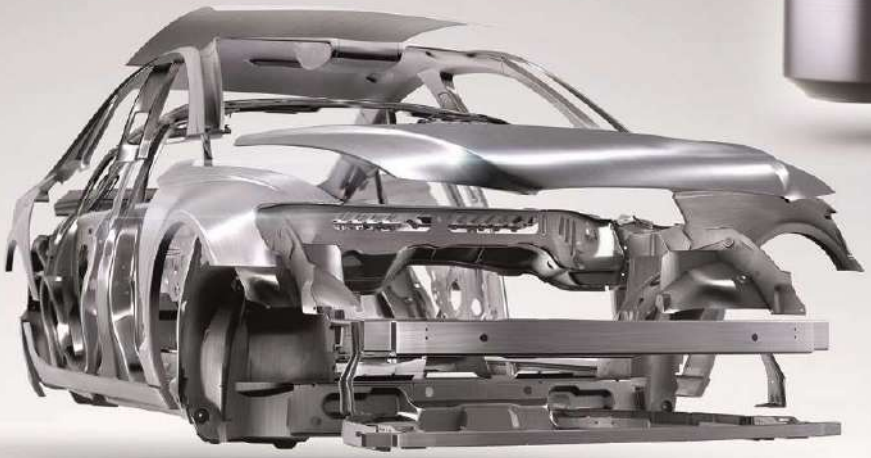


Enjeux et opportunités du développement durable dans la transformation de l'alumnium

24 janvier 2023

Tim Warner, Guillaume Bes, Sylvain Henry, Pierre-Yves Menet, Olivier Néel

Constellium

Plan

- Constellium et son domaine d’intervention
- Enjeux majeurs du développement durable dans la transformation de l’aluminium
- Comment réduire notre empreinte carbone
- Conclusions et perspectives

Constellium: a global leader in high value-added aluminum products

Company Statements

Who We Are	Our Commitment	Our Ambition
We are a **global leader** in innovative and high value-added aluminum products and solutions dedicated primarily to aerospace, automotive and packaging markets.	Minimize the impact of our operations on the environment, and work to improve the footprint of the aluminum life cycle throughout the value chain.	Innovate beyond the material to bring our customers complete, sustainable solutions and endless possibilities.

Key Figures

100+
years of experience

~12k
employees

27
production facilities

$7 Bn
2021 revenue

3
R&D Centers

- Voreppe, France
- Brunel Univ, UK
- Plymouth, MI

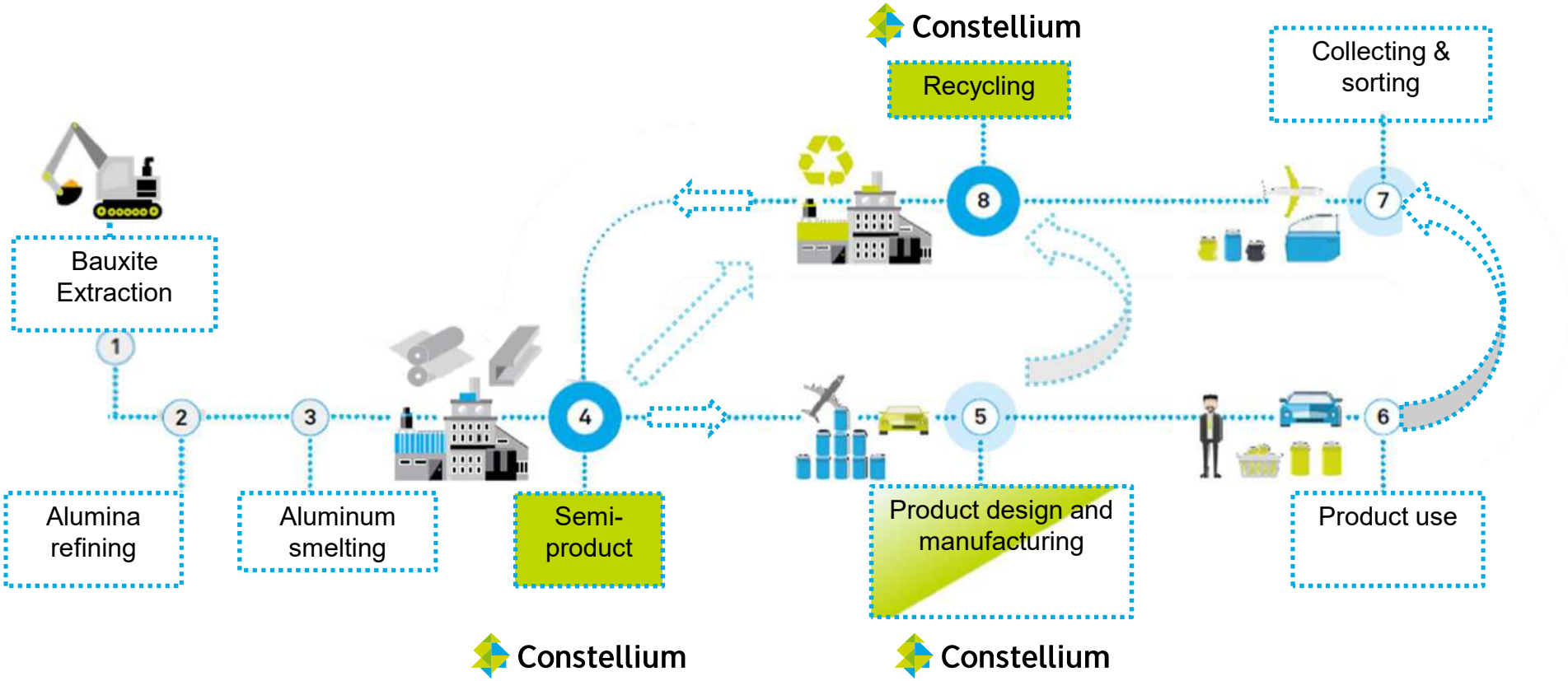
Geographical footprint

Largest plants

- Ravenswood, WV (Aero)
- Muscle Shoals, AL (Pack., Auto)
- Van Buren, MI (Auto)

