The Art of Alloy Sorting: Optimizing Aluminum Scrap Utilization in Recycling - Preventing Downcycling of Twitch and other Post Consumer Materials.

Frank van de Winkel

Aachen

21.11.2024

5,000
employees
globally

1.1
billion EUR
in 2022

Publicly listed on Oslo Stock Exchange (OSEBX: TOM)

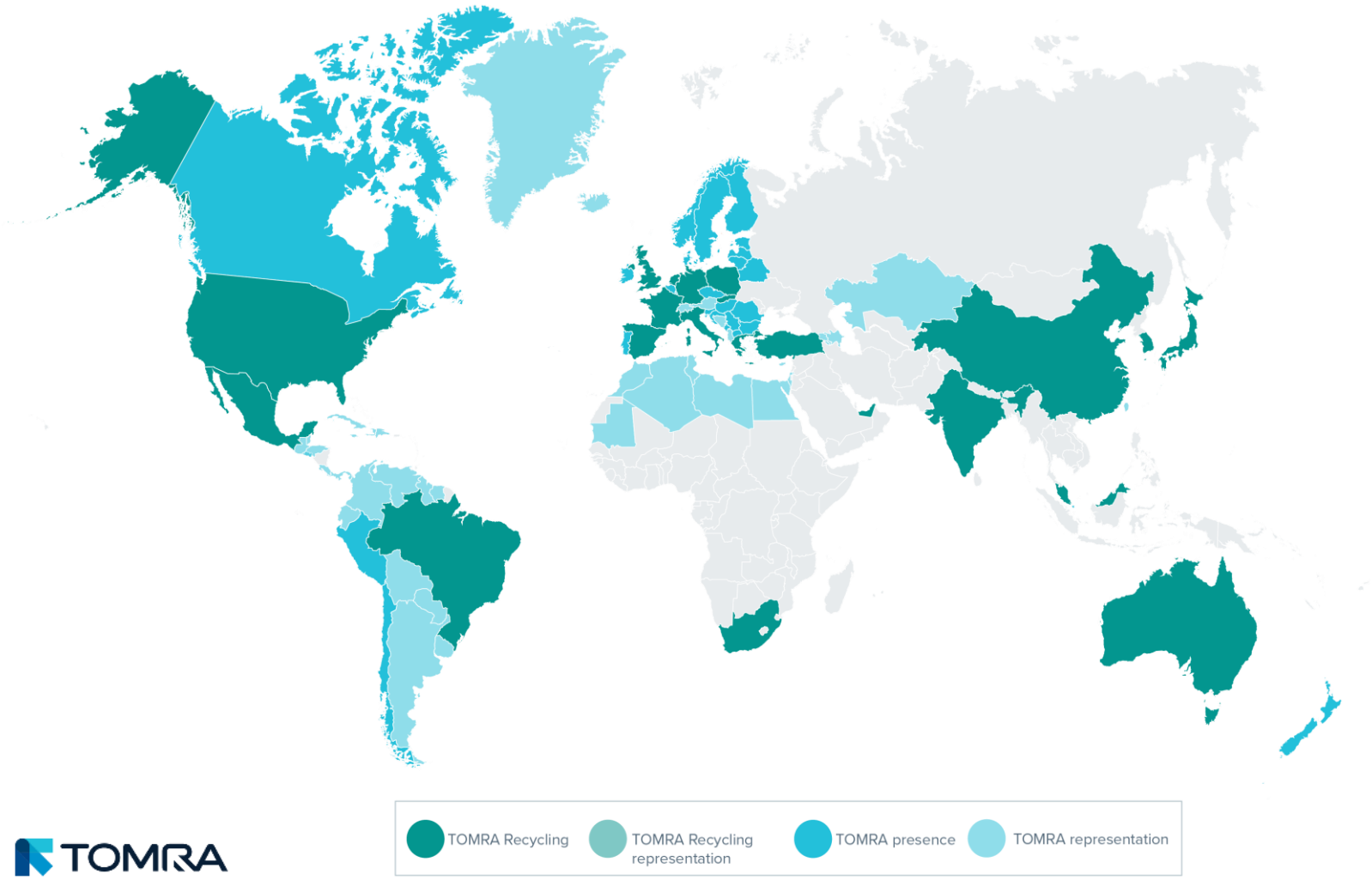
TOMRA

Collection

Recycling

Food

TOMRA Recycling’s global presence



Installed base worldwide

Americas
