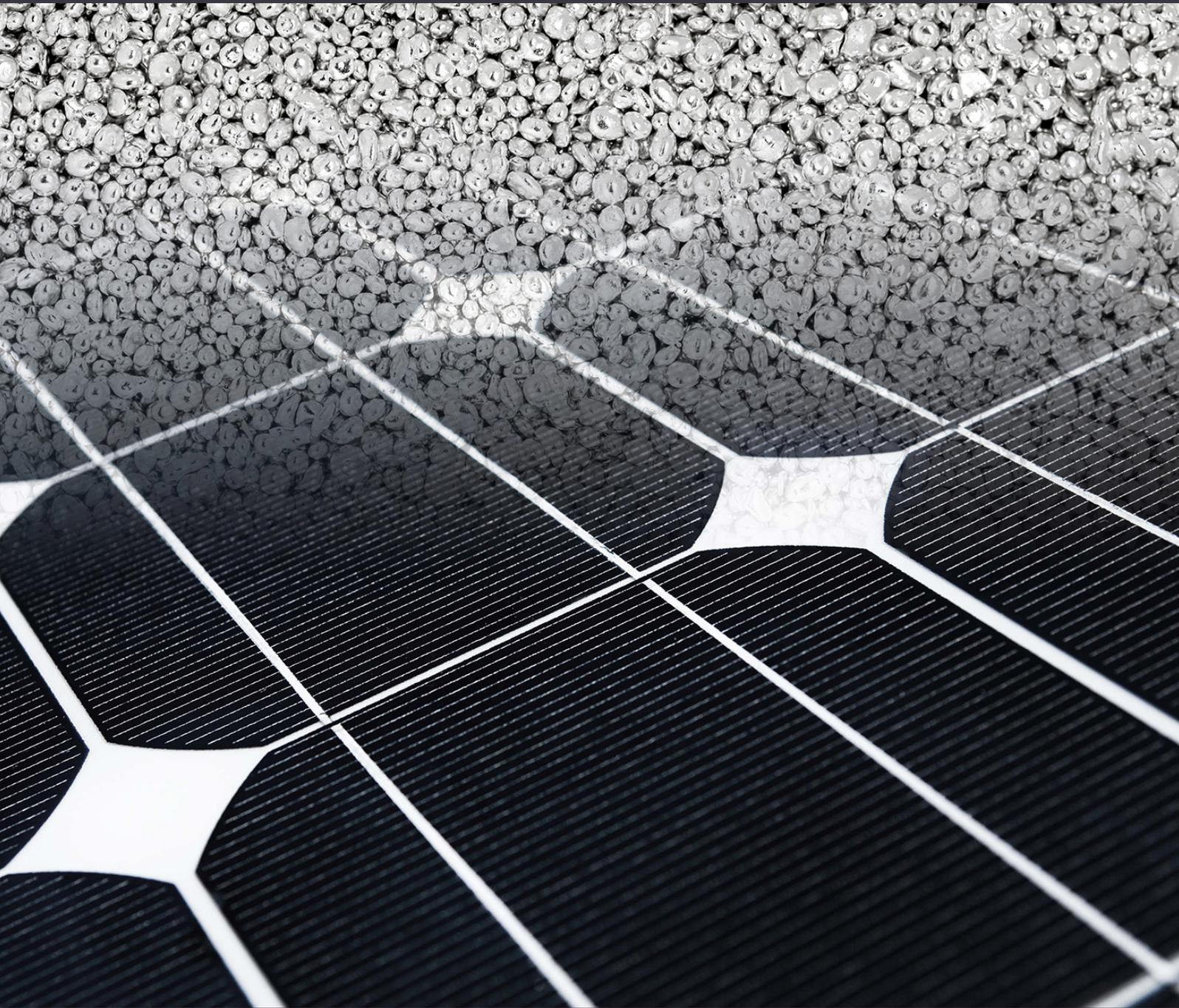


# M# METALS FOCUS

Prospects for the Chinese Silver Market

Prepared for The Silver Institute



September 2018



# Table of Contents

1. Introduction & Executive Summary	2
2. Photovoltaic Applications	5
3. Electronic Applications	9
4. Electrical Applications	12
5. Brazing Alloys and Solders	14
6. Other Industrial Applications	16
7. Jewelry & Silverware	17
8. Investment	19
9. Bullion Exports	21

# Chapter 1

## Introduction & Executive Summary

### Introduction

China is one of the most important markets for silver. Since 2010 it has consistently been a top-three mine producer. During most of that period, it has also been the second largest silver fabricator. Meanwhile, its commodity exchanges account for a large portion of global turnover in silver futures.

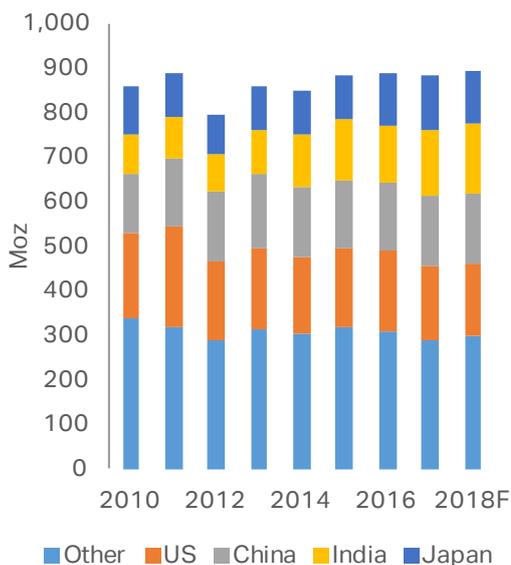
Starting with supply, Chinese mine production has averaged 110Moz (~3,440t) over 2010-17. During most of this period, the country was the third largest mine producer. In addition to what is mined locally, China is also a major processing center for silver bullion. This reflects the fact that more than 50% of global silver mine production comes as a by-product of base metals and the presence of a large number of base metals smelters and refineries in the country. This puts China in a position to also be a key supplier of metal to a number of silver-hungry nations, most notably India.

China is also a leading fabricator. During 2010-17, total Chinese fabrication averaged 153Moz (38,090t) accounting for 18% of the global total. Crucially, in addition to what is manufactured locally, China is the destination for a sizable portion of silver industrial fabrication taking place in the US and Japan. For instance, more than 70% of global photovoltaic cells are manufactured in China and local powder fabricators are only able to satisfy the smaller part of the required powder and paste. Taking into account these inflows, China is by far the largest consumer of silver globally.

China has also been an important center of trading liquidity during much of this decade. Activity in the Shanghai Futures Exchange (SHFE) silver futures contract has been particularly interesting, given its turnover exceeded that on the Comex over 2013-15. Although falling speculative activity in China has more recently seen volumes decline, the SHFE contract and that listed on the Shanghai Gold Exchange (SGE), combined, still accounted for around one quarter of global turnover in silver futures in 2017.

Against this backdrop, the Silver Institute commissioned Metals Focus to review the Chinese silver market. Specifically, we have investigated every major area of demand and identified the principal factors that drive them. We have also assessed their prospects for the foreseeable future. In doing so, where this was feasible, we went beyond our usual methodology of only focusing on fabrication, and have attempted to provide estimates for China's consumption of silver in end-use products. Finally, we reviewed the state of the country's bullion exports, in the face of changing government policies.

