Arthur D Little

Material efficiency KPIs applied to steel

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Material efficiency KPIs

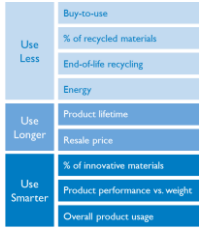
	KPIs	Description
Use Less	Buy-to-use	Material value in the product / material value used in production
	% of recycled materials	Weight of recycled / total weight of materials in new product
	End-of-life recycling	Weight of materials effectively recycled / total weight of materials
	Energy	Total energy consumption to produce the product
Use Longer	Product lifetime	Total lifetime of the product, from completion to waste
	Resale price	Resale price after Y years / initial price (Y is industry specific)
Use Smarter	% of innovative materials	Weight of new or innovative materials / total weight of materials
	Product performance vs. weight	Performance measurement of the product key functions vs. weight
	Overall product usage	% of the time the product is used relatively to its full capacity

Source: WMF & Arthur D. Little analysis

Arthur D. Little's contribution for WMF 2019

2016-17	2017-18	Booklet	2018-19	2019-20
KPI definition	KPI measurement for companies		KPI priorities by materials	KPI enablers

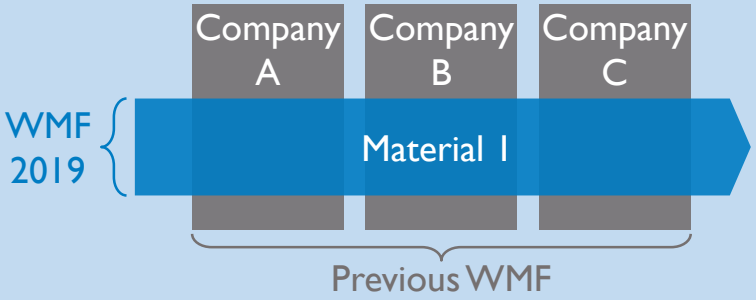
- Elaboration of the 9 KPIs



- KPIs dashboard to monitor a company:
  - KPI management
  - KPI measures

- Global overview by materials
- Identification of the top priorities by materials

- Analysis of the enablers:
  - P&L & internal pressure
  - Consumers
  - Finance
  - Regulation



Step 1

- Global overview of a material at each step of its cycle for material efficiency and risk: resource available, production, consumption, recycling

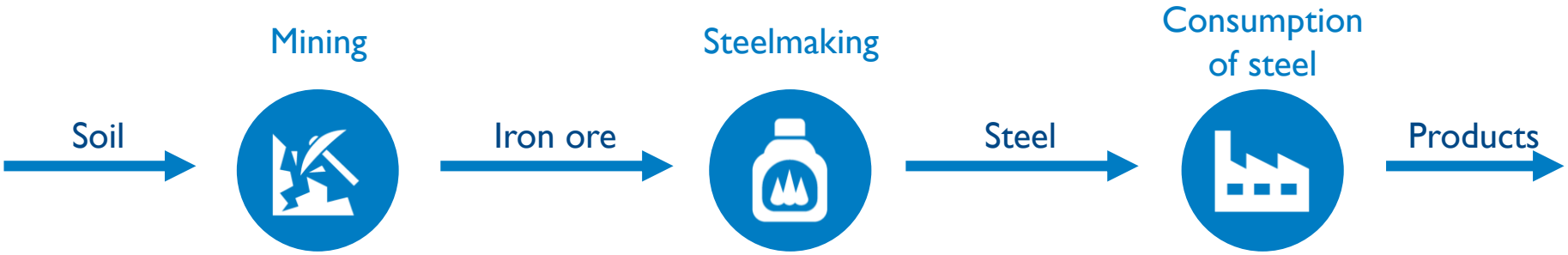
Step 2

- Identify top priorities among the material efficiency KPIs at each step of the material cycle

Source: Arthur D. Little analysis

The objective of the material efficiency is to decorelate the use of steel from the extraction of iron ore (1/2)