~1,300

EMEA
~6,300

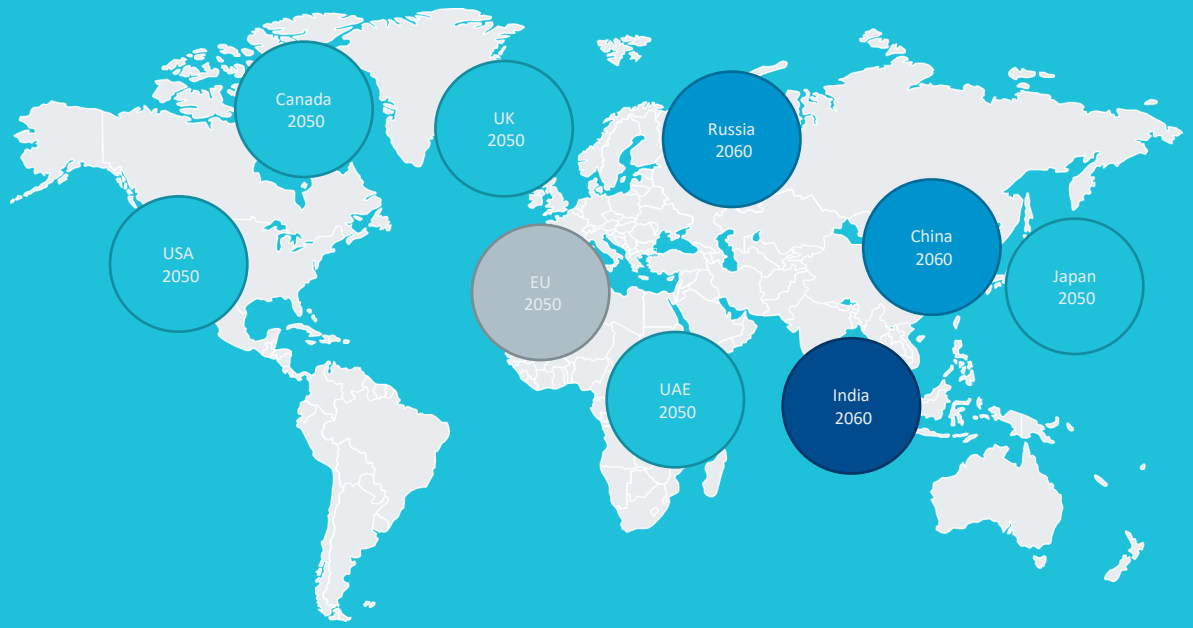
APAC
~1,400

Total ~9,000

*All figures are from 2022

There is a Global Trend to reach Carbon Neutrality:

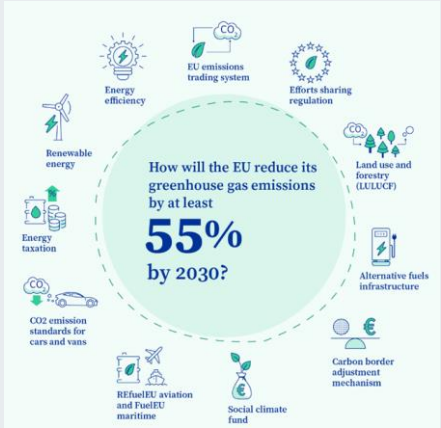
Several states have pledged/projected for carbon neutrality by:



Source: HARBOR Aluminum with Energy & Climate Intelligence Unit data; June 2022

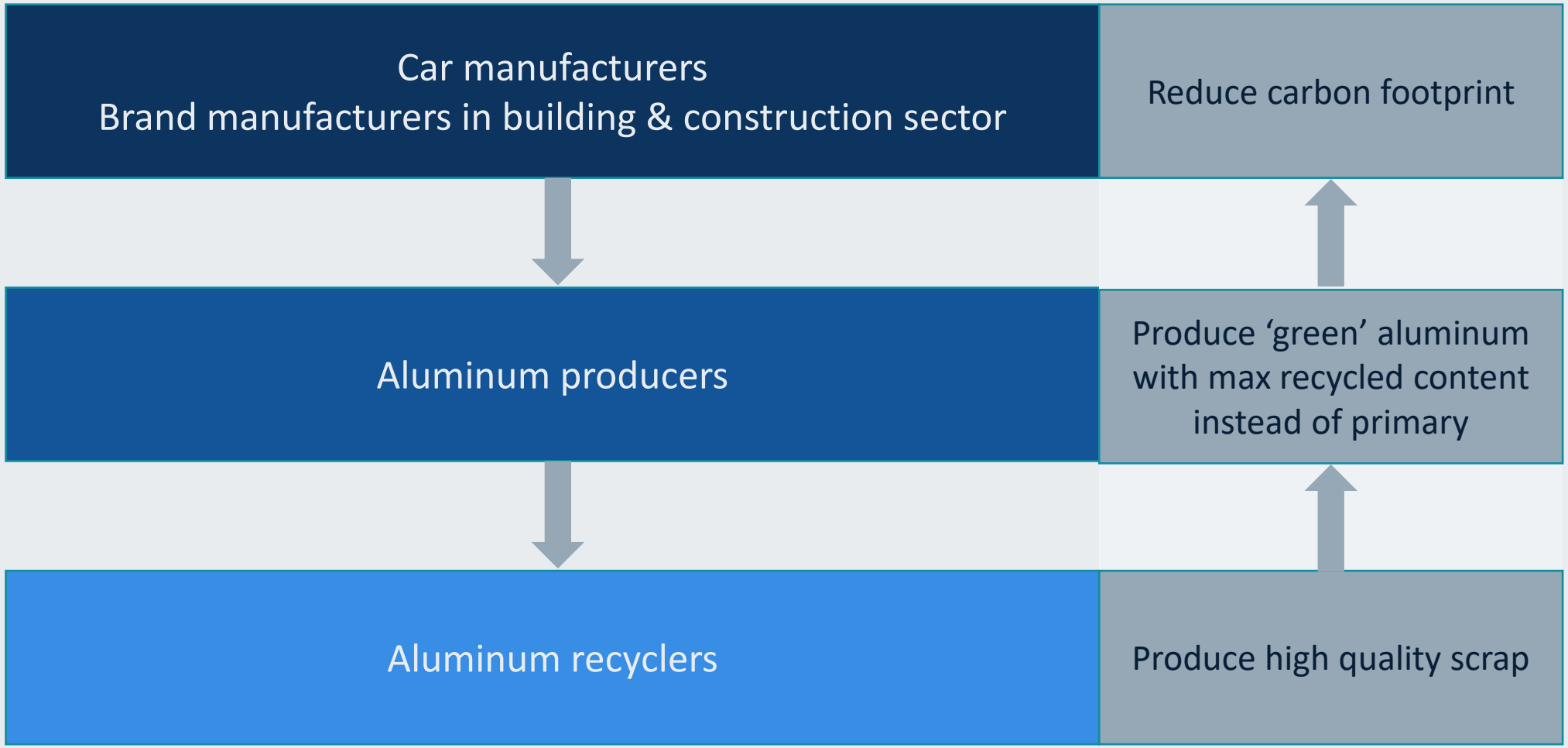
EU Green Deal and "Fit for 55 Initiative"