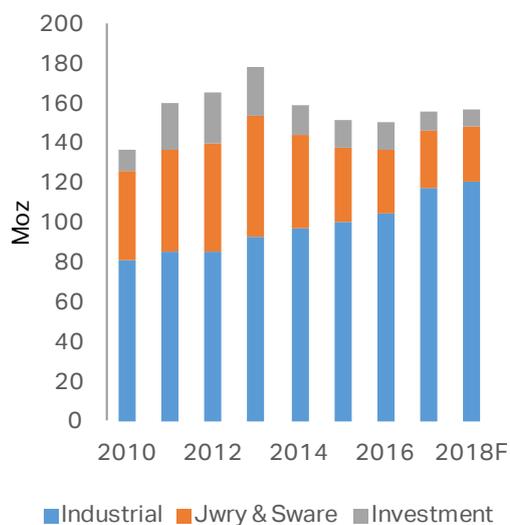
Global Silver Fabrication\*



\*Fabrication excludes silver bar investment

Source: Metals Focus

## Chinese Silver Fabrication



Source: Metals Focus

## Executive Summary

The last few years have seen Chinese demand significantly fluctuate. Following a peak in 2013, total demand experienced declines over 2014-16, before rebounding in 2017. Looking at the detailed breakdown of demand however reveals a stark contrast between the declines seen across jewelry, silverware and investment and the strong gains achieved by industrial demand, spearheaded by electrical and electronics offtake. Looking ahead, it is our view that silverware has already turned a corner and that the low point for the jewelry and investment markets are also in sight. Meanwhile, robust end-use markets and the scope for growing market share should guarantee that industrial fabrication will also continue to rise. This should see overall demand in China trend upwards over the next few years, rising by 1% y/y to 159Moz (4,932t) and reaching 166Moz (5,173t) by 2022.

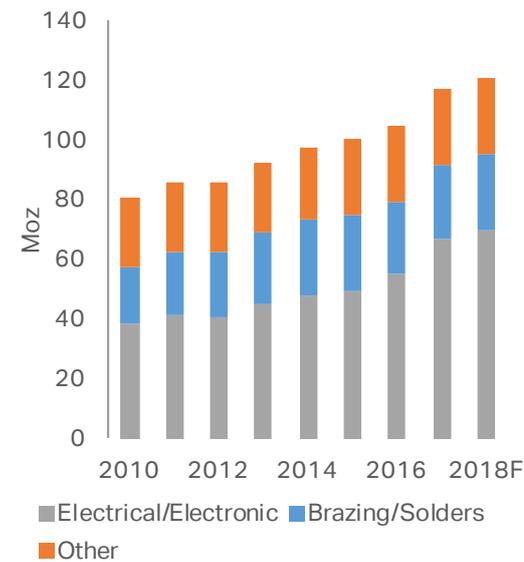
**Photovoltaic (PV)** demand has been a huge source of silver demand in China, mainly consuming powders fabricated in Japan, the US and elsewhere and increasingly also in terms of local fabrication. That said, the sector is facing headwinds due to recent changes in the country's policies, including subsidy reductions and the introduction of frictions to new project launches. In spite of this, we believe that the outlook for silver demand in PV applications in China remains solid, both on the back of still sizable local installations and healthy sales into other markets.

Silver use in **electronics** applications is also on an uptrend in China. Moreover, we expect that local manufacturers will also benefit from market share growth, given our estimates that only a little over half of domestic needs are currently satisfied by Chinese fabricators. Underpinning the growth in silver electronics demand are two major segments, namely touch panels and LEDs. In turn these are linked to a wide range of end-use applications, including hand-held devices, automotive touch panels and lighting applications, both stationary and vehicle-related.

Silver use in **electrical** applications China should maintain its modest uptrend for the foreseeable future, on the back of continued, albeit potentially slower, gains in fixed asset investments. Continued growth in electricity generation capacity in particular is expected to play a key part in this. Meanwhile, the Belt and Road Initiative (BRI), a development strategy adopted by the Chinese government centered on developing land and maritime trade routes, should also boost demand in this sector. Chinese investments in infrastructure abroad is an integral part of it and, as such, it should ultimately benefit Chinese equipment manufacturers' output and, in turn, silver demand.

**Brazing** demand should also experience further gains in the years ahead. A wide range of end-use applications, including railway infrastructure development, growing car sales, refrigeration and air-conditioning should provide fuel for this growth. Finally, the gains we project for **other industrial** demand for silver in China is mainly linked to continued expansions in the country's ethylene oxide production capacity.

## Chinese Industrial Fabrication



Source: Metals Focus

Leaving industrial demand, Chinese **jewelry** has suffered a series of consecutive declines in recent years, owing to changing tastes and consumption patterns in the country. However, there are clear signs that jewelry manufacturers, wholesalers and retailers are adapting to the new realities of the market and as a result we believe the bottom for the market is fast approaching, even if we are likely to see a couple more years of declines.

In contrast, **silverware** has already turned a corner. After falling over 2014-16, demand rebounded last year. Again, this reflected producers' change of strategy, following the clampdown on corruption which hit the gifting market hard. The industry's focus is now centered on products intended for daily use and also for home decoration.

Anti-graft policies have also been the principal driver of the declines suffered by **investment** in silver bars and coins in recent years. This is particularly striking when comparing the particularly weak performance of bar sales with the more benign picture seen for silver coin sales. Trading volumes on the SHFE have also been on the decline. Lower speculative appetite for silver against the backdrop of a falling price has played a part, as has lower activity from commercial participants.

We finally note the importance of Chinese silver **bullion exports**, both in terms of absorbing a sizable part of local bullion production as well as being an important source of supply for markets like India, Japan and Thailand. We believe that this will remain the case for the foreseeable future, particularly in the aftermath of the ban on silver concentrate imports into China having been lifted, thus providing local smelters with an added stream of raw materials to process into silver bullion.

## The Future of China's Silver Market

Metals Focus is confident that China will remain a leading force in the global silver market. With modest gains in domestic mine supply forecast out to 2022, the country is expected to retain its place as the third largest mining nation. Processing of imported raw materials by Chinese smelters and refiners should also remain healthy, particularly given the recent relaxation of silver concentrate import restrictions.

China is similarly expected to continue dominating silver demand, particularly when looking beyond what is fabricated locally and including imports of semi-manufactured products such as powders. As the country's economic growth remains healthy for the foreseeable future, domestic demand for a wide range of end-products containing silver should also continue to grow. Chinese investments abroad, particularly in infrastructure projects, is expected to be another factor supporting silver demand in the country. Finally, although in the near-term rising tensions over international trade may act as a headwind, we believe that China will also retain its role as a major exporter of end-products containing silver, particularly given it is home to much of the world's production capacity.

## Chapter 2

# Photovoltaic Applications

### Introduction

China is an extremely important market for silver PV demand. In addition to having seen sizable local installations in recent years, the country is also the biggest exporter of solar panels. Indeed, more than 70% of global solar panel production takes place in China.

In spite of this fact, historically very little PV powder was actually made in China. Until only a few years ago, local silver powder manufacturers were unable to produce materials that met the specifications of front-side PV paste fabricators, for instance in terms of grain size and variation. As such, until recently, domestic silver powder manufacturers had virtually no share of the market for powder that was used by panel makers in China in front-side applications. As a result, historically the bulk of PV powder intended for front-side modules was imported, mainly from Japan and the US. In contrast, as back-side paste specifications are far easier to meet, Chinese powder manufacturers have long accounted for the lion's share of that market.

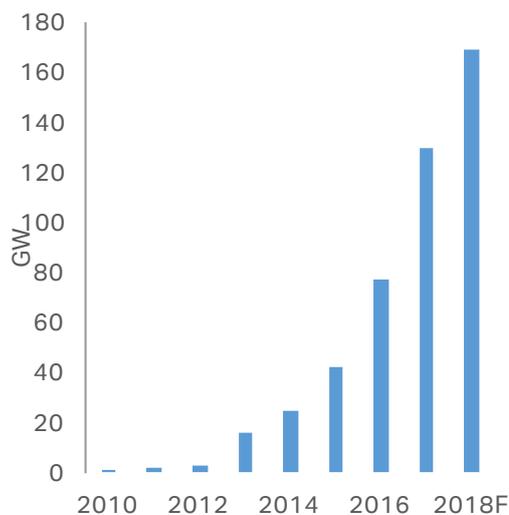
Recent years, however, have seen these norms change dramatically. Largely as a result of technological breakthroughs and aggressive marketing, Chinese PV powder manufacturers have been encroaching into the space that Japanese and US makers previously dominated. Specifically, local powder manufacturers have managed to close the quality gap, while keeping costs lower. Meanwhile, a sizable portion of solar installations in recent years have been utility-scale rather than distributed generation. In the case of the former, cell efficiency and footprint is less important than cost per gigawatt (GW). This also benefited local powder producers, rendering the technological advantage of foreign competitors less relevant.

