Technology Metals I Advanced Ceramics

The Tungsten value chain @ H.C. Starck

DERA Industrieworkshop Wolfram, Berlin

Our Business Areas

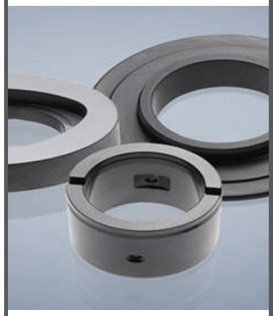
Advanced Metal and Ceramic Powders

- processing technology metals (ore and scraps) into high tech, customized metal powders
- production of ceramic powders for spray coating
- 7 manufacturing sites in Germany, Thailand, Japan, China, Vietnam and Canada

Fabricated Products

- converting technology metal powders into customized semi-finished and finished products
- 6 manufacturing sites in US, UK, Germany, and China

Ceramics



- manufacturing specialized technical ceramic parts and films
- 1 manufacturing site in Germany

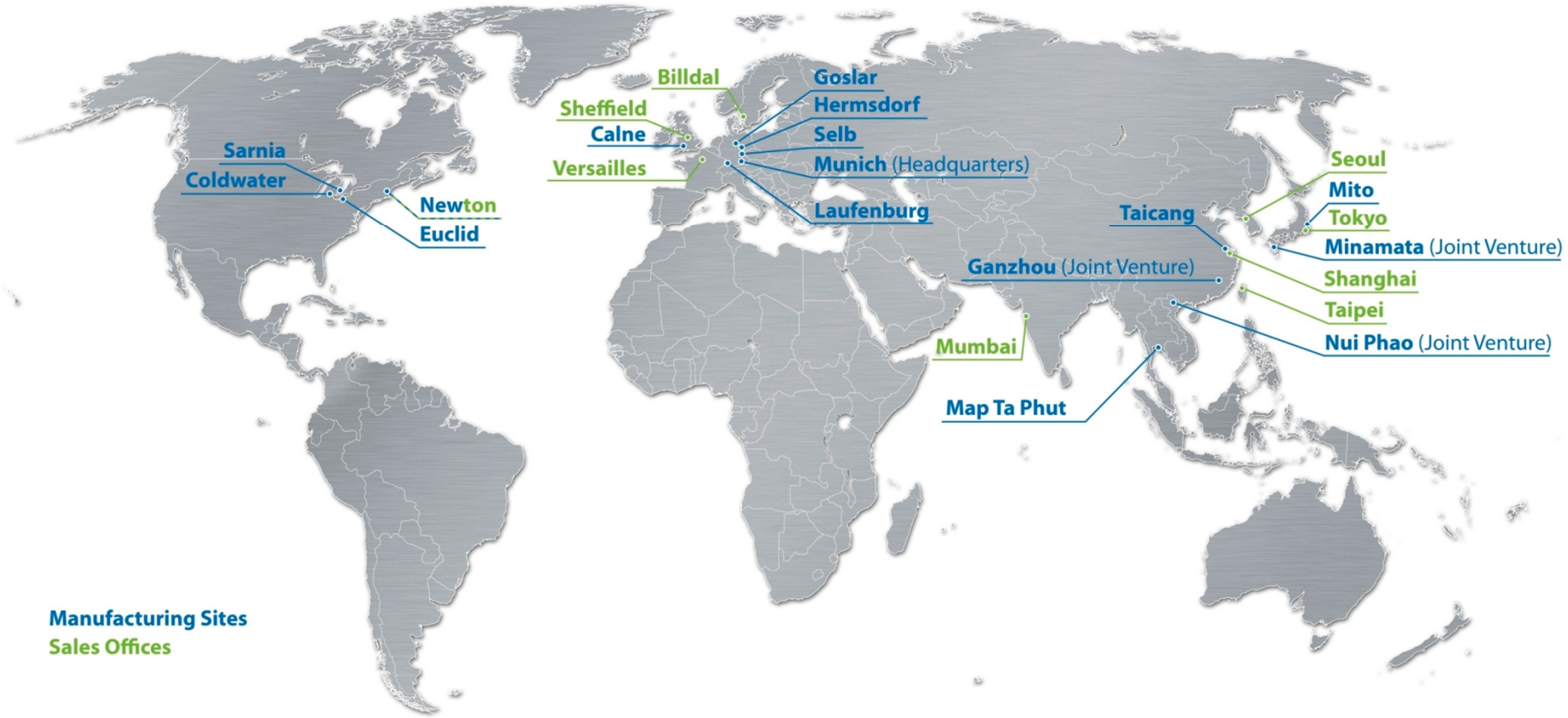
CS Energy Materials

- joint venture of H.C. Starck and Japan New Chisso Corp. for the production of cathode materials for lithium-ion batteries for electric and hybrid cars
- 1 manufacturing site in Japan

Leading know-how to process technology metals and advanced ceramics

Our Global Footprint – close to our customers

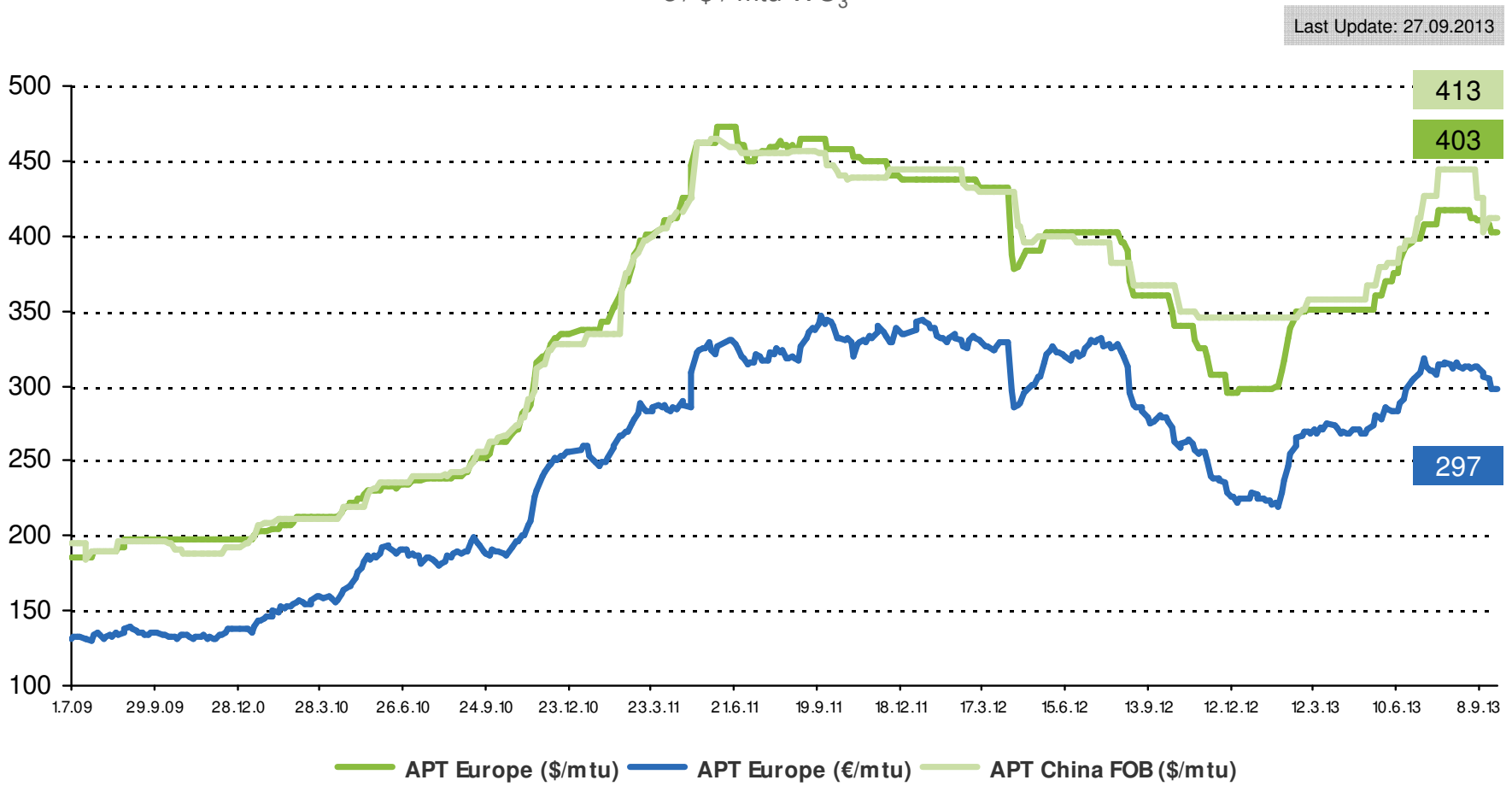
Our Manufacturing Sites and our Sales Offices



