

Ruthenium:

Industrial prospects for last year's best performer

IPMI EUROPEAN CHAPTER 2018

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Introduction to Mitsubishi Corporation (MC)

- MC is one of the core companies of the Mitsubishi group (a multitude of independent companies)
- MC has a strong relationship with the Mitsubishi group of companies



(J/V with Mitsubishi Heavy Industries)



Bank of Tokyo-Mitsubishi UFJ



MITSUBISHI
FUSO



Mitsubishi UFJ Morgan Stanley



Tokio Marine & Nichido Fire
Insurance Co., Ltd.



Mitsubishi UFJ Trust and Banking



and more...

Mitsubishi: current market positioning

- 1) **Large liquidity provider** to the market, both physically and financially:
 - Largest Platinum and Palladium trader on the Tokyo Commodity Exchange (TOCOM)
 - In the top 3 on the New York Mercantile Exchange (NYMEX)
 - Substantial over-the-counter and spot business

- 2) **One of the largest/most active players in PGMs:**
 - Market share of 20-30% in PGM leasing globally
 - The largest lender to industrial customers
 - Strong links to the automotive sector in Japan, US and Europe (for forward purchasing, leasing, term contracts)
 - Unique positioning in Rh, Ru and Ir

- 3) **Active in Market Development, e.g.:**
 - **Developing PGM investment in Japan** through the launch of ETF (Fruit of Gold series) in 2012, which is the **only physically-backed ETF in Japan.**



| | | |
|--------------------------------------|-------------------------------------|--------------------------------------|
| 44 Ruthenium Ru 101.07 2334 | 45 Rhodium Rh 102.906 1963 | 46 Palladium Pd 106.42 1555 |
| 76 Osmium Os 190.23 3033 | 77 Iridium Ir 192.22 2446 | 78 Platinum Pt 195.08 1769 |



Ru and Ir: rare but essential metals

Ruthenium and Iridium are key commodities which will contribute to the mega trends that are repainting the business landscape of the global economy, including:

| Mega Trends | Application in Precious Metals Industry | | | |
|-------------------------|--|---|--------------------|--|
| "Digitalization/IoT/AI" | Advanced Electronic Components | ✘ | Ru, Ir, Pt, Au, Ag | |
| | Data storage and processing | ✘ | Ru, Pt | |
| "Clean Energy" | Vehicle electrification | ✘ | Ru, Ir, Ag, Au | |
| | Fuel Cells and hydrogen | ✘ | Pt, Ru | |
| "Resource Scarcity" | Waste water treatment | ✘ | Ru, Ir | |
| | Green chemistry | ✘ | Ru, Ir, Pt, Pd | |
| "Aging Population" | Medical devices and treatments including synthesis of APIs | ✘ | Pt, Rh, Ru, Ir | |

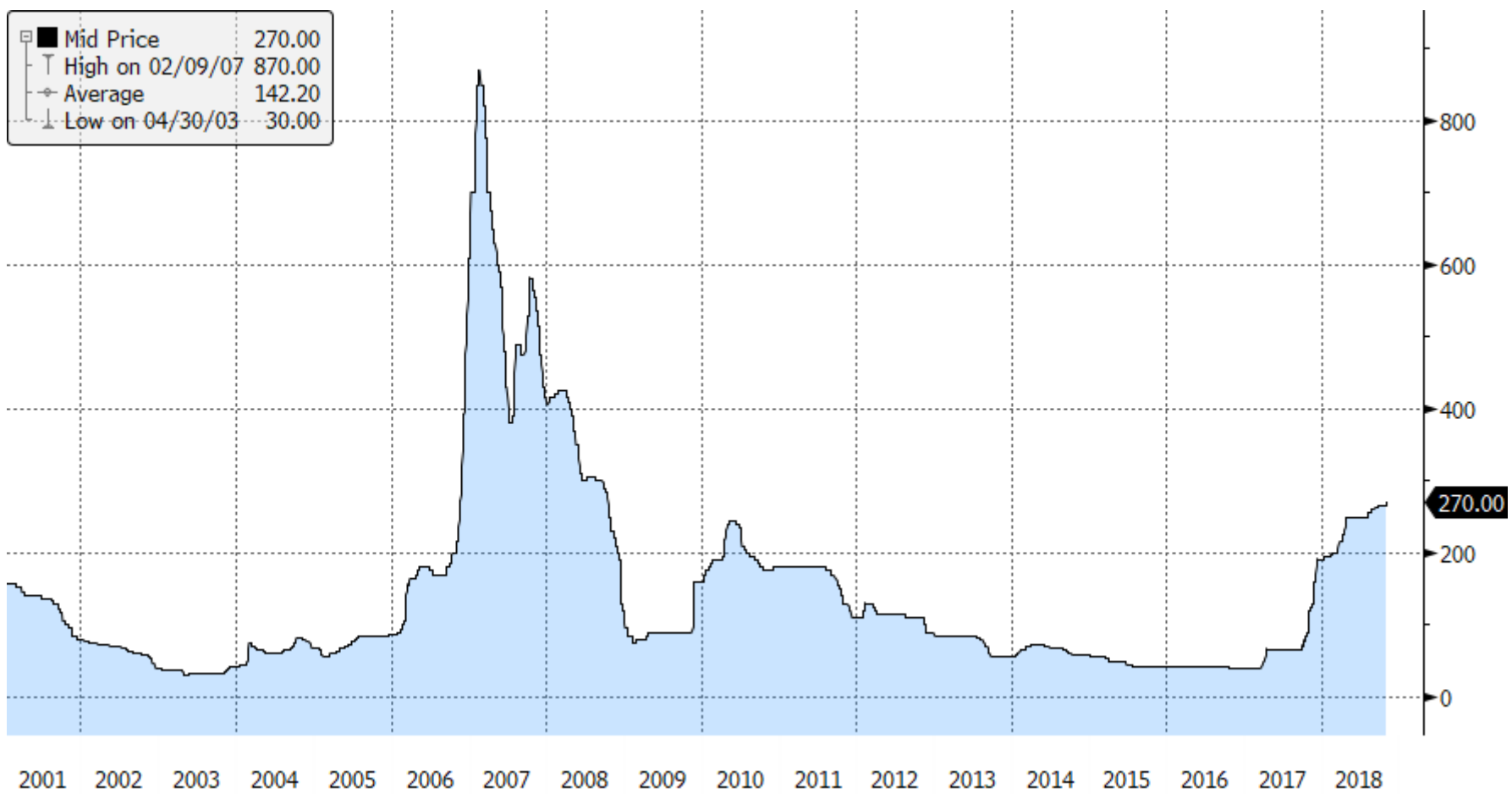


The world is going to need more Ir and Ru, but primary supplies are not growing and recycling is frequently difficult