- European climate law formulates legal obligation to reach climate neutrality by 2050
- Commitment by EU member stats to reduce greenhouse gas emissions by at least 55% by 2030 (compared to 1990 levels); legally binding
- Agreement reached in EU Parliament 04/2021 and EU Council approved in 05/2021

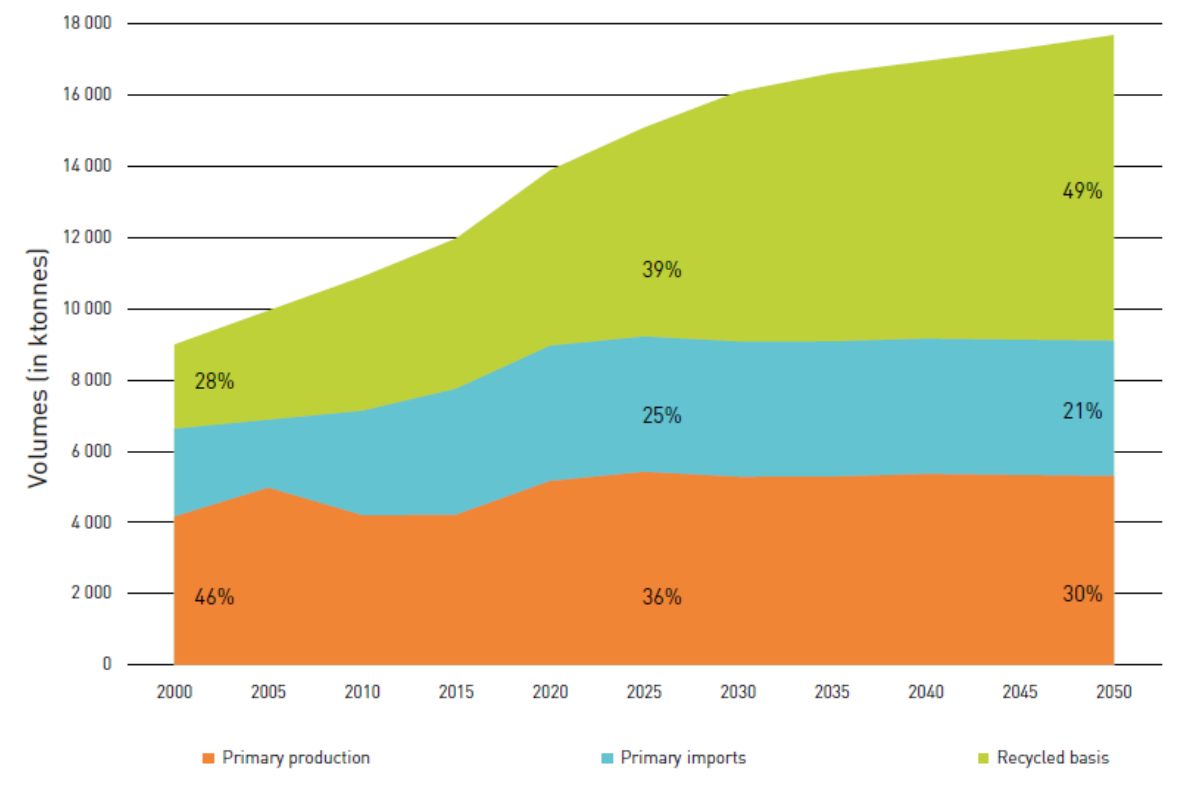


https://www.consilium.europa.eu/en/infographics/fit-for-55-how-the-eu-will-turn-climate-goals-into-law/

This global Development has Impacts and Effects in the Aluminum Industries and it’s connected Industries:



In the EU, Demands for Aluminum is going to rise, mainly fullfilled through Recycled Aluminum Content:



EU demand for aluminum ingots from 2000 to 2050 showing a growth scenario for aluminum on recycled basis[1].