Tungsten (APT Notation ex Metal Bulletin)

APT, Ø-daily, Jul 2009 – ytd 2013

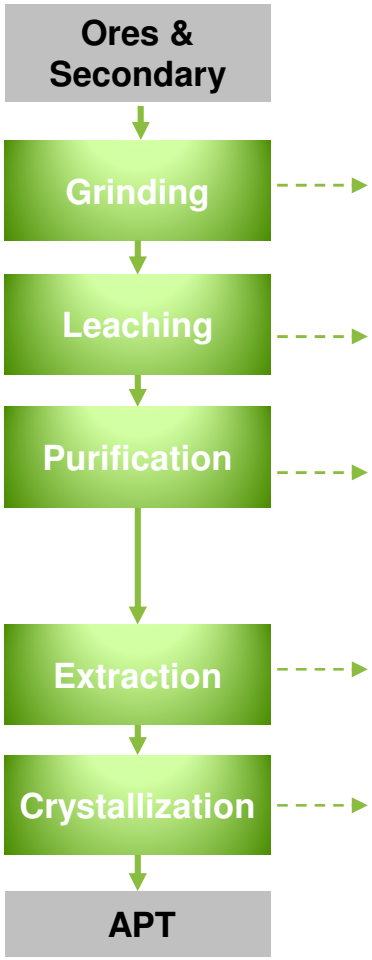
– € / $ / mtu WO_3 –



Sources: Metal Bulletin (Sep 2013) / ECB's Euro foreign exchange reference rates

Tungsten Chemistry – HCST process core aspects

H.C.Starck can process the full range of Tungsten raw materials



usage of energy efficient vibrating mills and **deforming of crystal lattice** to achieve a higher yield in leaching process (**mechanical activation**)

autoclaves with special designed agitators to achieve a **intense contact between reactant (NaOH) and mechanically activated ores**; usage of membrane filter presses to achieve maximum dewatered residuals (increased yield)

two step **removal of critical impurities** like Si, P, Al, F, V, Cr, Mo … by lowering pH values; permanent automatic adaptation of parameters (feed-rates of precipitation reactants) according to continuously fluctuating impurity levels and therefore **preventing of co-precipitation of tungsten** (usage of specific online analytic systems); pre-requisite to dump raffinate in compliance with governmental requirements in extraction process step

solvent extraction (mixer / settler units) to achieve **high purity ATS**

setting of process parameters to achieve a **high purity of APT**

Tungsten Dictionary

Explanation with regard to the usual abbreviations

- ST = Sodium Tungstate
- APT = Ammonium Paratungstate
- BTO = Blue Tungsten Oxide
- YTO = Yellow Tungsten Oxide
- AMT = Ammonium Metatungstate
- WMP = Tungsten metal powder
- WC = Tungsten carbide
- CTC = Cast Tungsten carbide
- FeW = Ferro Tungsten

Availability of Primary Raw Materials (1/2)

Raw material procurement becomes more difficult, due to lack of investments in new mines and reduced secondary raw material availability.

The majority of **Tungsten primary raw material reserves** are located in **China** or **„politically instable“** regions.