### Recent policy developments

According to China's National Energy Administration (NEA), new PV installations reached 24.3GW in the first half of 2018, which was virtually flat year-on-year. This took total installed capacity to 154.5GW by the end of June. Looking at the breakdown of installations, there was a 30% decline in utility-scale systems to 12.1GW and a 72% increase in distributed generation system installations to 12.24GW. Meanwhile, total PV cell production in the country grew by 22% to 39GW.

PV installations in China have required ¥80bn of annual subsidies. These amounts seem to be beyond what the government is able or prepared to pay and, as such, policy has been adapted to more realistic long-term levels. This is outlined in China's "531 policy", implemented on June 1st 2018, the key points of which are detailed below:

## Chinese PV Installed Capacity



Source: China Electricity Council

### 1. Subsidy reductions:

- Feed-in-tariffs (FiT) for both ground-mounted power plant (utility scale) and distributed generation output slashed by ¥0.05/kWh (Subsidies for county-level poverty alleviation projects are exempt and remain unchanged, with a FiT of ¥0.42/kWh.)
- Policy encourages local government to continue their support for the PV industry through non-subsidy policies.

### 2. Installation capacity control:

- Installation of ground-mounted power plants that require national subsidies will need approval by the central government.
- The total quota of distributed generation on rooftops that can benefit from subsidies is set at 10GW.
- Only distributed generation systems that were grid-connected before May 31st can receive government subsidies.

### 3. Innovation and market liberalization:

- All new power plants will go through an auction system and the bidding price should be lower than government standard price.
- Continue to support Front Run Programs and Poverty Alleviation Projects.

## Outlook for Chinese PV installations and output

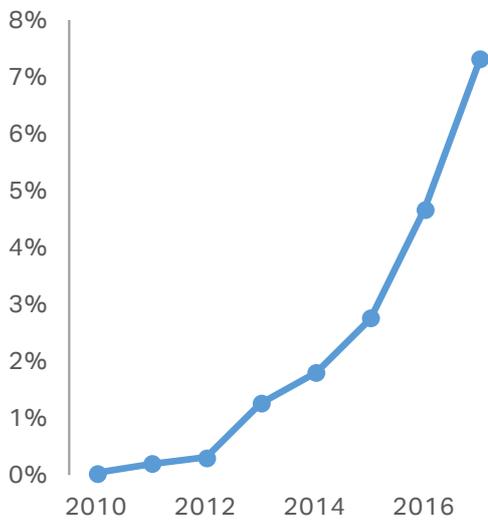
These policies are a game-changer for China's PV installations. The reduction in FiTs and introduction of central government approvals have cooled the previous rush in utility-scale related demand. Meanwhile, as the 10GW quota for distributed generation installations was already exceeded in the first half, that market has also stagnated.

As a result of the above-discussed policy changes, China's PV capacity installations are forecast to see their first decline this decade. Overall, market specialists and local industry bodies forecast installations will fall by more than 25% from 2017's record 53GW to under 40GW this year. Indeed, some of our market contacts feel installations could fall to levels as low as 35GW in 2018.

Turning to Chinese PV cell production, that reached 76GW last year according to the NEA, we expect this will suffer a more modest decline of around 5GW. This reflects ongoing growth in installations elsewhere. It is worth noting, for instance, that the latest projections by leading renewable energy consultancy GTM Research for 2018 call for 85GW of global installations and are based on their own forecast of 29GW being installed in China. Adjusting these projections in line with what our contacts in China target, would take global installations in a 90-95GW range. Metals Focus' own projections are even more optimistic, at around the 100GW mark. Moreover, we expect China will gain market share abroad, due to its falling module prices.

Naturally, such declines are hitting market participants across the whole supply chain hard, from powder makers to paste producers to cell

## Solar's Share of Chinese Electricity Generation Capacity



Source: China Electricity Council, National Bureau of Statistics

manufacturers. Compounding the pressure of lower volumes is the decline in PV cell prices, partly owing to falling capacity utilization. Last but not least, tightening environmental regulations are resulting in rising costs, further impacting margins.

Looking further ahead, although the impact of China's changing policies will probably last beyond 2018, the extent of this is likely to be limited. GTM Research has aggressively pared down its forecast for Chinese installations over the next five years, from 206GW to 141GW. However, the consultancy expects that this will eventually be, at least partly, offset by higher than previously expected installations elsewhere, fueled by the decline in module prices. Interestingly, the consultancy noted that this decline is expected to result in grid parity being achieved two years earlier than previously forecast across unsubsidized markets. It is interestingly to note that GTM Research sees installations recovering strongly already from next year and maintaining levels comfortably above 100GW per annum from 2020 onwards.

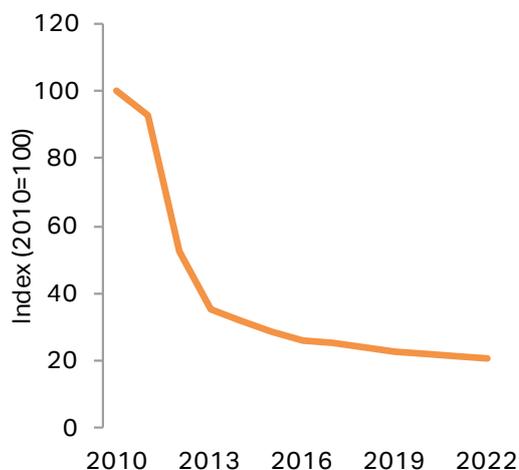
### Technological developments in the solar industry

Tighter policies may also drive technological innovation and improved efficiencies within Chinese panel manufacturers. This relates in particular to the NEA's Front Run Programs. These are investment projects that are only open to manufacturers that meet certain parameters, in particular high efficiencies and increased power generation. In particular, the programs specify technical requirement for panels and inverters. Three batches of these have been announced, with total capacity of 13GW. Against the wider backdrop of lower subsidies, we expect that manufacturers will strive to improve their efficiencies in order to qualify for such programs. In turn, given the surplus of existing capacity, this will likely lead to less efficient and uncompetitive production lines being phased out.

Crystalline silicon-based technologies are expected to continue dominating Chinese production for the foreseeable future, with mono-crystalline silicon expected to account for more than 50% of total crystalline silicon modules produced this year. Silver will continue to be the mainstream choice for metalization. However, loadings per cell will continue to decline, as a result of improving metalization technologies and the introduction of new cell structures.

One factor driving this decline in loadings is the move to cells using a higher number of busbars. The main benefit of this transition is their higher conversion efficiency and improved durability. However, they also come with lower silver paste consumption requirements, thus also offering cost benefits to cell manufacturers. In theory, moving from four to five busbar designs can result in a 10% reduction in silver loadings, while a transition from four to twelve busbars can drive a 30% reduction in silver usage. Busbar-less designs, using multiple wires to conduct the electricity generated by the cells, could in theory lead to an 80% or more reduction of silver loadings compared to current technologies. At present, three and four busbar designs are the mainstream, however as a growing number of

## Global PV Silver Loadings



Source: GTM Research, Metals Focus

producers are investing in product development, we would not be surprised if the share of five busbar designs were to exceed 20% by the end of 2018 and become the dominant technology next year.

