



Harrison
Manufacturing

fluid thinking

ASSESS TECHNICAL QUALITIES OF GREASE TO KEEP UP WITH MARKET DEMAND

12 NOVEMBER, 2019

ANDREW BLACK



OVERVIEW

1. Overview of **market trends** impacting grease formulations
2. Analyse the **drivers** influencing the movement from using **lithium-based** greases
3. Evaluate **grease specifications** for optimum machinery protection in light of this shift



MARKET TRENDS

1. Overview of market trends impacting grease formulations

2019 NLGI Annual Meeting – June 8-11 2019

Chuck Coe - 2018 NLGI Global Production Survey

Global Grease Production has declined

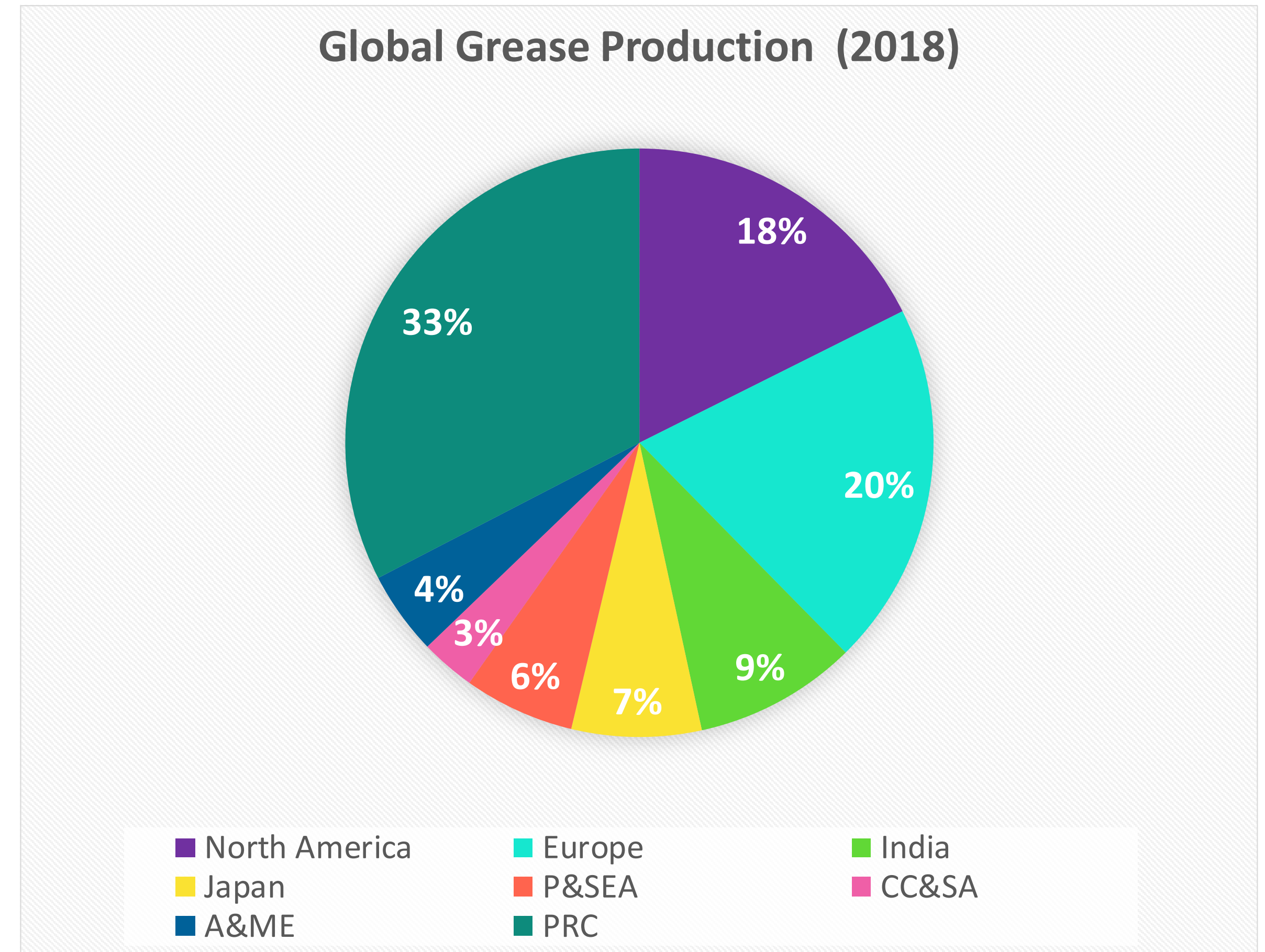
2017- 1.20M Tonnes 2018 - 1.17M Tonnes

China 383,000 Tonnes p.a.

Europe 235,000 Tonnes p.a.

North America 206,000 Tonnes p.a.

Source: 2018 Global Production Survey -Chuck Coe - Grease Technology Solutions, LLC