Additionally, China's secondary raw material imports from Western industrial nation have been **increasing continuously.**

Exploitation of Primary Raw Materials 2011*
~ % of 68,800 tons Tungsten content

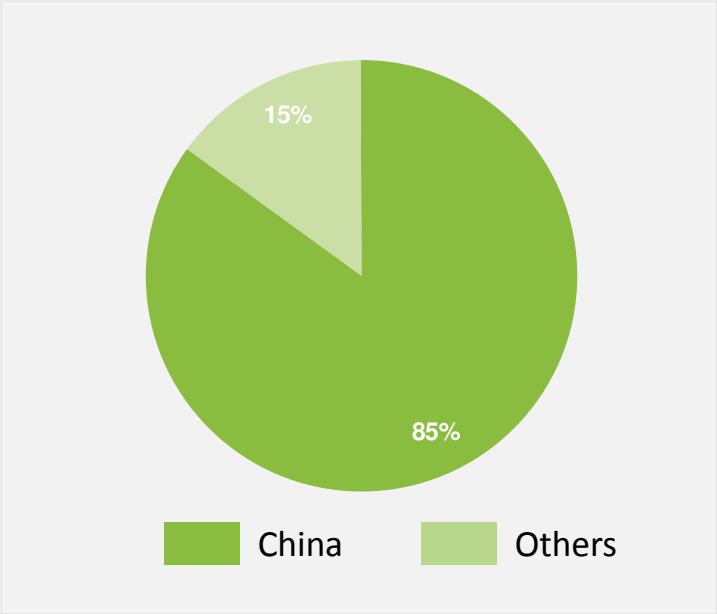
*Figures do not include the United States

Source: US Geological Survey 2013 – Mineral Yearbook 2011

Availability of Primary Raw Materials (2/2)

China is the major producer of primary Tungsten and has even grown its share in global supply from 2008 to 2010.

China's Concentrate Production Share, 2012e
~ % ~



- During the crisis in 2009, non-Chinese supply has dropped significantly and **not returned** to pre-crisis level yet, further increasing China's supply share to estimated **85%** in 2012 (estimated by USGS).
- Due to **continuously increasing demand some mines** which have closed in Australia, South Korea an the USA are now considering **re-opening.**
- In addition, due to current high price levels, renewed interest is seen in a few **new projects**, which were put on hold **during the crisis in 2009**.
- It is still unclear when, if at all, these new projects will start operating.
- Besides primary supply, **scrap recycling** is an important factor in the **world's tungsten supply**. It is estimated that today **some 35% is recycled.**

Source: US Geological Survey / Roskill 2011

Our Raw Materials Supply – sustainable and conflict-free

Two success factors for a secure and stable raw material supply

Primary sourcing

Recycling

With growing recycling activities and certified procurement we ensure a safe, sustainable and competitive raw material supply.

Our Raw Materials Supply – sustainable and conflict-free

Primary sourcing

- H.C. Starck exclusively sources from **conflict-free suppliers**
- Affirmative **certification** by **Electronics Industry Citizenship Coalition (EICC)** on conflict-free Tantalum supply chain at H.C. Starck and **Tungsten Industry Conflict Materials Council** for the Tungsten supply chain
- **Responsible Supply Chain Management System (RSCM)** to ensure conflict-free raw material sourcing, implementation confirmed by external auditor Bureau Veritas
- Projects to **ensure supply from primary sources** through certified and reliable partners (e.g. joint ventures)
- **Long-standing supply relationships** ensuring sufficient supply at competitive prices in structurally tight markets

