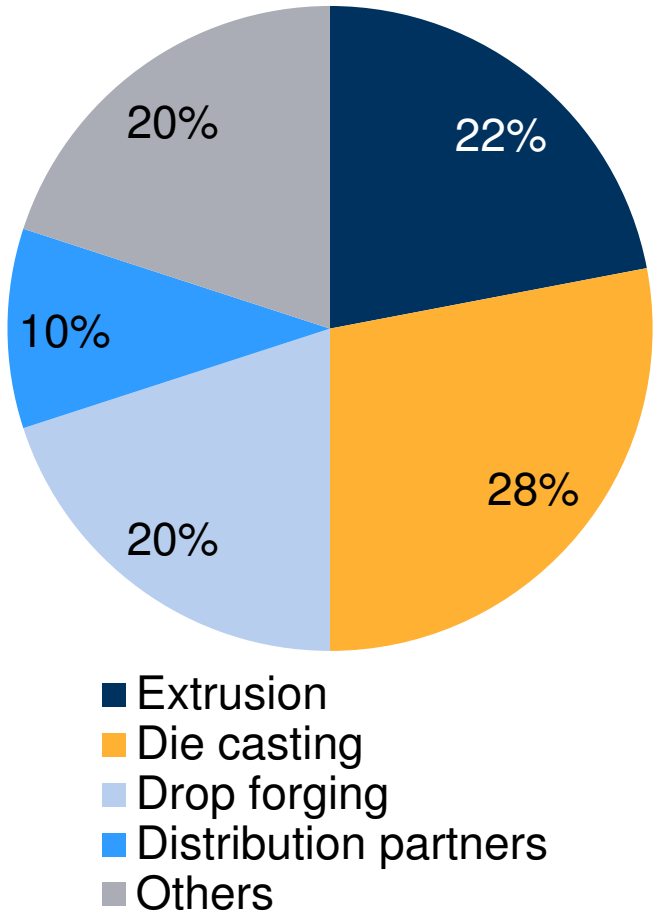
Perspective on tool steel usage in a changing manufacturing world

1. **A short introduction to Kind & Co.**
2. E-Mobility and the effects on tool steel use
3. Changes in the way we move – is car sharing/autonomous driving a growth killer?
4. Additive Manufacturing – the end of economies of scale?
5. Concluding theses

Kind & Co.: Hot work tool steel specialist, global but very down to earth

- Family owned since 1888 – 130 years of experience
- Fully integrated mill in Bielstein, Germany – from steel melting up to near net shape
- Own entities (processing, stocks) in Italy, US, China
- Long-time distribution partners in all relevant markets

Tool steel revenues 2016



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E-mobility is becoming a fact – but when and to what extent?

Most common expectations:

- Main driver: regulation
- Significant increase expected in the production of fully electric vehicles in the next few years
- 30% of total vehicle production number (passenger car) reached between 2030 and 2040
- Peak production of internal combustion engine (ICE) around 2025-2030

Is e-mobility following rational arguments?

Can the development path be derived reasonably?

Most common objections:

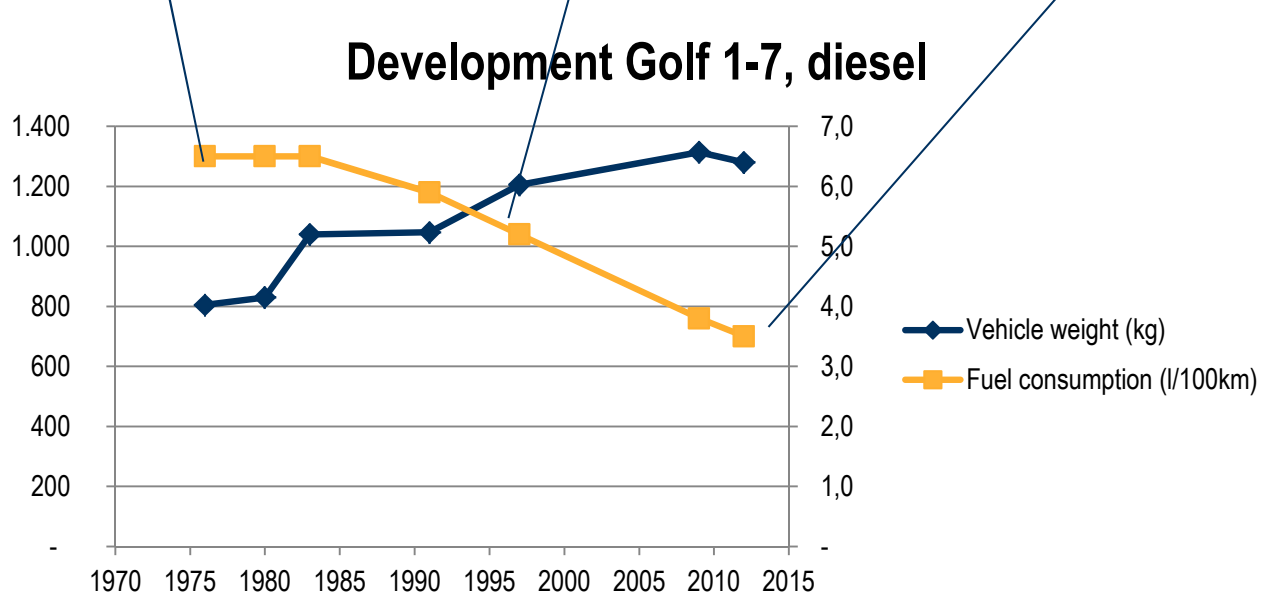
- Customer experience (day-to-day suitability, battery range, charging, …)
- Cost and value stability of the car/battery
- Cost increase for batteries at scale (60-70% raw materials)
- Charging infrastructure not present (30 bEUR investment need only for Paris, London, Milan, Frankfurt until 2030)
- Wheel to well CO2 balance not in favour of battery electric vehicles (BEV)
- …

Source: Deutsche Bank, Alix Partners, Bloomberg (03/2016); Kind & Co.

But then: when has the automotive industry ever been rational?

Example German car manufacturers

- 2/3 of the German home market for passenger cars are company cars that are leased for 3 years
- Company cars: no maintenance cost, no fuel cost. Only buying criteria: price and performance
- As a result: model variety is -to a large extend-
  - High (motor) performance/agility
  - High fuel consumption
  - Complex/ maintenance intensive



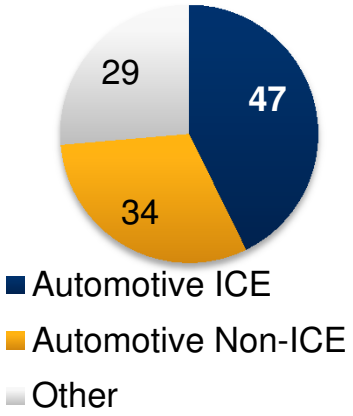
This irrational and ill-incentivized solution has been very successful also outside Germany! Why?

Source: Prof. Dr. Helmers (University of Trier, 2015); Wikipedia, Kind & Co.

Perspective on tool steel use is basically balanced between opportunity and risk

Die forging

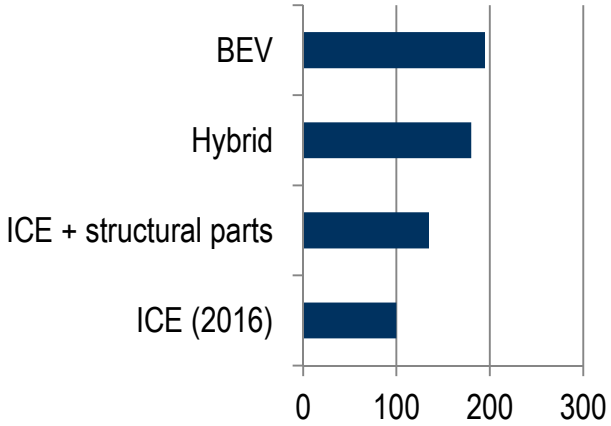
Bottom-up estimate of end use



- In 2030-2040, one third of the directly ICE-relevant parts are substituted by BEV
- Probably, the remaining parts are smaller (downsizing)
- Maybe 15-25% contraction in die forging possible?