CC&SA Caribbean, Central and South America

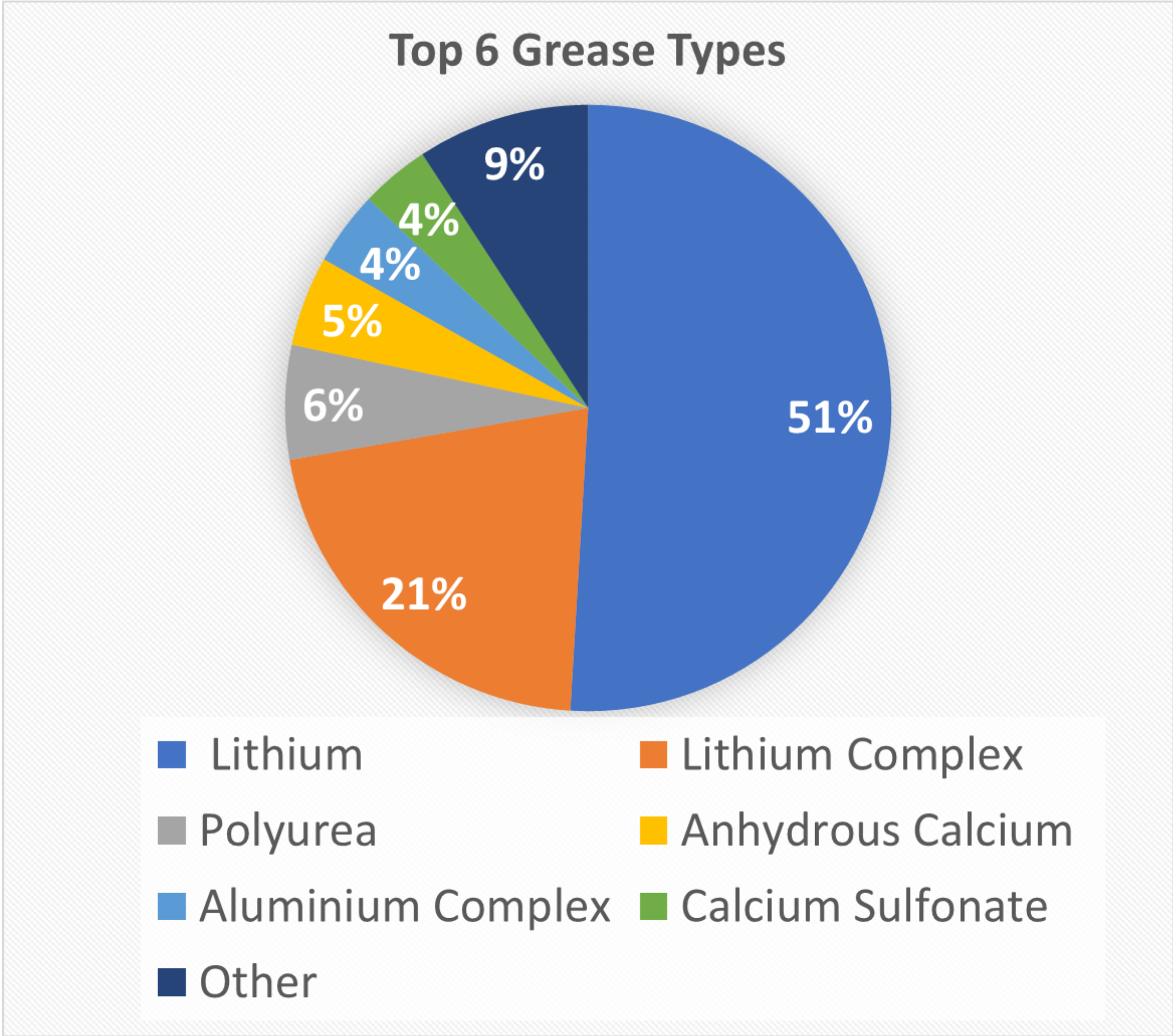
A&ME Africa and Middle East

P&SEA Pacific and Southeast Asia

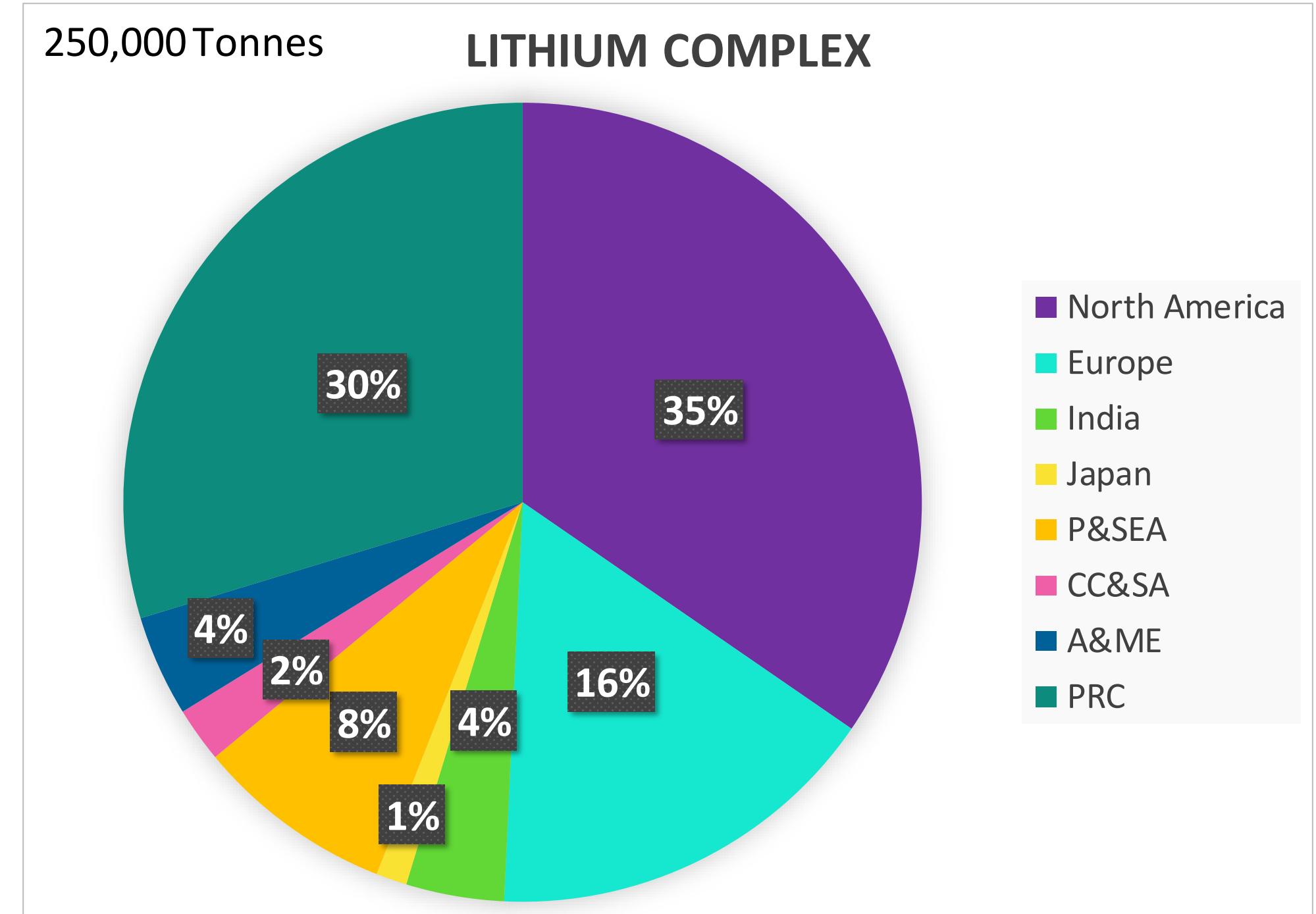
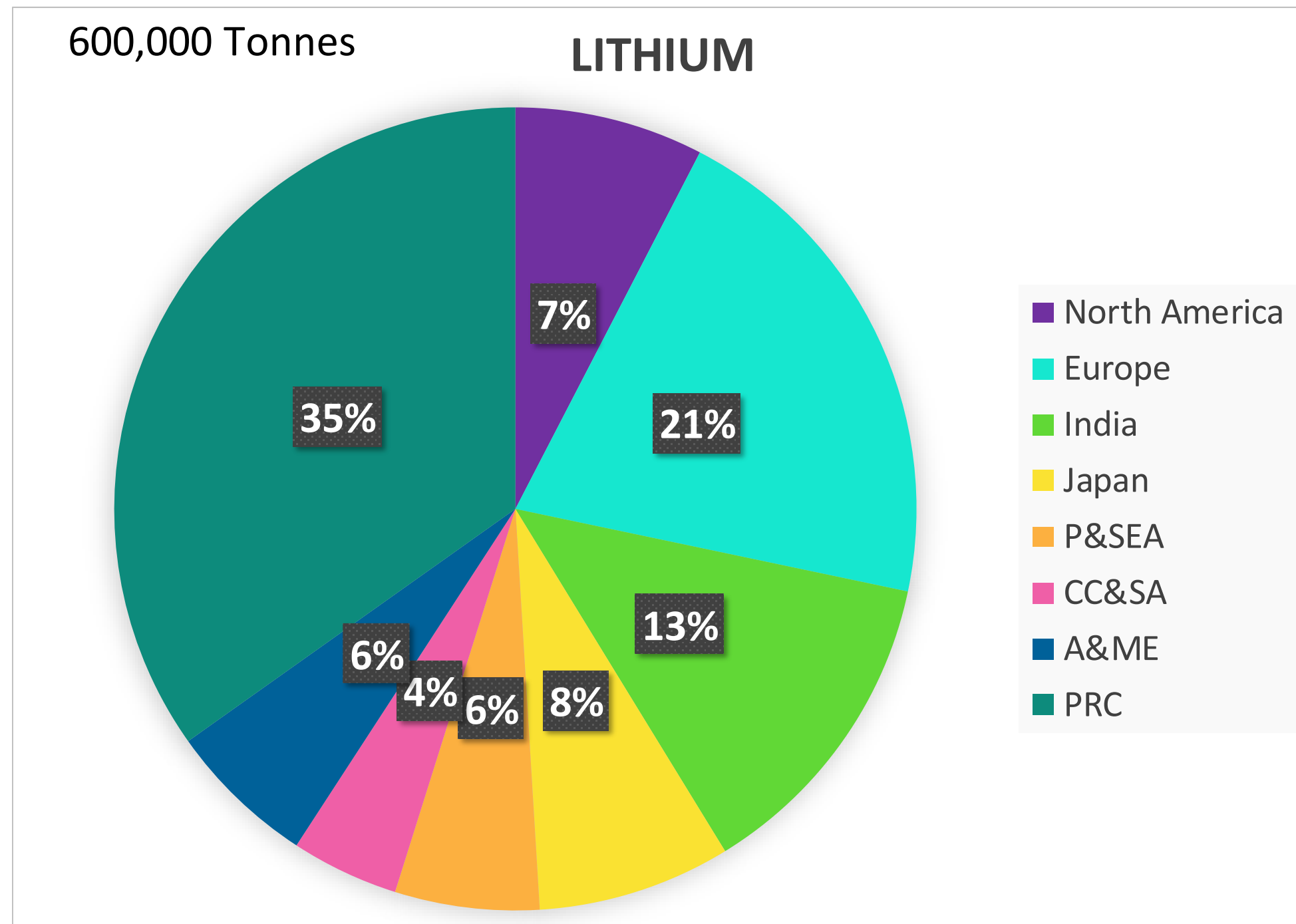
GLOBAL PRODUCTION

Lithium and Lithium Complex Grease dominate with 72% of the total production or 850,000 Tonnes p.a. combined

- 600,000 Tonnes p.a. Lithium
- 250,000 Tonnes p.a. Lithium Complex
- 72,000 Tonnes p.a. Polyurea



LITHIUM GREASES



CC&SA Caribbean, Central and South America

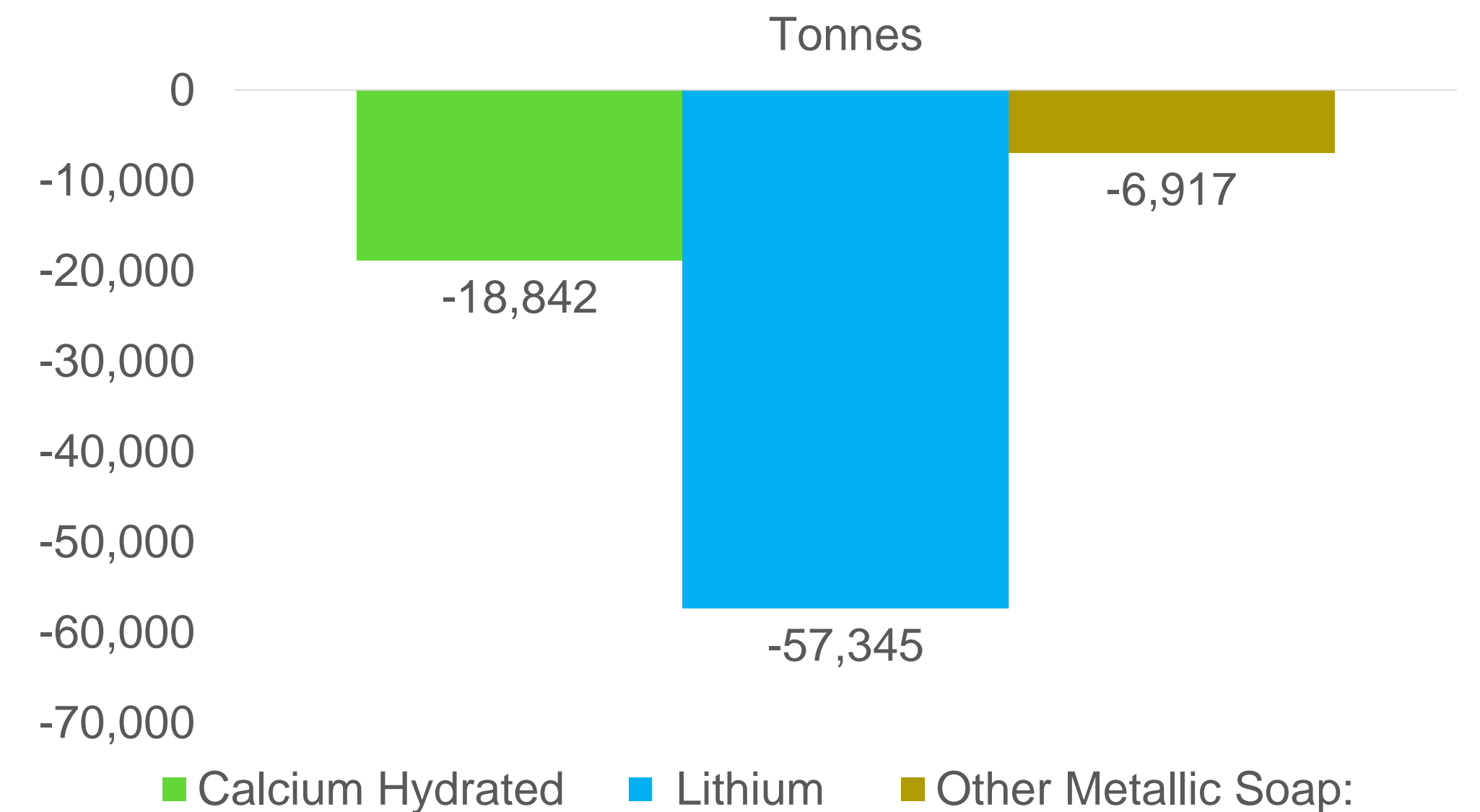
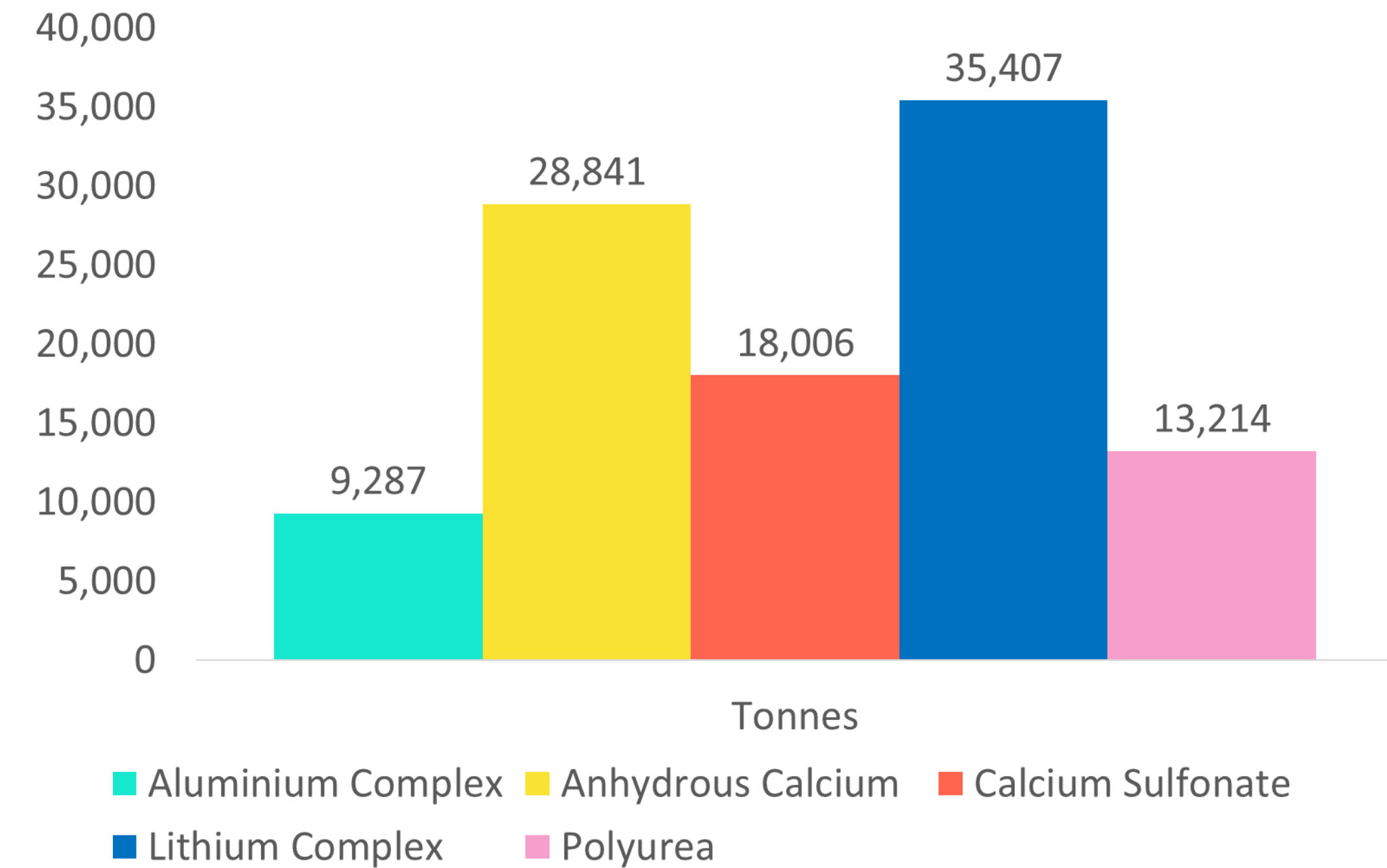
A&ME Africa and Middle East