As far as cell structure design is concerned, Passivated Emitter Rear Cell (PERC) is fast becoming the mainstream technology for high efficiency cells. PERC solar cells are designed in a way that materially improves light capture and by implication efficiency, compared to conventional modules. Meanwhile, heterojunction technology, involving a more radical re-design of the cell architecture, is looking quite promising to become the basis for the next generation of ultra-high efficient modules. The evaluation of low silver content paste for use in heterojunction technology is underway and could also drive loadings down in the years ahead. Elsewhere, with improvements in printing technology, the grid finger (the thinner part of the metalization grid that delivers the current to the busbars) width has reached 45 $\mu$ m (micrometer; 1 $\mu$ m = 0.001mm) in 2017 and is expected to fall further over the next few years, with a 22 $\mu$ m target in sight.

Elsewhere, substitution by copper using plating techniques continues to be researched. However, these efforts are still hampered by technical issues, in particular regarding reliability and adhesion. Our overwhelming feedback is that silver is expected to maintain its position as the de facto material for solar cell metalization, at least over the next few years.

### The outlook for silver PV demand in China

Turning to silver demand, Metals Focus estimates that overall end-consumption from the Chinese PV sector stood at 65Moz (a little over 2,000t) in 2017. As noted earlier, most of the powder was actually fabricated outside China and imported, either in powder or paste form. We estimate that a little over one-third of the total powder consumed in China was actually fabricated locally, amounting to approximately 23Moz (700t). Of this total, we estimate that 13.8-14.1Moz (430-440t) was used in front-side paste and the balance in back-side paste. We estimate that Chinese powder manufacturers' market share of local front-side silver powder demand reached 25% last year. Powder used in back-side applications was virtually fully supplied by local producers.

Moving to this year, given the aforementioned expected decline in installations, we forecast that total consumption of silver PV powders will fall to a range of 54.7-57.9Moz (1,700-1,800t), comprising roughly 48Moz (1,500t) for front-side and around 250t of back-side paste. We expect that around 8Moz (400t) of front-side powder will be supplied by local manufacturers, taking their market share to 27%. When taking into account also back-side paste, local manufacturers are expected to account for 37-38% of overall PV powder needs in China.

We should stress that there is a risk that these figures may prove somewhat optimistic, as the growth of five busbar designs could fuel a stronger than expected decline in silver loadings.

# Chapter 3

## Electronic Applications

### Introduction

Silver is used extensively for the fabrication of a wide range of electronics products. In turn these are used in a myriad of applications and end-products in diverse sectors, including among others, automotive, consumer electronics, industrial equipment, defense and aerospace. Given China is home to many major manufacturers specializing in these areas, it is no surprise that the country consumes large amounts of silver within electronics components.

Metals Focus estimates that around 33Moz (over 1,000t) of silver was consumed in 2017 in China for electronics manufacturing. We expect this figure to increase by 3% in 2018, underpinned by healthy demand for auto and handheld devices. Local fabrication, defined as the first conversion from silver bullion into an intermediary or final product, is far lower, approximately 18Moz (550t) in 2017 and expected to increase to some 19Moz (600t) this year. This reflects the fact that the markets for silver pastes, used in high-end applications as well as in halogen-free pastes, are still dominated by foreign fabricators, in particular those based in Japan and the US.

### Key silver electronic applications

According to Metals Focus investigations, the largest single application in terms of silver consumption is touch panel displays. Silver is used as a conductive line in touch panels, for instance in indium tin oxide (ITO) panels, due to its high conductivity. We estimate that around 6Moz (close to 190t) of silver was consumed in touch panel applications in China in 2017, which is expected to increase at the margin this year. Our field research also suggests that only around 40% of that total was actually fabricated locally, with the balance imported.

Similar to other applications, touch panel silver loadings have experienced a declining trend. Ongoing improvements in screen printing technology (which enable thinner silver lines to be printed onto screens) will most likely mean that this trend will continue for the foreseeable future. However, actual consumption of silver should remain broadly stable, with the decline in loadings offset by increasing final unit sales, as touch panels are adopted in an ever-increasing number of devices and also, in some applications, as screens are getting larger. For instance, it is now common for new vehicles to feature a touch panel, something which was not necessarily the case a few years ago and virtually non-existent more than a decade ago. Elsewhere, the market share of smartphones that are larger than 5.5 inches, that has already ballooned over the past three years, is expected to increase further in the next few. Importantly, although rising costs are pushing some manufacturers to shift capacity to other Asian countries, notably Vietnam, we believe that over the next few years China will remain a major producer of touch panels.

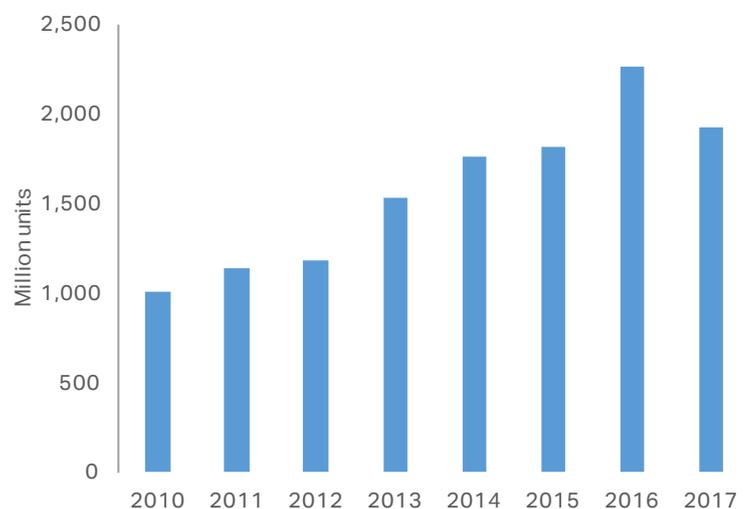
As far as technology is concerned, it is worth noting that ITO is the dominant conductive film solution adopted by the market, estimated to account for around 70% of the global total. However, other emerging conductive layer technologies, including silver nanowire, metal mesh (either copper or silver), silver nanoparticles and carbon nanotube, are starting to enter the mass market. These could eventually also weigh on average loadings, as these technologies utilize far less silver than the current mainstream ones. However, given their commercialization will require significant investment in new production capacity, we expect the transition to be slow.

Metals Focus estimates that silver consumption from China's LED manufacturers amounted to roughly 4Moz (130t) last year. The sector has been growing in recent years, underpinned by rising demand across a number of different applications, such as the flash on a smartphone camera, lighting and automotive, and strong exports to the US and Europe. The overwhelming bulk of silver wires and die-attach pastes, that are used by the Chinese LED industry, are imported, meaning that the impact of this sector on local fabrication is minimal, amounting to 0.4Moz (13t) in 2017.

