



IS THERE A THREAT TO COPPER IN RENEWABLES?

APRIL 2019

LEGAL STATEMENT

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

ANTITRUST GUIDELINES

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.

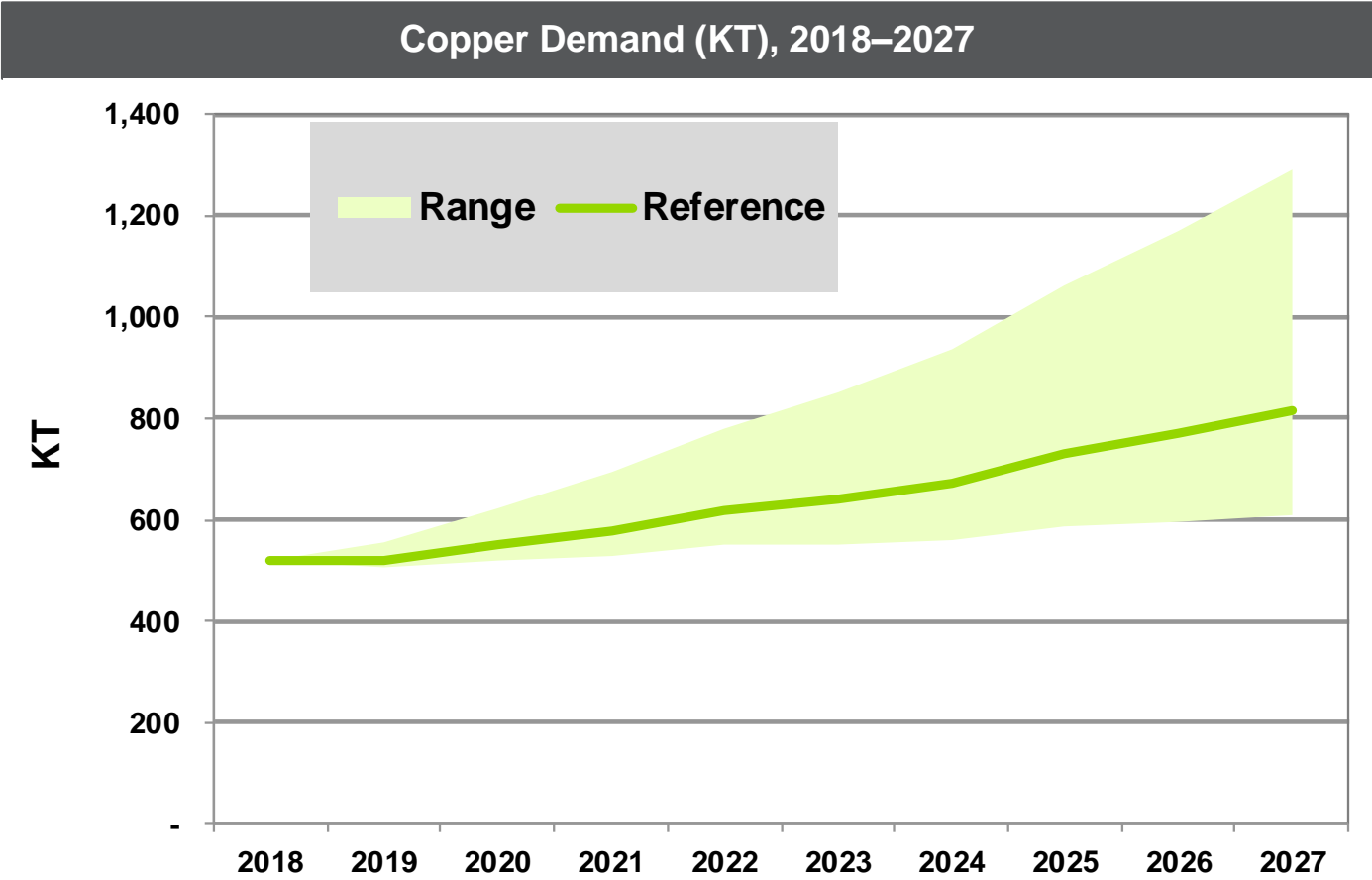
10/92, 5/93, 10/10

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

FORECAST METHODOLOGY

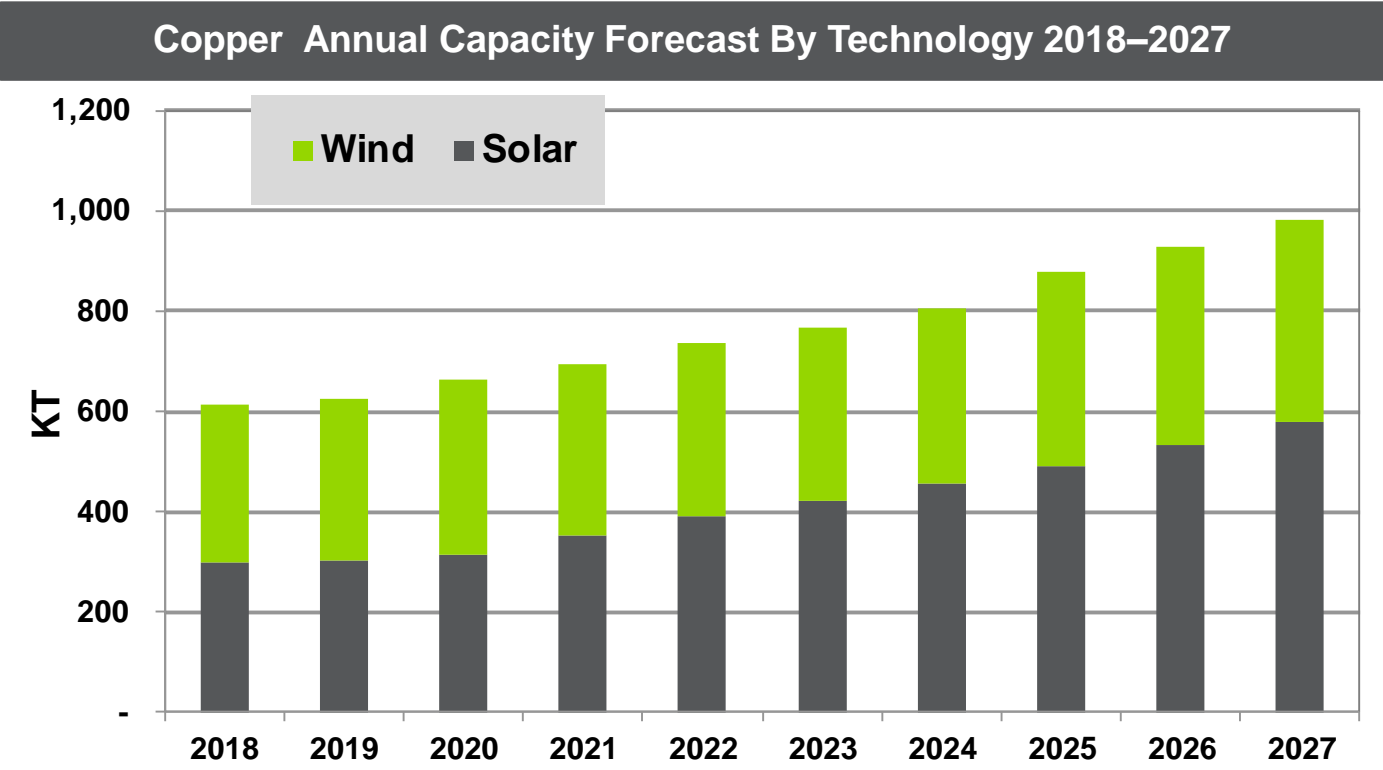
- Navigant Research's wind and solar forecasts are based on the current regulatory environment, the stage of development of the industry in each of the analyzed markets, and the economics of solar installations compared to retail electricity prices (for distributed solar) or wholesale prices (for utility-scale solar, onshore and offshore wind).