- Issoire, France
- (Aero)
- Neuf-Brisach, France (Pack., Auto)
- Singen, Germany (Pack., Auto)
- Decin, Czechia (Auto)

Our contribution to the aluminum value chain: transformation but also recycling and some product design/manufacturing



Our core markets are all industries for which lightweighting and/or recycling are key

- Car body closures
- Body-in-White
- Structural Components
- Crash Management Systems
- Battery Enclosures
- Chassis and mechanical parts
- Decorative parts and equipment
- Heat exchangers

Some of our customers

Audi, BMW Group, Daimler, Fiat Chrysler Automobiles, Ford, General Motors, Honda, Porsche, Stellantis, Subaru, Volkswagen

- Outer wing
- Center wing box
- Fuselage and nose fuselage
- Engine (incl. gear boxes)
- Landing gear

Some of our customers

Airbus, ATR, Boeing, Bombardier, Dassault Aviation, Embraer, Gulfstream, Lockheed Martin, Pilatus, SpaceX

- Beverage cans
- Food cans
- Closures
- Aerosols
- Cosmetics packaging
- Foil stock

Some of our customers

AB InBev, Amcor, Ardagh Group, Ball, Can-Pack, Crown, Coke

But also...

Defense

Constellium's lightweight alloys offer outstanding impact resistance for armored vehicles and military bridges.

Transportation

We offer a wide range of lightweight and high performance solutions for vehicles such as commercial trucks and trailers, boats and ships, trains and buses.

Industry

We have more than 100 years of experience in industrial applications, from precision plates to semiconductor equipment to architecture.

Constellium's Technology Centers are the heart of our product and process development capability

Key facts & figures

Locations

Brunel University London

Voreppe (France)

Plymouth (MI, USA)

22 Nationalities

300 Full-time employees

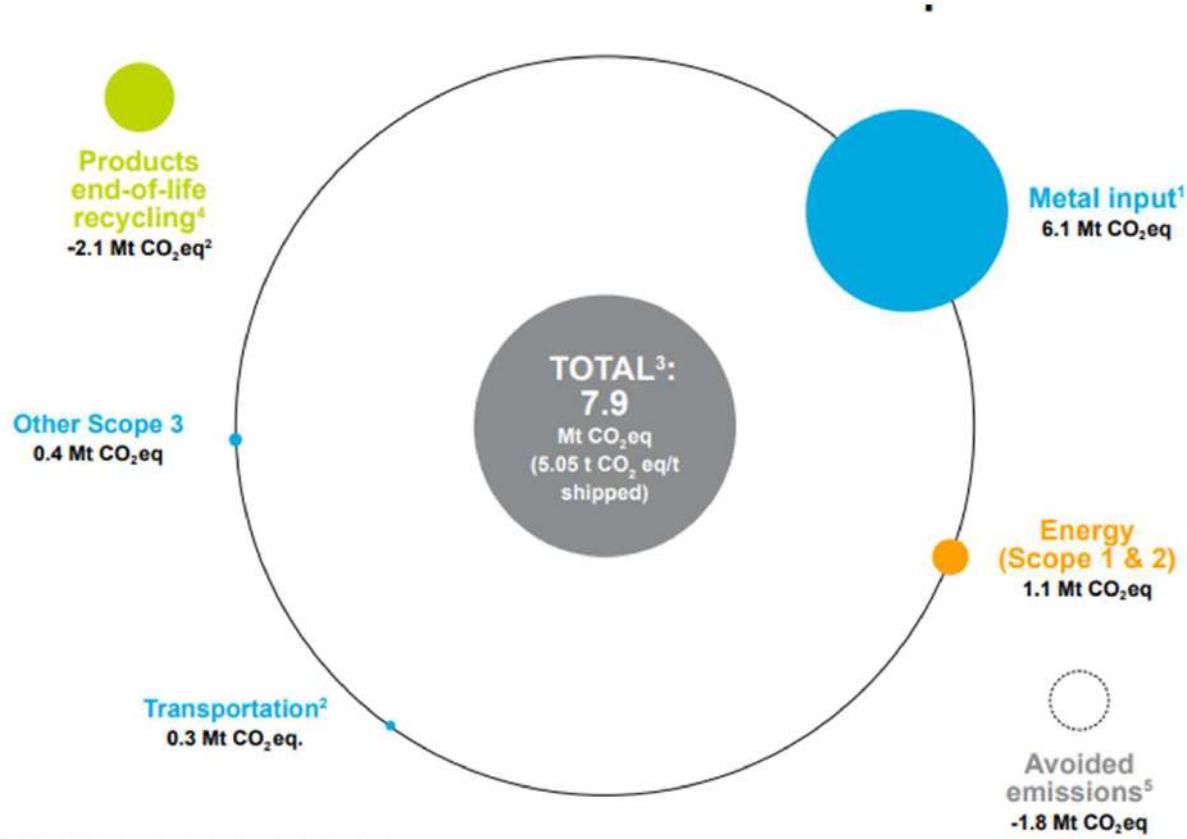
Over 200 patent families and trademark

20 patents filed in 2022

Plan

- Constellium et son domaine d'intervention
- Enjeux majeurs du développement durable dans la transformation de l'aluminium
- Comment réduire notre empreinte carbone
- Conclusions et perspectives

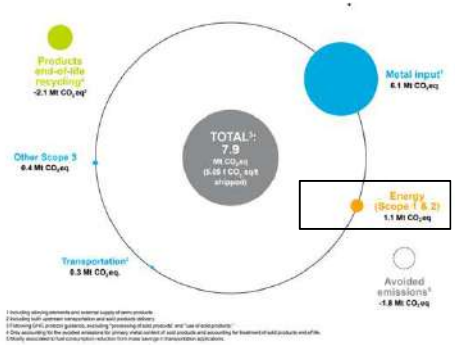
Constellium's overall greenhouse gas footprint is dominated by the embedded content of upstream metal, with a lesser but significant contribution of our own processes