Looking ahead, we believe that growth in LED related consumption of silver in China will be mainly driven by automotive lighting applications, which we believe will continue rising, albeit at a slower pace than in recent years. Given the high penetration of LED (stationary) lighting and the products' long life cycles, we believe that the scope for growth from this segment of the market is limited. Looking further ahead, the sector may benefit from the commercialization and success of mini-LEDs for display applications, expected to start this year. In contrast to micro-LEDs (which are unlikely to achieve mass production before 2020), mini-LEDs can be manufactured using existing capacity and methods. Although less expensive than organic light-emitting diodes (OLED), mini-LED powered displays are more expensive than conventional ones and may, at least initially, only penetrate niche applications that benefit from power saving, thinner profile or odd

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## Chinese Mobile Phone Production



Source: China National Bureau of Statistics

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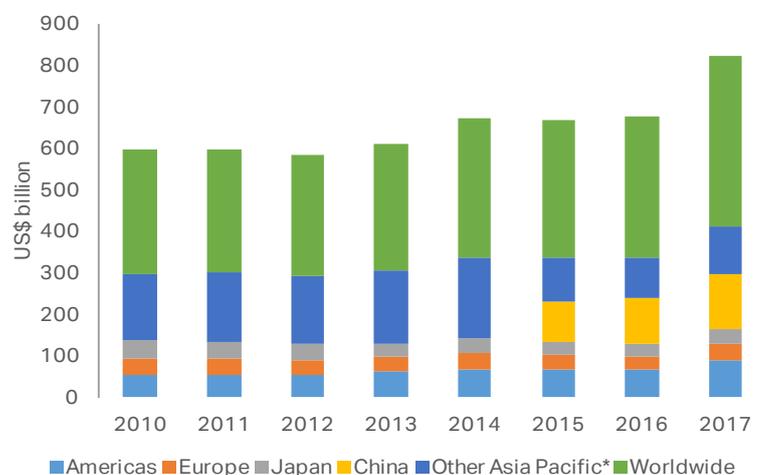
shapes (e.g. notch displays), such as smartphones, virtual reality (VR) displays, automotive TV etc.

Membrane switches and flexible printed circuit boards, used in keypads, control panels, medical devices and wearables, are another application with sizeable usage of silver and specifically low temperature silver paste. We estimate the sector consumed around 3Moz (nearly 100t) last year, around 90% of which was also fabricated locally. The growing adoption of flexible electronic devices in healthcare and consumer electronics and their penetration into fields including military and automotive applications should see demand from this sector grow modestly over the foreseeable future.

Car defogging/defrosting are a mature segment of silver demand, which we estimate consumed in the region of 3Moz (nearly 100t) of silver last year, half of which was fabricated locally. Given a lack of alternative emerging technologies and expected gains in automotive production in China over the foreseeable future (LMC Automotive, a leading automotive industry consultancy, forecasts average annual passenger car production growth averaging 3% over 2018-25), we expect to see steady gains in silver demand over the next few years from this sector in China.

Piezoelectric materials are materials that can convert mechanical energy to electricity and vice versa. They are found in a variety of products, including actuators, injectors, transducers and sensors. They are widely used in the automotive industry and industrial automation systems. Many applications include silver conductive lines or electrodes and we estimate such products manufactured in China absorbed 0.8Moz (a little over 25t) of silver in 2017, which is expected to grow to 1Moz (30t) this year. Continued car electrification and automation, related to improved safety, energy efficiency and compliance to ever-tightening emissions legislation should underpin further gains in silver demand from this sector in the country.

## Global Semiconductor Billings



\*Prior to 2015 refers to total Asia Pacific, as China-specific figures were not available

Source: Semiconductor Industry Association

# Chapter 4

## Electrical Applications

### Introduction

Chinese silver consumption in contacts and other electrical products is estimated at around 45Moz (1,400t) in 2017, with the majority of fabrication (around 90%) taking place locally. According to our field research, silver demand for electrical applications is experiencing a modest uptrend, underpinned by rising sales of low-voltage equipment used in a wide variety of applications. These include construction, whether residential, commercial or infrastructure related, power generation and industry.

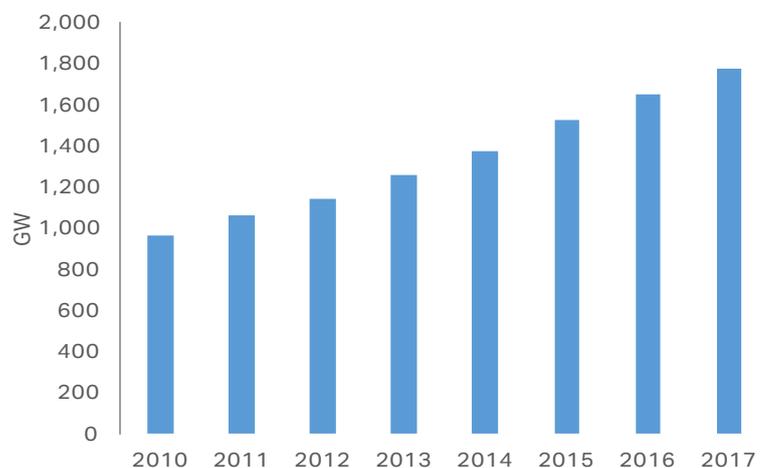
Naturally, demand is closely linked to fixed asset investment in China, which in 2017 grew by 7.2%, down from 8.1% the previous year. A further slowdown is expected for 2018, as the January-July cumulative figure was 5.5%.

### Key silver electrical applications

It is worth looking at some of the key end-industries in detail. Starting with real estate, after experiencing somewhat of a slump in 2014-15, the sector has been recovering, based on China's National Bureau of Statistics data on newly started projects. We expect growth to remain positive over the next few years, although authorities' efforts to keep the sector from overheating should prevent a return to the boom seen during the previous decade.

Moving to the power sector, according to the China Electricity Council, installed power generation capacity in 2017 reached 1,777GW, marking a 7.6% increase y/y. Electricity output, meanwhile, totaled 6,418TWh last year, a 6.5% rise. To put this in perspective, our research suggests that approximately 60,000 different types of low-voltage equipment are needed when 10MW of power generation capacity is installed. In addition to the capacity increases, the rapid development of a smart grid and new

### Chinese Electricity Generation Capacity



Source: China Electricity Council

energy sources in China has further boosted the demand for low-voltage equipment, using silver alloy contacts.

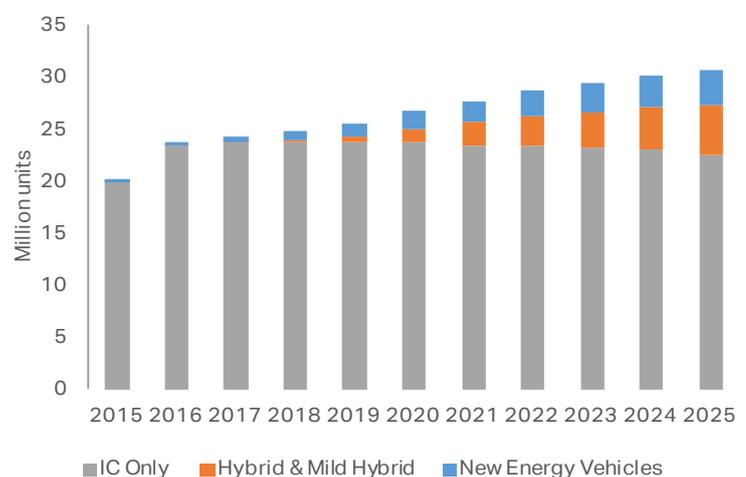
The Belt and Road Initiative, including China's call for a global intercontinental energy system, has also so far helped and should continue to do so. This is through smart grid and other power investment projects implemented by Chinese firms outside the country. Examples include Angola's Caculo Cabaça hydroelectric station, Brazil's Belo Monte hydroelectric dams and the Chashma nuclear power station in Pakistan. One potential issue concerns the sustainability of the debt related to such projects, as well as questions over national security within partner countries.

Moving to the automotive industry, in addition to the growth in vehicle production, the trend of electrification has fueled strong gains in electrical contacts. New Energy Vehicles in particular contain significantly higher levels of silver, due to the need for more electrical equipment such as relays for electrical circuit control and energy storage. It is also worth noting that automotive contacts and switches are one area of electrical applications where foreign firms have a sizable presence, meaning there is scope for market share gains from local players, potentially boosting local fabrication.

Finally, there is continuous development and investment in wireless infrastructure, with plans next year to commercialize 5G networks in China. This should also underpin growth for electrical contact materials, as relays are key components in base stations.