- EU demand for aluminum to **grow +40%** from 2018-2050
- Growth predominantly covered by **recycled aluminum**
  - Limited primary production capacity
  - Circular economy pushing legislations for CO_2 reduction and incentivizing recycled content

Sources:

1. *European Aluminum Vision 2050; 2. European Aluminum Circular Economy Action Plan, 2020*

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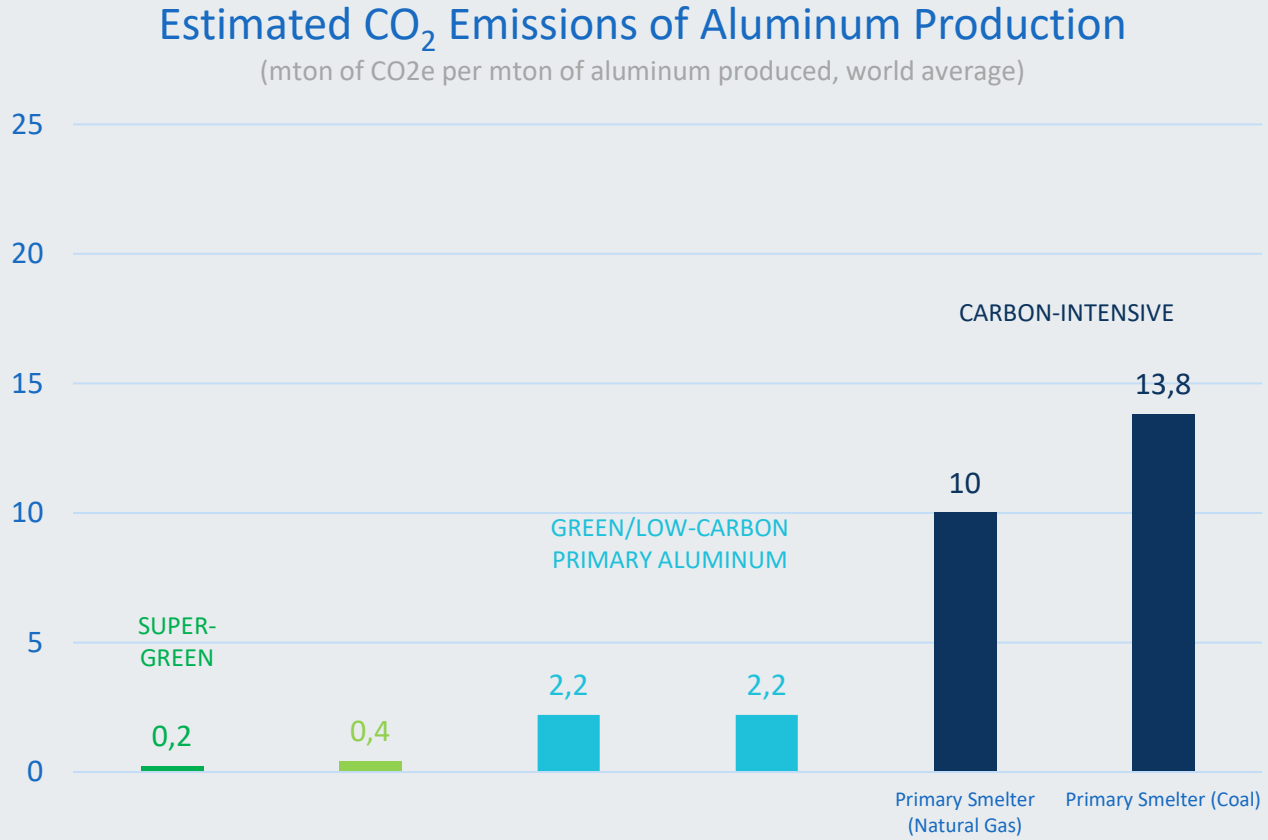
One important Measure to achieve Emission Goals is the increased Usage of Scrap, as it is the only way to get close to Net-Zero:



Source: HARBOR Aluminum, 14th Aluminum Summit, June 2022, Chicago

Carbon intensive aluminum

Primary aluminum is used; electric energy by using fossil fuels

Green/low-carbon primary aluminum

Primary raw materials; electric energy by using renewable energy

Super-green aluminum

Utilization of primary + renewable energy + certain production methods

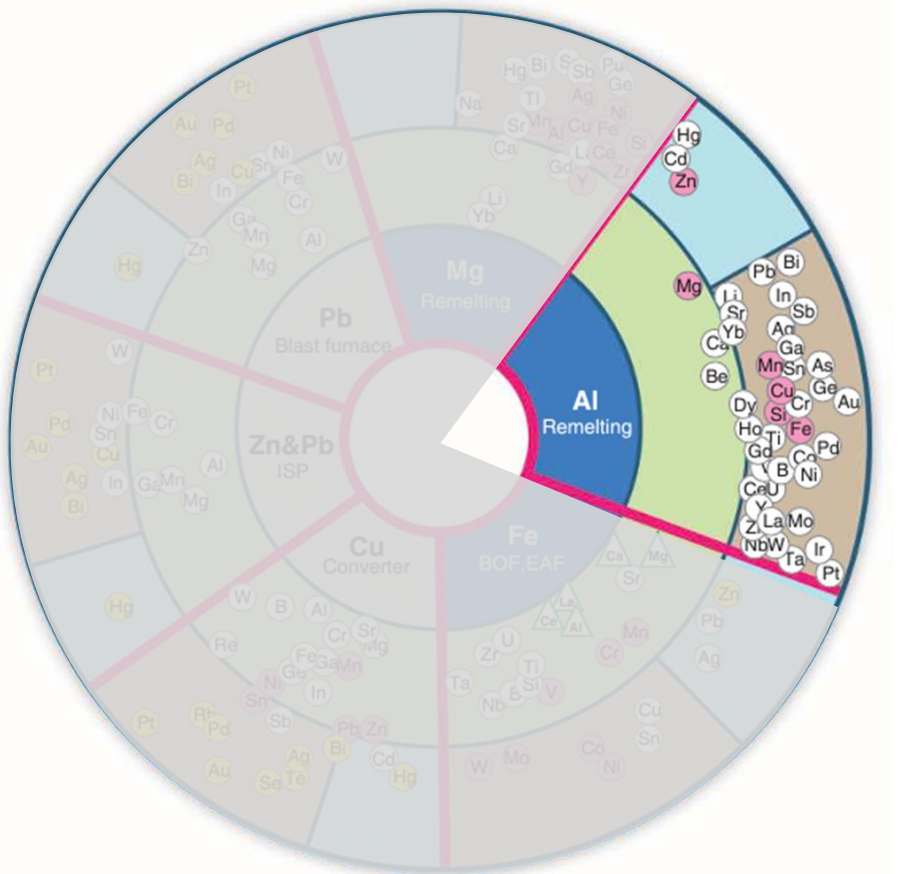
Super-Green - utilization of scrap

A few conclusions towards carbon neutrality

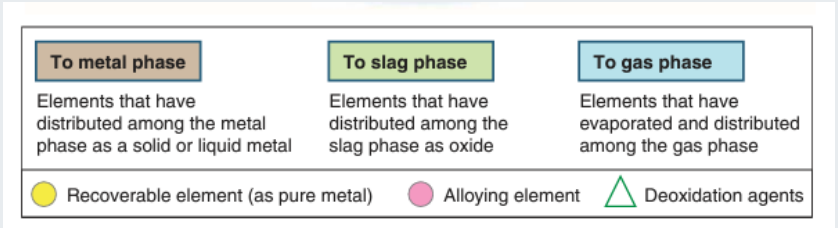
1. The aluminum industry is spending tremendous efforts to reach the goal!
2. Without a significant utilization of scrap, carbon neutrality cannot be reached!
3. In order to utilize more scrap in aluminum production, **clean** scrap fractions are needed!

Aluminum Scrap sorting is essential!

Non-Extractable Elements in Metals Hinder Recycling: Clean, Alloy-True Scrap is Essential for High-Quality Recycling.