- **Projections should be used as general guidelines** given the many uncertainties associated with policy frameworks and other factors likely to change significantly over the next decade as existing solar markets mature and new markets emerge. Estimates of the outcome beyond 2023 are based on an interpretation of the geopolitical picture in relation to climate change and energy security issues, as well as commitments to renewables.
- The forecast includes global and regional market size for copper in solar PV and wind (including offshore) for the next decade (2018–2027) and the risk of replacement by aluminum.

GLOBAL DEMAND



(Source: Navigant Research)

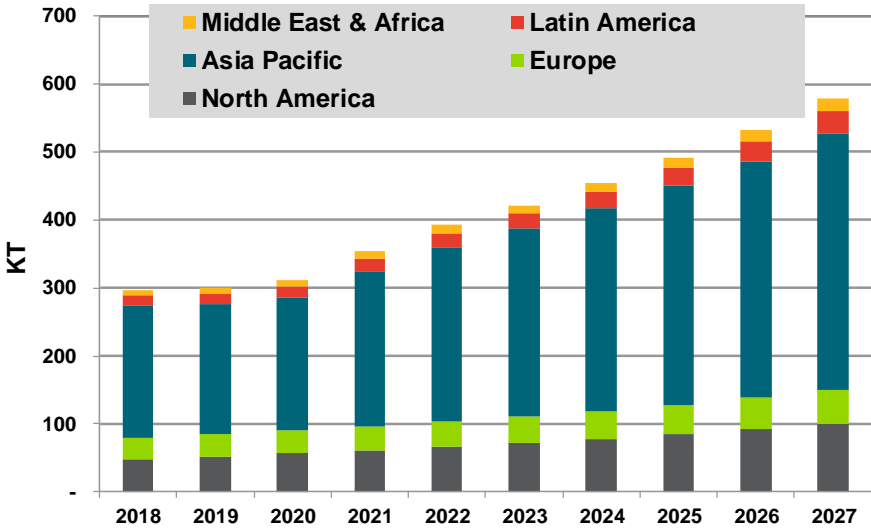
WORLD SOLAR AND WIND FORECAST OVERVIEW



(Source: Navigant Research)

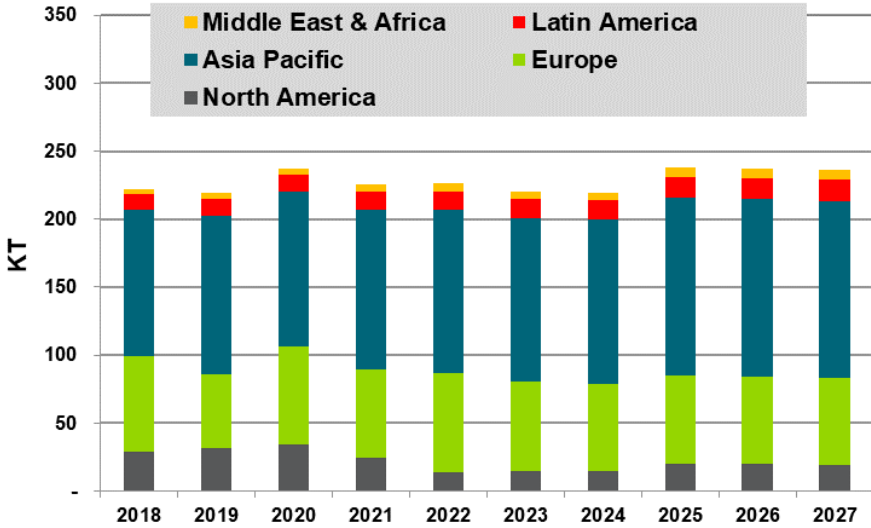
GEOGRAPHICAL SPLIT

Solar Demand (KT)