To conclude, although slower compared with historical levels, we expect Chinese infrastructure spending growth will continue for the foreseeable future, underpinned by ongoing gains in power generation capacity and other infrastructure projects. Coupled with growth in automotive production, and foreign projects related to the Belt and Road Initiative, this should see silver fabrication in contacts and other electrical products maintain a decent growth rate of 3-5% per annum through to at least 2020.

### Chinese Passenger Vehicle Production Forecast



Source: LMC Automotive

# Chapter 5

## Brazing Alloys & Solders

### Introduction

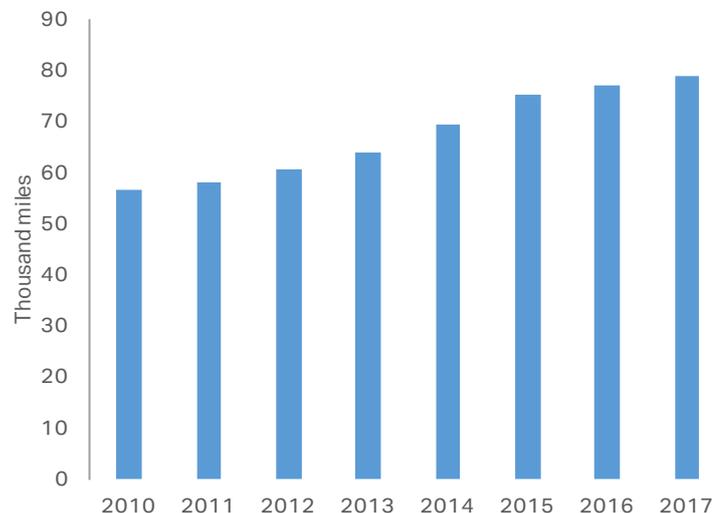
Silver fabrication for brazing alloys and solders has accounted for 15-18% of Chinese demand over the last few years and in 2017 demand amounted to around 24Moz (760t). Used in a wide range of applications, most notably related to construction and infrastructure, we expect demand for brazing alloys and solders to experience modest steady increases, in the low single digits, over the next few years. There are a number of factors that we expect will drive these gains, all of which relate to the brazing alloy segment.

### Key silver brazing alloy applications

First, we expect to see continued investment in the country's railway infrastructure. According to China Railways Corporation, new tracks in operation reached 1,888 miles (3,038km) in 2017 and are targeting 2,485 miles (4,000km) in 2018, including 2,175 miles (3,500km) of high-speed railway tracks. Looking further ahead, the domestic railway construction budget is projected to be broadly stable over the course of the 13th five-year plan period (2016-20) and a key driver of the expansion is the Belt and Road Initiative. A total budget of more than \$900bn is being dedicated to connecting trade routes from Asia to Europe through railways, highways and sea corridors.

Second, there are continued gains in automotive production. As illustrated in the chart that was featured in the previous chapter, LMC Automotive projects annual average increases of nearly 3% for passenger vehicle production over 2018-2025. Light commercial vehicle production, meanwhile, is forecast to grow on average by 2% per annum. Brazing is a necessary joining process used during the manufacturing of vehicles, used across different parts, including bodywork, radiator, intercooler, piping systems, and engine tappets.

### Rail Tracks in Operation in China



Source: China National Bureau of Statistics

Third, we highlight investment in industrial automation systems. Rising input and environmental compliance costs coupled with a shortage of skilled labor and ever-rising wages in the country is pushing the Chinese industry towards increased automation, helping to improve productivity and ultimately competitiveness. Silver brazing benefits from the installation of pressure, vacuum and piping systems for automation tools.

Fourth, we expect to see stable demand from refrigeration and air conditioning systems. In 2017, output of refrigeration systems fell by 8%, but air-conditioning unit output rose over 12%. Rising personal incomes and continued urbanization should be supportive over the next few years, however headwinds from authorities' curbs on real estate markets should partly offset this.

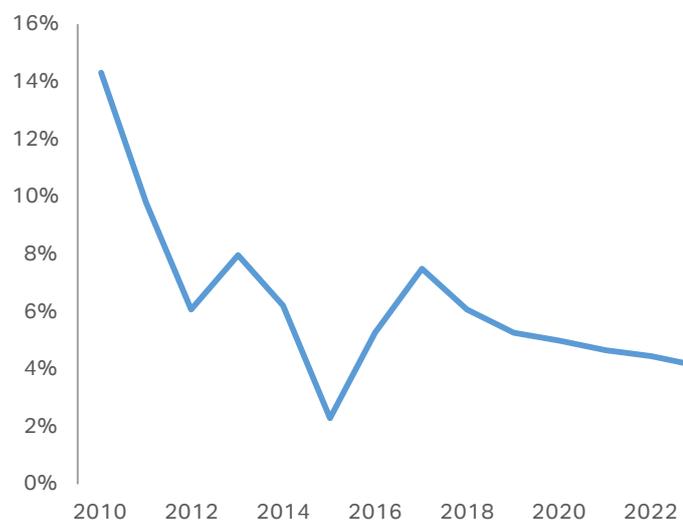
Fifth, we anticipate robust growth in machining tools. Silver brazing is one of the best joining technologies for carbide alloys, which is extensively used in this sector. For instance, the growing need for precision mechanical machining should underpin demand for carbide machining knives, which usually require the use of silver brazing alloys.

Sixth, rapid growth in the demand for medical equipment is forecast, as the population ages and incomes grow. Given that more ceramics and special alloys are used in medical devices, brazing alloys are a common solution to join different materials. Although the market is small in weight terms, growth is fast and margins for producers are relatively high.

Finally, growth of aerospace and military technology applications and equipment. Brazing alloys are used heavily in turbine engines and assemblies for sensors and electronics. It should be noted here that, while consumption from this sector within China shows promise, this is unlikely to benefit local fabricators, as foreign manufacturers dominate this space.

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### Growth of Chinese Gross Capital Formation\*



\* Investment or gross capital formation is the total value of the gross fixed capital formation and changes in inventories and acquisitions less disposals of valuables for a unit or sector.

Source: IMF World Economic Outlook

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# Chapter 6

## Other Industrial Applications

### Introduction

The use of silver in other industrial applications in China is estimated to have consumed around 7Moz (almost 230t) in 2017, accounting for a little over 6% of total Chinese silver fabrication demand. This covers several areas including: medical devices, 3D printing-related applications and the ethylene oxide (EO) market.

### Ethylene Oxide

This decade, global EO capacity has risen by around one-third from 27.3 million tons (mt) in 2010 to 36.3mt (source: PCI Global) last year. Much of this growth has been underpinned by expansion in China, where capacity has jumped from 3.5mt to 8.8mt over the same time frame. As a result, since 2014 the country has become the leading EO producer. That said, since 2016, there has been a slower pace of expansion, although Chinese capacity is still expected to reach 10mt by 2020.

One reason for the above slowdown in new EO plants in China is the overcapacity affecting the industry, reflected in average plant utilization at a little over 80% (with 7.13mt of EO production last year). As such, the average EO catalyst life cycle in China has grown to around 30 months. Another noteworthy aspect is that the rate of recovery for domestic refineries, at around 95%, tends to fall below that of overseas players. However, because of a 17% export duty all spent catalysts are recycled locally. That said, the supply of new catalyst remains dominated by foreign suppliers, with local producers only supplying around 10% of the Chinese market.

With regards to recent developments, in 2017 it appears as though just 200,000 tons of new capacity was added in China. For this year, we expect to see around 300,000 tons of newly installed capacity. This, together with estimated recycling losses of 5% for change-outs, suggests that total EO silver demand in China will be 5Moz (160t) in 2018 (consisting of 3.2Moz, 100t, of new capacity and 1.9Moz, 60t, to meet recycling losses).

