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## The Unsung Hero Of The Green Energy Transition



**WHITE PAPER**

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# TABLE OF CONTENTS

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01. PRICES HITTING FRESH HIGHS
02. WHY IS CHINA STOCKPILING MOLY?
03. A CROSS-CUTTING MINERAL
04. FUTURE USES
05. CONCLUDING REMARKS
06. REFERENCES
07. DISCLAIMER

# PRICES HITTING FRESH HIGHS

Molybdenum (Mo) ("Moly") has had a remarkable run over the last five years, moving up from below \$15/kg in the beginning of 2017 to \$46.3/kg in May 2022.



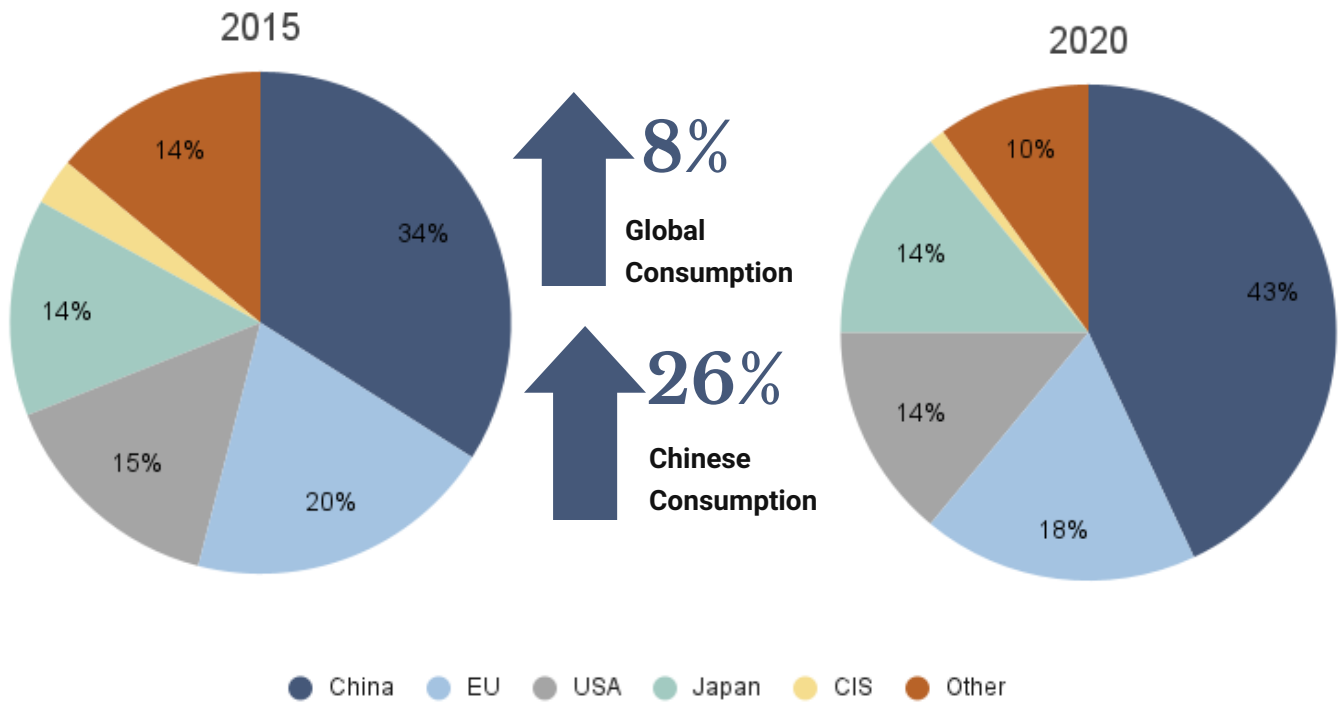
Source: Trading Economics, 30 May 2022

To date, this rise has been the result of three main factors, namely:

- **Demand for better quality steel:** Moly's anti-corrosive and hardening properties make it an important alloy to increase electrical conductivity, hardness and resistance to corrosion in steels. In recent years, there has been a rising demand for better quality steels, which has given Moly a significant boost.
- **Increased drilling activity in the oil sector:** In oil, as Moly is 100% soluble, it is a useful additive for lubricants to reduce friction.
- **Rising geopolitical tensions** have spurred governments to increase investments into their defense sectors where Molybdenum has important applications.