(Source: Navigant Research)

Wind Energy Demand (KT)



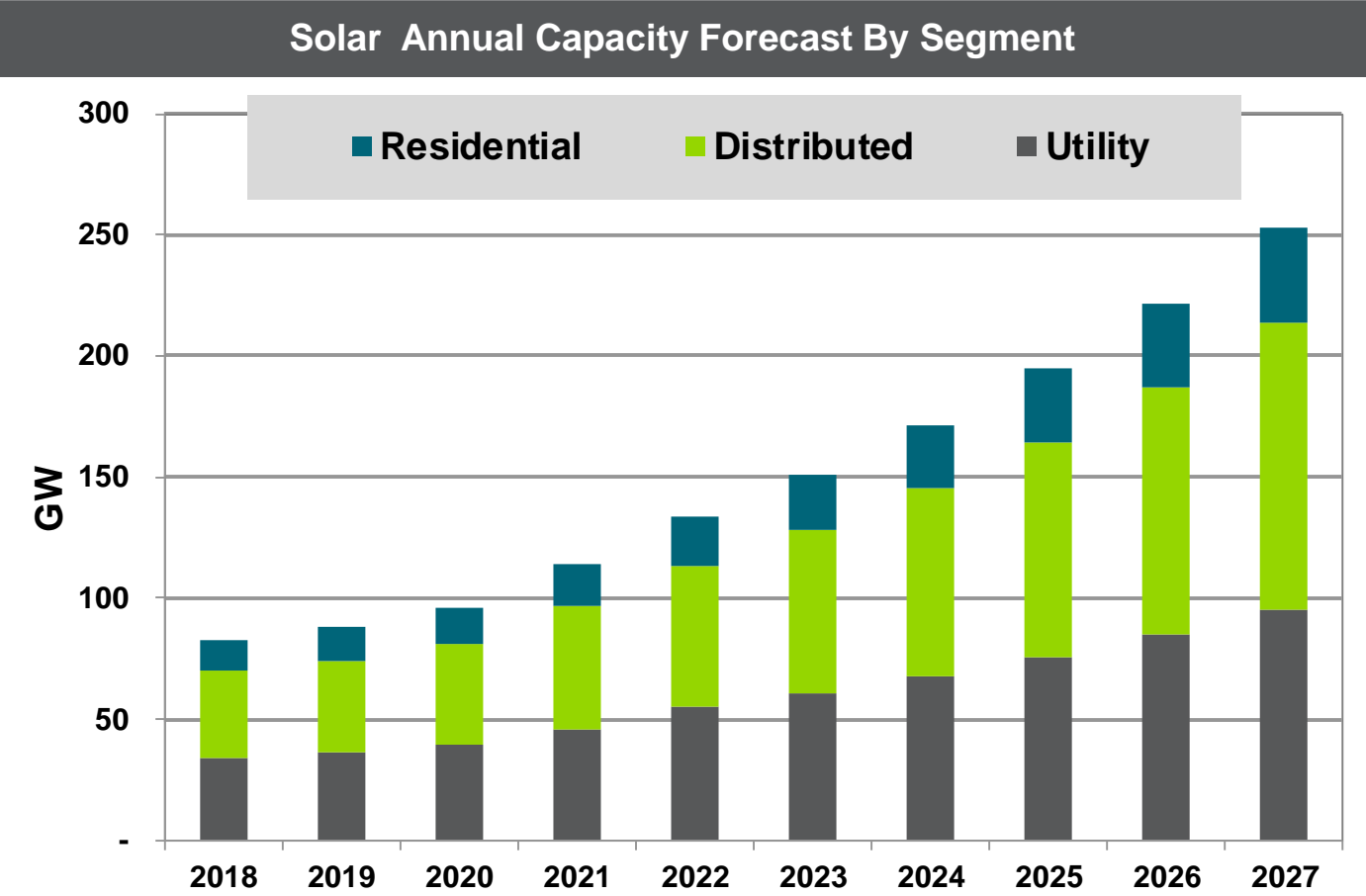
(Source: Navigant Research)