Overview of our objective



$$\text{Buy-to-use} = \frac{\text{Iron ore weight}}{\text{Extracted soil weight}} \times \frac{\text{Steel weight}}{\text{Iron ore weight}} \times \frac{\text{Weight of steel in product}}{\text{Weight of steel input}}$$

(Data not available) (Data partly available) (Data partly available)

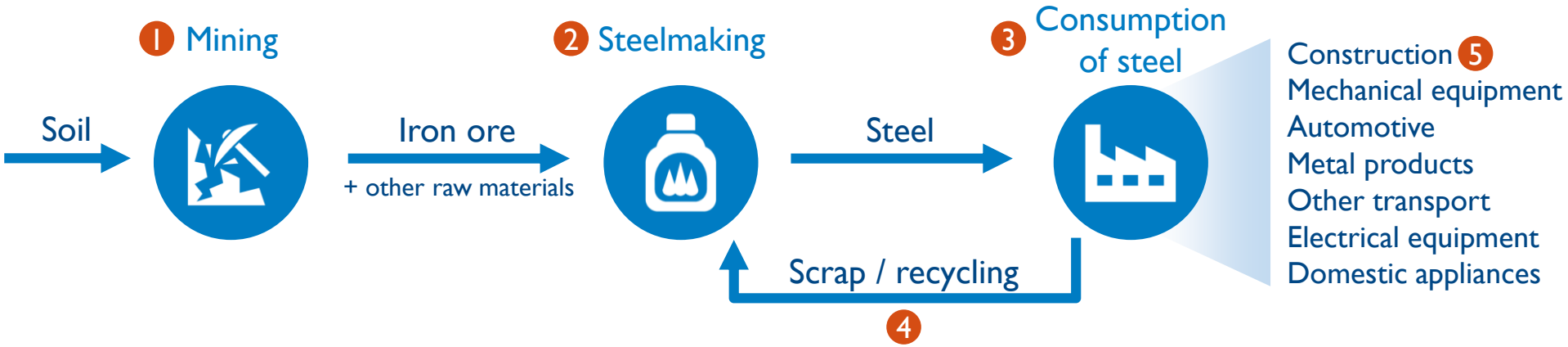
$$\text{Buy-to-use} = \frac{\text{Weight of steel in product}}{\text{Extracted soil weight}}$$

Core objective of material efficiency

Source: Arthur D. Little analysis, World Steel Association

The objective of the material efficiency is to decorelate the use of steel from the extraction of iron ore (2/2)

Simplified overview of the steel cycle



Relevant KPIs			
	Use Less	Use Less	Use Less
			Use Longer
			Use Smarter

Each step of the cycle must participate in reducing the extraction of iron ore, while keeping the end-user needs fulfilled

Source: Arthur D. Little analysis, World Steel Association

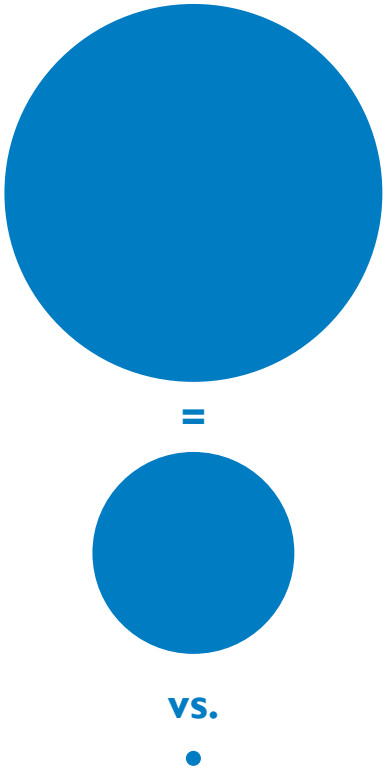
There is no risk in term of iron ore supply, with very large known available ressources (~200 years of current consumption)

Main iron ore mining countries

Main iron ore producers
Secondary iron ore producers

- Brazil and Australia are the main global producers of iron ore, each having about one-third of total export

Available resources



> 800 billion tons
of crude ore available

=

> 230 billion tons
of iron available

vs.