### Other Uses

Looking briefly at some of the other segments, we expect to see growing silver offtake in the medical field, helped by increasing demand in a number of applications, including catheter coating, wound dressing and cancer treatment. However, one challenge with regards to the volume of silver demand is that many end-uses tend to prefer nanoparticles. Even so, these still represent a very attractive option for manufacturers, given the high value-added nature of these medical devices.

With regards to 3D printing, the key application here is the use for 3D printing of jewelry. In recent years, this segment has enjoyed growing popularity in China, for both silver and gold, as jewelers increasingly attempt to offer a differentiated product, in what is a crowded retail market.

# Chapter 7

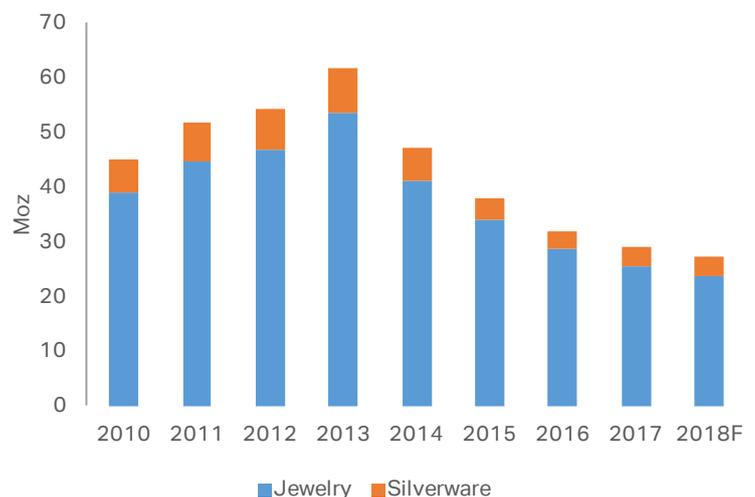
## Jewelry & Silverware

### Jewelry

China's silver jewelry market has been on a downtrend for a number of years. A number of factors lie behind this trend. First, the wider change in tastes experienced by Chinese consumers, away from plain, quasi-investment jewelry and towards lighter premium and design focused pieces, has been affecting offtake across all precious metals. Second, and again not affecting silver in isolation, jewelry has suffered from competition from other areas of discretionary spending, including consumer electronics, branded fashion as well as travel and leisure. Third, as incomes have been increasing across lower-tier cities, many consumers that had previously bought silver have increasingly switched to gold.

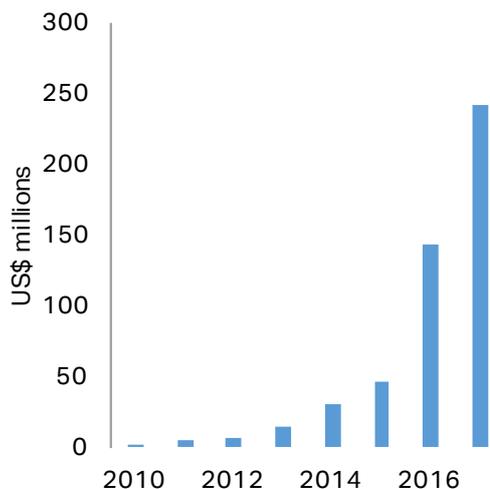
Confronted with these new realities, manufacturers, wholesalers and retailers have been ramping up their efforts to adapt. Many have invested in technology, design and licensing (e.g. famous cartoon or film franchises), to develop products that are more appealing to an increasingly discerning, fashion conscious and younger consumer base. Promotion and brand development are other areas that we have seen investments being made in by the silver jewelry supply chain. Business strategies have also been transformed. One example worth mentioning is that some manufacturers have in recent years started organizing frequent trade fairs for retailers to replenish stocks, meaning they can easily adapt their inventory to fast-evolving market trends and different gifting occasions. Finally, we have also noticed efforts to build brand loyalty by offering additional services to consumers. For example, some leading retailers offer free cleaning and repair services to clients for the life of the product.

### Chinese Jewelry & Silverware Fabrication



Source: Metals Focus

## Pandora's sales into China



Source: Pandora Annual Reports

It is worth noting some specific examples here. From a product development perspective, Myshine Silver Jewelry and Silverware is a manufacturer that operates its own retail brand and has been focusing its efforts on product lines with special designs and concepts that are targeted to specific consumer groups. The company also produces a silver bracelet series that is compatible with a third party wearable device featuring heart-rate and blood monitors, activity tracking and cell phone alerts, which has proven popular. One example of successful promotional activities is that of Seven Good Silver Jewelry, that provides special discounts on the 7th, 17th and 27th of every month throughout the year and also has a month-long promotion in July.

Market players that have adopted one or more of the above-mentioned strategies have often noticeably outperformed their peers. The promise of focusing on premium and branded products is also evident when looking at the strong performance of international brands, notably Pandora, in the Chinese retail market. Importantly, these efforts, coupled with the secular decline in demand having largely run its course, are starting to have an impact on silver demand. While offtake in 2017 was once again down year-on-year and further losses are likely also this year, the rate of the decline is slowing considerably, with 2018 forecast to see the first single digit decline since 2014, of 7% to 24Moz (~740t). We also believe that the bottom for the market is in sight and forecast a return to growth from 2020 onwards.

## Silverware

Until recently, Chinese silverware had also been on a decline. In contrast to jewelry, fashion had little to do with this trend. Instead it was the impact of the clampdown on corruption that saw silverware fabrication in China fall from around 8Moz (250t) in 2013 to a low of 3Moz (under 100t) in 2016. Historically, the gifting market had accounted for the lion's share of Chinese silverware sales, and as such it was hard-hit by anti-graft policies and the resulting collapse in conspicuous gifting.

Faced with these challenges, the industry shifted its focus away from gifting items and towards daily use products, as well as those designed with home decoration in mind. Similar to what was seen across jewelry manufacturers, investments were made on product innovation, marketing and distribution channels. In some cases, mixed material products, for instance combining porcelain, wood, jade and colored stones with silver, were also developed successfully. Promotion of silver's antibacterial and water softening properties has also been successful in broadening silverware's appeal. New sales avenues, including e-commerce, TV shopping as well as tie-ups with commercial banks have also been developed, to widen silverware's consumer base.

There were signs that these efforts were starting to yield results already in 2016 and finally last year they turned the market around, fueling an 8% rebound to 3.6Moz (111t). Looking ahead, we expect this new trend will be maintained for the foreseeable future. As a result, we forecast modest year-on-year gains over the next few years, leading to 4Moz (124t) in 2022.

# Chapter 8

## Investment

### Physical Investment

In contrast to its dominant position in industrial applications, China has historically only accounted for a small share of overall physical silver investment demand. Even during its peak for this decade in 2012, bar and coin demand in China totaled a relatively modest 23Moz (713t), accounting for just 10% of the global total. However, in recent years, the country's share has fallen into a 4-6% range, as volumes have eased back.

This largely relates to historical and cultural factors driving Chinese investors towards gold rather than silver. Indeed, our field research suggests that the bulk of domestic bar demand was linked to gifting rather than genuine investment demand. Meanwhile, coins and medals were driven by a combination of collector and gifting related purchases.

As such, in the aftermath of the aggressive clampdown on corruption in China from 2014 onwards, silver investment has come under immense pressure. Similar to most other traditional gifting items, silver, and in particular bars, were often used as a means of informal payment. Naturally, bars have borne the brunt of the decline, falling to a fraction of their former norms in 2014 and continuing to slide ever since.

In contrast, coin sales have been more resilient, as their role in such informal payments had been limited. However, last year these were weak, due to a combination of market saturation (the fall followed six years of strong sales) and concerns among Chinese investors over the outlook for the silver price.