P&SEA Pacific and Southeast Asia

MARKET TRENDS

Six year movement (2012-2018) shows:

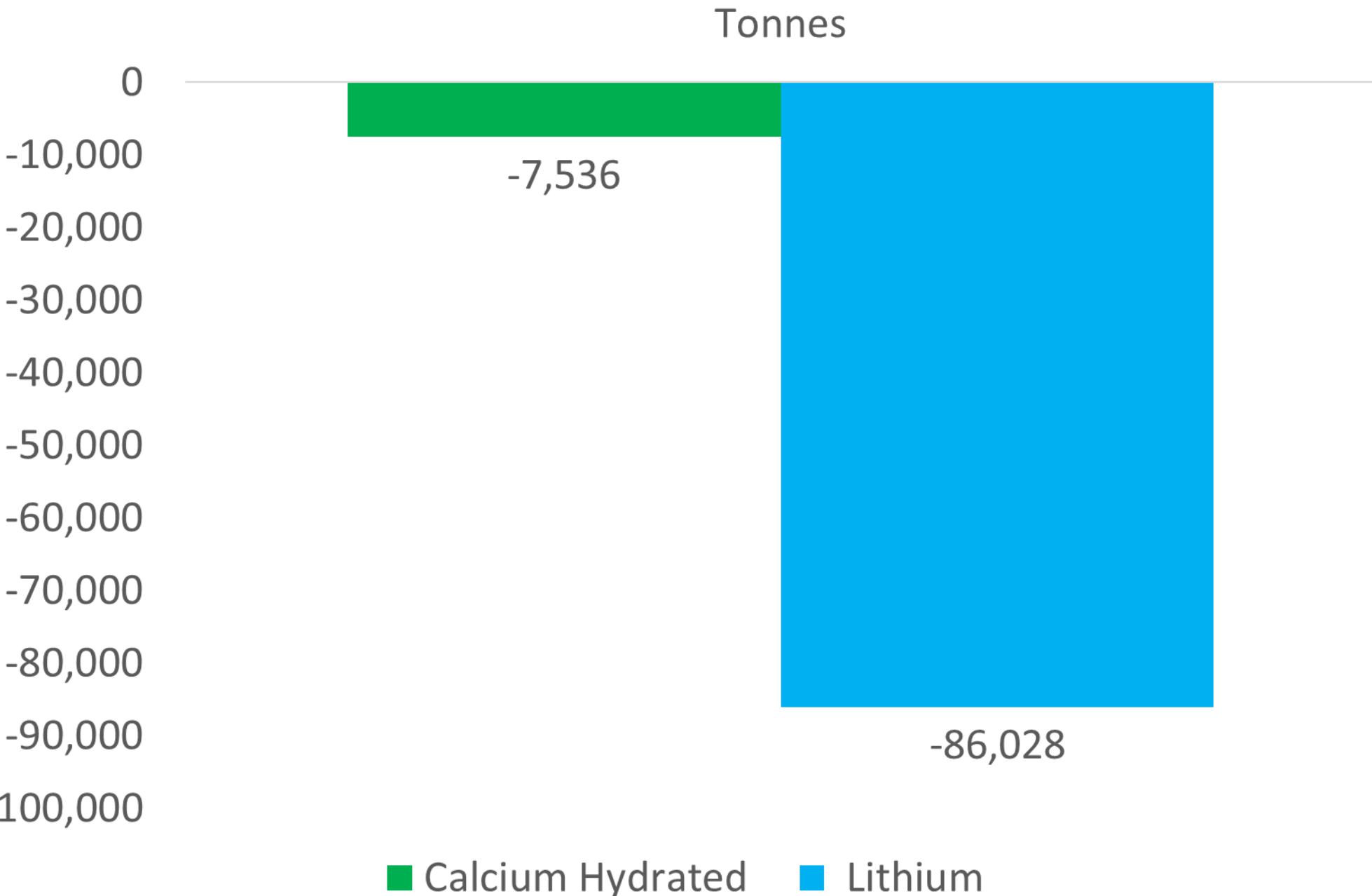
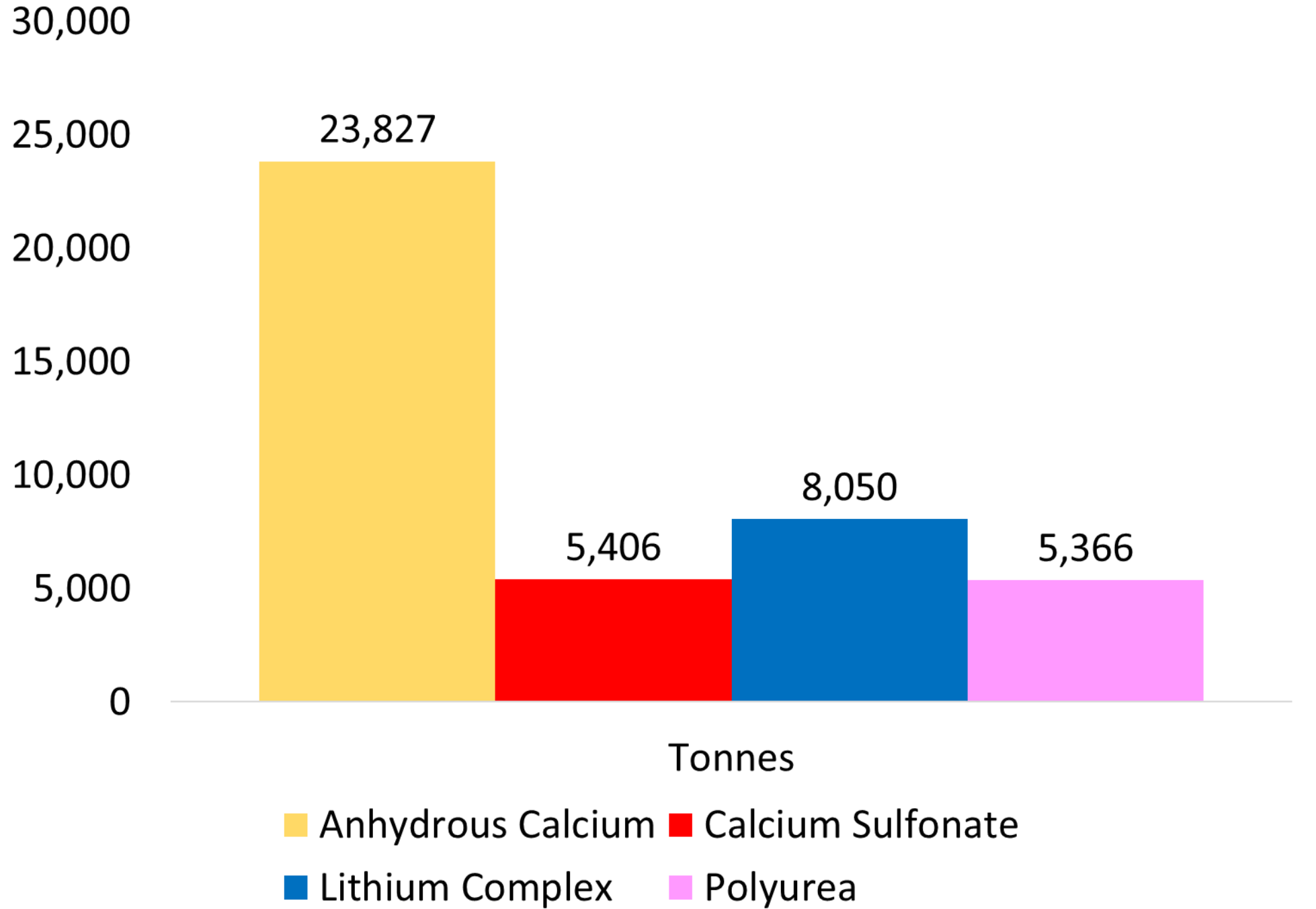
- Decline in simple Lithium (Lithium 12-hydroxystearate) based grease
- Increase in Lithium Complex grease
- Decline in simple Hydrated Calcium
- Increases in Anhydrous Calcium and Calcium Sulfonate greases
- Growth in other higher technology eg Polyurea, Aluminium Complex greases