SOLAR ENERGY TRENDS

Key Market Trends Affecting Copper Demand

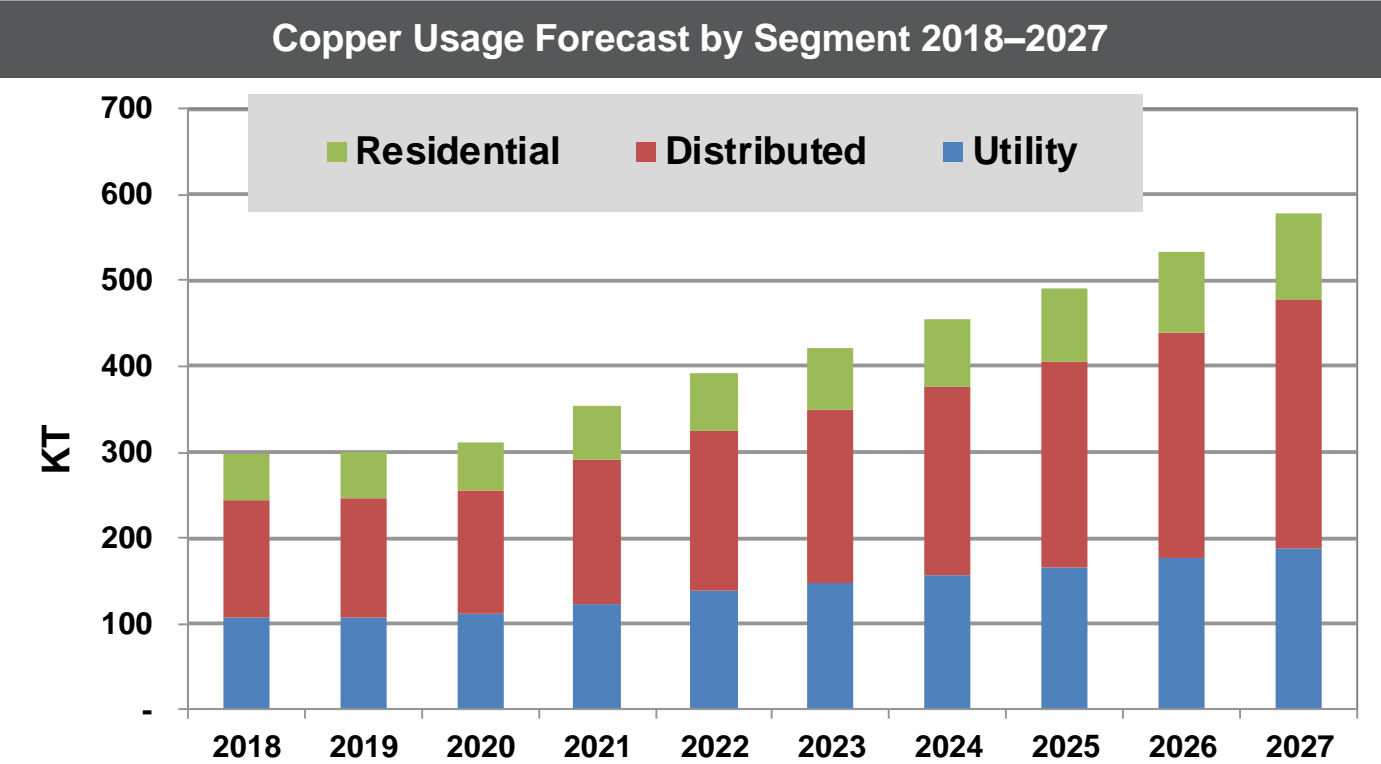
Regulatory changes and a shift towards distributed solar	<ul style="list-style-type: none">• Recent policy developments will have a mixed effect on the growth of solar globally over the forecast period. The Section 201 tariffs could affect US growth if the global market for solar modules tightens.• The elimination of the Feed-in Tariff scheme in China is expected to reduce demand for solar as the industry adjusts, although reduction in cost caused by the policy changes has incentivized solar in other regions, nullifying the impact on the Chinese market. Any change in annual solar PV deployments will impact copper demand.
Higher module efficiency	<ul style="list-style-type: none">• Wiring is the main use of copper in Crystalline modules. Copper use per module is not expected to change significantly, but as modules become more efficient, the amount of copper per Watt will fall. On a per Watt basis, copper use in modules could fall by up to 30% if there is an increase in efficiency from 16.5% (current efficiency) to 21% (the most efficient modules currently on the market).• The impact of efficiency gains will more likely be felt in wiring and cabling demand in the installation because solar farms sizes of the same capacity will cover a smaller area.
New power electronics and installation topologies	<ul style="list-style-type: none">• The impact new power electronics and topology have on copper demand is moderate. Efficiency gains and new topologies have reduced inverter costs by up to 70% 2010–2017 (with a similar reduction in the use of copper per W of capacity).• As with solar modules, the most significant effect of more efficient technologies and changes in topology are felt in the wiring and cable demand of the solar installation.

SOLAR CAPACITY IN UTILITY-SCALE, DISTRIBUTED AND RESIDENTIAL MARKETS



(Source: Navigant Research)

SOLAR DEMAND FORECASTS



(Source: Navigant Research)



SOLAR ASIA PACIFIC

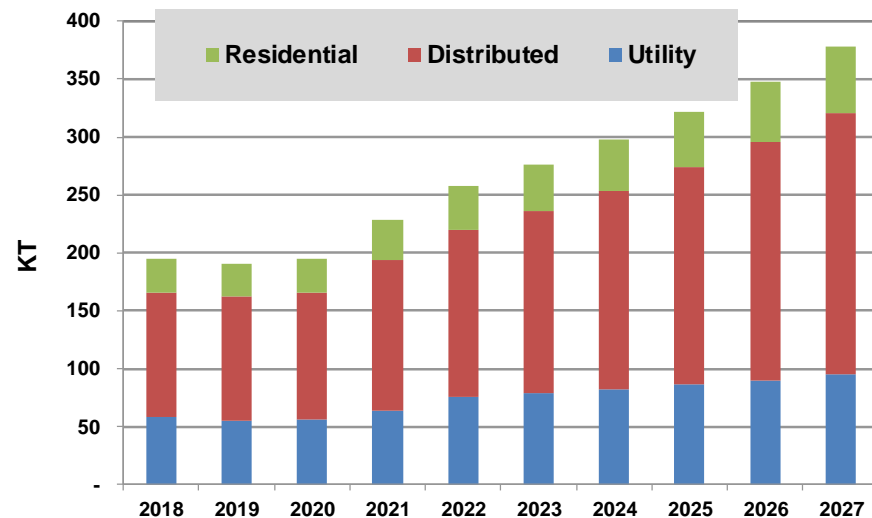
Copper Usage in Solar Energy

- The solar industry in Asia Pacific is expected to use 195,081 KT of copper in 2018, growing to 378,097 by 2027.
- The distributed segment will use 50% of all copper used in the region in 2018. 37% will go into utility-scale installations and only 13% to residential installations.
- By 2027, this will increase to 54% for distributed solar, 32% for utility-scale solar and 14% for residential.