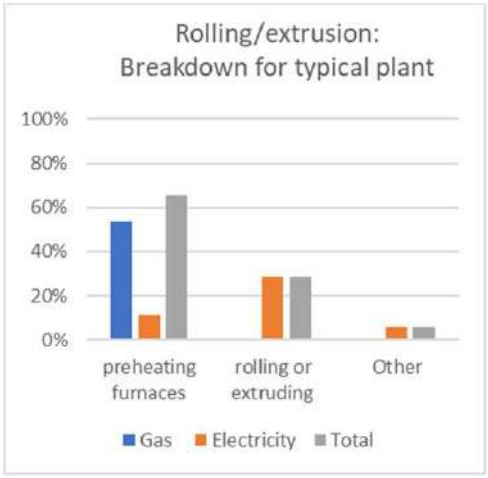
1 Including alloying elements and external supply of semi-products.
2 Including both upstream transportation and sold products delivery.
3 Following GHG protocol guidance, excluding "processing of sold products" and "use of sold products."
4 Only accounting for the avoided emissions for primary metal content of sold products and accounting for treatment of sold products end of life.
5 Mostly associated to fuel consumption reduction from mass savings in transportation applications.

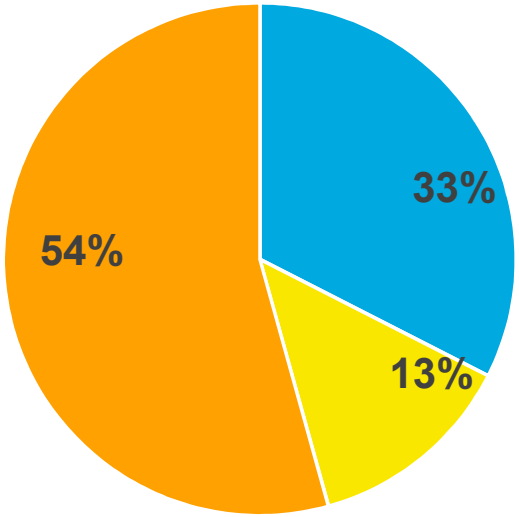
Data from Constellium's annual sustainability report

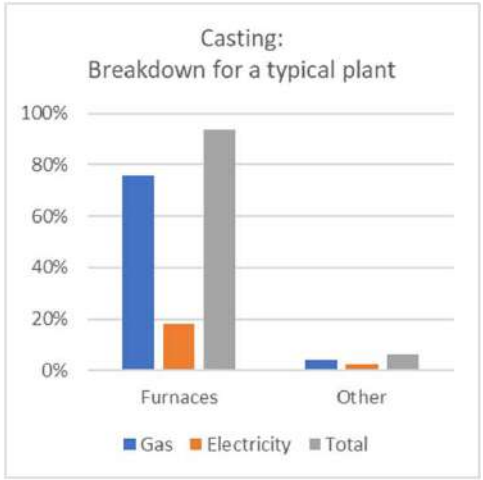
Constellium's energy consumption is dominated by casting and reheating furnaces, which are mostly gas fired



Energy 2021

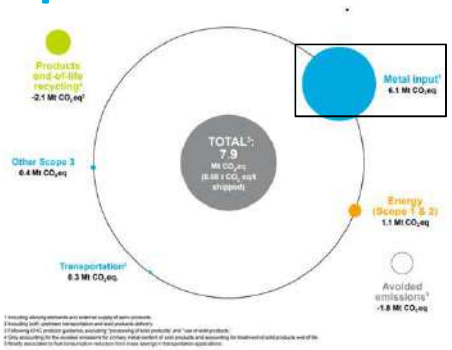


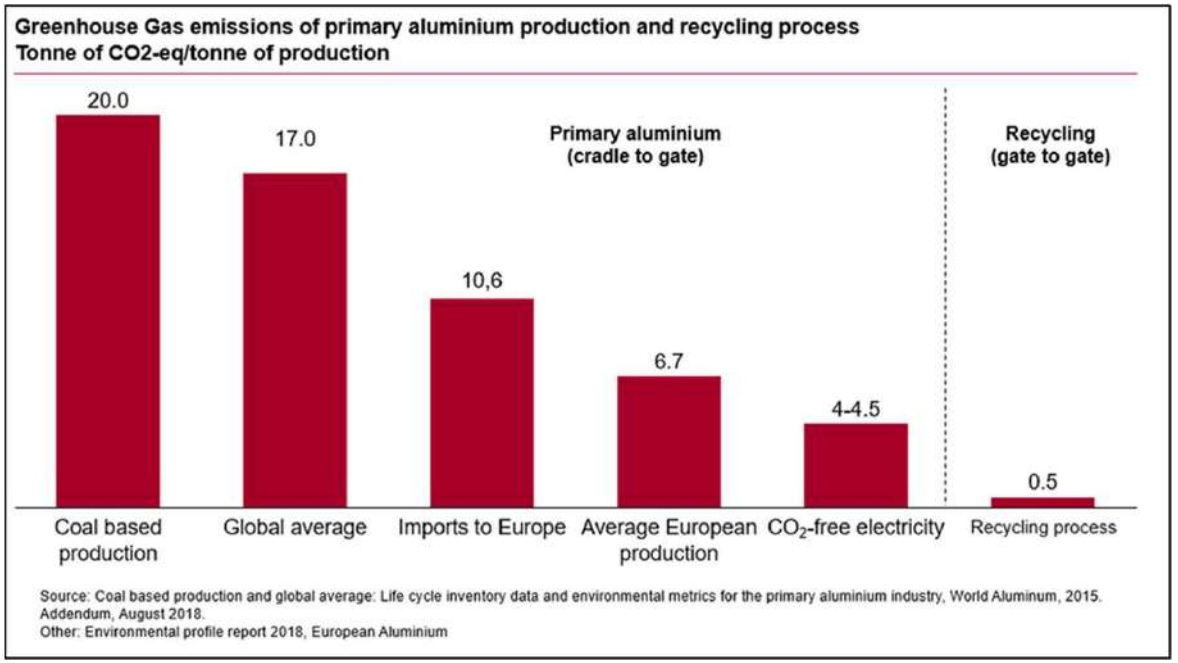




- Casting
- Recycling
- Rolling, extrusion, finishing

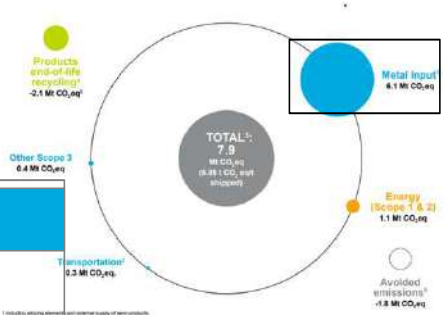
Metal sourcing has a strong impact on both overall energy consumption and GHG emission