Physical silver investment in China has also suffered from the disappointing performance of the silver price in recent years. It is also worth noting that

### Chinese Physical Silver Investment



Source: Metals Focus

demand has underperformed gold. This is mainly due to the emergence of diversifying and/or safe haven purchases of gold bars in recent years by high net worth investors looking to protect their wealth from local currency depreciation and an uncertain outlook for other asset classes in China. As silver is not perceived to have the same quasi-monetary and safe haven attributes as gold, the metal has not enjoyed similar inflows.

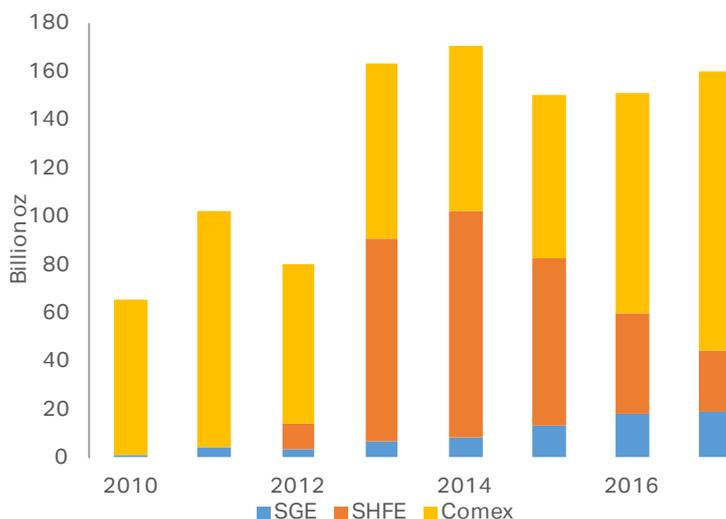
Looking ahead, it is hard to envisage a strong recovery in silver bar and coin demand. We do however see 2018 marking the end for the downtrend that began four years ago, as our field research suggests the secular declines have now run their course. Indeed, our projections for the next five years see a marginal increase in purchases, underpinned by coin and medal sales.

## Commodity Exchanges' Activity

While not exclusively used by speculators, it is worth commenting on silver activity on the Shanghai Gold Exchange (SGE) and Shanghai Futures Exchange (SHFE). The former has two silver contracts, one standard spot contract and a "deferred" one, which is effectively a perpetual (i.e. with no specified expiry) futures. The SHFE silver contract, meanwhile, is a traditional futures one, similar to those listed on the Comex.

Silver activity on the SHFE exploded over 2013-15, with volumes on the exchange exceeding those on the Comex. The catalyst for this was the introduction of evening trading hours, that meant the SHFE was "live" while Western markets were most active, creating arbitrage opportunities. Other factors were also at play at times, including spikes in speculative interest and increased involvement from corporate participants. As these factors receded, volumes declined in recent years, although they remain significant. In contrast, activity on the SGE's deferred Ag(T+D) contract has been steadily increasing since its launch. Recently, this has actually been partly at the expense of the SHFE, owing to the SGE's more attractive fee structure.

### Turnover on Chinese Exchanges and Comex Silver Futures\*



\*Volumes have been converted to ounce-equivalents to facilitate comparisons  
Source: Metals Focus

# Chapter 9

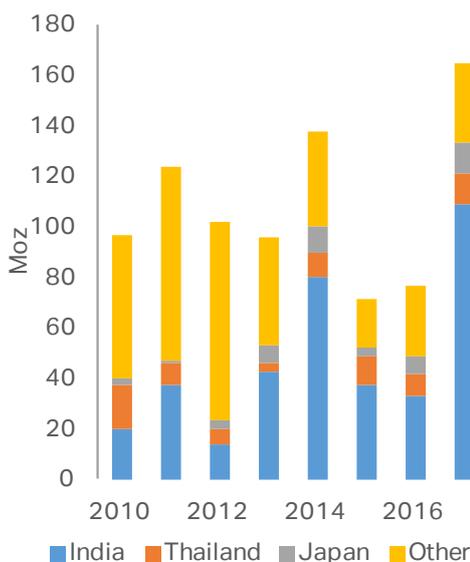
## Bullion Exports

Although silver bullion exports are not an area of demand, we believe it is important to include a chapter on these flows in this report. In particular, these are a key “draw” on the amount of metal that is available in the Chinese market. Moreover, China has for a number of years now been a key supplier of bullion to the global market and will likely continue to play this role.

China has traditionally been a net exporter of silver. This is due to the structural oversupply of silver in the Chinese market. In turn, this relates to the fact that a huge amount of metal is imported into the country, contained in base metals concentrates, that are processed by local plants to produce base metals that have historically been in short supply.

This abundance of silver bullion has more recently been boosted by a change in trade policy in 2015, that was implemented from the start of 2016. This allowed the import of silver concentrates into China, having previously been prohibited. The impact of the policy change on volumes had a lag, and it was only in 2017 that a material increase in silver bullion exports was noted. The delay was due to frictions relating to documentation and processes, a lack of clarity (at least initially) regarding the rules guiding the sale and export of the metal produced using these imported concentrates and also the time it took for producers to adapt their procurement strategies to the new source of material. Exports in 2017 were also boosted by a draw-down of Chinese inventories.

### Hong Kong\* Silver Bullion Exports



In terms of export markets, by far the biggest destination for silver bullion originating from China is India; Thailand and Japan represent a distant second and third. The overwhelming bulk of Chinese exports leave via Hong Kong, although direct flows to India have in recent years grown, albeit from a very low base. It is also worth noting that bars exported from China are usually non-LBMA bars sold at a discount to the London price.

Looking at the regional distribution, the two key provinces where concentrates are being imported into are Hunan and Henan, accounting for 33% and 19% of the country’s total imports respectively in 2017. It was not surprising therefore to see that these two regions also account for the majority of the country’s total silver bullion exports, with Hunan at 47% and Henan at 24%. Exports from Henan jumped from less than 2Moz (57t) in 2016 to more than 20Moz (628t) in 2017. This was due to the increasing number of lead refineries in the region becoming qualified as processing importers under the terms of the above-mentioned 2015 trade policy reform.

Looking ahead, the exceptionally strong levels of outflows seen in 2017 are unlikely to become the norm. However, we expect China will remain a major exporter of silver bullion, owing to a combination of increasing domestic mine production and robust recoveries from imported raw materials for many years to come.

\*Most of China’s silver bullion exports are shipped via Hong Kong. Moreover, the majority of Hong Kong’s exports originate from China. Hong Kong export statistics therefore provide a clear picture of the breakdown by destination.  
Source: Metals Focus

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## Notes & Definitions

### Notes

Throughout the tables, totals may not add up due to independent rounding.

What one country reports as an export to another may be different to the imports reported by the receiving country for a variety of reasons, including conflicting rules of origin, classifications and timing. As a result, similar flows on different maps and/or tables may not be reciprocal due to reporting variations. The tonnage figures shown are fine weights calculated by Metals Focus from the data provided by each origin for exports and by each destination for imports.

### Units

<b>Troy ounce (oz)</b>	One troy ounce - 31.103 grams
<b>Ton (t)</b>	One metric ton - 1,000 kilograms (kg) or 32,151 troy ounces
<b>Dollar (\$)</b>	US dollar unless otherwise stated

### Definitions

<b>Fabrication</b>	Captured in the country where the first transformation of silver bullion or grain into semi-finished and/or finished products takes place (such as silver nitrate or silver oxide).
<b>Consumption</b>	The sum of domestic jewelry fabrication plus imports, less exports, adjusted for changes in trade stocks.
<b>Recycling</b>	Covers the recovery of silver from fabricated products, including unused trade stocks. Excludes scrap generated during manufacturing (known as production or process scrap). The recycling is captured in the country where the scrap is generated, which may differ from where it is refined. The one exception to this is ethylene oxide, where the recycling of silver is measured at the point where it is recovered.

## About Metals Focus

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