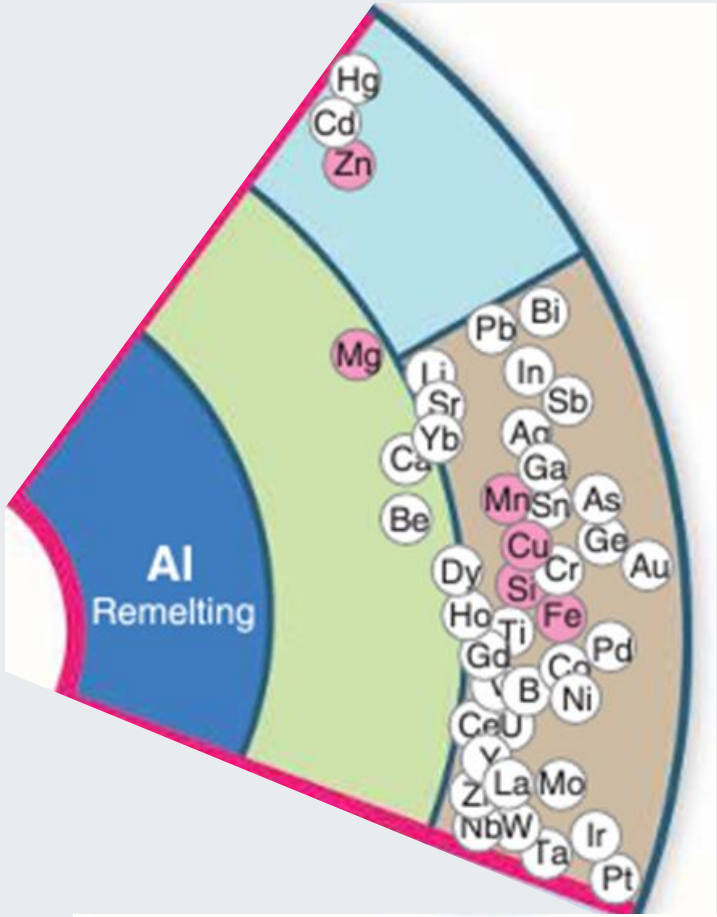


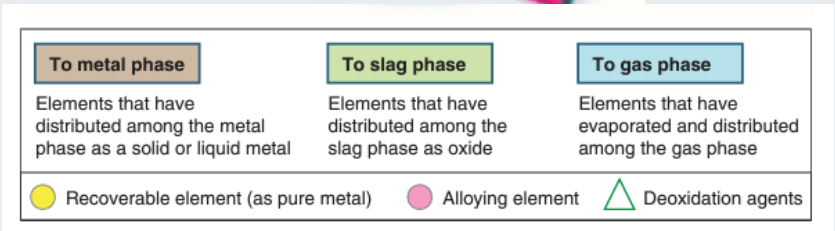
[5] Science 337, 690 (2012), Barbara K. Reck and T. E. Graedel, Challenges in Metal Recycling



- Metal materials and products are rarely used in their pure form; alloys are extensively prevalent.
- Alloying elements (chemical elements) are intentionally added to metals to achieve specific material properties.
- End-of-life materials re-entering the material cycle still contain these alloying elements, potentially compromising the quality of the recycled material.
- The ability to remove alloying elements varies based on the reactivity (nobility) of the metal, as these elements can remain in different phases and are not easily extracted metallurgically.
- High-quality, mono-material or mono-alloy scrap is essential for effective recycling; pre-sorting will be necessary to achieve optimal results.

Non-Extractable Elements in Metals Hinder Recycling: Clean, Alloy-True Scrap is Essential for High-Quality Recycling.





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Post Consumer Aluminum Scrap is in High Demand for Recycling into new Aluminum

The focus currently lies on 3 different aluminum scrap materials that need quality enhancement and sorting into different alloys:

TAINT TABOR

Scrap material that is pre-dominantly a mix of aluminum wrought alloys; with an aluminum content of >98%

EXTRUSIONS

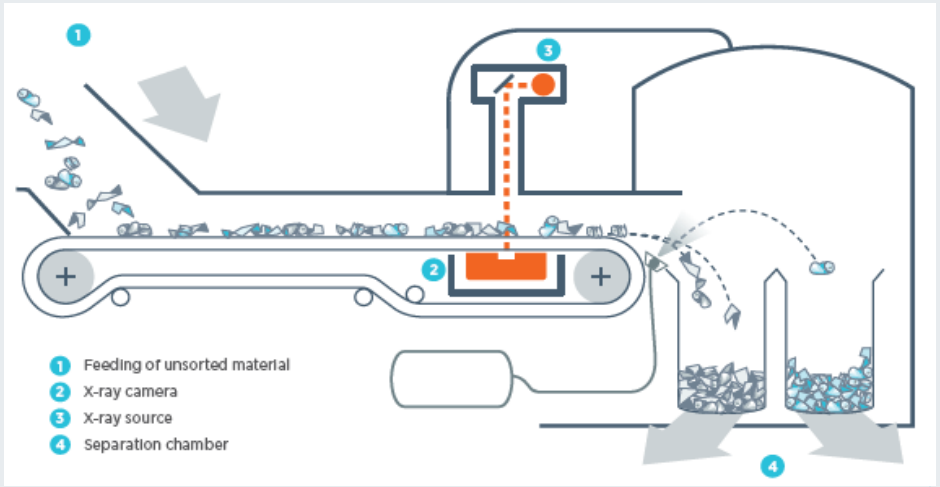
Scrap that is comprised of aluminum profiles, e.g. from windows

TWITCH (generated from ZORBA)

Scrap that is generated in ELV recycling and is pre-sorted by density, aluminum content >98%

Sorting by Atomic Density

X-Ray Transmission (XRT) technology is utilized to Differentiate and Sort Aluminum Scrap by Atomic Density