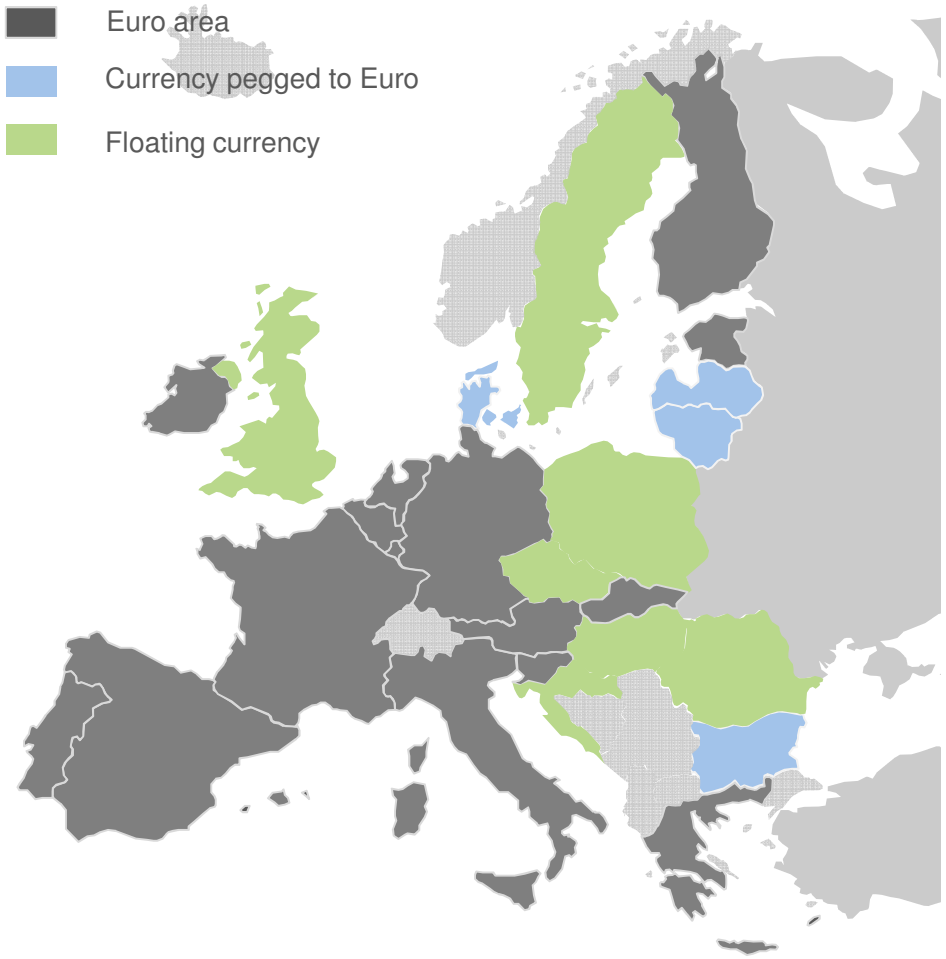
Our Raw Materials Supply – sustainable and conflict-free

Recycling

- Using **innovative technologies**, we are recycling **increasing volumes** of post-industrial waste, slags, and scraps and turning them into high quality and high-performance technology metals
- **Recycling** contributes continuously **increasing share** of raw material
- Recycling enables a **secure, long-term raw material supply with stable costs**

Tungsten Consumption in Europe

A fistful of countries consume about 85% of Europe‘s Tungsten consumption.



74
5828
3680
19.3
W
Tungsten
183.85

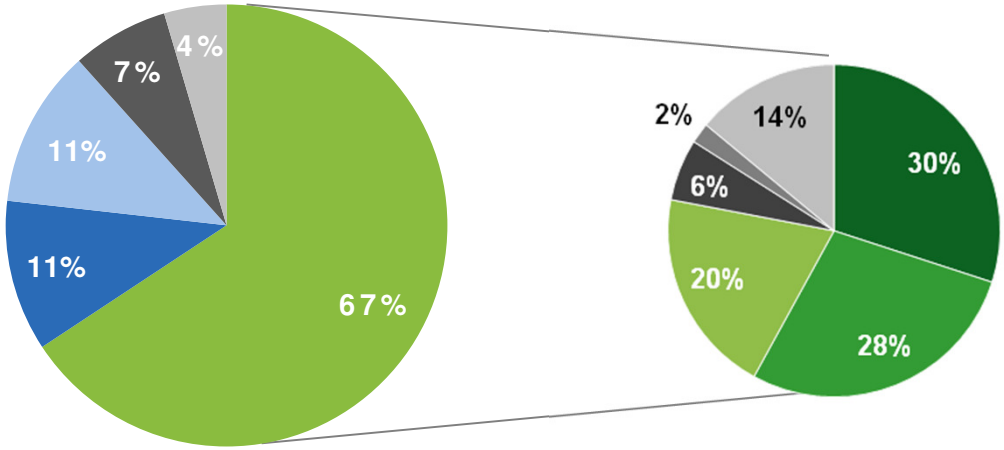
Sweden
Italy
UK
Germany
Austria
Luxembourg
France