# WHY IS CHINA STOCKPILING MOLY?

As ever, China has been at the forefront of buying up this important metal. China is the world's largest producer of Molybdenum, though in recent years, this behemoth has been soaking up the world's Moly supply to keep up with its infrastructure requirements.

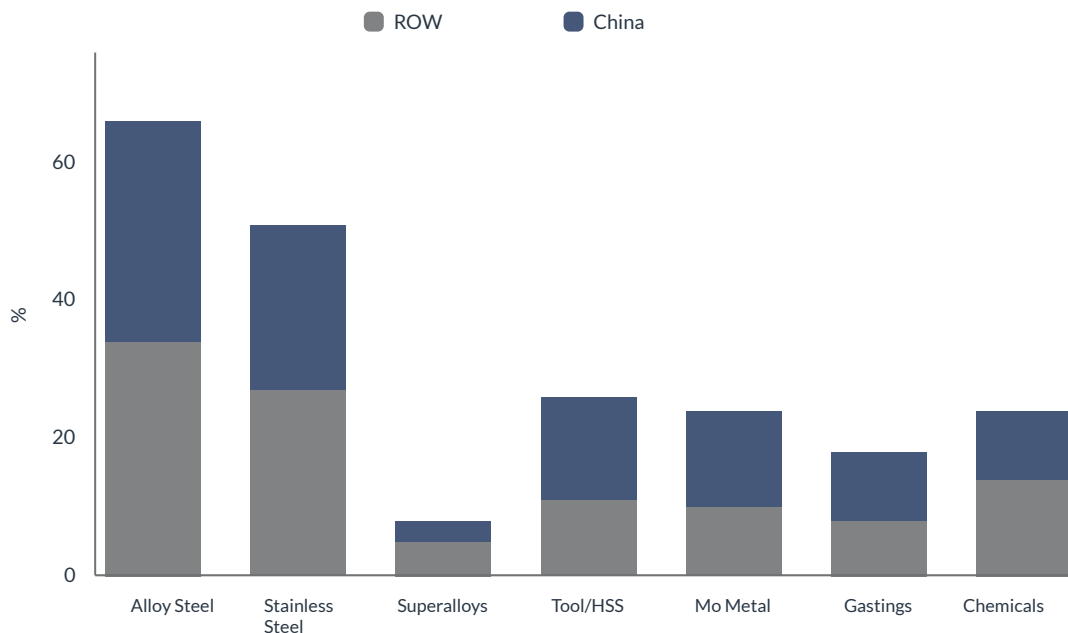


Source: IMOA

According to Macquarie Bank, a detailed account of the Chinese market showed that the first main use of the metal was in ferromolybdenum, which is used in the steel industry and accounts for 80% of Chinese consumption.

Compared to other markets, China uses a smaller share of the molybdenum in superalloys, stainless steels and alloy steels and a higher share in tools and high speed steels, molybdenum metal, castings and chemicals.