Copper Key Issues and Trends

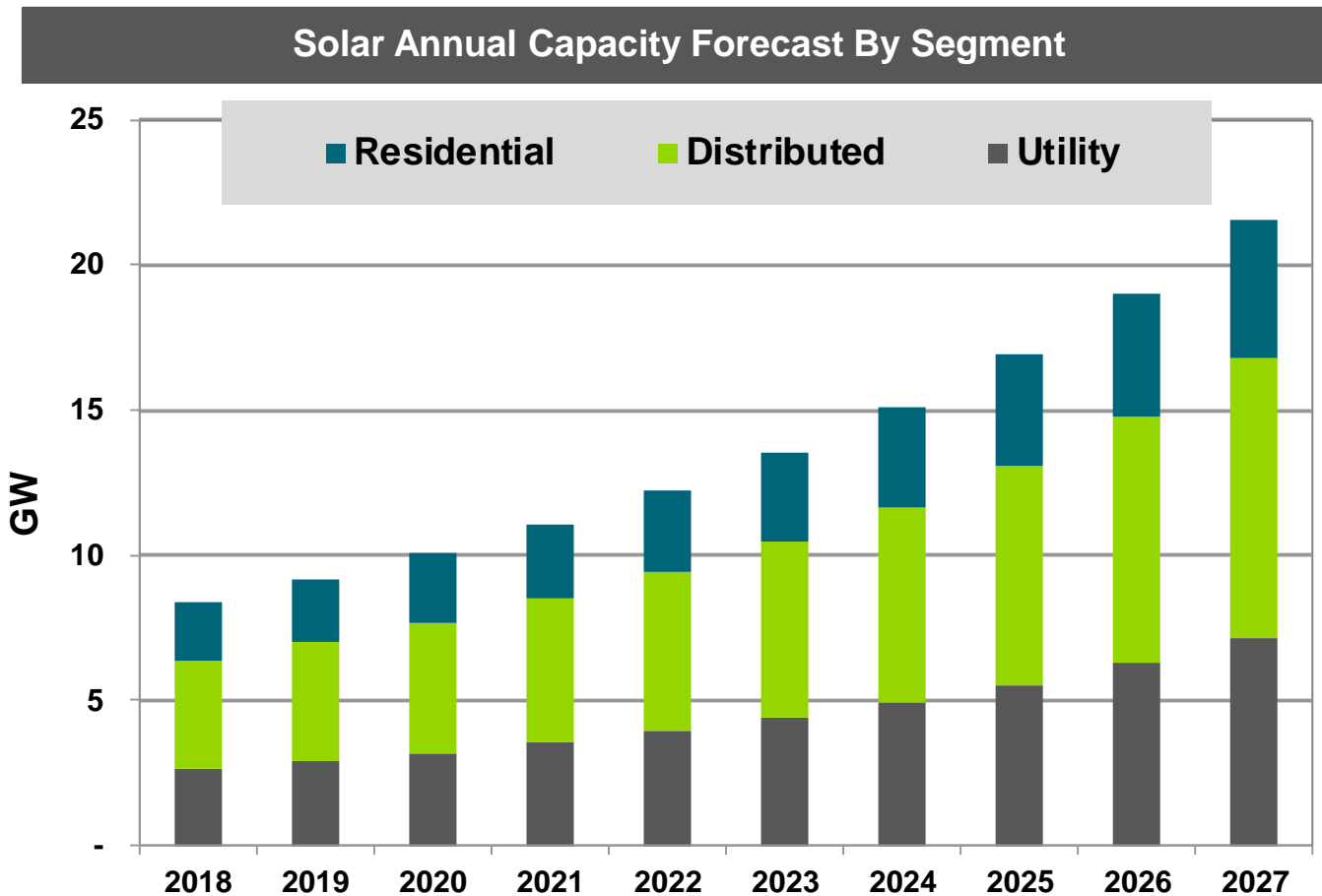
- Solar and wind industries faces similar issues in the developing parts of Asia Pacific, which are price sensitive and where copper theft is an issue, supporting aluminum wires and cables in the region.

Copper Usage (KT) Forecast 2018–2027



(Source: Navigant Research)