Die casting

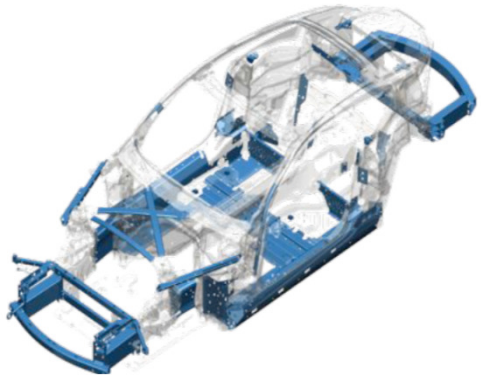
kg of Al cast parts per car



- Weight saving remains a driving force (battery range)
- Potential for growth in, e.g., Al die casting
- Maybe even cross-OEM optimization of battery housing etc.?

Extrusion

Aluminium extrusion profiles for crash load paths and reinforcements



- Be it BEV or ICE, there is a trend for extruded Al profiles especially for crash relevant parts
- The alloys used and the geometry of profiles require premium extrusion die steel (in a formerly perfectly commoditized market)

Source:Aston Martin; LCMS (taken from Gießerei-Kolloquium Dec. 2016); Kind & Co.

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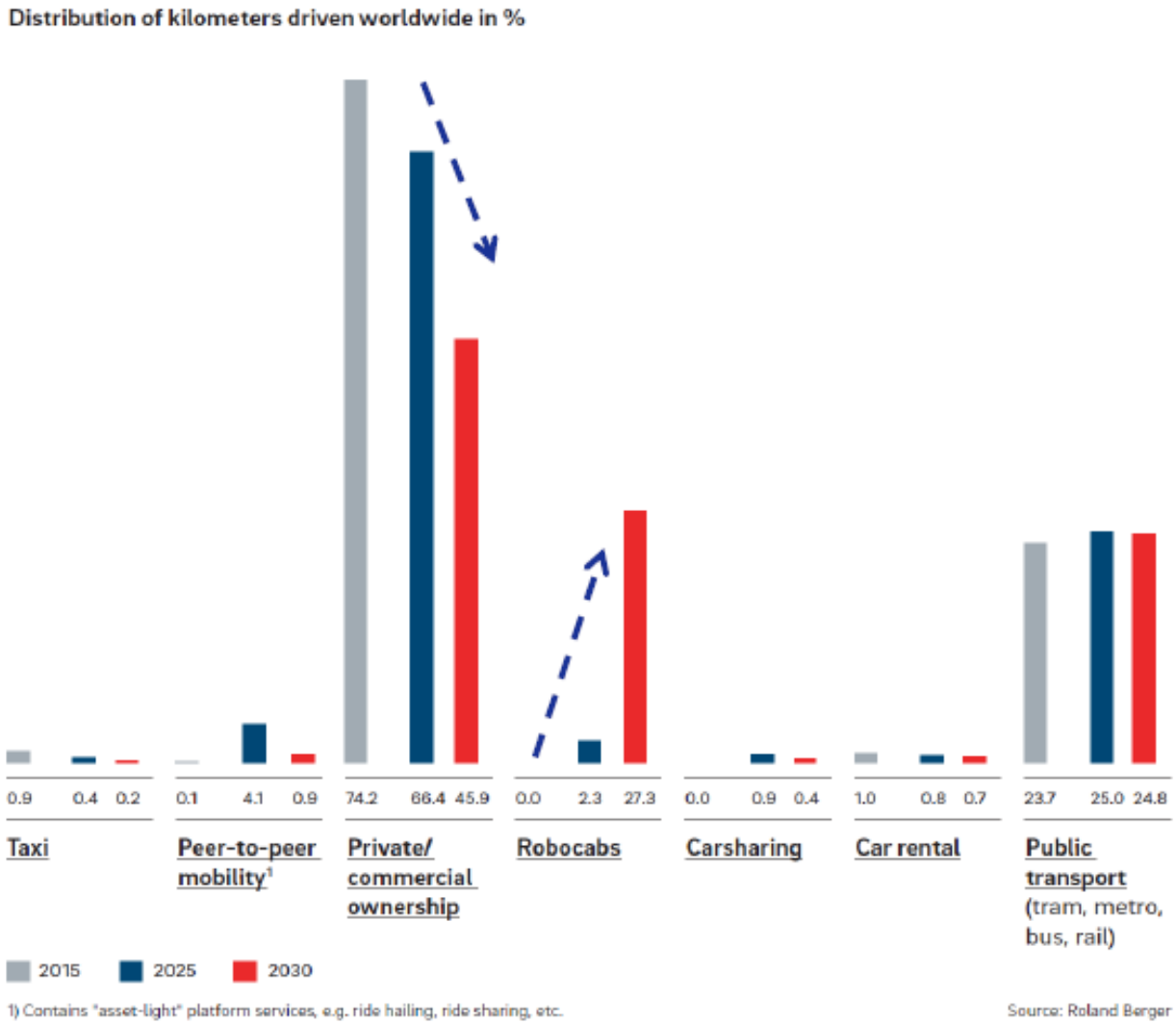
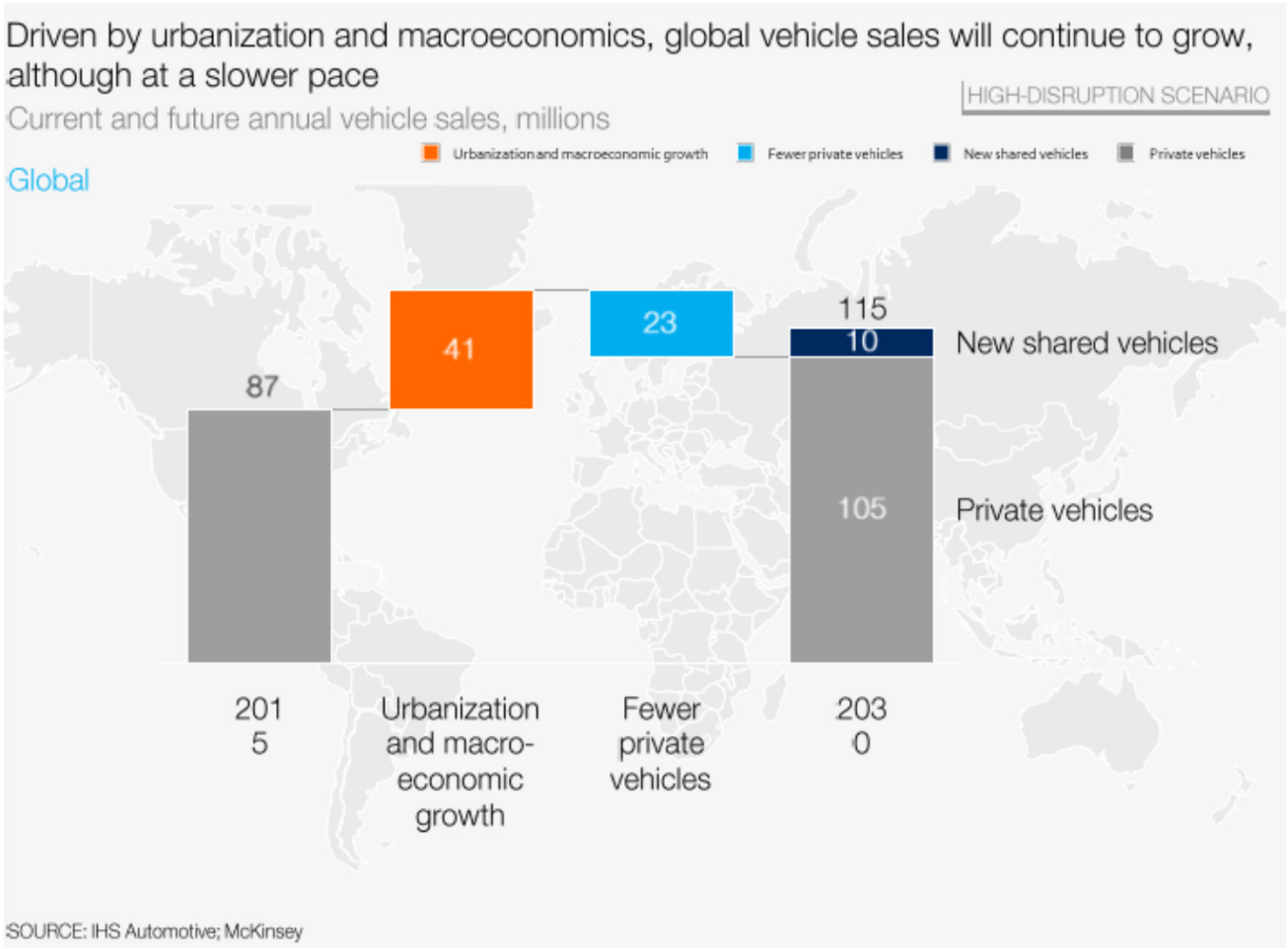
Car sharing/ride sharing of minor importance compared to autonomous driving