- GHG emissions vary significantly depending on the metal source
- Recycled material requires approximately 5% of the energy required for primary aluminium, and enables similar reductions in GHG emissions

High recycling rates are already a reality in some markets…



An aluminum atom will be part of 3 different cans a year on average

- Recycling rate of Al cans: > 95% in multiple countries

Constellium plants in Muscle Shoals, AL and Neuf-Brisach, France: capacity to recycle **32 billion cans a year**

Can production and use

Used beverage cans

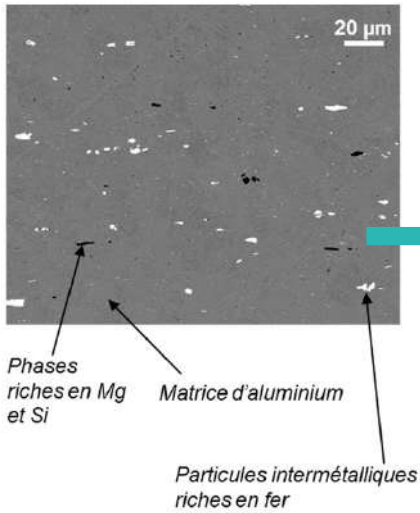
Recycling furnace

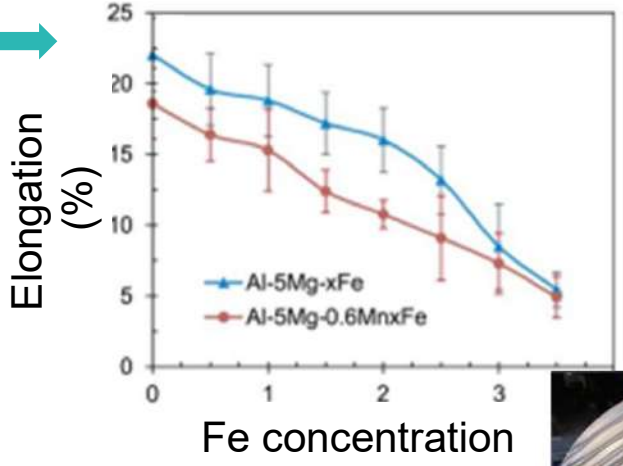
Rolling

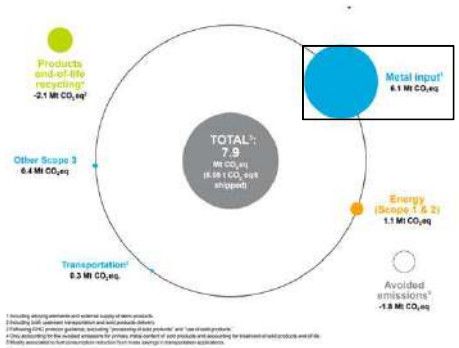
Casting

- Recycling rate in transportation and building industries: > 90-95%

But larger impurity concentrations associated with higher recycling are increasingly detrimental to ductility, i.e. to dimensioning properties for some major Constellium applications





