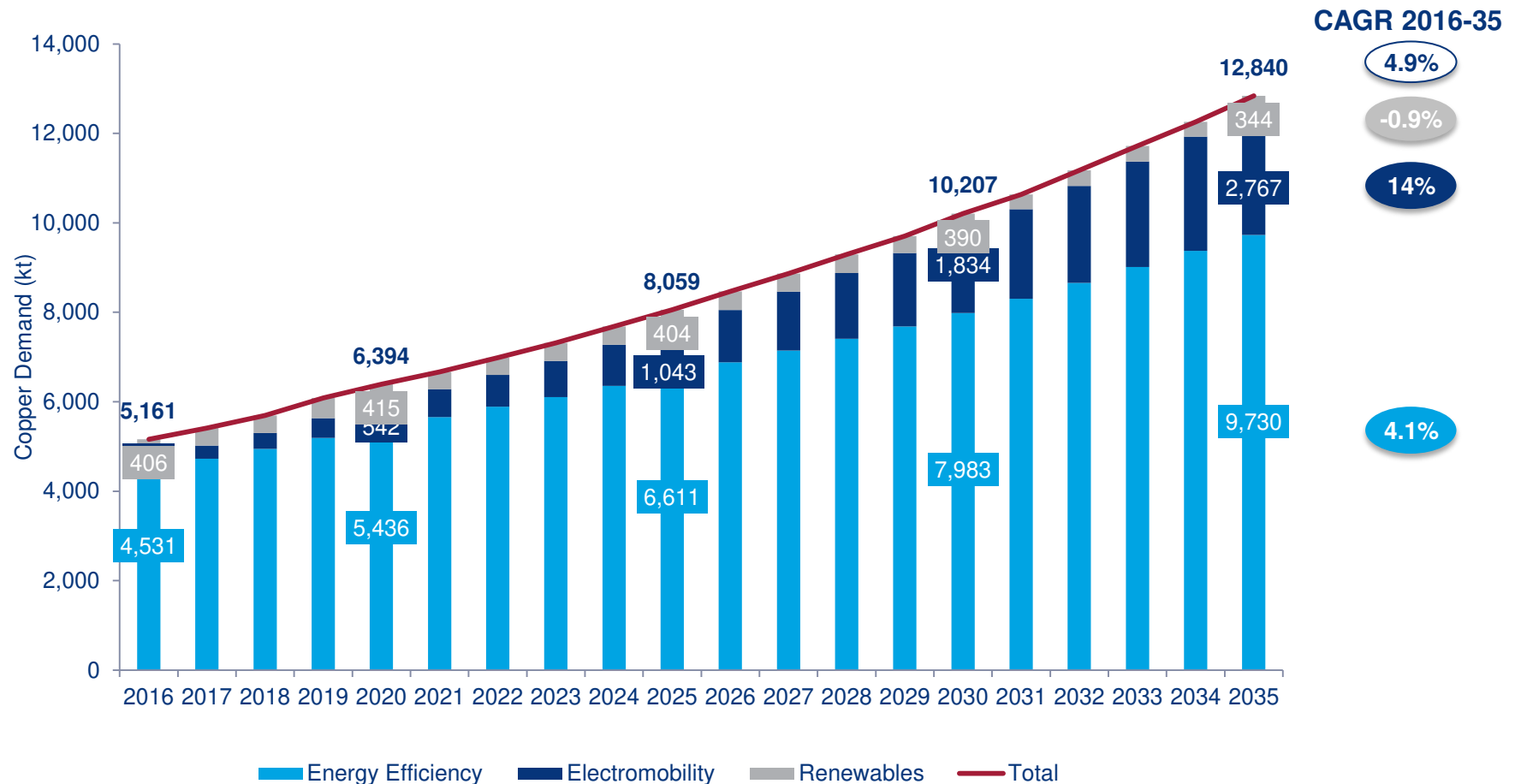
■ Distribution Transformers ■ Electric Motors ■ Air Conditioners



The energy efficiency sector will contribute most to copper demand for the megatrends analysed but electromobility grows faster

Energy efficiency contributes 80% of demand but the rapid growth in electric vehicle production sees electromobility increases at 14.2% CAGR vs 4.1% for energy efficiency

Forecast copper demand by sector





Disclaimer

Confidential

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