~ 85% of European Tungsten Consumption

Tungsten Products Market Sectors

The main application are Hard Metals

Tungsten Consumption, Europe, 2012
~ % WO3 ~



- Hard Metals
- Steel & Superalloys
- Heavy Metal & Mill Products
- W-Chemicals
- Surface Technology
- Round Tools
- Inserts
- Wear Parts
- Mining & Road Construction
- Oil & Gas
- Others

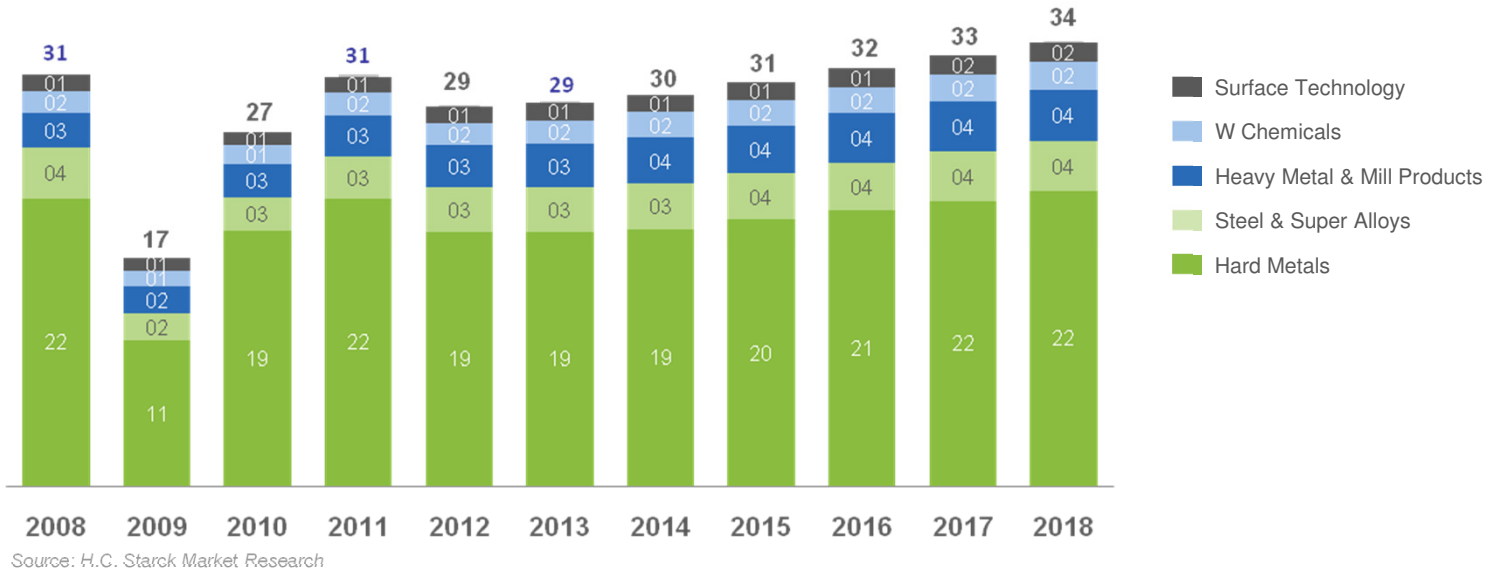
Source: H.C. Starck Market Research

Market Development

Slow market growth projected in the next five years

EMEA Tungsten Demand History & Expectation, Volume 2008-2018e

~ thousand tons WO_3 ~



Source: H.C. Starck Market Research

- In 2013, external demand is the main driver for the European economy. By 2014, domestic demand will be taking over as main demand driver.
- Strong influence of the Tungsten market Europe on the global Automotive, Machine Tools and Mining Industry!
- As a result, Europe Tungsten market outperforms the European Union GDP growth.

Thank you for your attention!