## First and End-Uses of Molybdenum in China

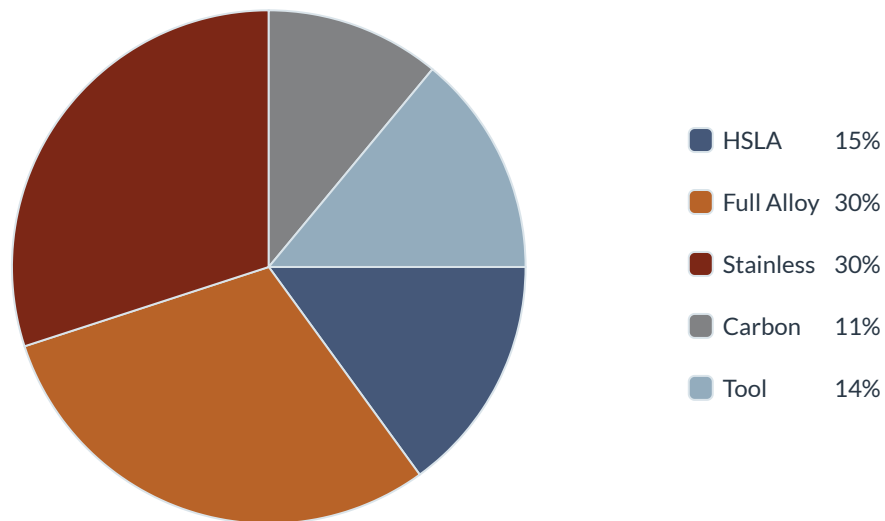


SOURCE: SMR

The largest share of molybdenum use in China is found in engineering steels, followed by stainless steels. However, looking specifically at the amount of molybdenum added per tonne of carbon steel in China, compared to other regions, shows that China uses less than half the amount of other major steel-producing countries.

On average, China uses around 55g/t carbon steel compared to global producers of 133g/t. The corresponding figures for stainless steel are 1.1kg/t in China versus 2.9kg/t in other regions. Consequently, there is still a significant potential to increase the use of Molybdenum in the Chinese steel industry and the Chinese government is actively seeking to improve the country's steel quality. This was evidenced by the rollout of new rebar standards, RB3, in 2019 which called for increased hardness and anti-corrosive properties in China's steel rebar.

### % of Moly Consumed by Different Steel Types



SOURCE: SMR

Over 90% of the total global steel output is carbon steel. This type of steel, however accounts for merely 11% of the molybdenum consumed for all steel uses. Carbon steel lacks corrosion resistance and underperforms in high temperature environments, making it less suitable for more sophisticated industrial applications that are required in later stage industrialization.

As emerging economies industrialize, their use of higher strength and stainless steels increases. This raises the intensity of moly use in the steel industry.

Another key growth area for Moly-based steels is in water purification. Currently around 40% of the global population, 3 billion people, inhabit water-scarce regions. For several years now, the smart money has touted water as the key commodity to add to ones' portfolio. Famously, Michael Burry announced his strategy of gaining investment exposure into water via investment into water-rich agricultural lands. Meanwhile, large corporates such as Levi Strauss and SABMiller are not only trying to reduce their carbon footprint, but are actively trying to reduce their "water footprint." Furthermore, the Bill Gates Foundation is pouring money into developing toilets in order to solve a sewerage crisis that not only brings water-borne diseases to the world's poorest nations, but threatens the global drinking and agricultural water supply.

This represents a major opportunity for Molybdenum as desalination plants operate in extremely corrosive environments, requiring the plants to be comprised of Molybdenum-rich stainless steel to retard or at least reduce the corrosion process.

For instance, the MARAFIQ desalination plant in Saudi Arabia requires 16,500 tons of 6% Moly-rich steel. This translates to 2.1m lbs of Molybdenum for a small plant (800t/day water) and needs to be replaced every 6 to 7 years. Singapore has five plants which are much larger than those in the Middle East. The newest one produces 30 million gallons per day (945,000 tons/day, 136 million litres per day) 188 times larger, thus requiring much more Moly-enriched steel.