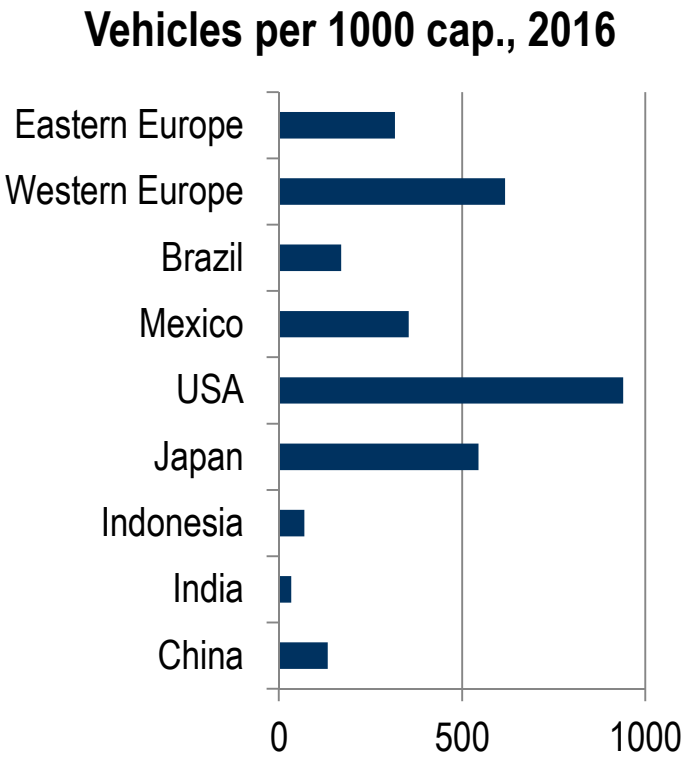
- Peer-to-peer mobility as a bridge technology
- The real game changer can be autonomous driving, in the form of “robocabs”
- Available after 2025?
- Likelihood is, that the amount of km driven world wide is even increasing, due to the new transportation comfort!

Source: Roland Berger; Kind & Co.

Urbanisation and macroeconomics will drive vehicle sales – sharing will only dampen the expected growth



One of the reasons behind urbanization and macroeconomic growth is population as a factor:



Source: „Automotive revolution – perspective towards 2030" (McKinsey); LMC Automotive 2016/Deutsche Bank; Kind & Co.