1,2 billion tons
of steel produced in 2017
(excl. recycling)

Source: Arthur D. Little analysis, World Steel Association

1 Iron ore is extracted from open-pit mines, and processed for steelmaking: this process generates large amount of waste which can still contain iron

Mining

- Iron ore is:
  1. Excavated from the ground
  2. Crushed into 20mm-or-less particles
  3. Screened between granulated, sinter and pellet (powder)
  4. Shiped to steelmaking facilities
- Iron ore waste is constituted of rocks and other minerals and is stored nearby the mines

Material efficiency

- Iron ore extraction is currently under pressure following:
  - Waste dam collapses in Brazil
  - Tropical hurricanes in Australia
- Thus, increasing the performance of iron ore extraction is key
  - E.g. waste can still contain iron ore, which can be retrieved to increase the material efficiency of the iron ore mining

$$= \frac{\text{Iron ore weight}}{\text{Extracted soil weight}}$$

Material efficiency	none	Use Less Buy-to-use	Use Less Energy

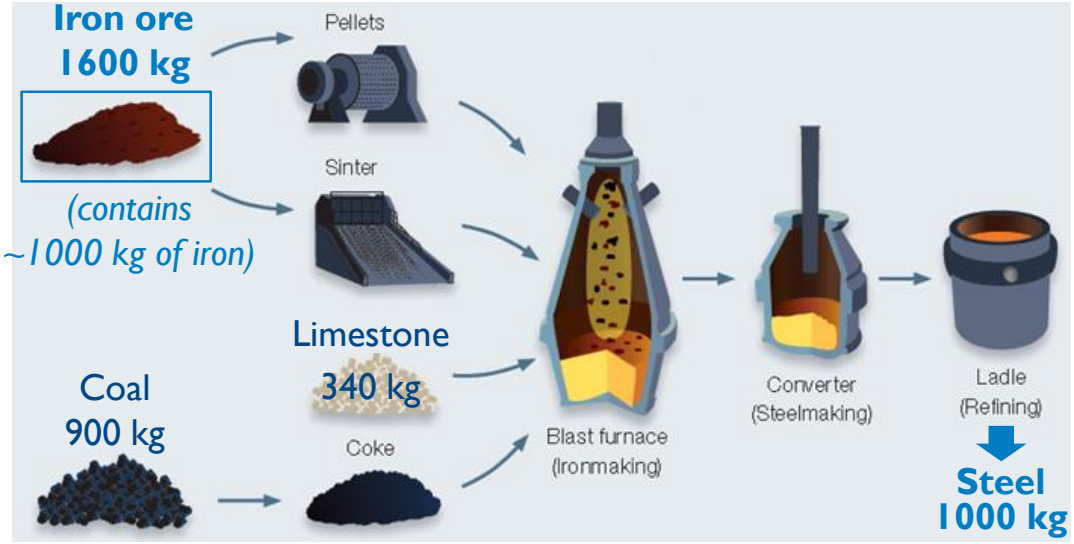
Source: Arthur D. Little analysis, World Steel Association, Vale

KPI already mature | Priority for improvement | Not diagnosed in the study

2 Steelmaking is already optimal in terms of material efficiency (considering only the iron)

Main steelmaking processes and related material efficiency

Blast Furnace Steelmaking
(mainly used for iron ore: 67% of production)



Electric Arc Furnace Steelmaking
(mainly for recycled steel: 33% of production)

- This steelmaking process directly consists in introducing the steel to be recycled into the electric arc furnace
- Steel is 100% recyclable and can be infinitely reused

Material efficiency[1]		
Use Less	Buy-to-use	■ *none*
Use Less	% of recycled materials	Use Less Energy