## Facts About Usable Water and Moly



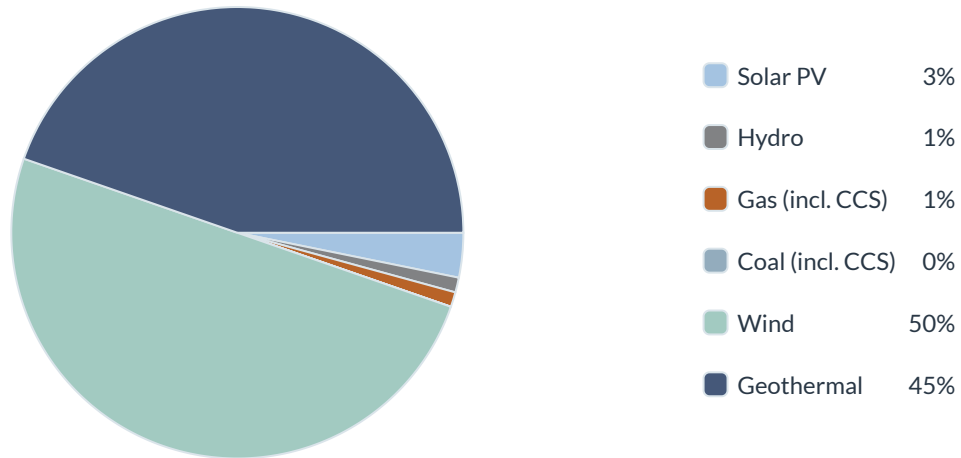
SOURCE: IMO A Case Study- Desalination

# A CROSS-CUTTING MINERAL

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More interesting than the steel market, is that around 40% of all molybdenum is consumed in the energy sector and Molybdenum is seen as key in the decarbonization of our global economy.

## Projected Share of Molybdenum Demand in the Global Energy Industry by Technology 2050



Source: World Bank

According to the World Bank, by 2050, the greatest share of demand from Molybdenum from electricity generation and energy storage technologies comes from wind (47%) and geothermal (42%) with all other generation and energy storage technologies together accounting for only a small share (11%).

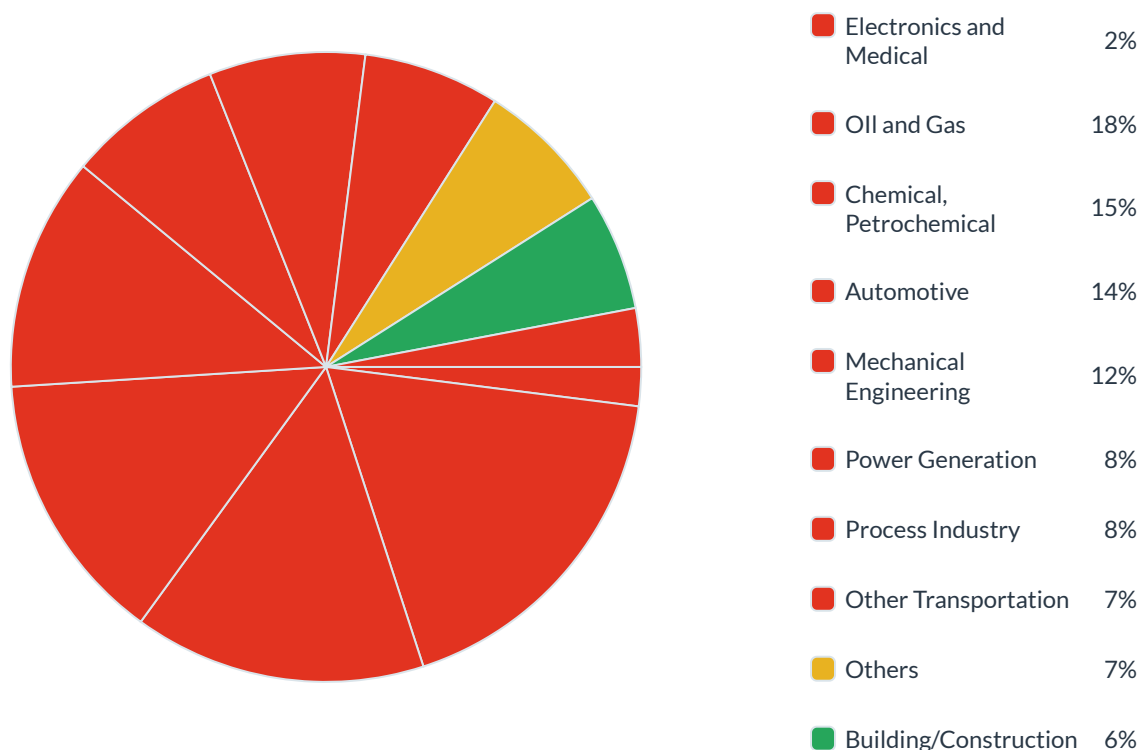
Molybdenum is therefore the one to watch as it is referred to as a “cross-cutting mineral” along with Chromium and Copper. This means that it is used across a wide variety of clean energy and generation technologies and therefore has very stable demand conditions compared to Cobalt, Lithium and Graphite. While Cobalt, Lithium and Graphite have skyrocketed in recent years and have become synonymous with the green revolution, they are only needed for one or two technologies and therefore possess a higher demand uncertainty as technological disruption and deployment could significantly derail their current demand.