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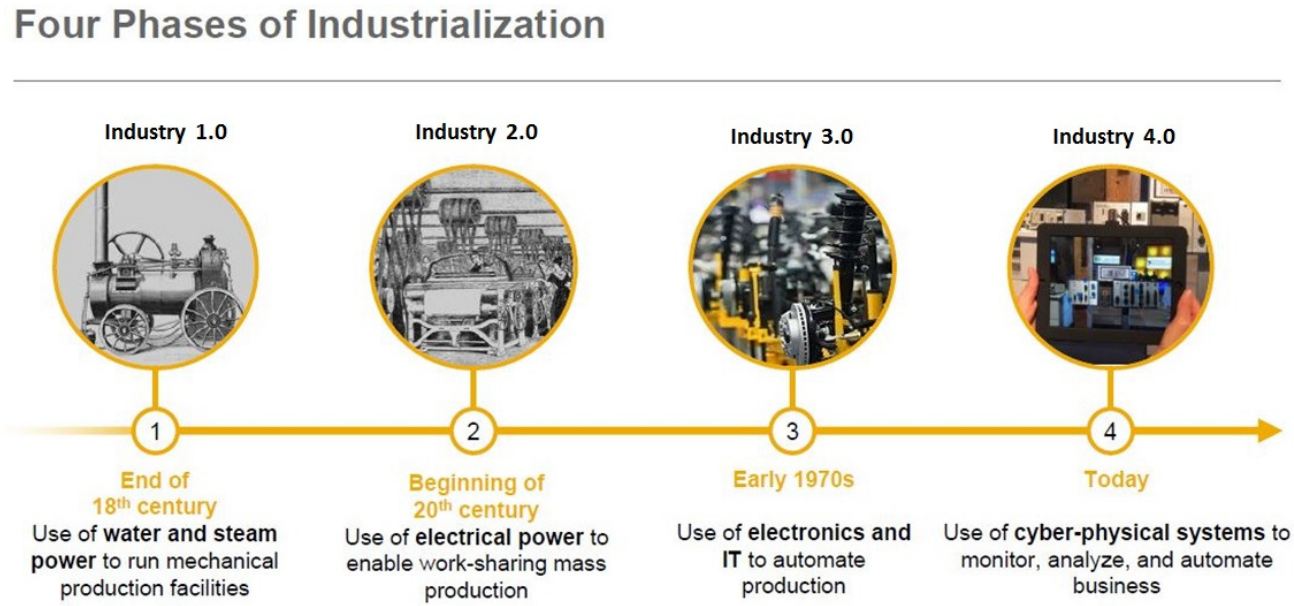
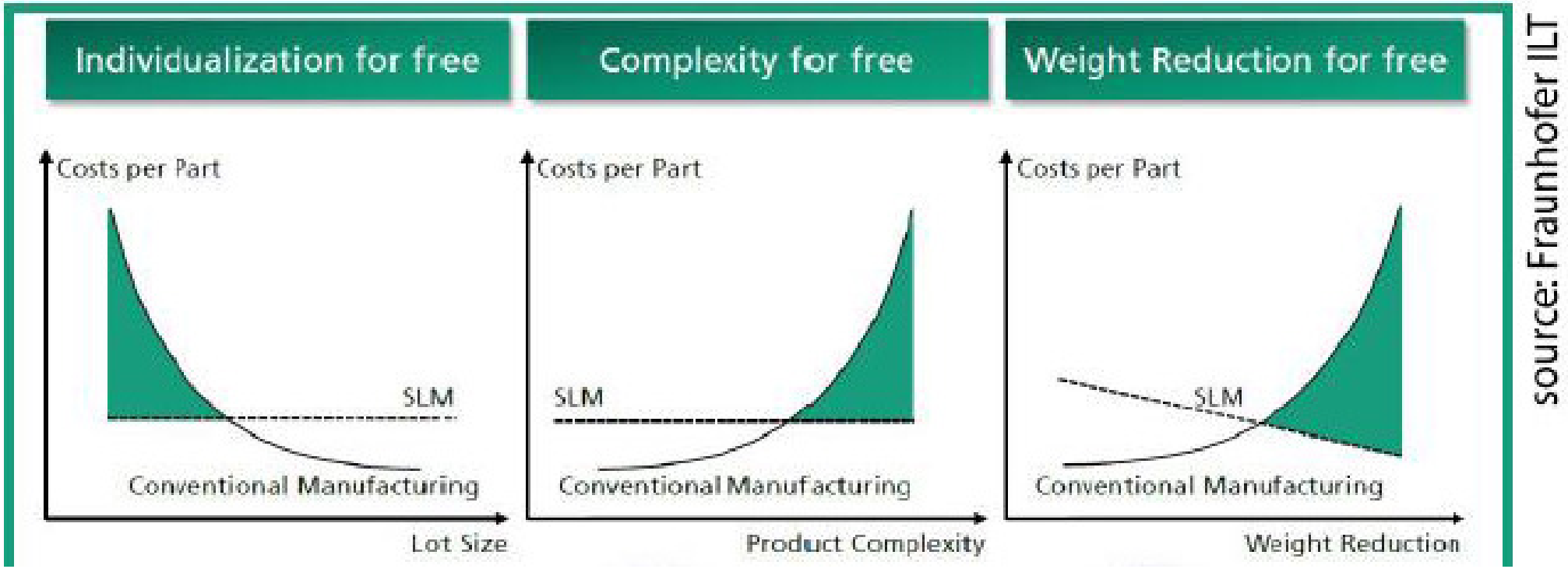
Economies of scale have strongly driven industrial development so far – and tool steel has been instrumental in this development



Economies of scope				
Economies of scale				
Competition	Regional on end product	Regional on part/step	Global on part/step	Global against everyone
Know-How required	Broad	Deep	Globally specialized	Big data/ parametrized

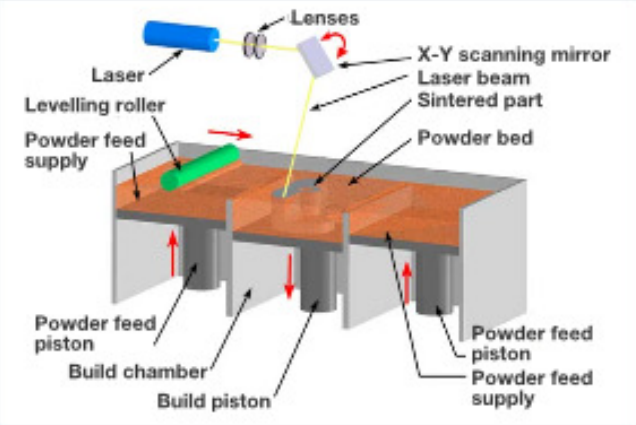
Source: SAP Hana tutorial; Kind & Co.