CHINA

Six year movement (2012-2018) shows:

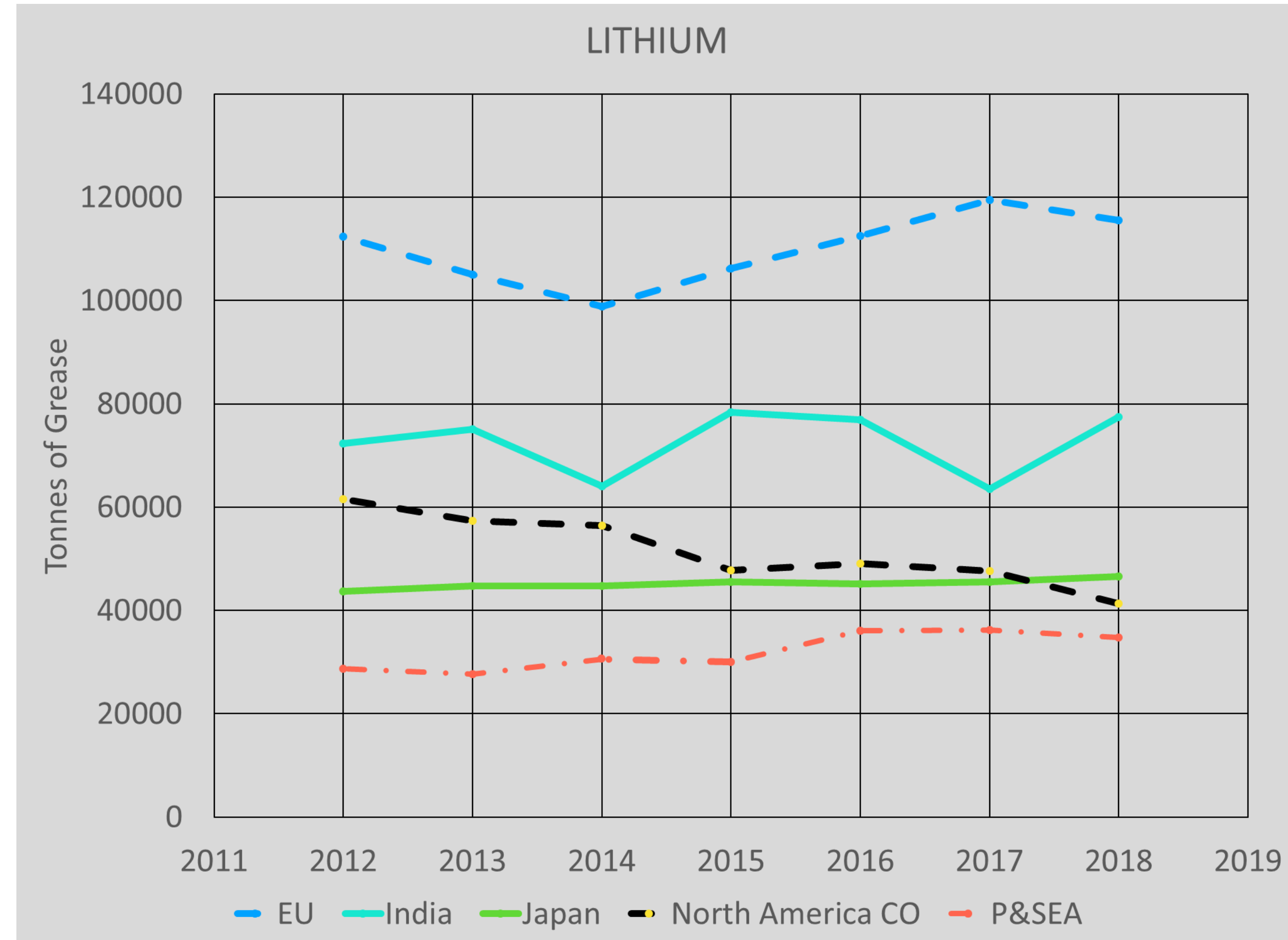
- Move away from Lithium based grease
- Overall PRC showed a decline by 7% in 2018
- 8 Chinese companies did not participate in the survey
- However, Lithium has shown a steady decline over 5 years



OTHER MARKETS

Six year movement (2012-2018) shows:

- EU has had an increase Higher value products and recent decline in Lithium
- North America continued decline in Lithium and increase in higher value products
- India recent growth in Lithium
- The Pacific and South East Asia show growth in Lithium Complex and Calcium Sulfonate, recent decline in Lithium



MARKET TRENDS

Summary 1:

- Worldwide grease production declined slightly in 2018
- **China** accounts for over a **third** of grease production and growth continues
- There is increased production of **higher performing** and more expensive greases
- Lithium and Lithium Complex still account for **72%** of production
- Lithium has **declined** but still represents over **half** of all greases produced



THE DRIVERS

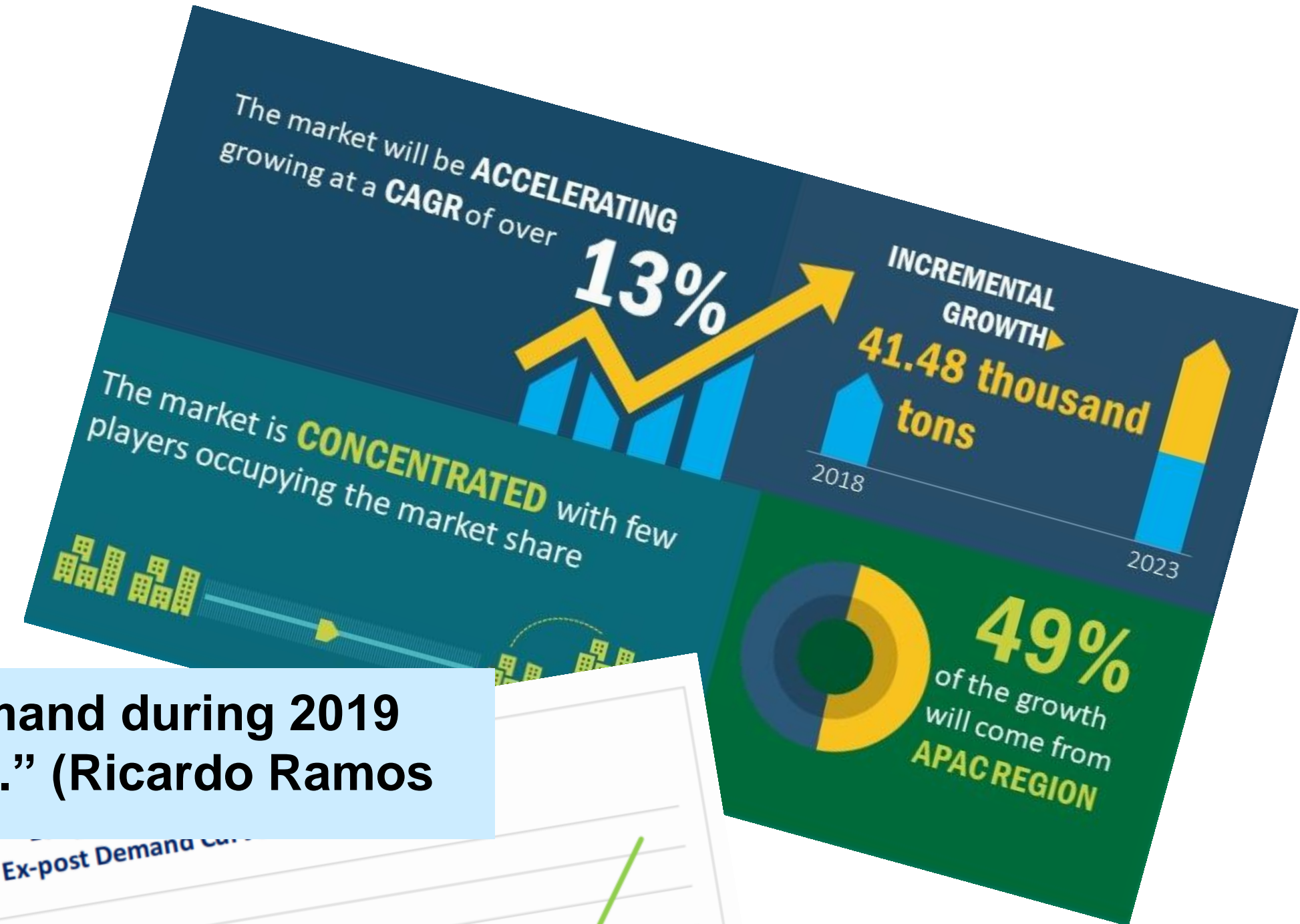
2. Analyse the drivers influencing the movement from using **Lithium-based** greases