Low density → High density

Magnesium

Wrought aluminum

Cast aluminum

Heavy metals

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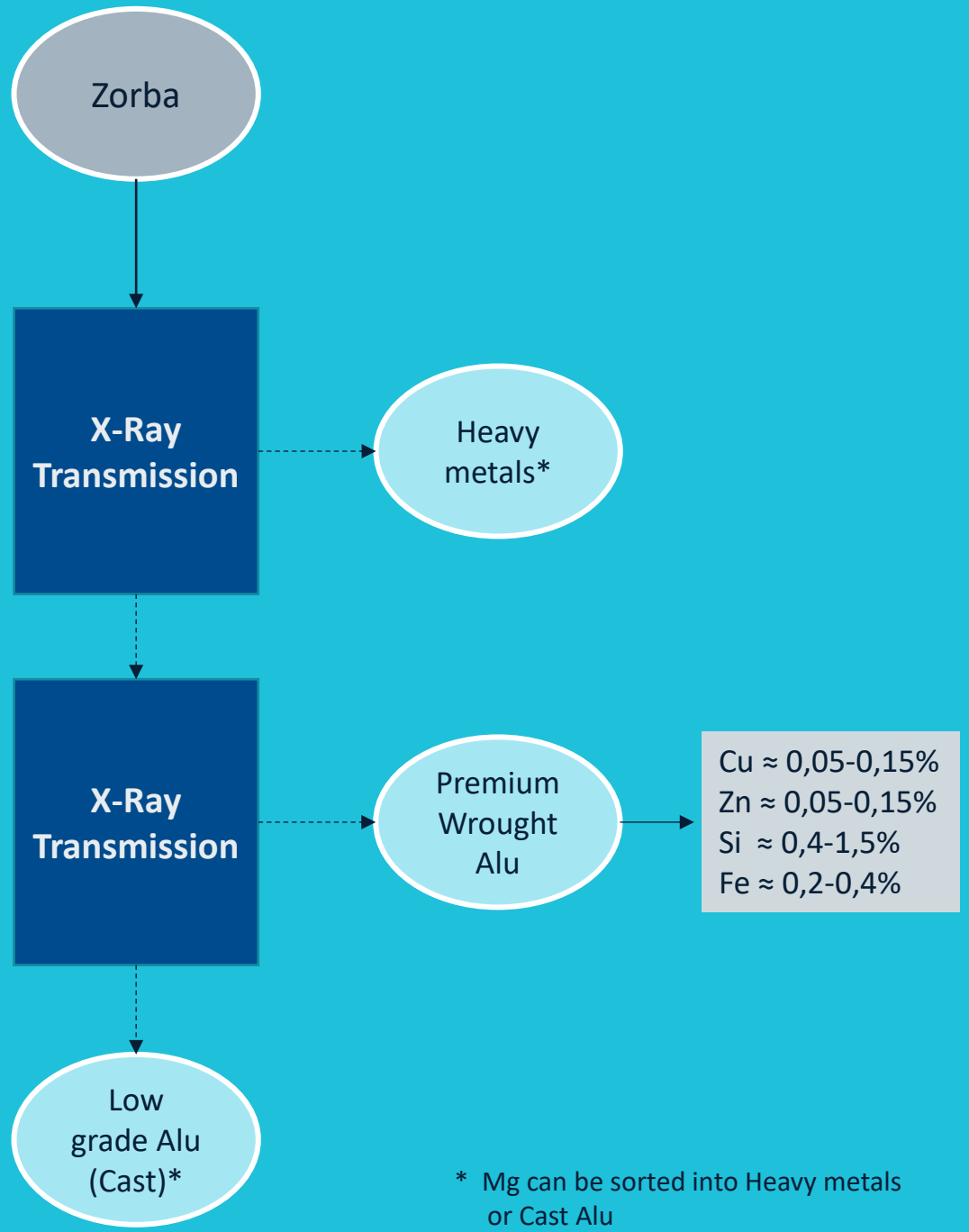