ASIA PACIFIC SOLAR CAPACITY IN UTILITY-SCALE, DISTRIBUTED AND RESIDENTIAL MARKETS

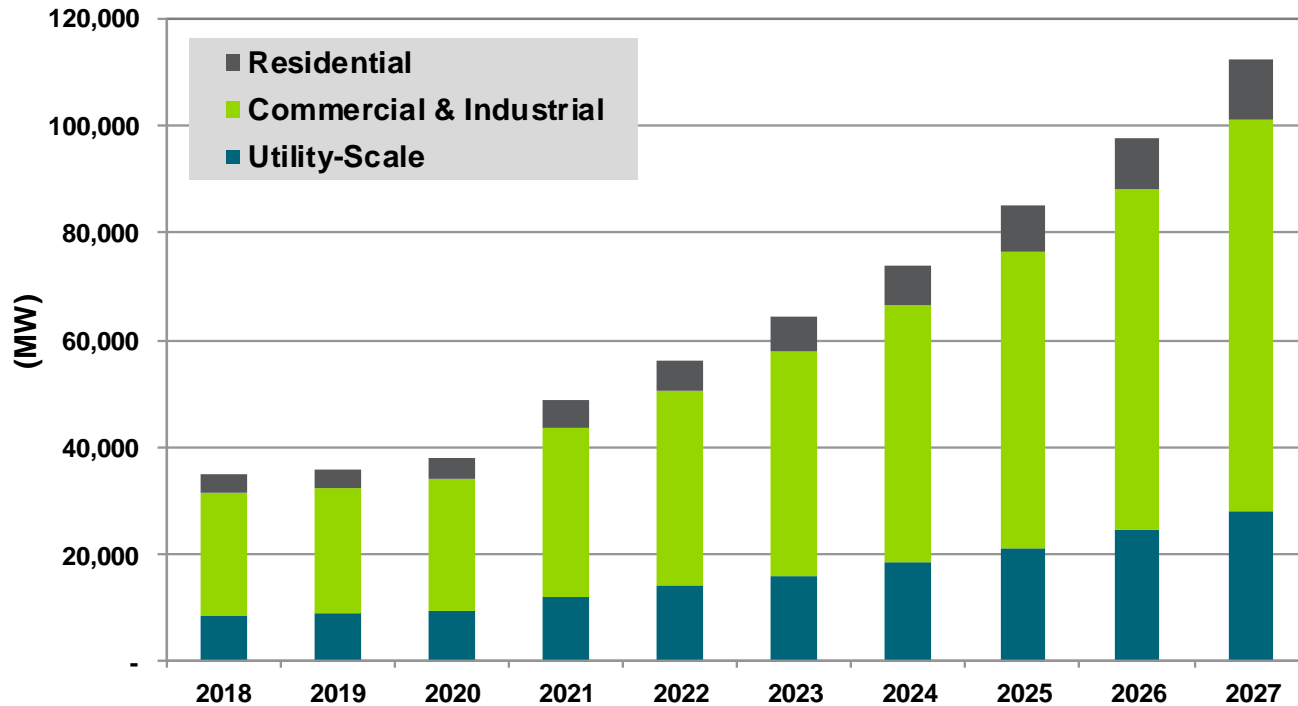


(Source: Navigant Research)

CHINA SOLAR CAPACITY IN UTILITY-SCALE, DISTRIBUTED AND RESIDENTIAL MARKETS



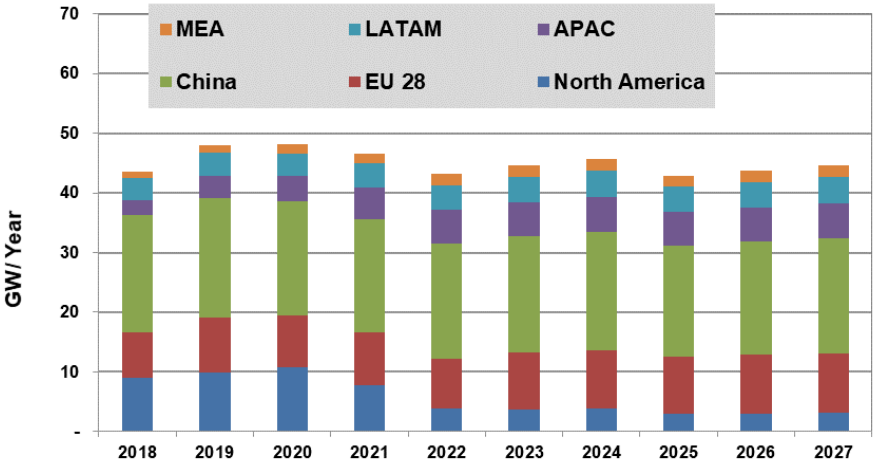
Solar Annual Capacity Forecast By Segment



(Source: Navigant Research)

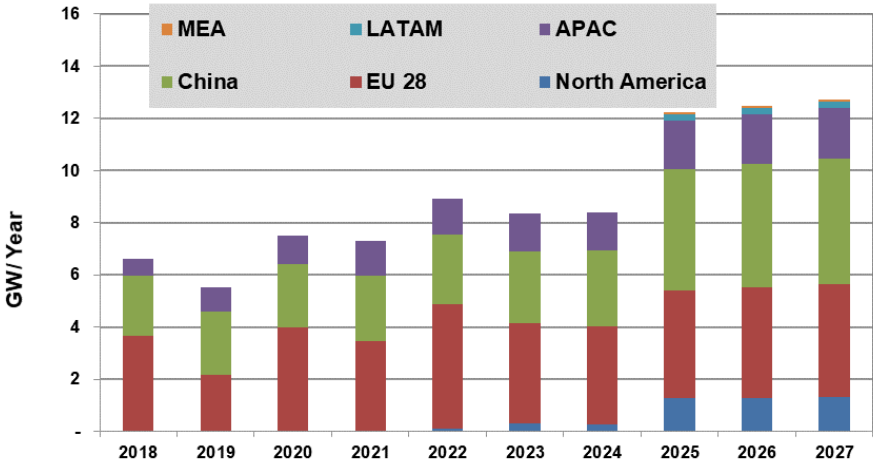
WIND ENERGY CAPACITY FORECAST

Annual Onshore Capacity Forecast



(Source: Navigant Research)

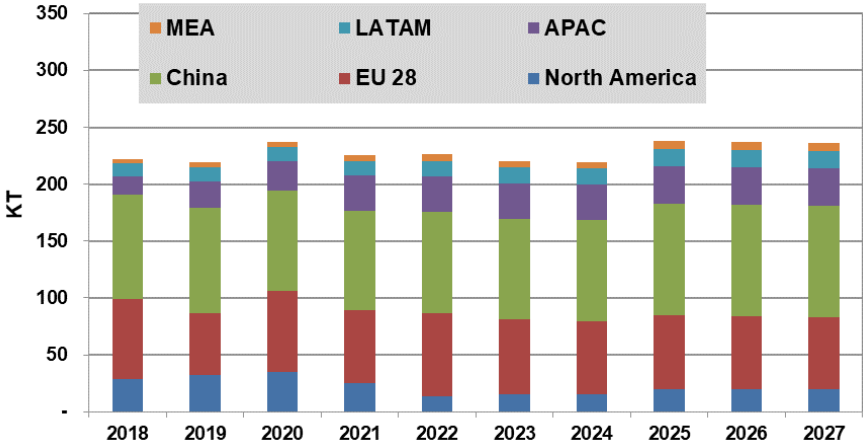
Annual Offshore Capacity Forecast



(Source: Navigant Research)