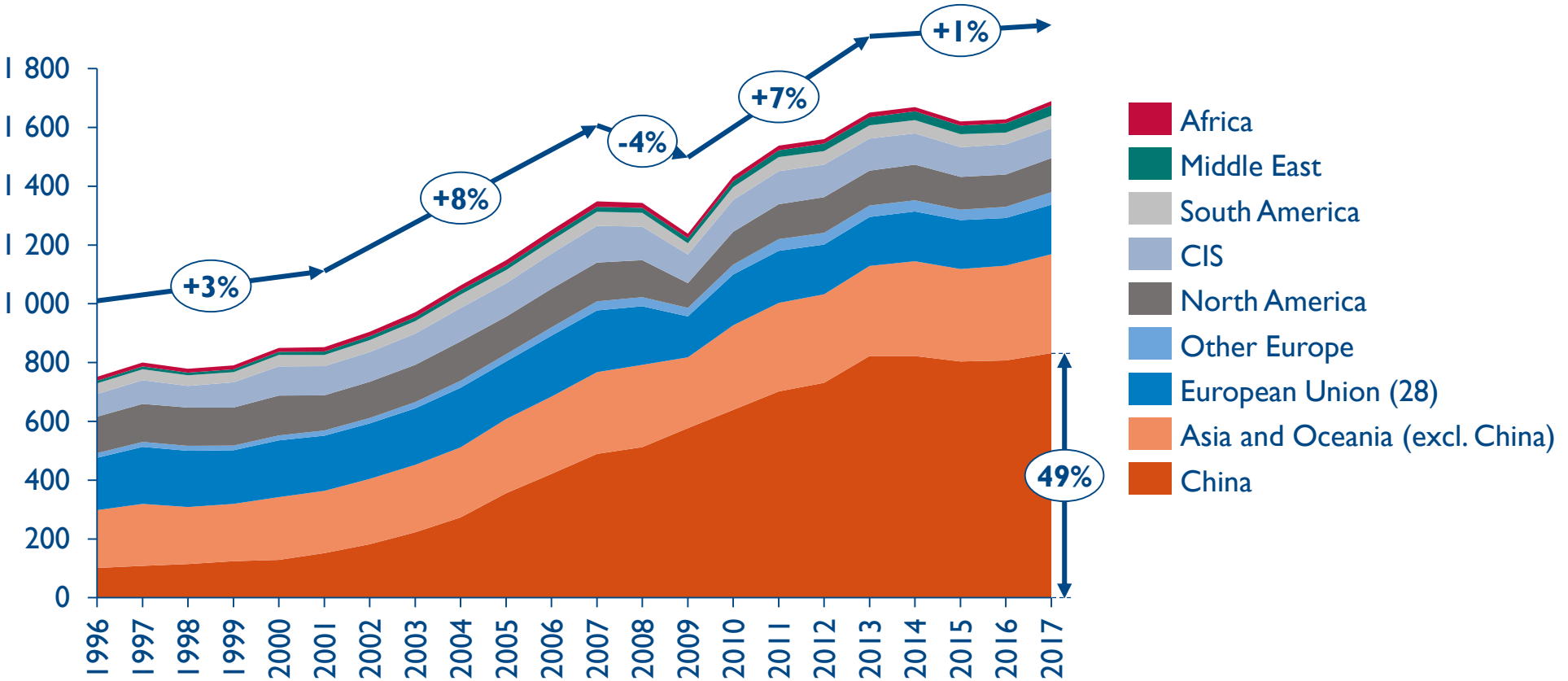
Source: Arthur D. Little analysis, World Steel Association
[1] Material efficiency of coal and limestone were not studied

■ KPI already mature ■ Priority for improvement ■ Not diagnosed in the study

2 Mainly driven by China, the global steel production has been stabilizing since 2013, along with China's production (49% of global production)