Ruthenium prices

Currently at 10-year highs

JM Base Price \$/oz



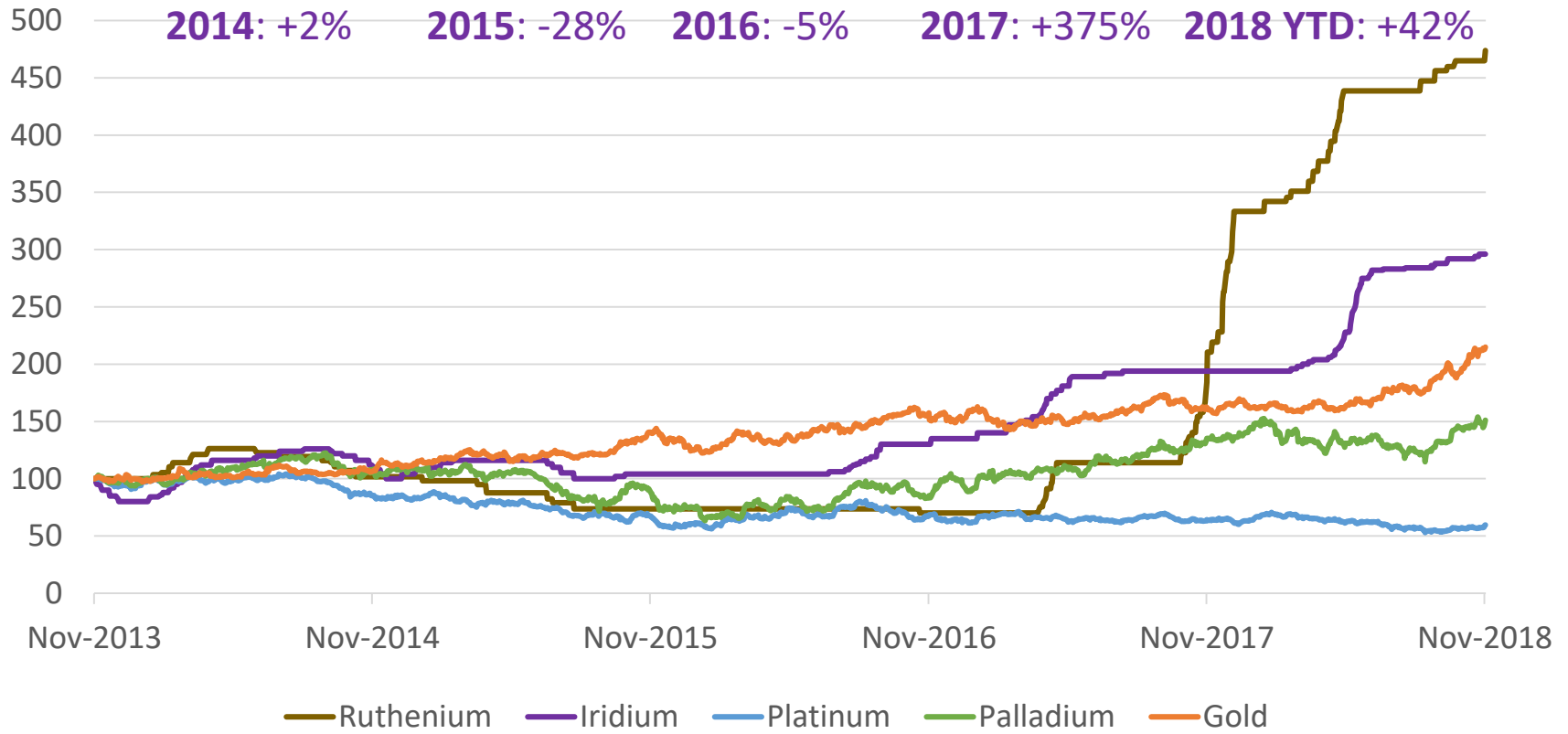
Source: Mitsubishi from Bloomberg

Ruthenium prices

Long term correlations

Indexed performance (where Nov 2013 = 100)