- Lithium Hydroxide Supply
- Higher Performance Market Needs



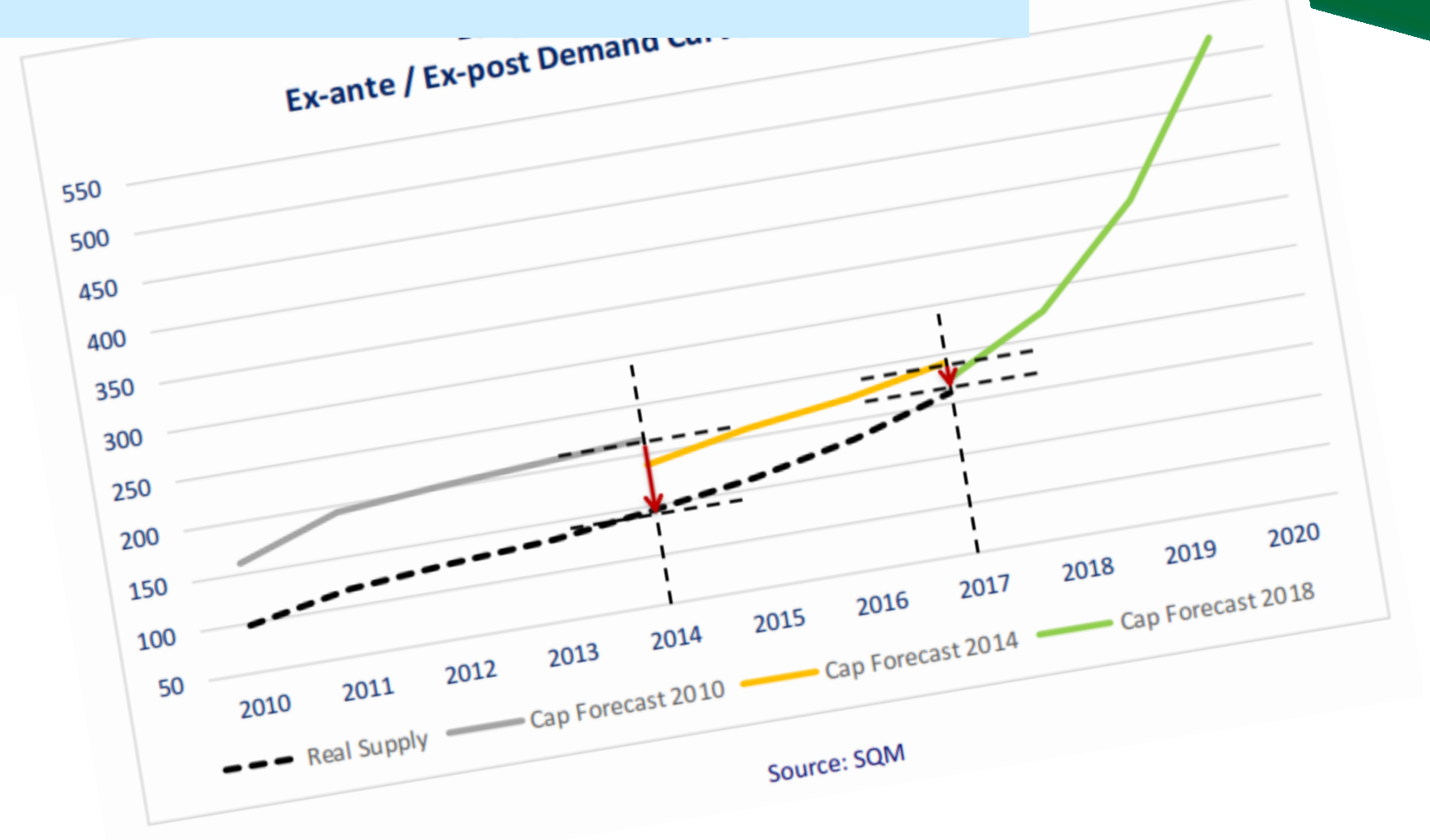
LITHIUM SUPPLY

Lithium ion battery demands and a discussion of lithium supply crisis: How worried should we be?
 Dr. Raj Shah and Ms. Shana Braff
 Koehler Instrument Company
 Holtsville, NY, USA



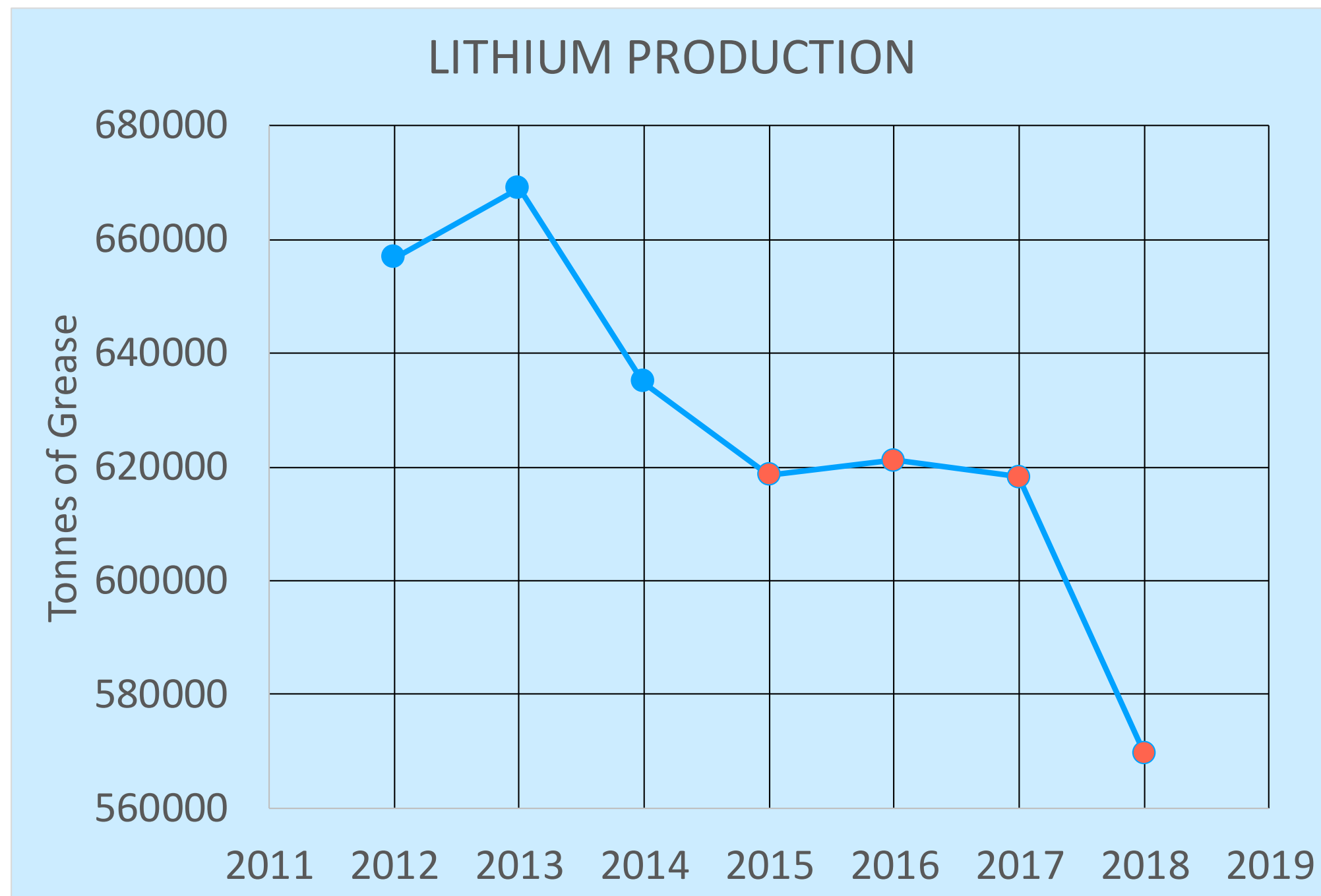
Lithium supply is set to continue to ...outpace demand during 2019 which will ... continue to have an impact on prices.” (Ricardo Ramos SQM AUG 2019)

Will the world suffer a lithium crisis?
 The foreseeable surge in demand for batteries in electric cars raises the following question: will global lithium production keep up with global demand?
 5 December 2017 Didier Julienne



LITHIUM PRICE

Lithium Hydroxide Price could have a short term impact



● Lower comparative production data used for 2015-2018 – continued participants in survey



Lithium commodity stock price decreased 7.25 points or 6.78% since the beginning of 2019

Lithium reached an all time high of \$157.11 (USD) in Feb 2018 and low of \$62.79 in Feb 2016. (Trading Economics)

Will Lithium production grow now price has dropped?

PERFORMANCE

Lithium Complex uses 1.5-2 times Lithium Hydroxide than Simple Lithium

Lithium Complex up CAGR 2.4%

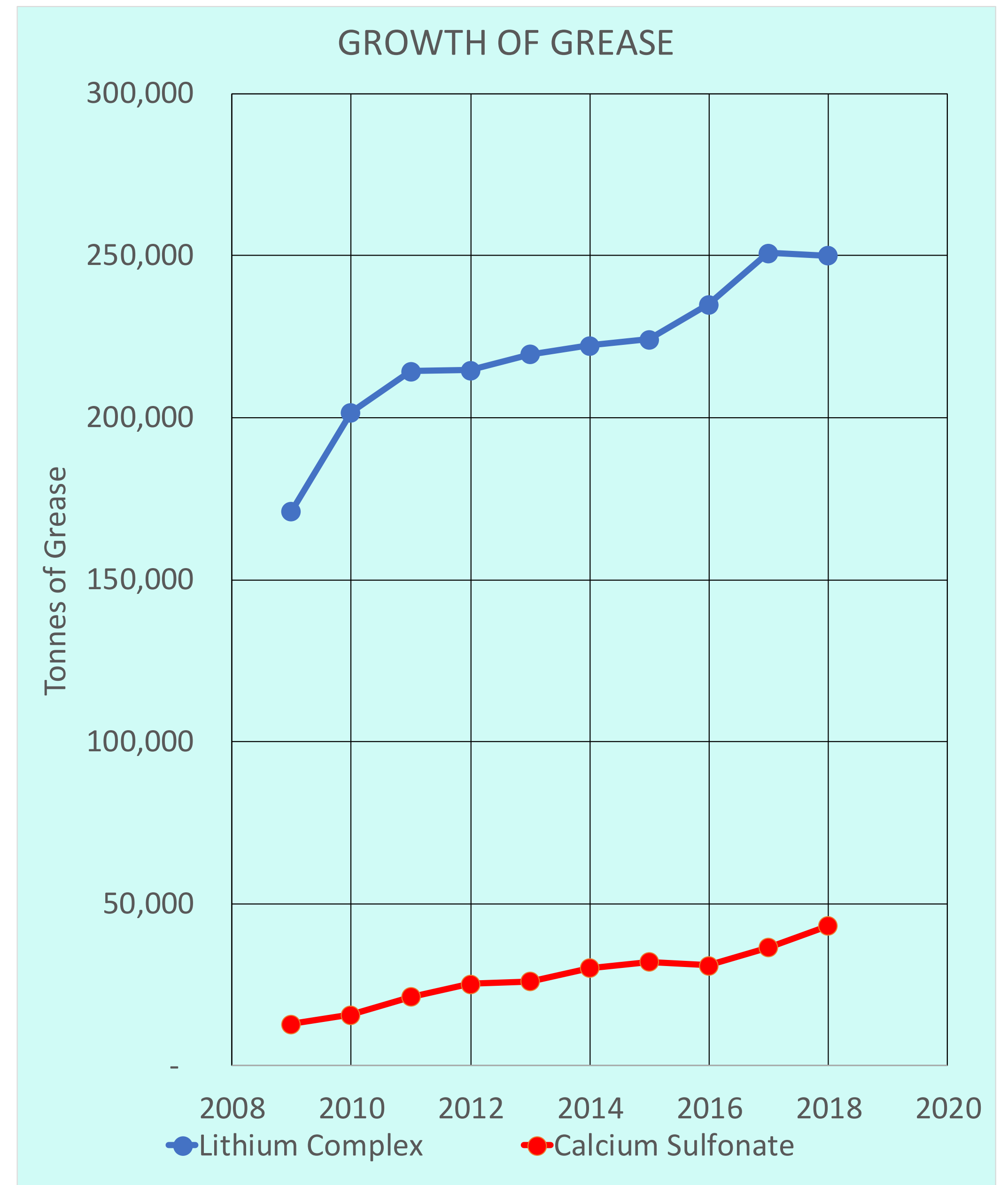
Simple Lithium down CAGR -1.7%

Performance, not initial price is most likely driving the change

Calcium Sulfonate CAGR of 13%

Aluminium Complex CAGR 3.1%

Polyurea CAGR 2.2% (EU 9.7% Japan 1.6% China 0.8%)



MARKETS NEED PERFORMANCE

Existing markets and emerging markets are demanding **higher performance and driving** the move away from Simple Lithium and other simple greases.