World steel production by region

1996-2017, in millions of tons of crude steel

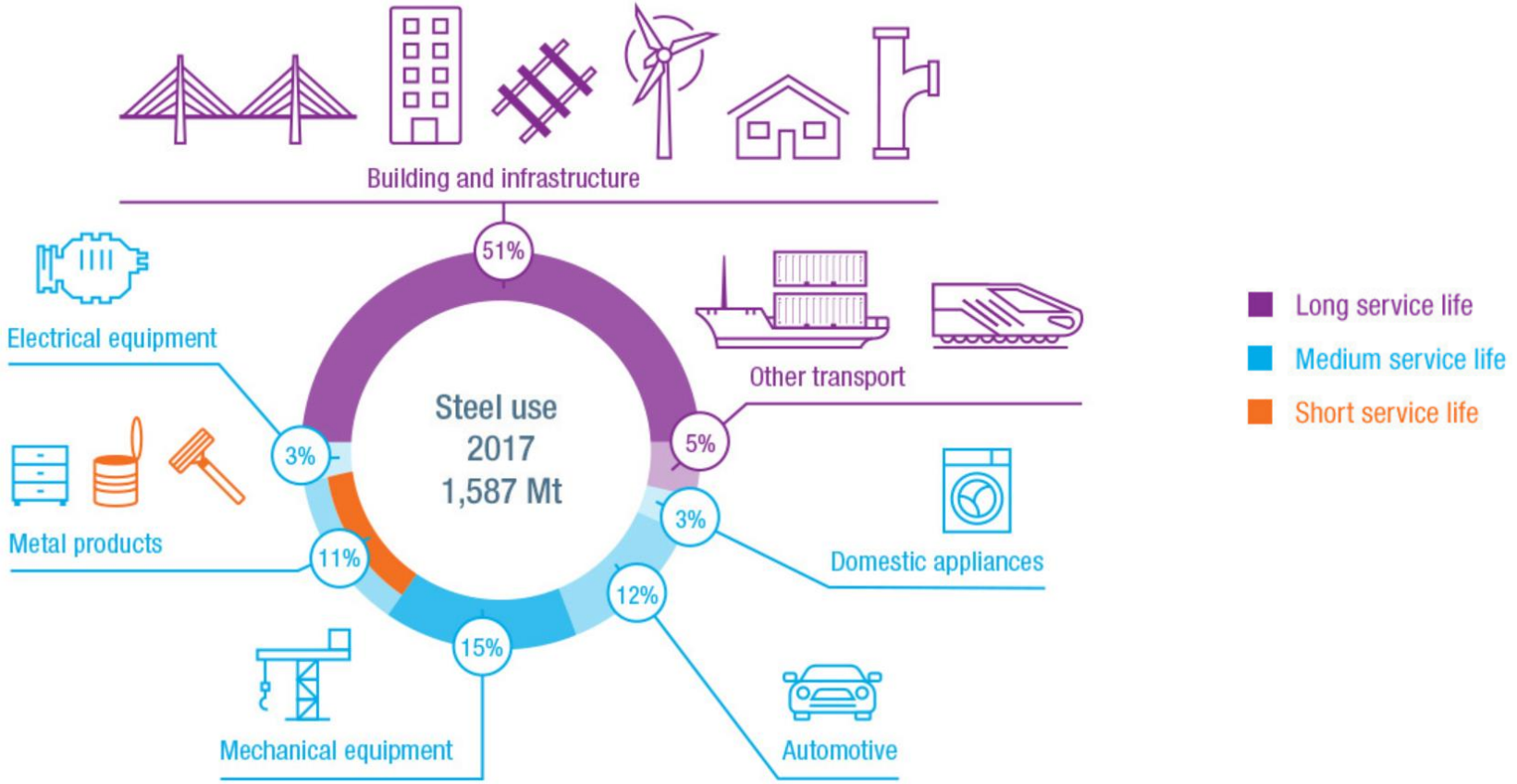


Source: Arthur D. Little analysis, World Steel Association

3 World steel consumption is dominated by construction sector (51%), followed by mechanical equipment (15%) and automotive (12%)