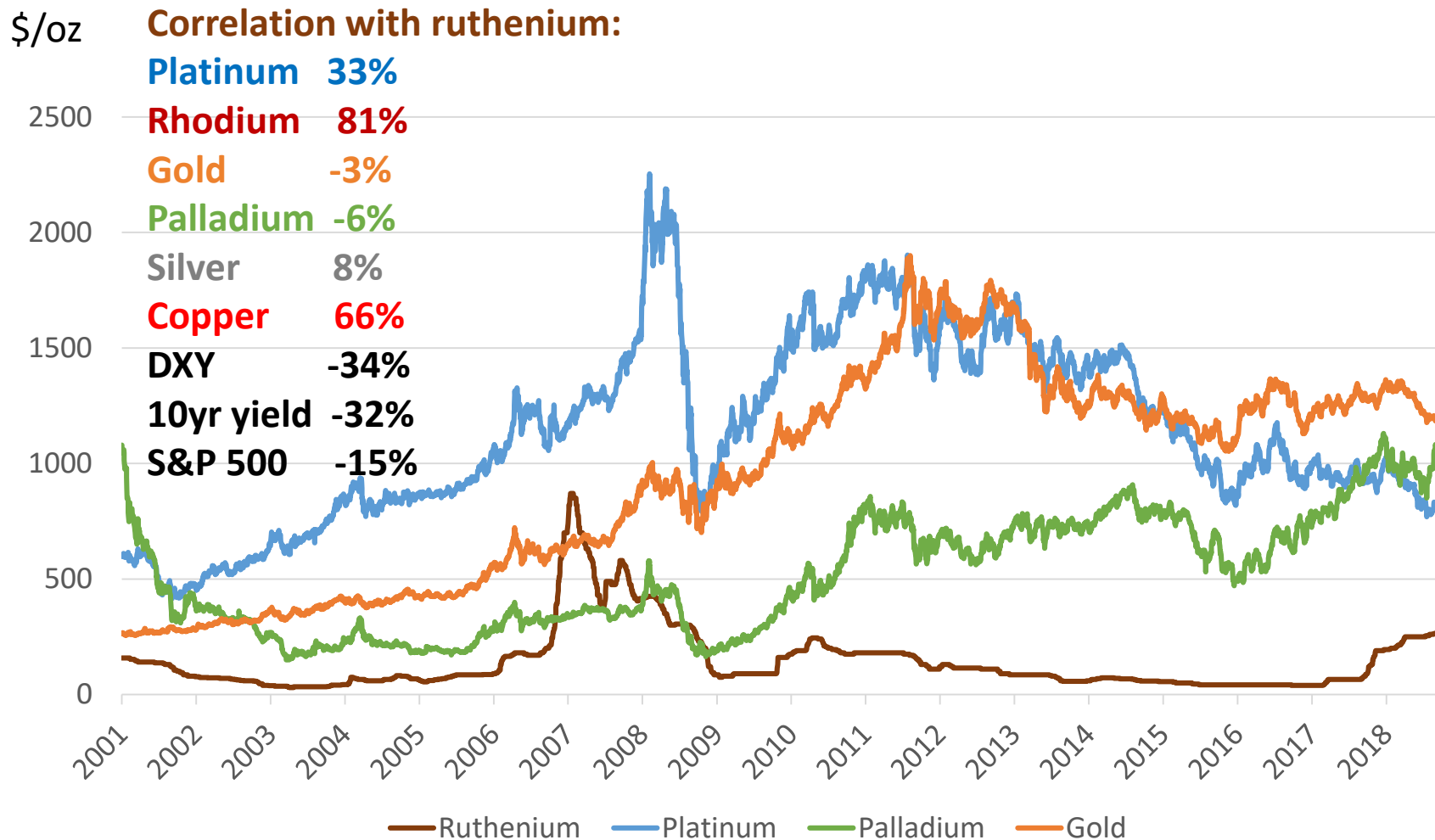
Ruthenium performance:



Source: Mitsubishi from Bloomberg

Ruthenium prices

Correlations with other assets

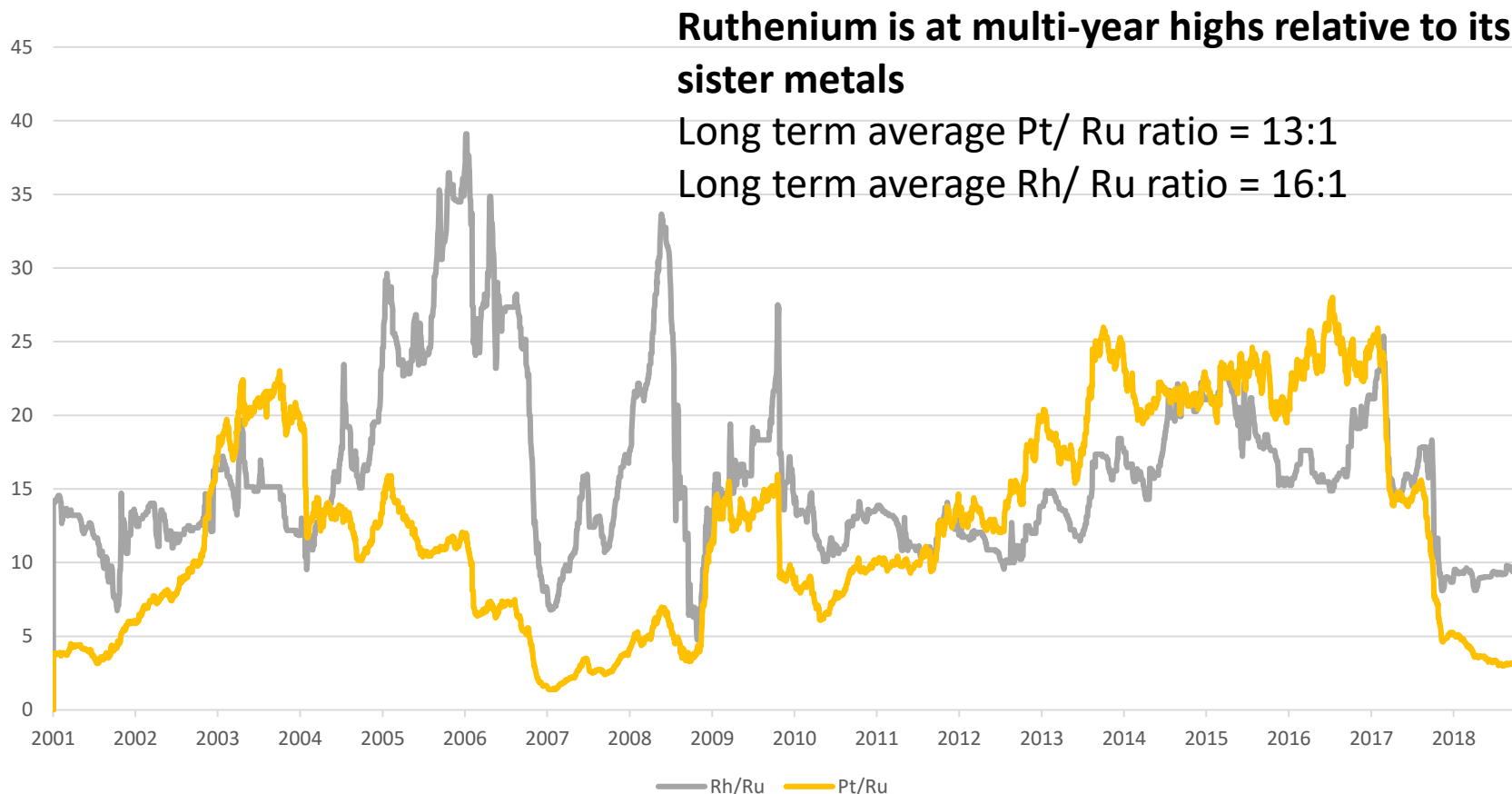


Source: Mitsubishi from Bloomberg

Ruthenium prices

Low price relative to platinum is positive for Ru adoption

Platinum / Ru and Rh /Ru ratio

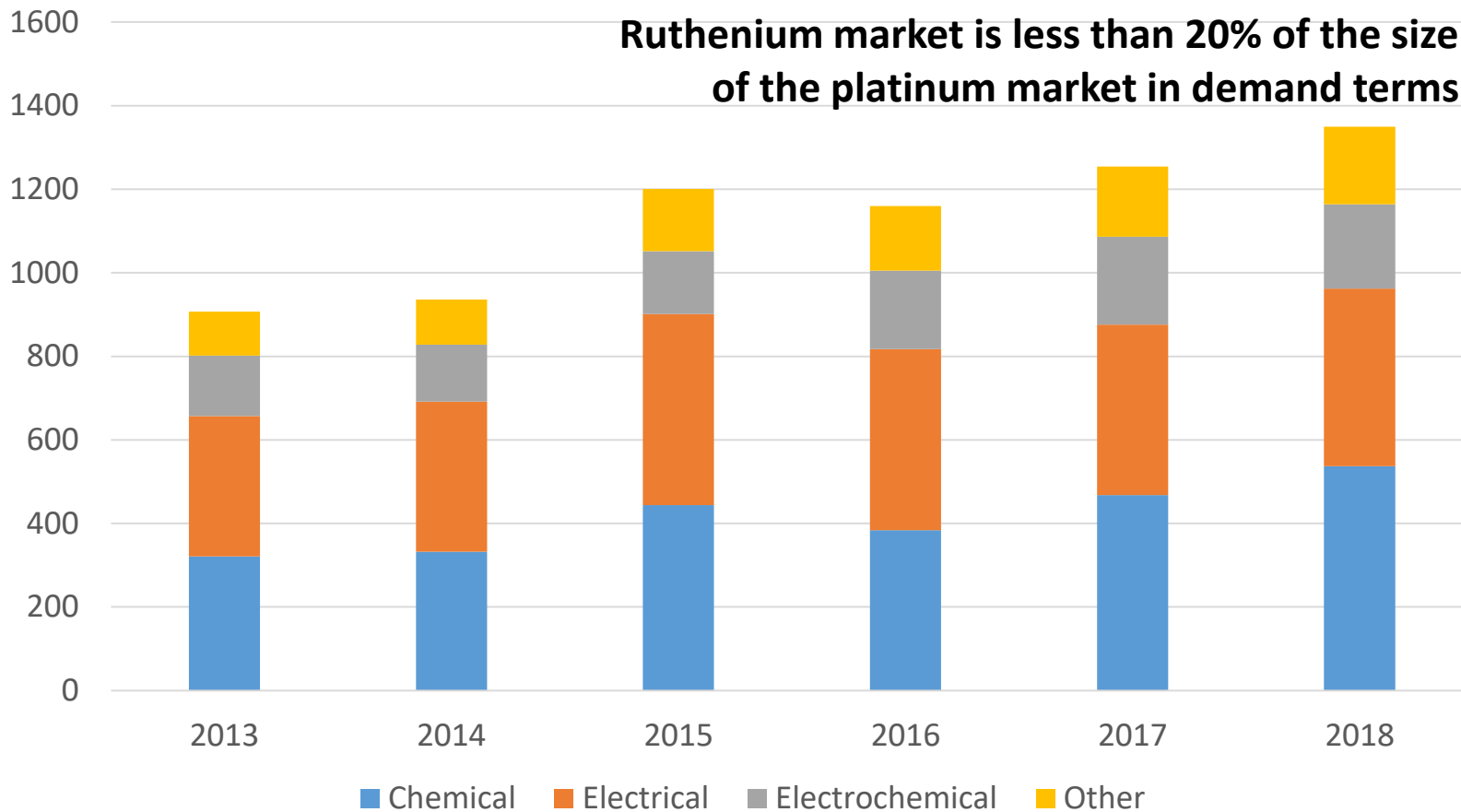


Source: Mitsubishi from Bloomberg

Ruthenium demand

Diverse demand areas

Ruthenium demand (koz)



Source: Mitsubishi from Johnson Matthey

Chemical demand

Growth in overall demand was driven by chemical industry

Ruthenium is used as a catalyst in the production of caprolactam and adipic acid used in polyamide (nylon-6, nylon-6-6) production, mainly for auto applications, as well as acetic acid used ultimately in coatings, polymers and packaging



Current market

Nylon

- New installations of caprolactam and adipic acid capacity in China drove up demand for ruthenium in 2017-18 and this is likely to continue in the short term

Acetic acid

- Ruthenium use in the Cativa and Monsanto Process as a promoter catalyst has also helped demand

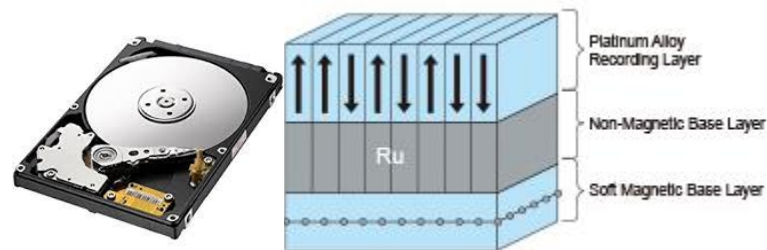
Future market

- Strong growth in nylon production for automotive components due to vehicle lightweighting
- Competition from alternative routes
- Positive prospects but growth could be slowed by less demand for plastics in future for environmental reasons

Electrical demand

Hard disks are the mainstay of demand

Ruthenium's major use in the electronics sector historically has been in hard disk drives, specifically in perpendicular magnetic recording where a Ru base layer on the storage medium helps increase storage density



Current market

Data storage

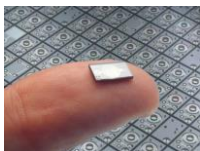


- Stable as growth in cloud data storage requirements offsets falling demand from uptake of flash memory devices