These markets include:

- Wind Energy
- Automotive and Electrical Vehicle
- Mining and Agriculture
- Other Extremes – eg Steel & Paper Mills

Other Markets such as Food Grade where Lithium Grease is not suitable will continue to grow e.g. Aluminium Complex, Calcium Sulfonate, Clay, Polyurea



MARKET NEEDS

Higher Performance requiring greases that

- Have longer re-greasing intervals
- Performance in more demanding operation conditions
- Are suitable for use remote delivery or centralised automated grease delivery systems
- Consider total lubrication costs rather than just product costs

This translates to a requirement for

- Longer component life
- Higher Temperature performance
- Shear stability
- Oxidation Stability
- Pumpability
- Other application specific requirements eg water tolerance, rust, corrosion, extreme-pressure



DRIVERS

Summary 2:

- Emerging and existing markets require **higher performing** products
- These may have higher initial cost but **lower total** maintenance cost
- Lithium Hydroxide **price** may have had a short term impact on Lithium Grease demand



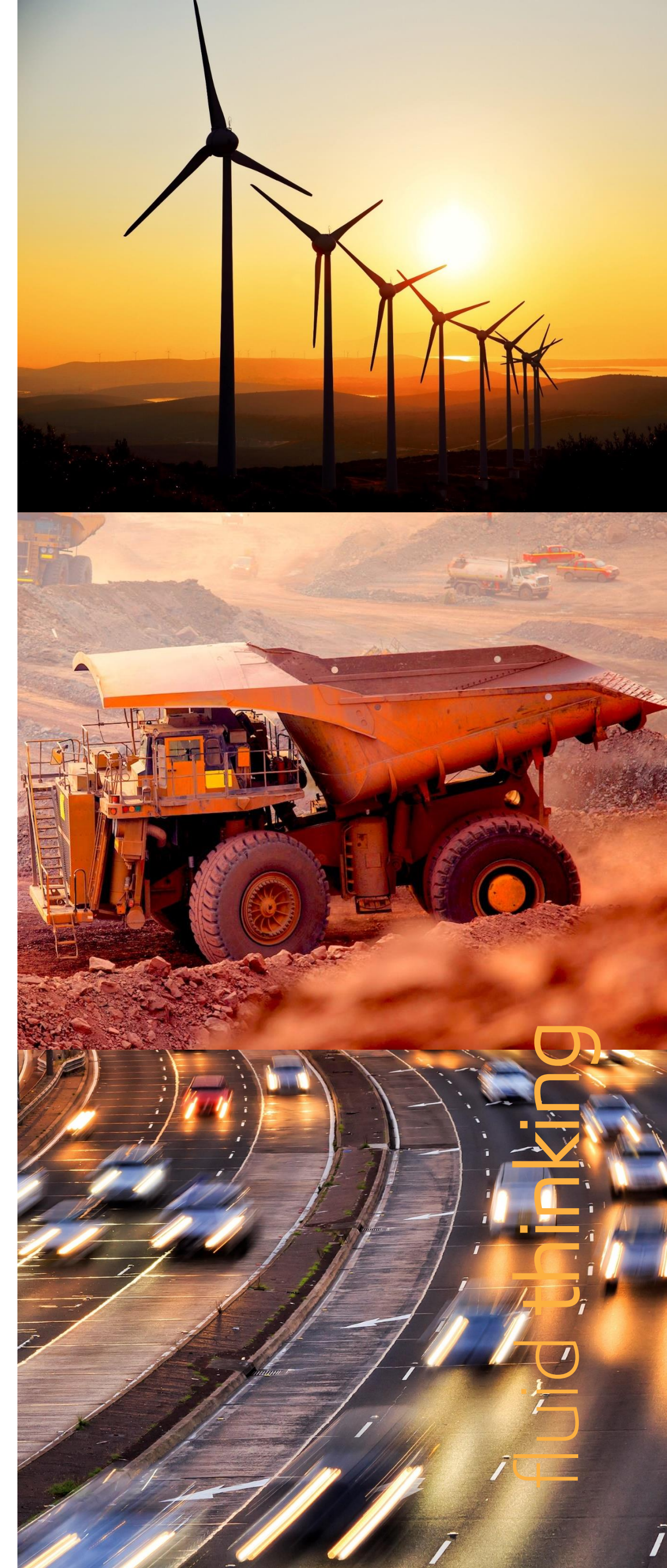
GREASE SPECIFICATION

3. Evaluate **grease specifications** for optimum machinery protection in light of this shift.

Examples:

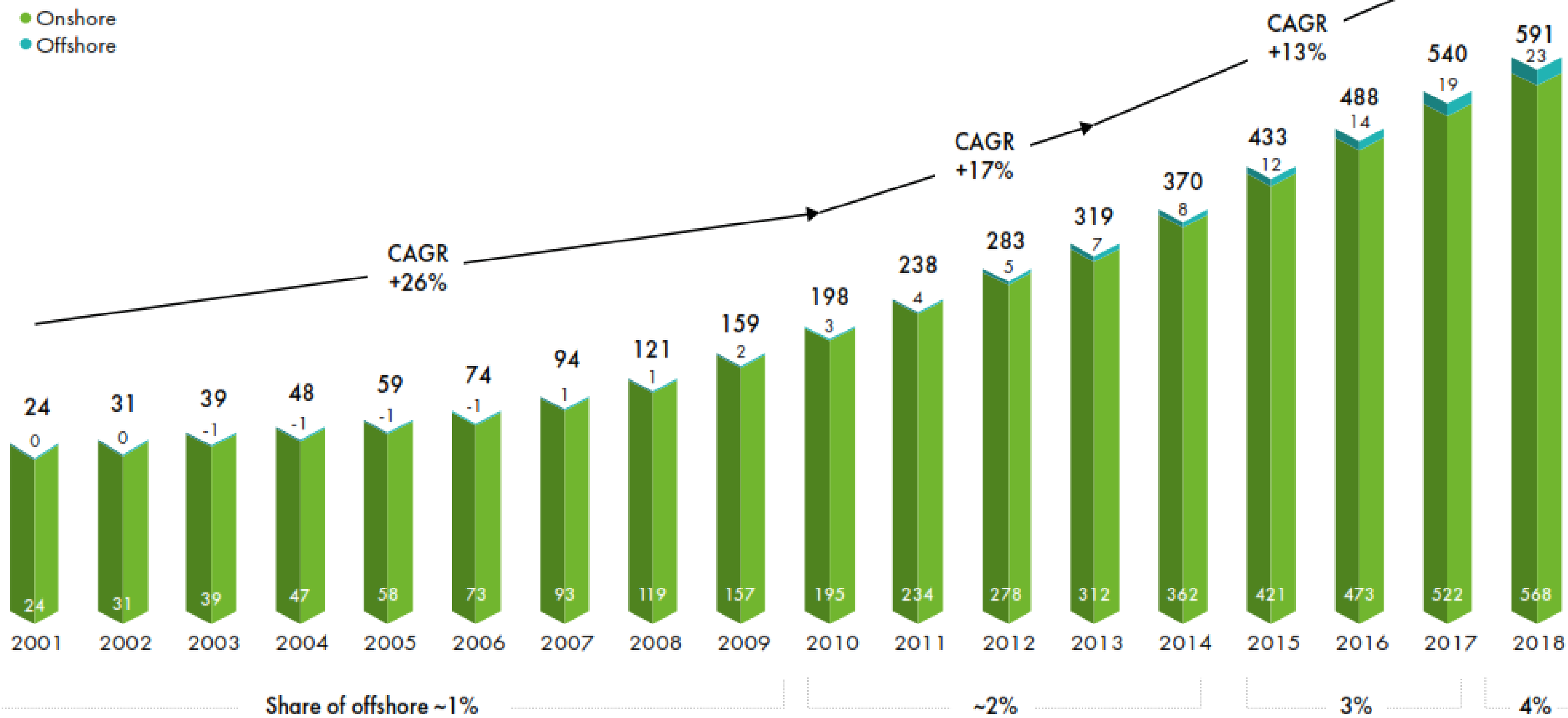
- Wind Turbines
- Automotive
- Steel Mills
- Mining and Agriculture

Improving Lithium to meet mining grease specification



WIND TURBINES

Historical development of total installations x 1,000 GW



Offshore represent 4% of the historical total and 8% of 2018 installations

TURBINE REQUIREMENTS

Grease Applications include the **main** shaft bearing, **yaw** drive bearings and the **blade pitch** bearing[†].

- Challenging the environmental and physical conditions
- Remoteness and relubrication heights particularly offshore

Performance Requirements.

- Extended life – longer service intervals
- Reduced downtime and maintenance costs
- Good lubricity for reduced energy consumption
- Operates in temperature extremes - high and low
- Resistance to hostile aqueous environment
- Resistance to rust, wear and corrosion
- Suitable for centralised lubrication systems or local delivery systems
- Resistance Vibration – potential for fretting corrosion (unlubricated) or false Brinelling