Global steel use by sector in 2017

Source: World Steel Association

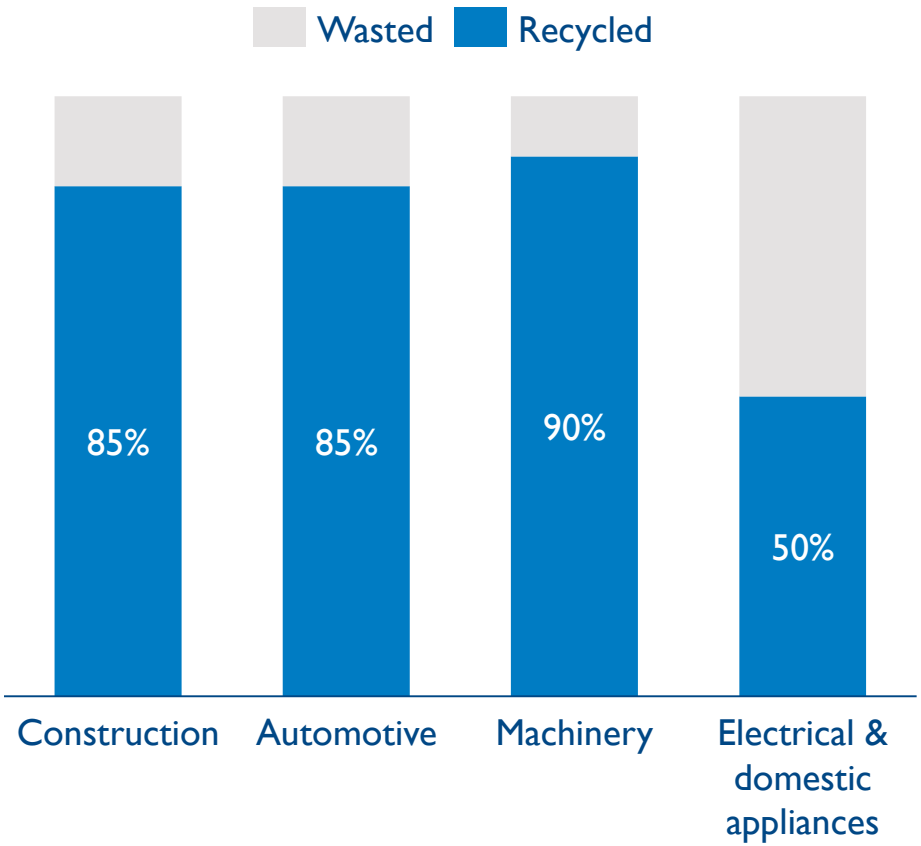


Source: Arthur D. Little analysis, World Steel Association

4 Recycling rate are above 85% (except for elec. & domestic appliances), with recycled steel accounting for 1/3rd of new steel produced in 2017

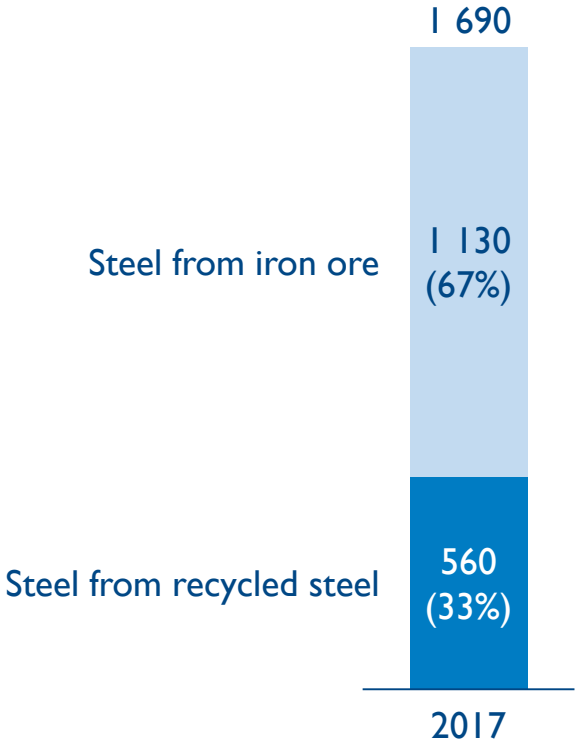
Recycling rate by sector

Estimation WSA for 2017, global



Origin of new steel production

In billion of tons, 2017, global



Source: Arthur D. Little analysis, World Steel Association

5 Increasing the end-of-life recycling and the buy-to-use in construction could have major effects on overall steel material efficiency