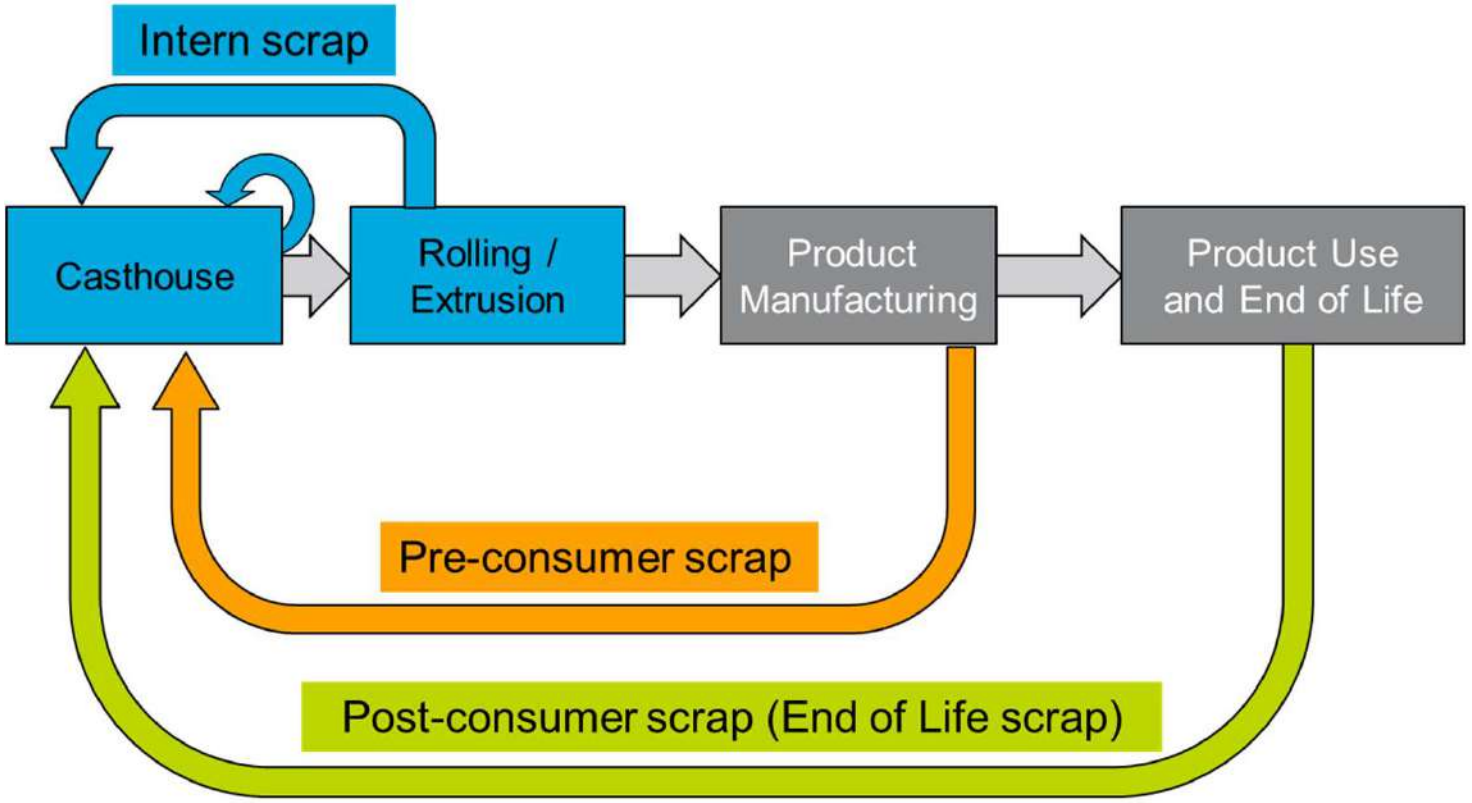


D. Raabe et al., Making sustainable aluminum by recycling scrap: The science of "dirty" alloys, Progress in Materials Science,(2022)

Plan

- Constellium et son domaine d’intervention
- Enjeux majeurs du développement durable dans la transformation de l’aluminium
- Comment réduire notre empreinte carbone
- Conclusions et perspectives

Context: different types of recycled content



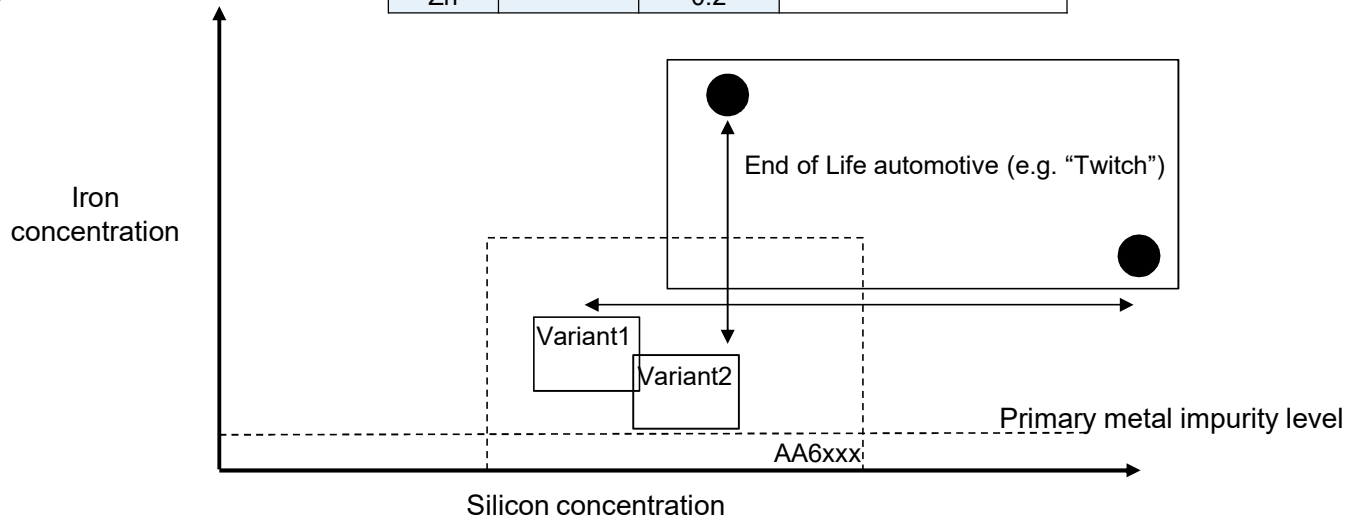
ISO14021 defines pre-consumer and post-consumer scrap.

Other names exist, but need to be defined (new scrap, process scrap…)

Context: remelting end of life scrap within existing aluminium alloys

- Aluminium alloys contain defined contents of “hardening” elements, grain controlling elements, but also maximum impurity levels
- Within an Aluminium Association range, suppliers have tighter targets reflecting plant equipment and/or customer requirements
- Compared with other metal sources, end of life scrap compositions are:
  - Not consistent with an existing alloy composition
  - More variable
  - Lower purity

Element	AA6005 Min (wt%)	AA6005 Max (wt%)	Function
Si	0.5	0.9	Hardeners
Mg	0.4	0.7	
Cu		0.3	
Mn		0.5	Dispersoid formers
Cr		0.3	
Ti		0.1	Cast grain refiner
Fe		0.35	Impurities
Zn		0.2	