Source: † Dr Fish ELGI Athens Greece 2019

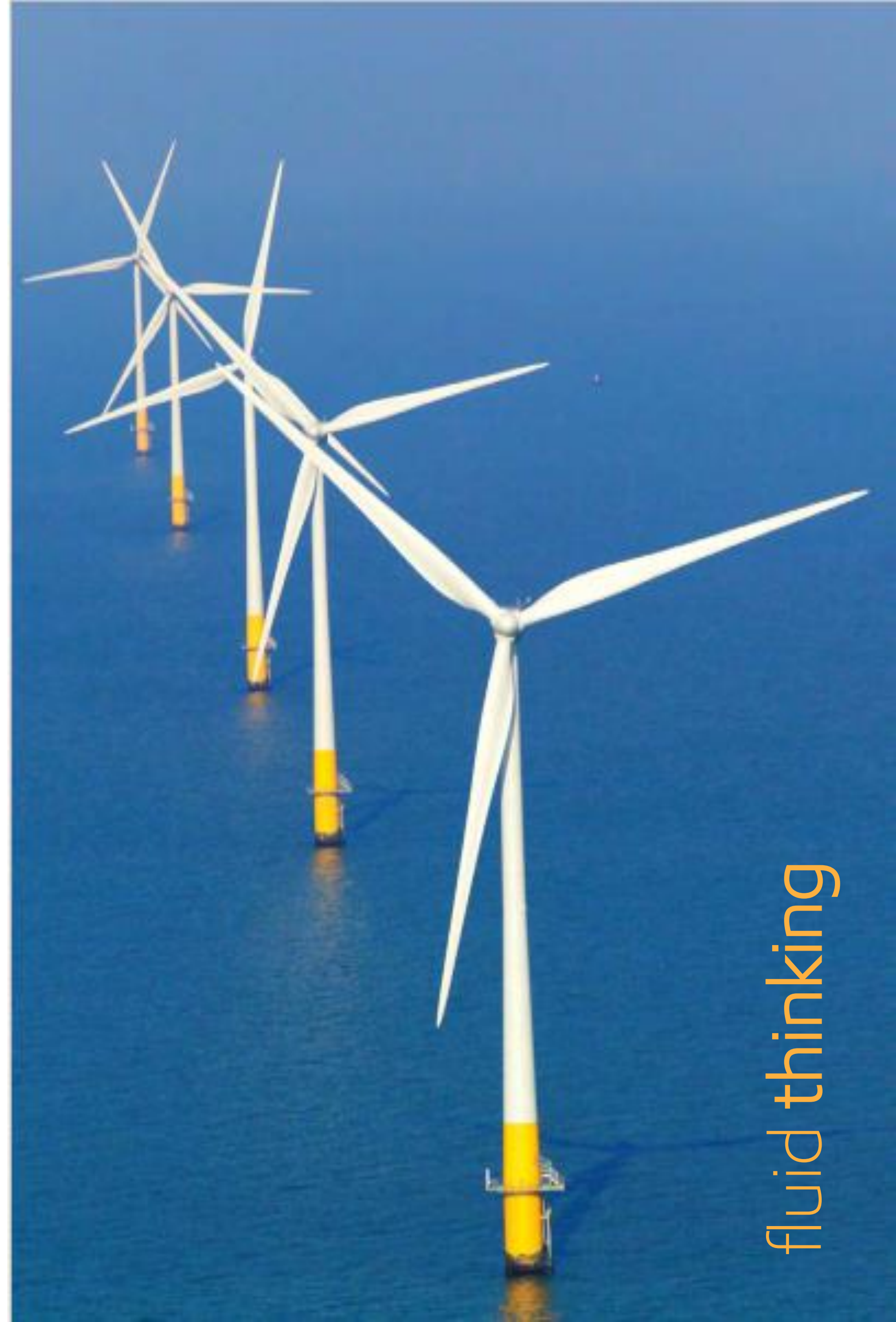
The development of Lubrication Greases for Wind Turbine Applications



SPECIFICATION

Examining 7 commercial greases used in **Main Bearing Application**

- NLGI 1-2 -**Synthetic** base oil
- Thickeners (Lithium Complex , Calcium Sulfonate, Modified Lithium)
- BOV 460 cst @ 40 °C
- -40°C to 130°C operating temperature range
- Dropping Point (D 2265) >250 °C
- Flow pressure (Kesternich)1400 mbar (DIN 51805) <-40 °C
- Emcor Rust Protection (D6138) 0,0
- Water Washout (D1264) <5%
- EP properties (D2598) 4 Ball 250-500kg
- Fretting wear resistance (SRV) False Brinelling (IME Riffle test)



AUTOMOTIVE REQUIREMENTS

There has been a push toward sealed for life bearings. Polyurea greases, Japan (24,000 Tonnes), preferred in this application and other automotive applications such as CV joints. China, NA and EU are also large Polyurea producers.

Polyurea greases have

- inherent oxidation stability
- thermal stability
- excellent water resistance
- low oil bleed characteristics

With 3 to 5 times the life expectancy they will displace Lithium, Lithium Complex particularly at the OEM level.

Longer life has reduced servicing requirements.

The uses of Polyurea is expected to grow particularly in China (20,000 Tonnes) which has seen rapid growth in the Automotive sector



AUTOMOTIVE- CAR

MANUFACT

China has become the dominant player.

Expect to see an increase in Polyurea consumption and manufacture.

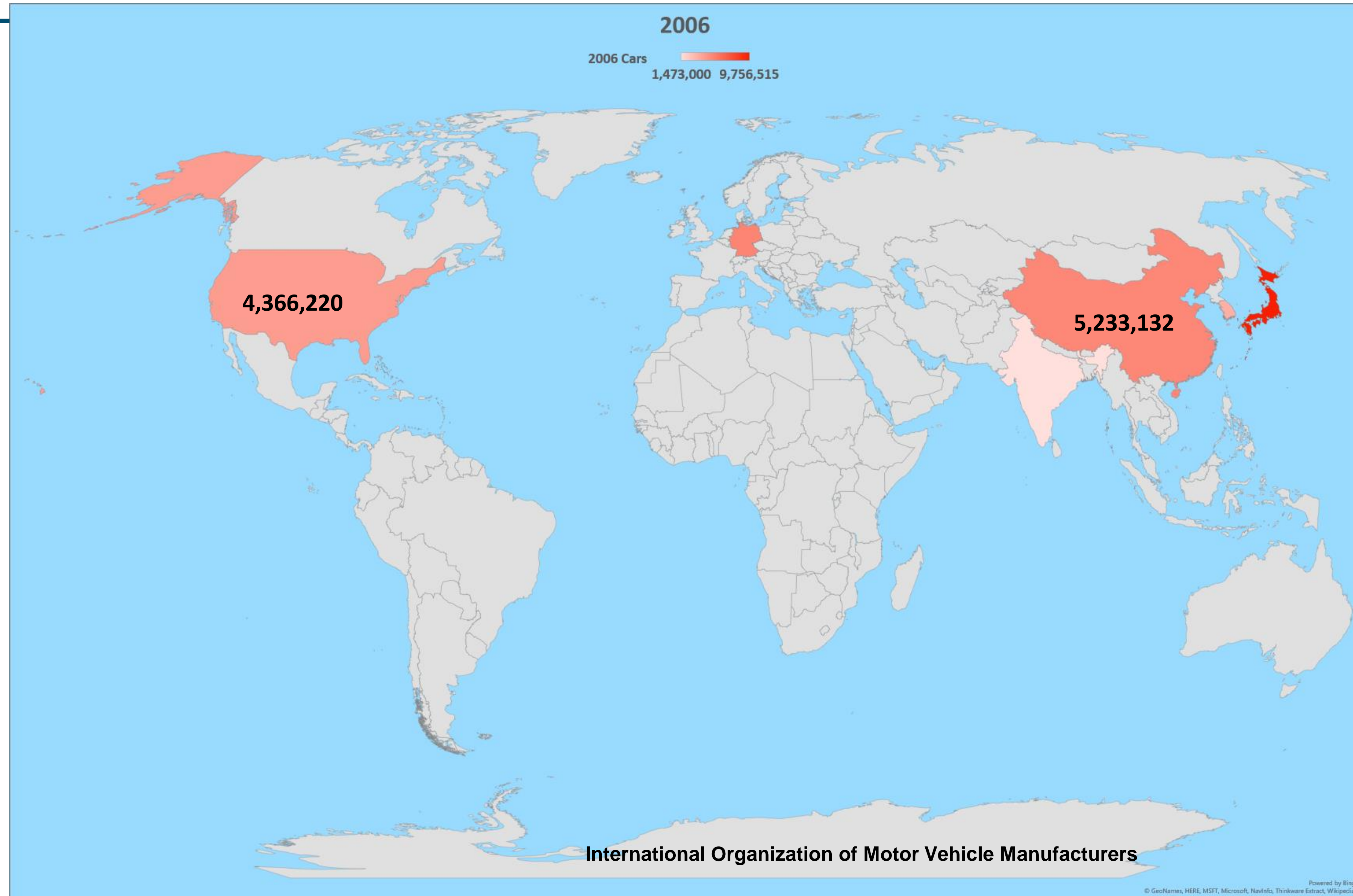
12 year Trends (2006-2018)

Japan 9.7M - 8.3M

Germany 5M - static

Korea 3.5M -static

India 1.5M to 4M



SPECIFICATION

Working Groups at ELGI and NLGI are looking at Test Methods and the automotive grease specifications.

ASTM – D4250- Automotive service-fill applications.

NLGI – The future of the **GC-LB** specification (Dr G. Fish – Lubrizol)

Automotive service greases are classified into two general groups.

- “G” prefix for service lubrication of axel and wheel bearings”
- “L” prefix (chassis greases) ball joints, steering pivots, universal joints, and other chassis components

For vehicles operating under mild to severe duty, the Automotive Specification is GC-LB



SPECIFICATION (CONT)

NLGI have a 10 year plan to replace GC-LB so that it is more relevant to the grease industry.

- Is there a need for a performance standard for automotive service when 90% of applications are sealed for life requiring no service?
- Many OEMs think that current performance standard is inadequate

NLGI is examining an improved general multi purpose grease specification and addition specifications with performance increases in select areas

- Water Resistance
- Salt Water Corrosion Resistance
- High Load Carrying Capacity
- Longer Life



TEST METHODS

Acceptable Tests

D217 Cone Penetration
D1264 Water Washout
D1742 Storage Bleed
D1743 Rust
D2266 4-Ball Wear
D2596 4-Ball EP

Problematic Tests

D2265 and D566 Dropping Point
D3527 High Temperature Grease Life+
D4290 High Temperature Grease
Leakage
D4170 Fretting Wear
D4289 Elastomer Compatibility
D4693 Low Temperature Torque

Tests need to represent true long term bearing life and be relevant to current bearing configurations.



STEEL MILLS

Suitable greases are grease that have high temperature and water resistance performance attributes such as **Aluminium Complex** and **Calcium Sulfonate**.

1. ExxonMobil* in China. Replace **Lithium** with **Lithium Complex** >adhesion and < water washout Reduced bearing failures. Consumption down 60% saving \$61,000/Yr
2. Tata Steel India** – successful replacement of **Lithium** with **Poly Urea** grease. > oxidation stability , >higher temperature <water washout saving \$19,600/yr in lost production
3. Li Jiwei et al , Sinopec+ Used of alkyl naphthalene as base oil in **Calcium Sulfonate** complex grease > high temperature performance > oxidation resistance double the re-greasing period

*ExxonMobil - Steel Rolling Mill Jiangsu P.R. China 2016

**Beat the Heat by J.S Nag Lubes 'N' Greases June 2018 Issue 6

+NLGI Spokesman 82(01) 2018. Li Jiwei et al , Sinopec Lubricant Co. Ltd



MINING & AGRICULTURE

Common mining production equipment include Draglines, Shovels, Dump Trucks and Dozers and various other mobile equipment

Operation conditions

- hot, dry , wet and dusty
- slow moving high load carrying capacity
- resistance to shock loads and vibration

Lithium and Lithium Complex dominant players in Australia and the region. There has been some resurgence of Lithium simple grease

Calcium Sulfonate – with high EP and superior wet performance has gained some traction but, despite higher initial cost, its sector continues to grow globally



REQUIREMENTS

Typical Specification for slow moving bearings and open pinions and slewing rings

- NLGI 2 – Lithium , Lithium Complex and Calcium Sulfonate Greases
- 4 Ball Weld (ASTM D2596) 500 -800 kgf
- 4 Ball Wear scar (ASTM D2266) <0.5 mm
- Base Oil Viscosity @ 40 °C 460-800 cSt
- Good mechanical shear stability
- Good surface adherence with added protection against rust and corrosion
- High water resistance and resistance to contamination
- Boundary lubricant solids e.g. molybdenum disulfide for Extreme Pressure (EP)
- Suitable for central lubrication systems⁺

Similar specification are required for **Agriculture**.