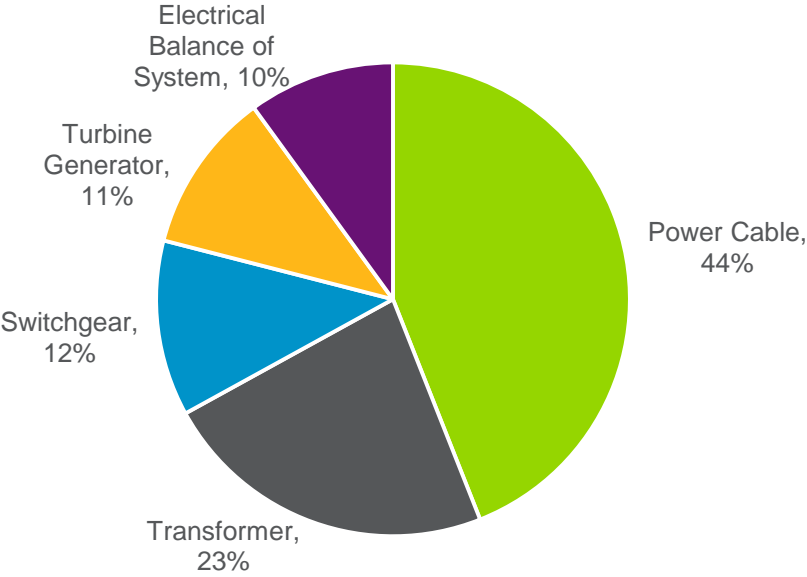
WIND ENERGY DEMAND

Copper Forecast 2018–2027



(Source: Navigant Research)

Copper Megawatt Intensity as % of Total Wind Plant



(Source: Navigant Research)



CHINA WIND

Copper Usage in Wind Energy

- China will overwhelmingly maintain its leadership in terms of new annual installations over the next five years, followed by Europe as a region and the United States for second largest country market.
- China is also the world's largest copper consumer in wind energy, accounting for 42.5% of global demand in 2018.

Copper Key Issues and Trends

- China aims to improve installation quality and invest in more energy-efficient products in the wind energy sector. Therefore it is very likely to continue to use copper across its electrical components and cables.
- This drives an increase in copper demand based on unrivalled electrical conductivity and energy-efficiency.

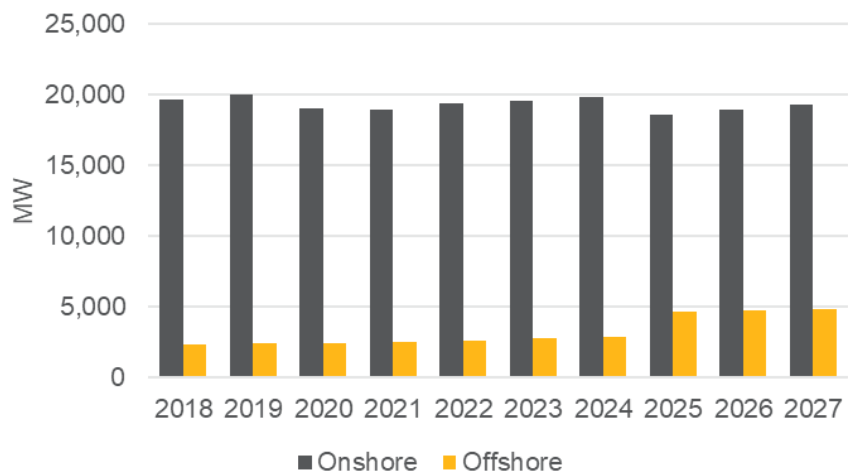
Aluminum Key Issues and Trends

- There is a lot of scepticism around the usage of aluminum in wind plants specially in the electrical components.
- Lack of skill and inexperience with the usage and handling of aluminum in the wind power sector has restrained adoption of aluminum in China.



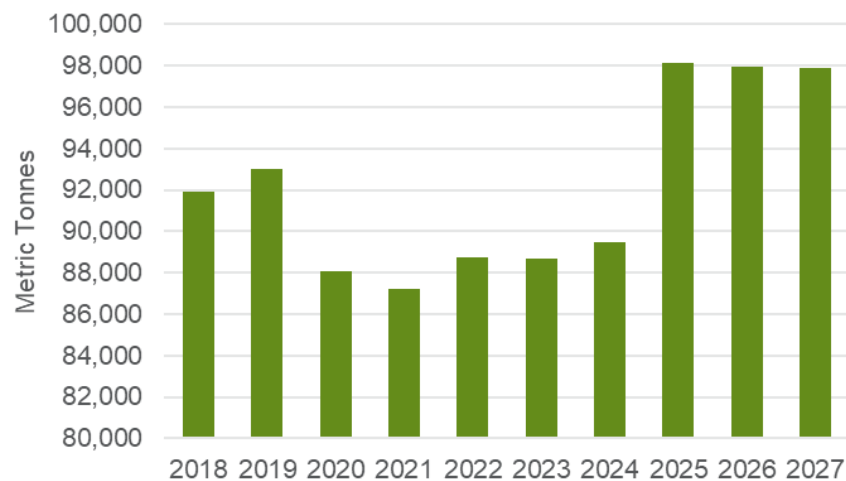
CHINA COPPER USE FORECASTS

Wind Installed Capacity Forecast 2018–2027



(Source: Navigant Research)