Chip resistors

- Ru-based thick film chip resistors are a key part of the electronics sector

MEM sensors



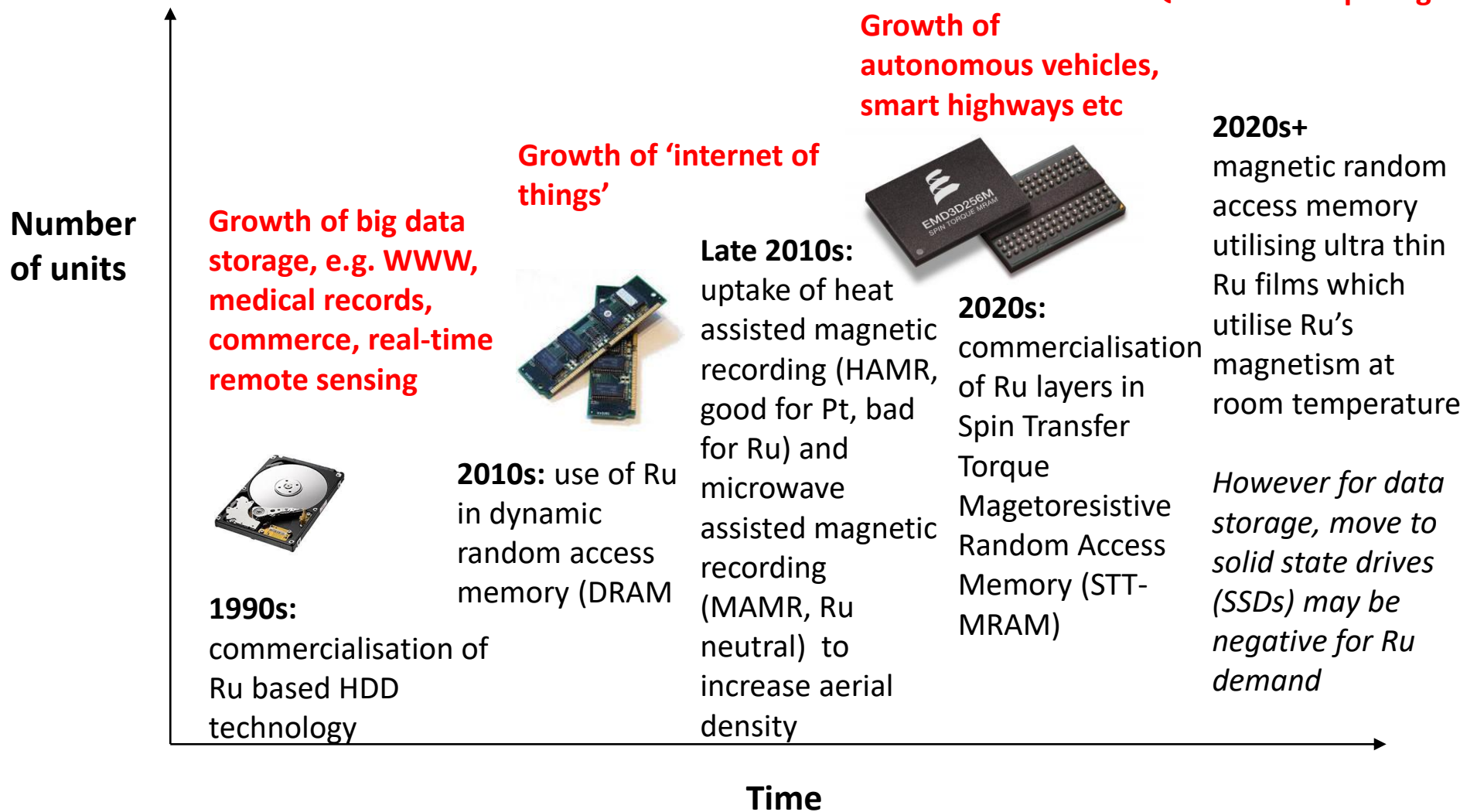
- Micro electromechanical sensors (MEMS) have great potential in autonomous driving, healthcare and the consumer electronics sector – many of these use small amounts of Ru in the sensors

Future market

- Developments in heat assisted magnetic recording (HAMR) could be negative for Ru, but strong growth potential in wider data storage from STT-MRAM etc.
- Projected growth in electronic automotive and communications devices is positive but trade related economic slowdown may present challenges