SPECIFICATIONS

This is a Price Sensitive Market with stringent OEM Specifications

Trade off between Cost and Performance

Some OEM's specify 5% molybdenum disulfide

EP additives - a significant cost contributor

However 3% and lower are known to meet the EP requirements

- Graphite- blended with MoS_2 is an even cheaper alternative *
- Calcium Sulfonates – having inherent EP characteristics

Lithium has been used for cost saving and better pumpability

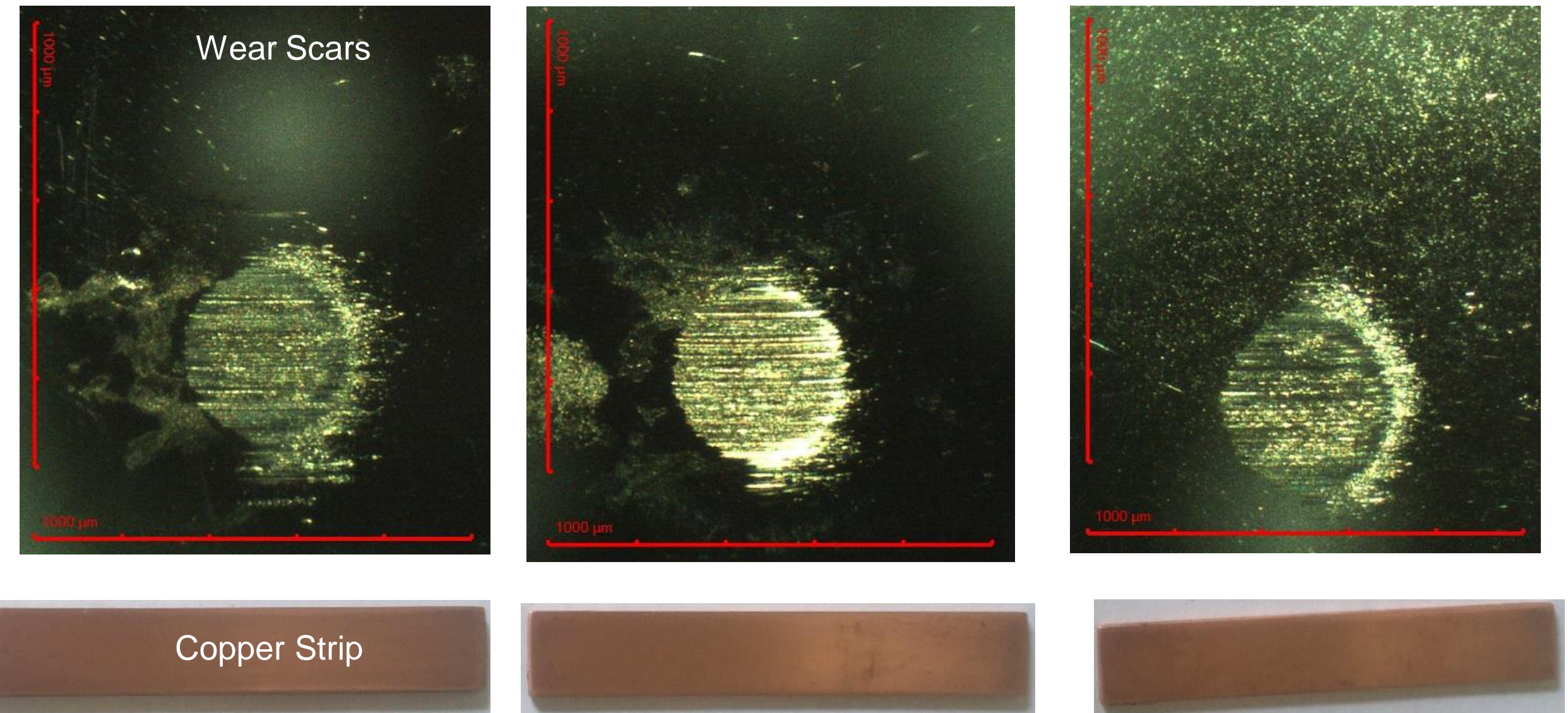
- Opportunity for improving Lithium Greases with Borate chemistry and meet higher specification



IMPROVING LITHIUM GREASE

Borate Esters have been shown to improve the dropping point of Lithium greases but also the high temperature shear performance*

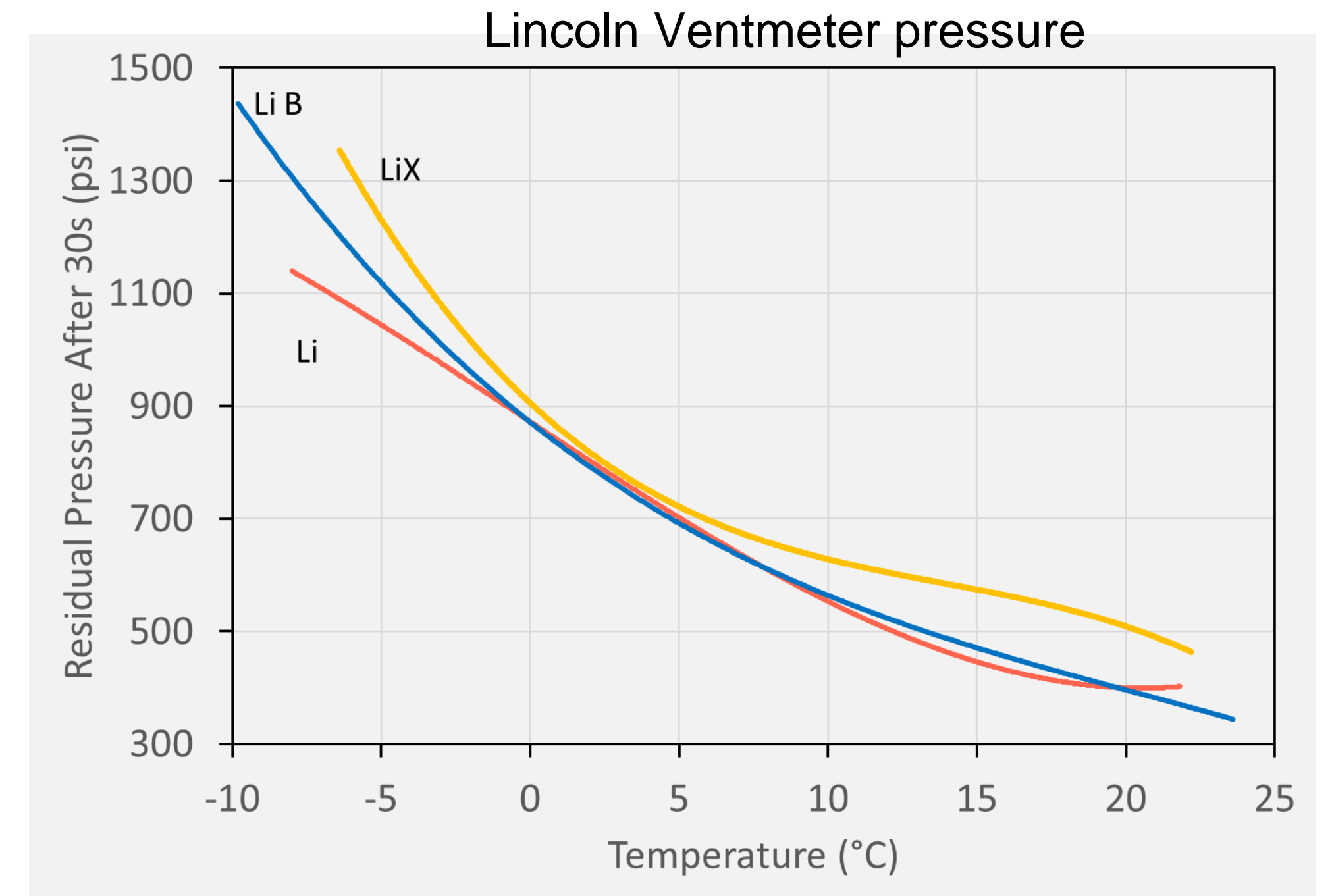
Experiments were conducted to see if the high temperature performance of Lithium mining grease could be improved while maintaining the superior pumpability. An Afton HITEC Borated additive was used



Borate Additive	0%	1%	2%
Weld Load kg	500	400	400
Wear Scar mm	0.42	0.41	0.41
Copper Corrosion	1a/b	1a/b	1a/b
Oil Separation	1.36%	1.31%	1.47%
Dropping Point	197	217	237

IMPROVED LITHIUM GREASE

- Borated additive is shown to improve dropping point while maintain the superior pumpability of Lithium Grease
- Raw Material Cost increase 11%
- Lithium Complex 40% more and longer cycle time.
- Potential to match higher grease specification at a lower cost.



Borate & Sulfurised Ester	Control	3%, 1%	3%, 2%
Weld Load kg	500	400	500
Wear Scar mm	0.42	0.41	0.40
Copper Corrosion	1a/b	1a	1a
Oil Separation	1.36%	1.31%	1.47%
Dropping Point	197	243	241

SPECIFICATION

Summary 3:

Specifications are changing and require **higher performing** greases

Examples include

- Wind Turbines – Temperature Extremes and Long service Intervals
- Automotive – sealed for life bearing
- Mining & Agriculture – High EP loading, dusty wet, hot, dry environments
- Suitable for centralised lubrication systems

CONCLUSION

Changing market needs are requiring **higher performing, higher value** products

- **Specifications** are changing to meet higher performance requirements
- Choosing the right greases for a specific application should result in **lower total** lubrication cost.
- **Lithium** grease has declined but still represents over **half** of all greases produced
- **Lithium greases** will still be the dominant category but higher technology products will continue to grow.
- **China** is and will continue to be the **dominant** grease producer

THANK YOU...

Acknowledgement:

Dr Nekane Reta – Polyurea research

Saad Ahmed – application engineering

Chris Civitella – work on Borated additives

Afton – supply of the Borated additives