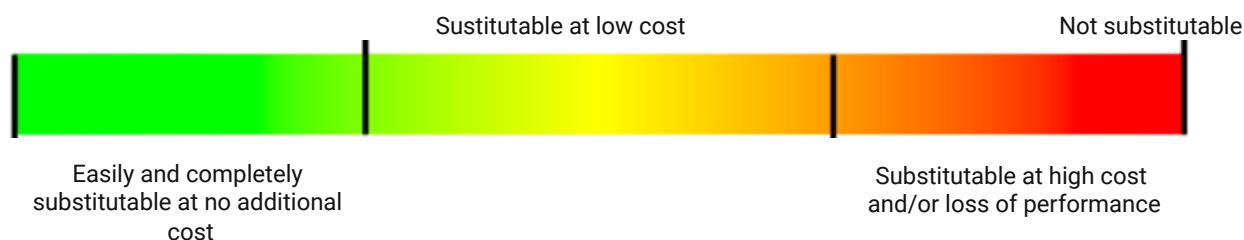
By contrast, Molybdenum does not depend on the deployment of any one specific technology within the clean energy transition as it is used in more than eight clean energy generation and storage solutions. Moreover, its substitutability for most applications is very low. In steels, Molybdenum substitution is mainly related to switching among hundreds of different steel grades. For instance, Stainless Steel grade 316 can be substituted with grade 445M2, which has higher Chrome content. In alloy steels, there is the potential to substitute mMly with Boron, Chromium, Niobium or Vanadium. And in tools, Moly and Tungsten are often interchangeable.

In general, however, we find that Molybdenum not only has several uses, but it's extremely challenging to substitute Moly with any other metal.