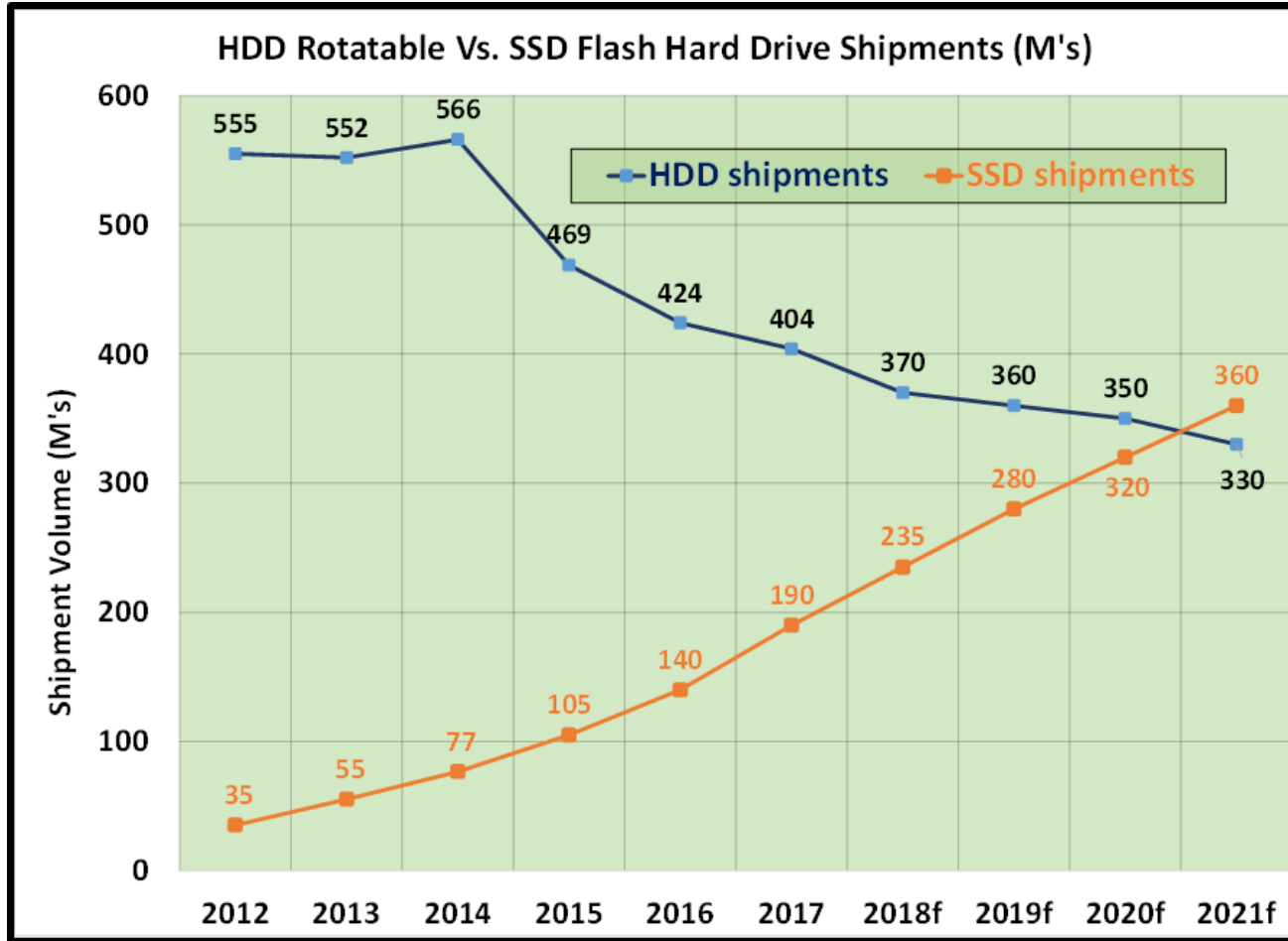
Electrical demand

Data storage prospects



Electrical demand

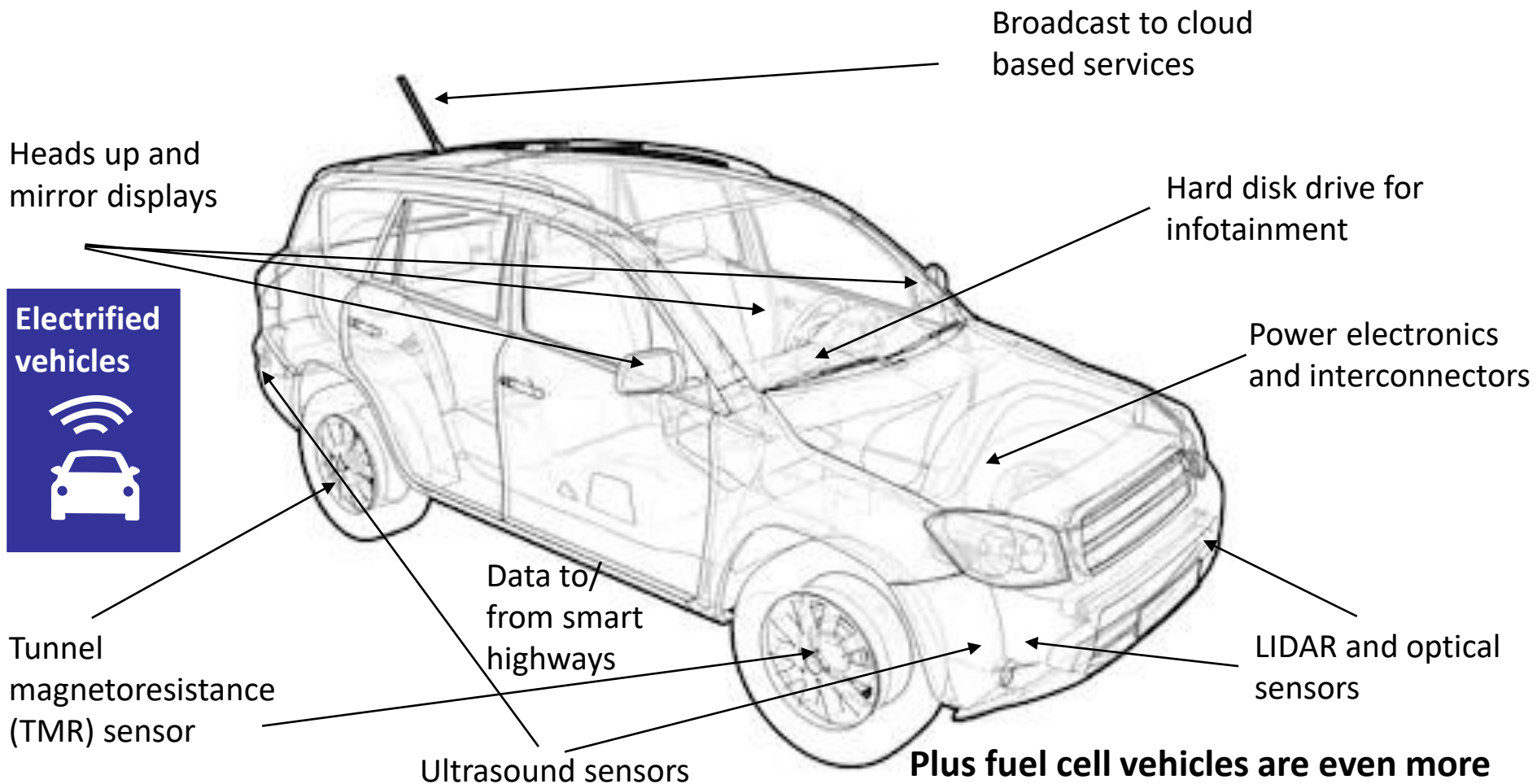
HDD faces competition from SSD



Data courtesy of Matt Watson, Precious Metals Commodity Management LLC

Electrical demand

Electrified vehicles are positive for Ru demand in sensors and chip resistors



Plus fuel cell vehicles are even more positive for Ru demand in fuel cell catalyst, reforming and gas monitoring