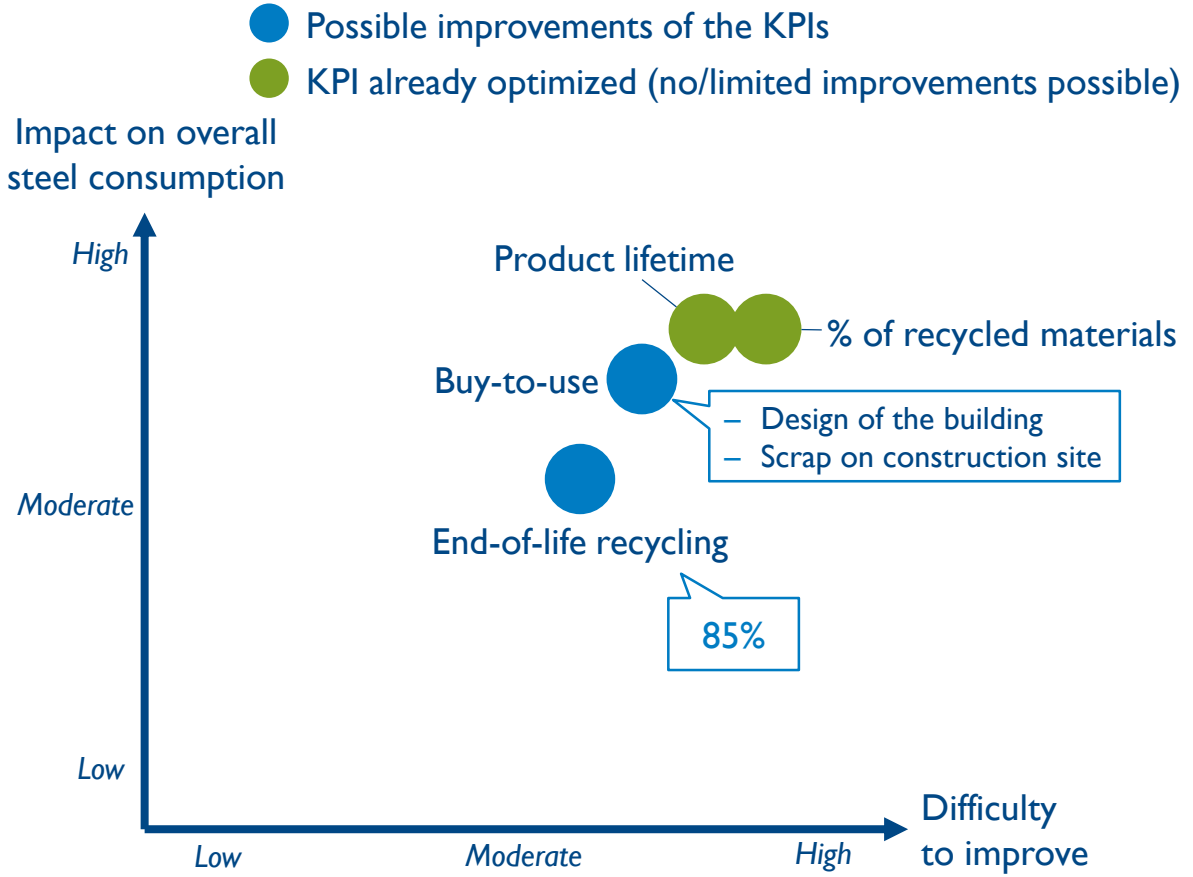
Steel in Construction

Consumption of steel

Construction
- Mechanical equipment
- Automotive
- Metal products
- Other transport
- Electrical equipment
- Domestic appliances