### Substitution Potential By Application



Source: World Bank



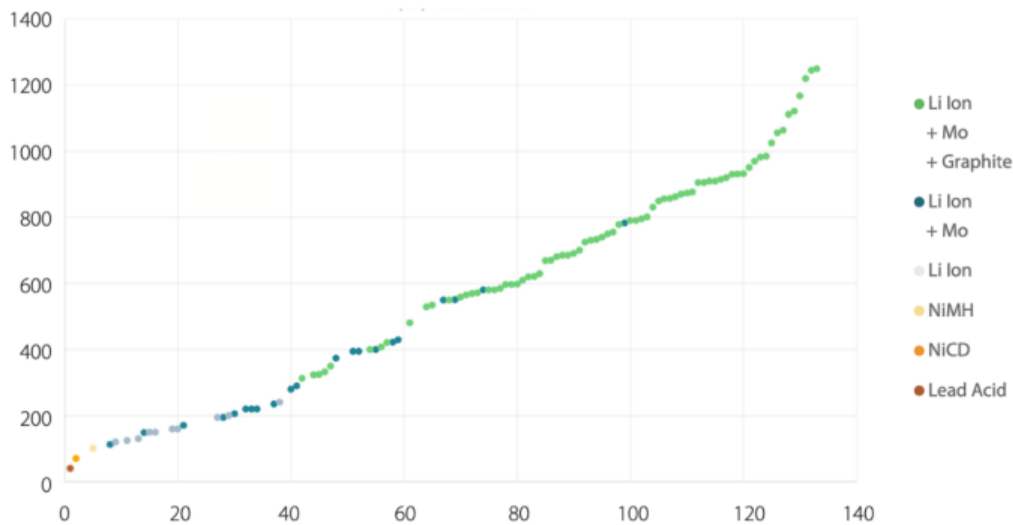
# FUTURE USES

As with most minor metals, the advent of new technologies over the last few years have brought new applications for these metals and Molybdenum is no exception.

Since the middle of 2016, there have been numerous academic studies demonstrating that using Molybdenum in various states and compounds greatly improves battery performance. Adding Molybdenum with other strategic metals in the electrodes of the batteries seem to be increasing the current Specific Energy Level considerably, from 150-240 range to as much as 500-700. Current research seems to suggest that this is not just true for Lithium-ion batteries, but for all batteries.

Sodium-ion and Potassium-ion batteries are being explored as a possible alternative for Lithium-ion batteries as the materials are much cheaper and more abundant than Lithium.

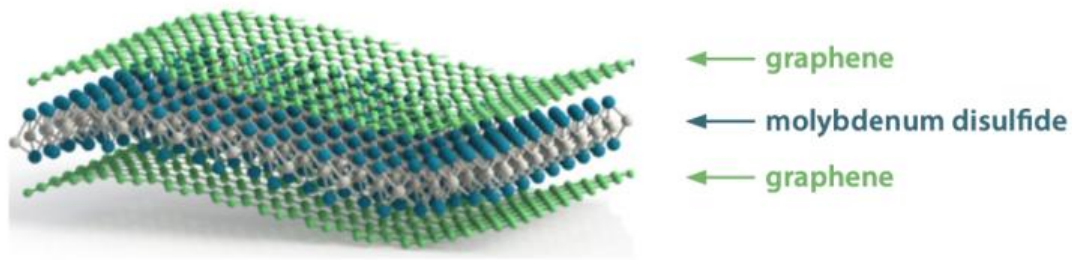
## Capacity of Lithium-ion Batteries



Source: International CUMO

Adding layered Molybdenum disulfide was again shown to improve the specific energy of the Sodium battery and similar results were shown in the Potassium-ion battery.

Lithium-ion batteries still command the lion's share of global battery research budgets. To date, three types of studies have been completed, namely those that involve bulk Molybdenum, mixing Molybdenum together with the Lithium or Molybdenum/Graphite combinations. In each instance, adding Molybdenum was shown to improve the capacity of the Lithium-ion batteries and the addition of both Molybdenum and Graphite/Graphene combination improved the performance of the battery by 5-to-6 times that of the current battery technology.



*Source: International CuMO*

# CONCLUDING REMARKS

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Molybdenum is on the precipice of a new era. Well known applications for steel are expected to see continued growth for this market as China looks to improve its steel quality. Compared to other known alloying substances and steel additives, there is very little scope to substitute Molybdenum for other metals. As such, China has been shoring up Lithium stocks for several years.

Beyond steel applications, the World Bank has come to refer to Molybdenum as a cross-cutting metal and key for realizing a decarbonized future. The term cross-cutting has come to mean that the metal has varied applications and “cuts across” several technologies needed for the advancement of our modern economy.

Going forward, new breakthroughs in battery research have shown time and time again significant improvements to the battery capacity and specific energy when adding even a limited amount of Molybdenum. This is true regardless of the battery type be it Lithium based, Sodium or Potassium-based batteries. As one of the largest untapped resources on the planet, Idaho Copper is well placed and highly relevant as a future source of this *wunder* metal.

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