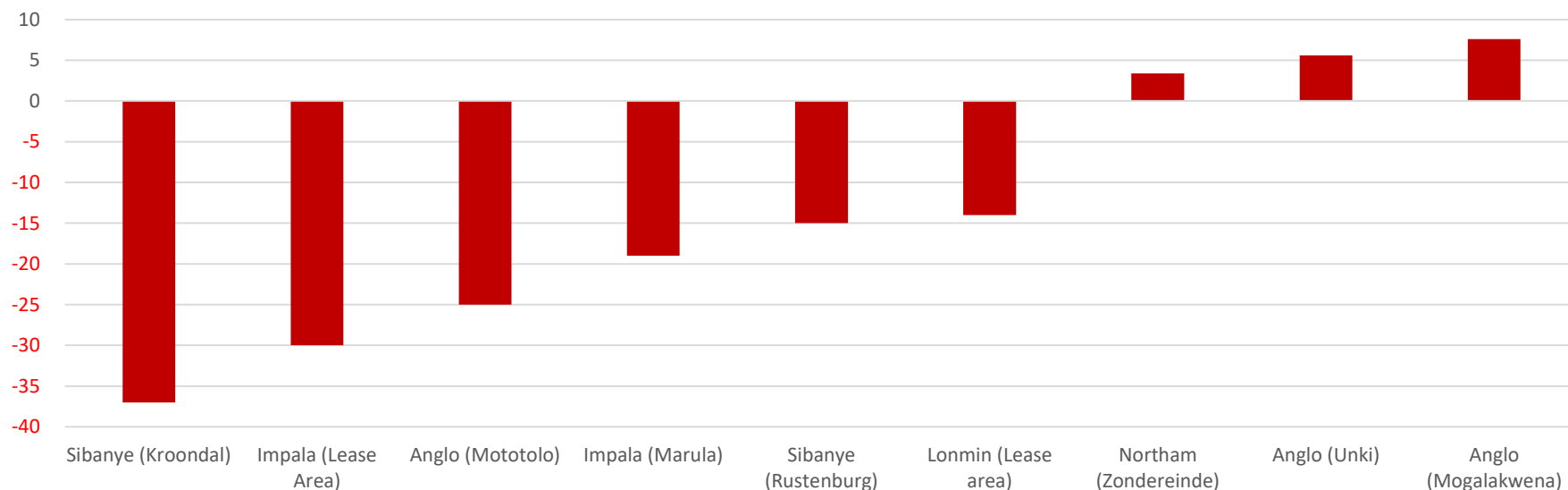
Future of mining in Southern Africa 2017-2022: ruthenium

Overall picture

Net decline of ~105 koz in South African ruthenium output between 2017 and 2022 is forecast

- Decline in output at Sibanye, Impala and Lonmin on key UG2 and Merensky ore bodies has a large negative impact on Ru output
- Offsetting effect from increased production at Mogalakwena is limited due to low Ru content in northern limb ore body (Platreef)
- However mothballed UG2 production can be 'switched on' fairly cheaply / easily, especially if Rh and Ru prices remain high

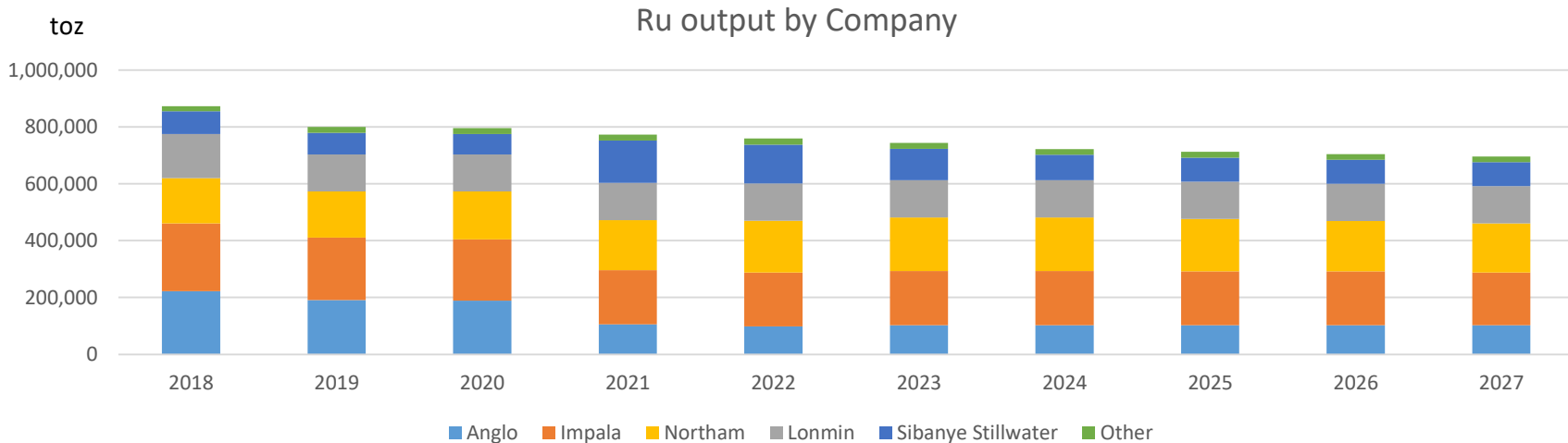
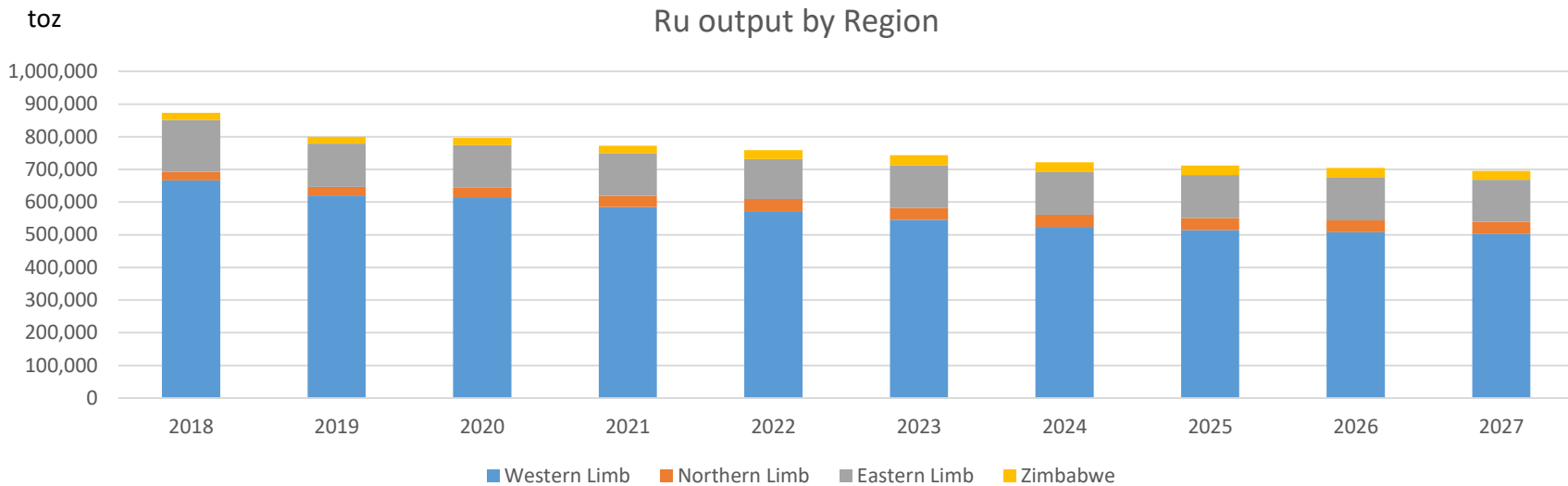
Koz of Ruthenium