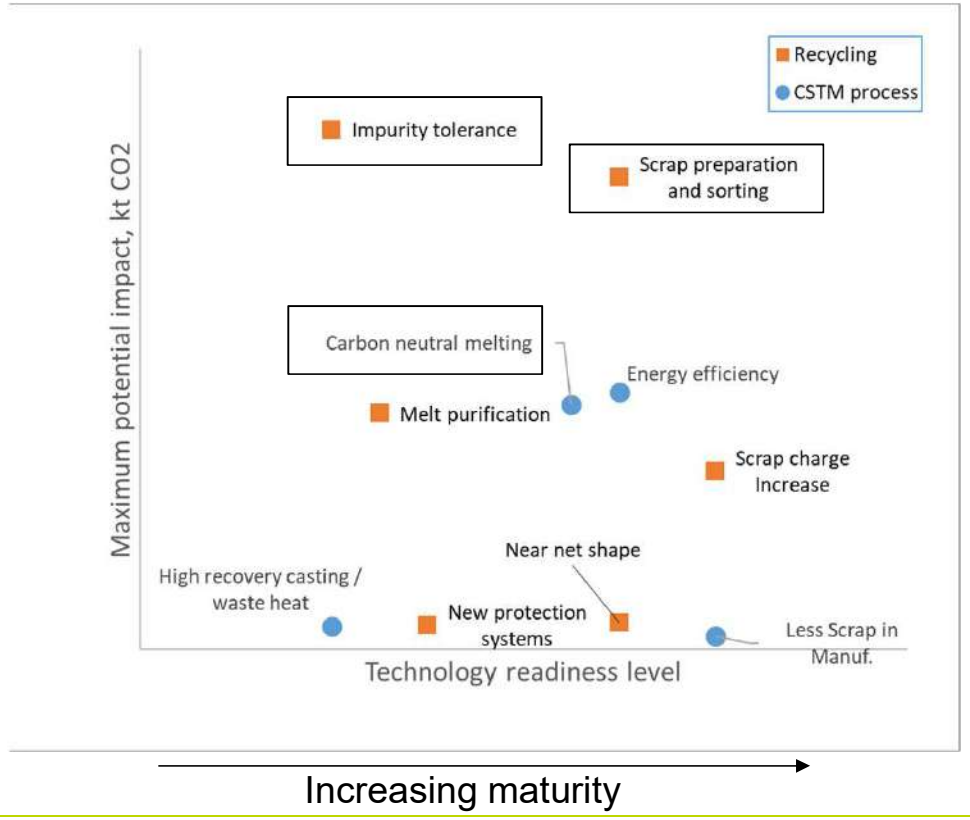


Open challenges: reducing/managing the variability of EOL scrap, accepting higher impurity levels, living with wider chemistry windows.

Selected GHG reduction initiatives: impact vs technology readiness

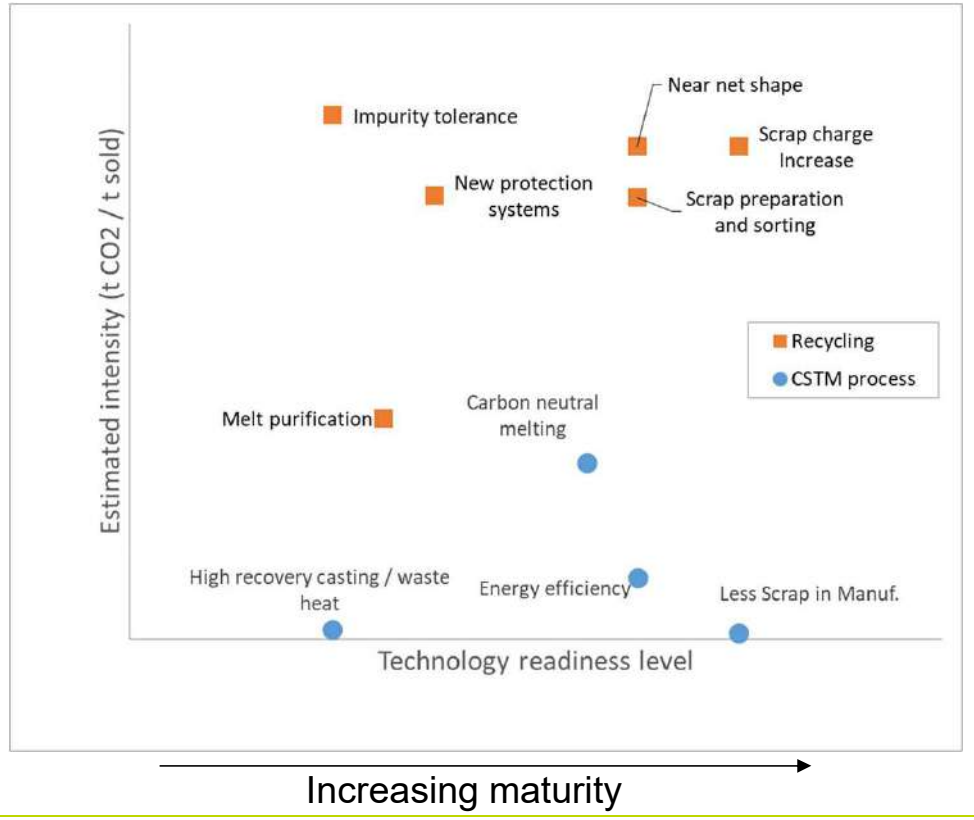
- Ranking different between overall Constellium assessment, impact for specific products
- Impurity tolerance, scrap preparation/sorting and Carbon neutral melting are high impact in both views