Additive manufacturing vs. on economies of scale?

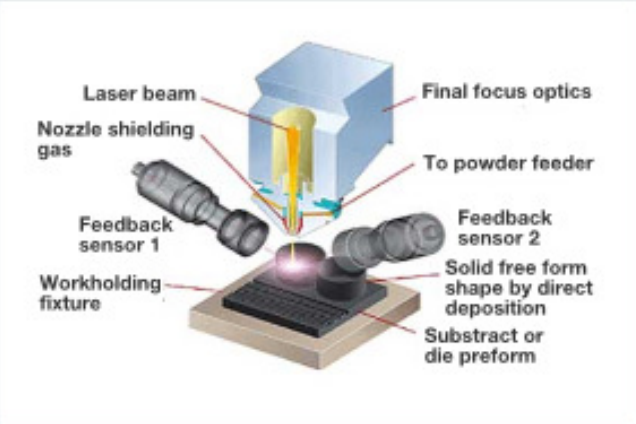


Tools (thus tool steel) are the enablers of economies of scale, so: what is the impact of Additive Manufacturing on tool steel?

Two technologies dominate metals 3-D printing



Powder bed fusion. A thermal-energy system employing a laser. The laser melts the outline of the part into a thin powder layer. Another powder layer is then spread onto the first layer and the laser melts the part's outline again. This process is repeated layer by layer until the part is complete and can be lifted out of the (now filled) powder bed.



Direct energy deposition. A thermal-energy process that fuses material by melting it. Unlike in powder bed fusion, here the powder flows through a nozzle and is melted by the bean as the printer deposits it on the surface of the part being built. This process is also known as laser cladding, laser metal deposition, or electron-beam-directed energy deposition (when an electron beam is used instead of a laser).

Source: McKinsey, „How 3-D printing will transform the metals industry“, 2017

A perspective on today‘s usage of metals 3-D printing

	Printing parts (direct AM)	Printing molds (indirect AM)

Powder bed	• Mainly used for high-value material (Ti, Ni-base, …), and where geometry is conventionally not possible
	• Early adopters: medical and aerospace
	• Limitations:
	  • Slow (but improving), small parts (but enlarging)
	  • Porosity (sometimes HIP required)
	  • Not suitable for parts under tensile load or with high temperature gradients
	  • Not economical for series
	  • Unclear quality assurance
		• Application potential for mold „hot spots“, e.g., for die casting or press hardening, in order to enable optimized cooling channels
		• Limitations
		  • Slow (but improving), small parts (but enlarging)
		  • Porosity (sometimes HIP required)
		Obstacles for small, high thermal load inserts in molds smaller than for parts – likelihood of adaptation higher?

DED	• Mainly used for machine parts/spare parts
	• 10x quicker than powder bed
	• Limitations:
	  • Limited in design freedom/geometry
		• Well-known technology for repair since many years
		• Potential for cladding for wear resistance already largely captured where reasonable
		• Limitations:
		  • Layer thickness/porosity
		  • Time consumption and cost for large area/macroscopic structures

Source: McKinsey, „How 3-D printing will transform the metals industry“, 2017

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The world keeps changing – and tool steel will continue to be instrumental

Some fundamental changes and challenges ahead of us: e-mobility, car sharing/autonomous driving, additive manufacturing, and some opinions about it:

» Hot work tool steel is needed, whatever the powertrain of cars might look like. We expect an evolutionary development towards more e-mobility.

» Cars will continue to be widely used and produced in high and growing numbers. Car sharing will only dampen the growth. Autonomous driving is key for a shift in transportation patterns.

» Additive Manufacturing and tool technology will coexist – and benefit from each other. We do not believe AM is going to replace mass production completely.

Kind & Co. as a small but relevant hot work tool steel specialist is excellently positioned in this context.

Thank you very much for your attention!

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