Mines where Ru output will decline (2017-2022)

Mines where Ru output will increase (2017-2022)

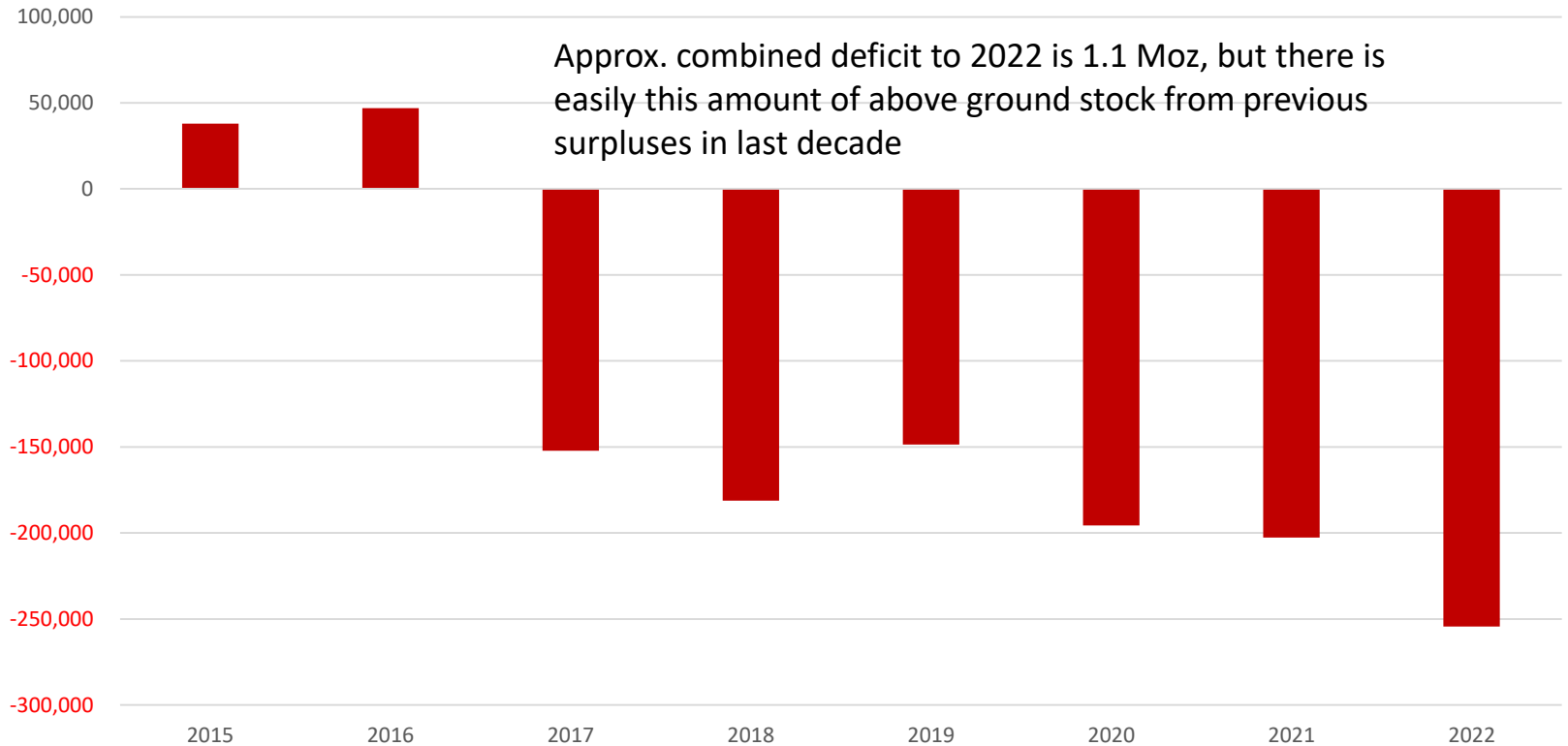
Future of mining in South Africa 2017-2022: ruthenium



Supply-demand balance

Deeper deficits projected to 2022

Supply-demand surplus/deficit (toz)



Source: Mitsubishi estimates

Ruthenium: Summary and outlook

- **Adequate liquidity:** there is still plenty of above ground stock including some producer / fabricator inventories
- **Mine supply:** falling SA output in next 5 years could drive further price spikes, accentuated by industrial users covering and speculative positioning
- **Recycling:** Some fabricators are investing in additional ruthenium refining capability which could help ease the market tightness
- **Demand outlook is positive, but possible headwinds from trade tariffs:**
 - **Electronics** sector is strong with growth prospects in automotive and communications applications for chip resistors and sensors. Hard disk demand may increase in the short term as sputtering targets are built for next generation MAMR hard disk drives
 - **Chemicals:** exceptional levels of chemical demand in 2017-18 probably won't be repeated
 - **Electrochemical:** growth in line with water electrochlorination but price sensitivity may impact demand
- **New future demand growth areas:**
 - Fuel cells, hydrogen production
 - Novel highly active olefin metathesis catalysts
 - Use in medical applications

Thank you!

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