Total potential impact



Increasing maturity

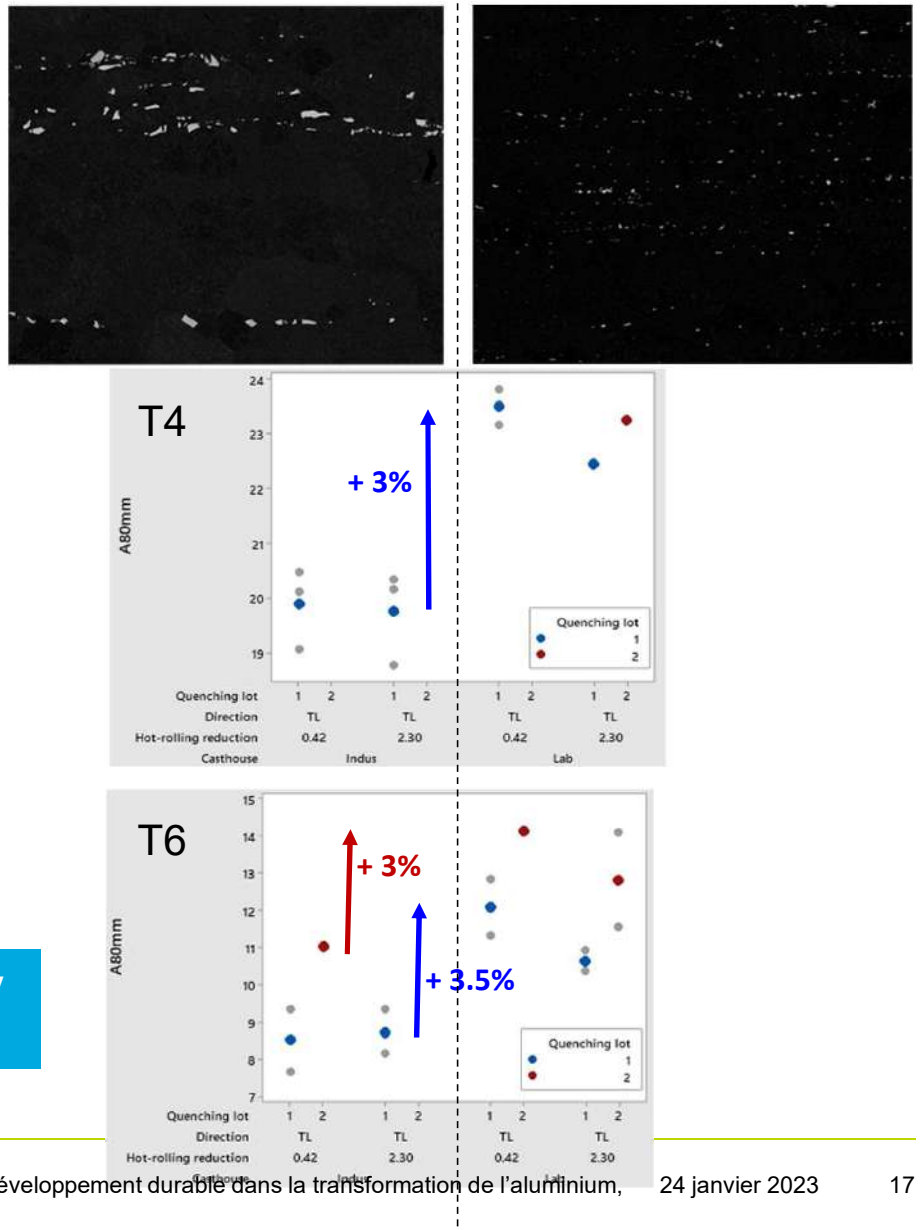
Impact per ton sold of relevant product



Increasing maturity

Impurity tolerance: effect of intermetallic phase (IMP) distribution on elongation of an aluminum 6xxx alloy

- At identical alloy composition (IMP volume fraction, rolling, heat treatment) elongation depends on IMP size / distribution
- Finer IMP result in higher elongation in both T4 (quenched and naturally aged) or T6 (peak aged) tempers
- No effect on strength (not shown)



Open challenge: how to refine IMP distributions sufficiently at an industrial scale

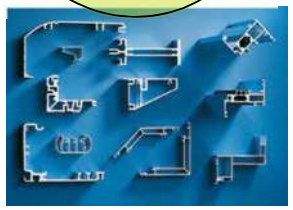
Scrap sorting and preparation: status in France

Current re-use of “French” aluminium scrap ➔ **"Downcycling »**




Looping aluminium alloy and keeping the value of the material ➔ **Development of regional "RE"cycling**



Used as oxygen getter in iron casting process
➔ **lost for aluminium cycle**

Used in cast engine part
➔ **decrease of Al alloy purity & decrease of cast alloy demand**

Open challenges: increasing can recycling rates in France, anticipating the end of cast engine parts, increasing pre-consumer scrap retrieval in aero

Scrap preparation and sorting: steps from end-of-life to new part

EOL multi-material product

Shredding

Disconnect material

Shreds of mixed material

Sorting

Separation of material

Shreds of painted aluminium

Paint removal

Coating

Clean aluminium shreds

From shred to molten Al

Remelting

Alloying, casting & transformation

Manufacturing

Open challenges: cost-efficient and environment-friendly decoating, optimal sorting

Low/zero-carbon casting: the cast house of the future

Constellium has launched a major initiative at Voreppe (DAFNE 2), with the help of the Plan de Relance, to develop the cast house of the future

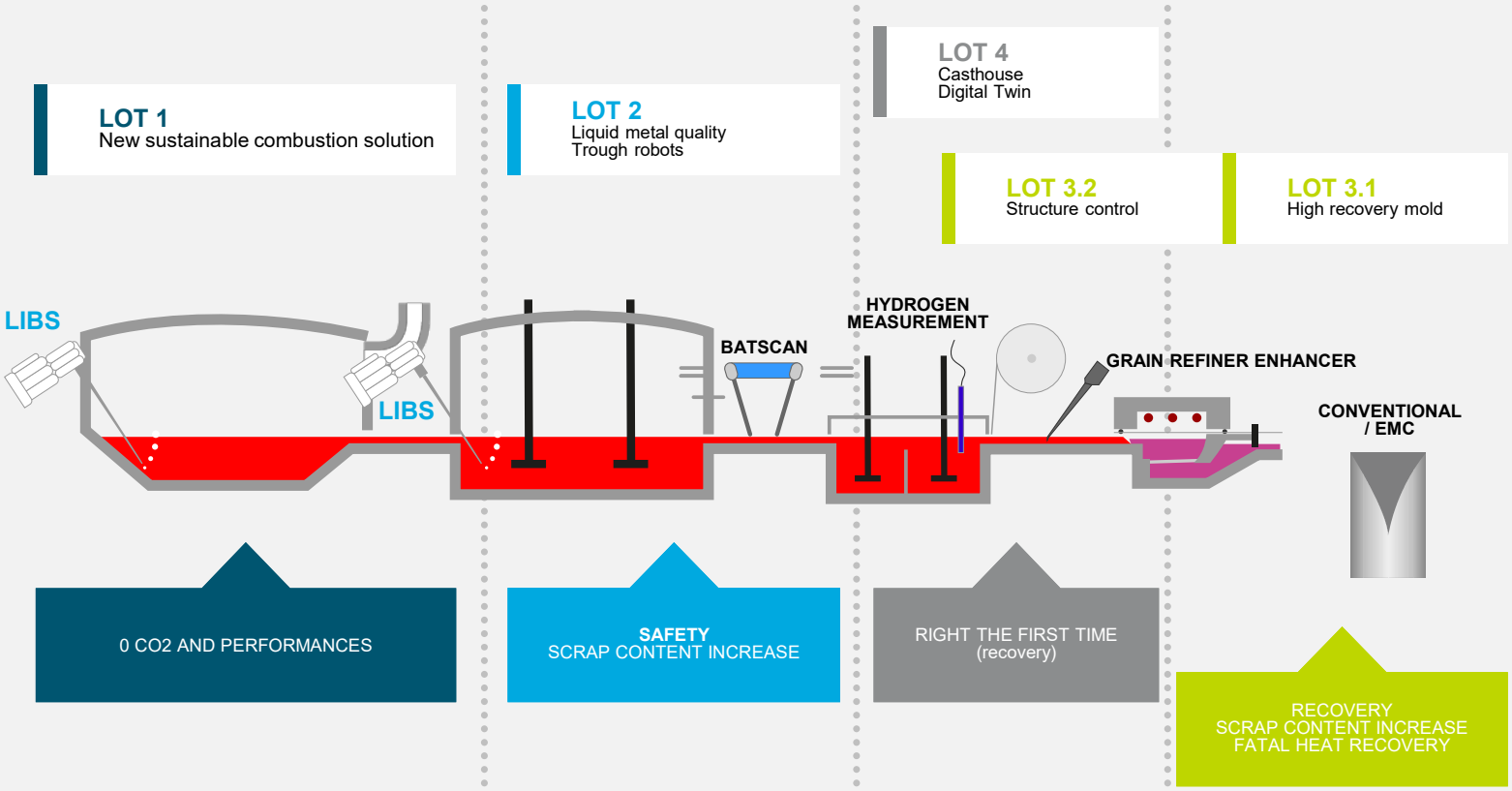
3-year project to build a demonstrator at C-TEC of the Casthouse of the Future (2030 horizon) to:

- Determine best option to reduce CO_2 emissions from gas-fired reverb furnaces, through evaluation of several combustion alternatives. Prove the concept of CO_2 capture on oxyfuel combustion on reverb furnaces.

- Enable higher recycled content through:
  - Improved process monitoring, especially liquid metal quality
  - Controlling intermetallic size and distribution to allow for higher impurity levels (e.g. Fe).

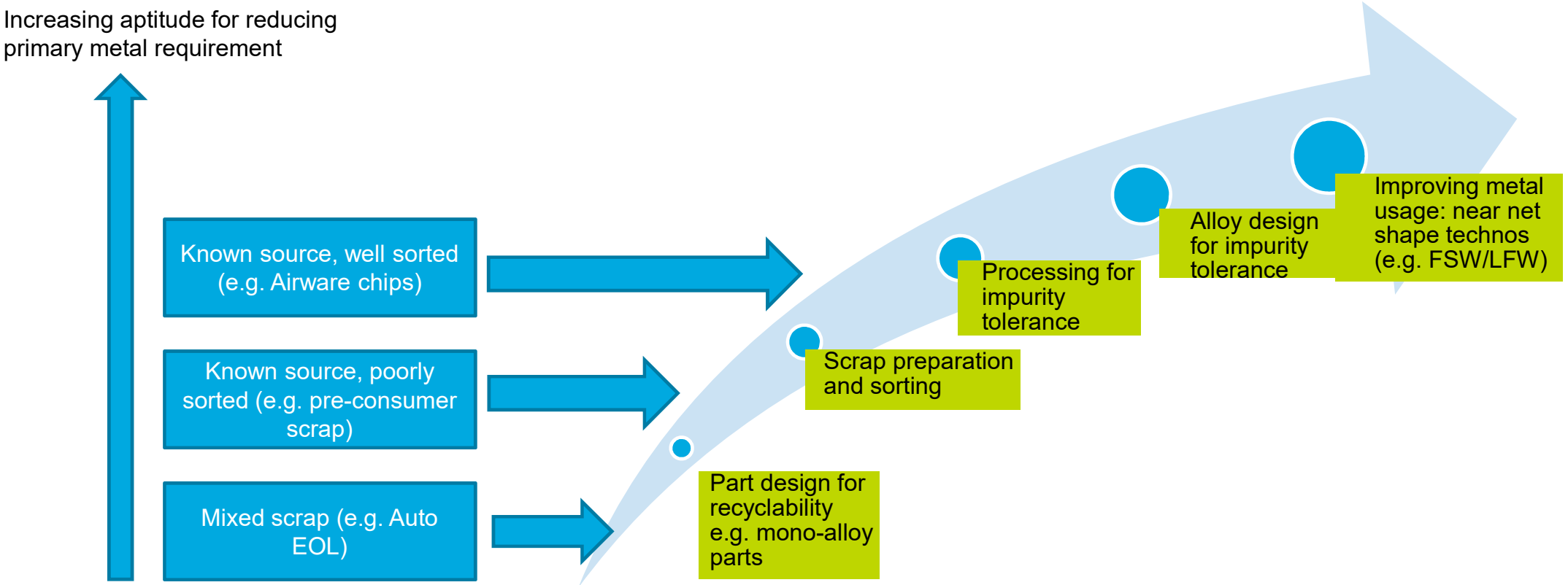
- Develop breakthrough casting technology to improve head and butt sawing recovery, scalping recovery both in conventional and electromagnetic, waste heat recovery from casting cooling water. Its development will be enabled by the implementation of the casting digital twin.

Overall DAFNE 2 program content



Opportunities: alternative burner / heating technologies? Waste heat recovery and storage technololgies?

A combination of approaches tailored to each major application will be required to minimize the requirement for primary metal in Constellium's products



Conclusions

- Sustainability, and in particular reduction of GHG emissions, is a key driver for the materials industry
- Aluminum presents a unique set of opportunities and challenges:
  - An already well developed recycling culture due to:
    - Excellent intrinsic recyclability
    - A high economic benefit to recycling
  - Which needs to be extended into all markets
    - With the challenge of meeting high performance requirements while accepting less controlled metal input
- Constellium is active in addressing these challenges
  - Industrially: committed to -30% GHG emissions by 2030
  - In our R&T: creating new solutions further improving both our own footprint and that of our customers
- There are multiple outstanding challenges, including:
  - Developing impurity and/or variability tolerant alloys
  - Developing recyclable parts (e.g. mono-alloy)
  - Optimizing the scrap recuperation, treatment, sorting strategies.
  - Identifying cost-efficient and low emission alternatives to current gas-fired furnaces


Thank you!
Questions?
Constellium