Copper Usage Forecast 2018–2027

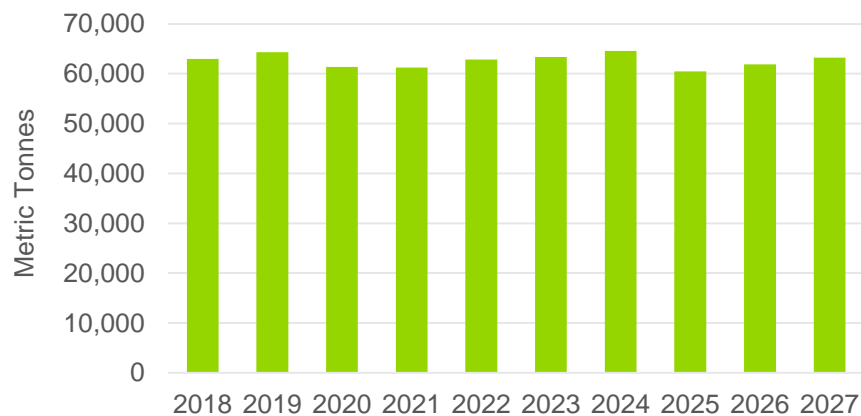


(Source: Navigant Research)



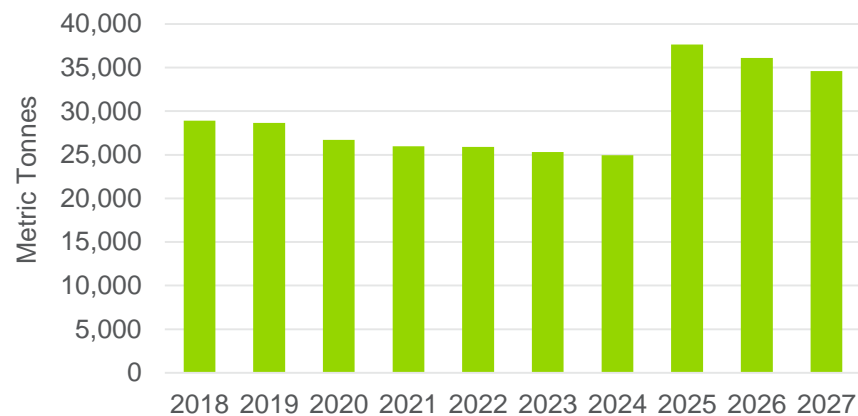
CHINA COPPER USAGE IN ONSHORE AND OFFSHORE WIND

Copper Usage in Onshore Wind Forecast



(Source: Navigant Research)

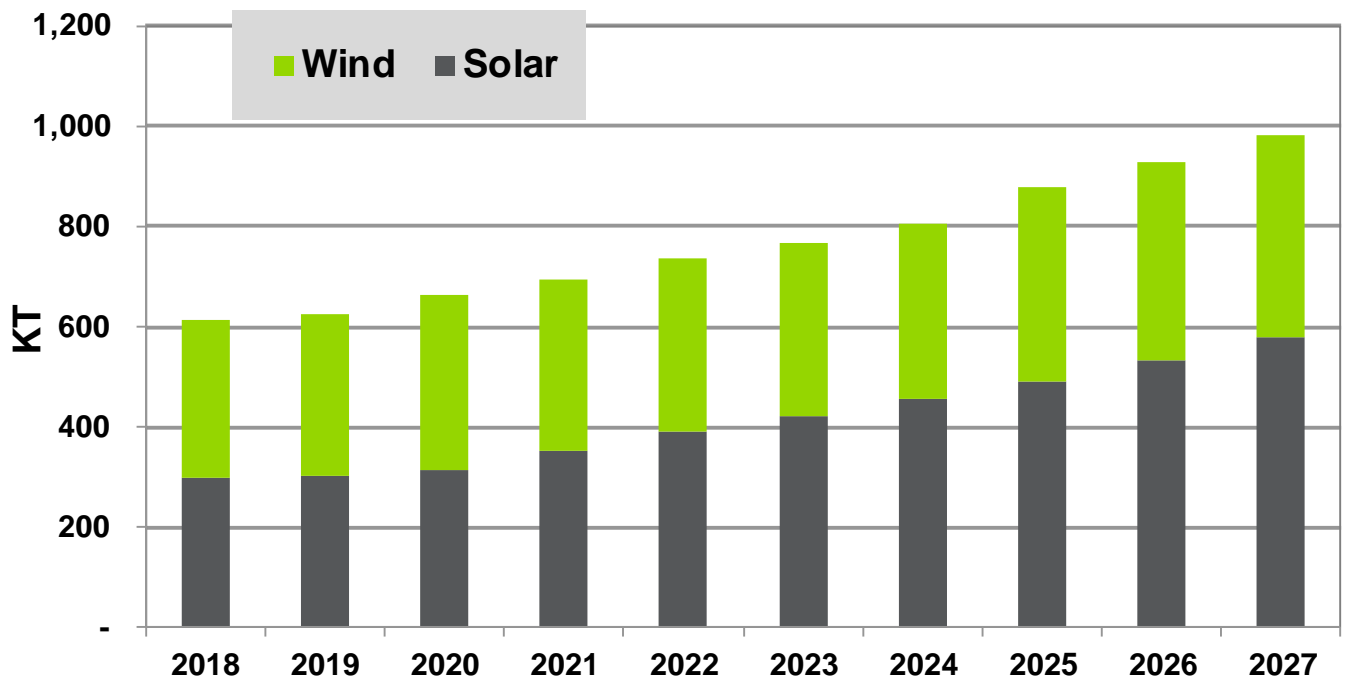
Copper Usage in Offshore Wind Forecast



(Source: Navigant Research)

GLOBAL DEMAND RENEWABLES

Copper Annual Capacity Forecast By Technology 2018–2027



(Source: Navigant Research)