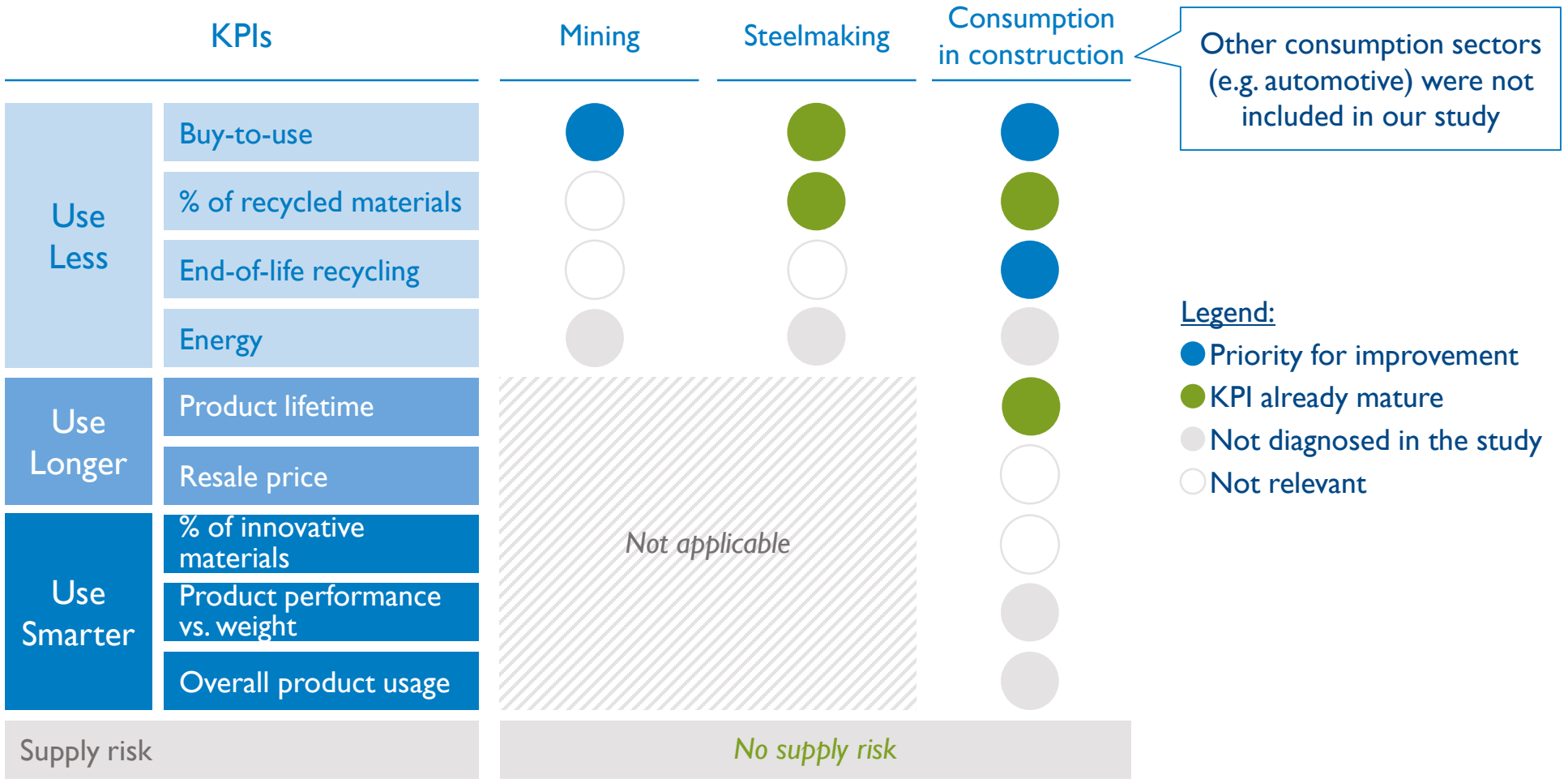
- Includes building, transportation infrastructure, energy infrastructure, water infrastructure, etc.
- Represents 51% of the total steel consumption

Prioritization of KPIs improvement



Source: Arthur D. Little analysis, World Steel Association

To conclude, we have identified 3 KPIs that must be monitored as priority to improve the overall steel material efficiency



Source: Arthur D. Little analysis

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