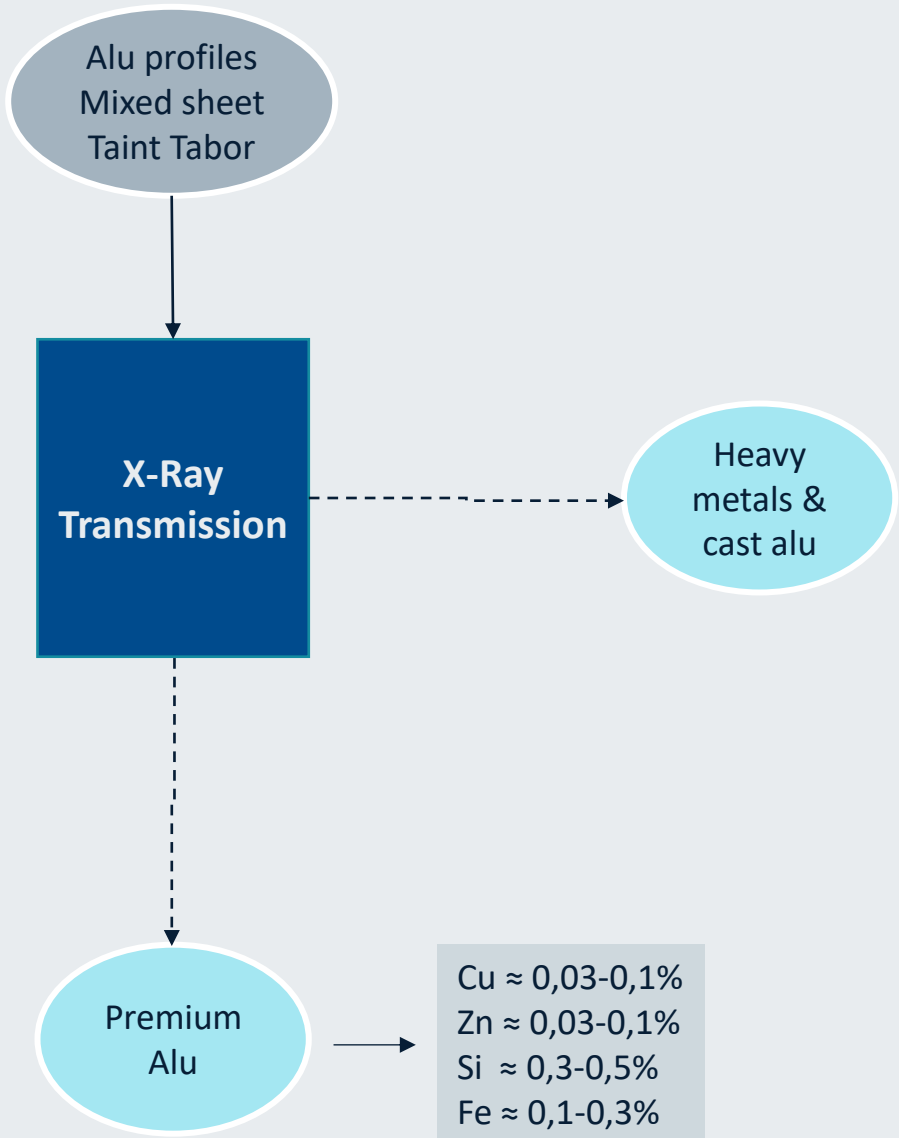
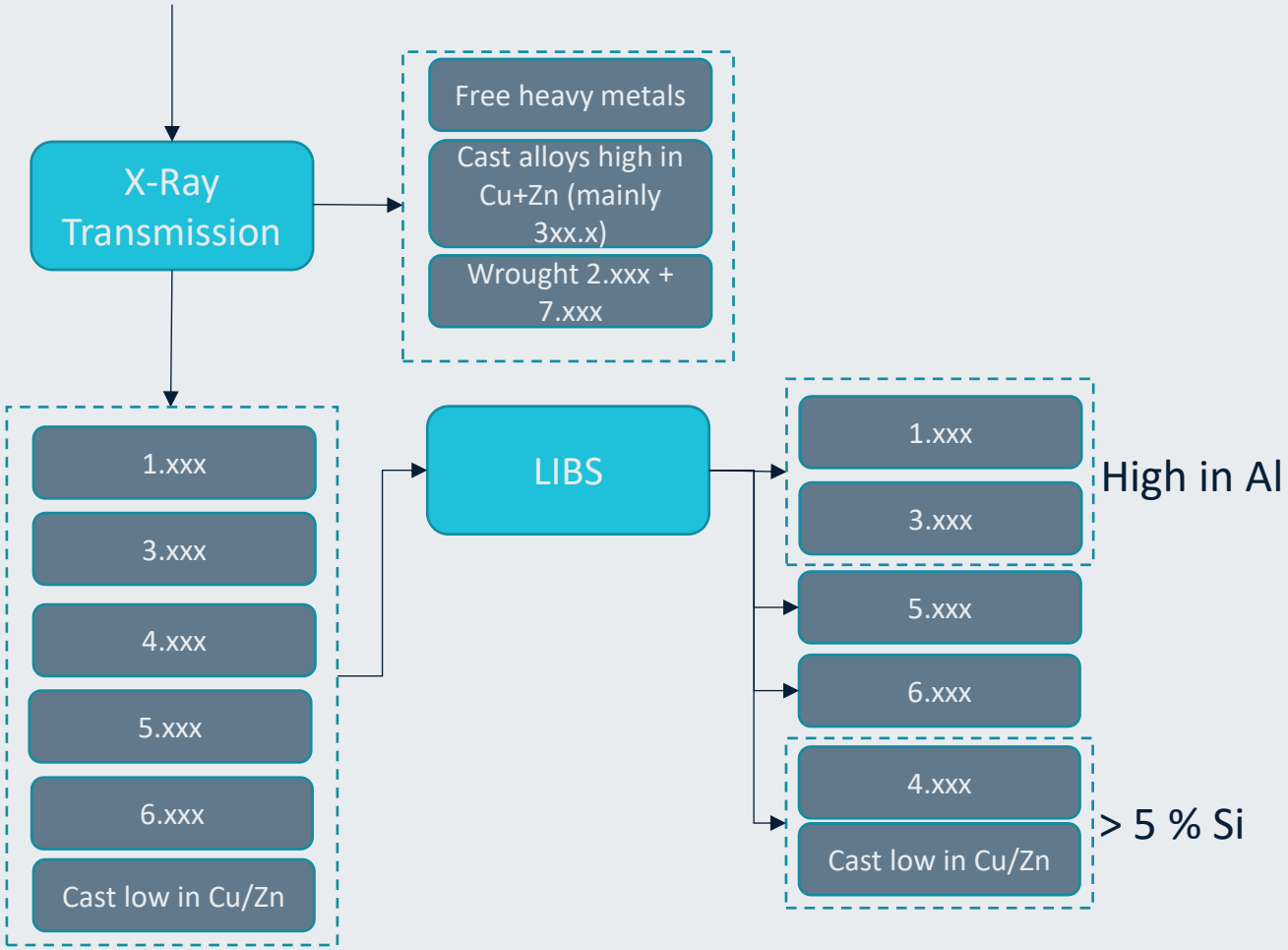


* Mg can be sorted into Heavy metals or Cast Alu



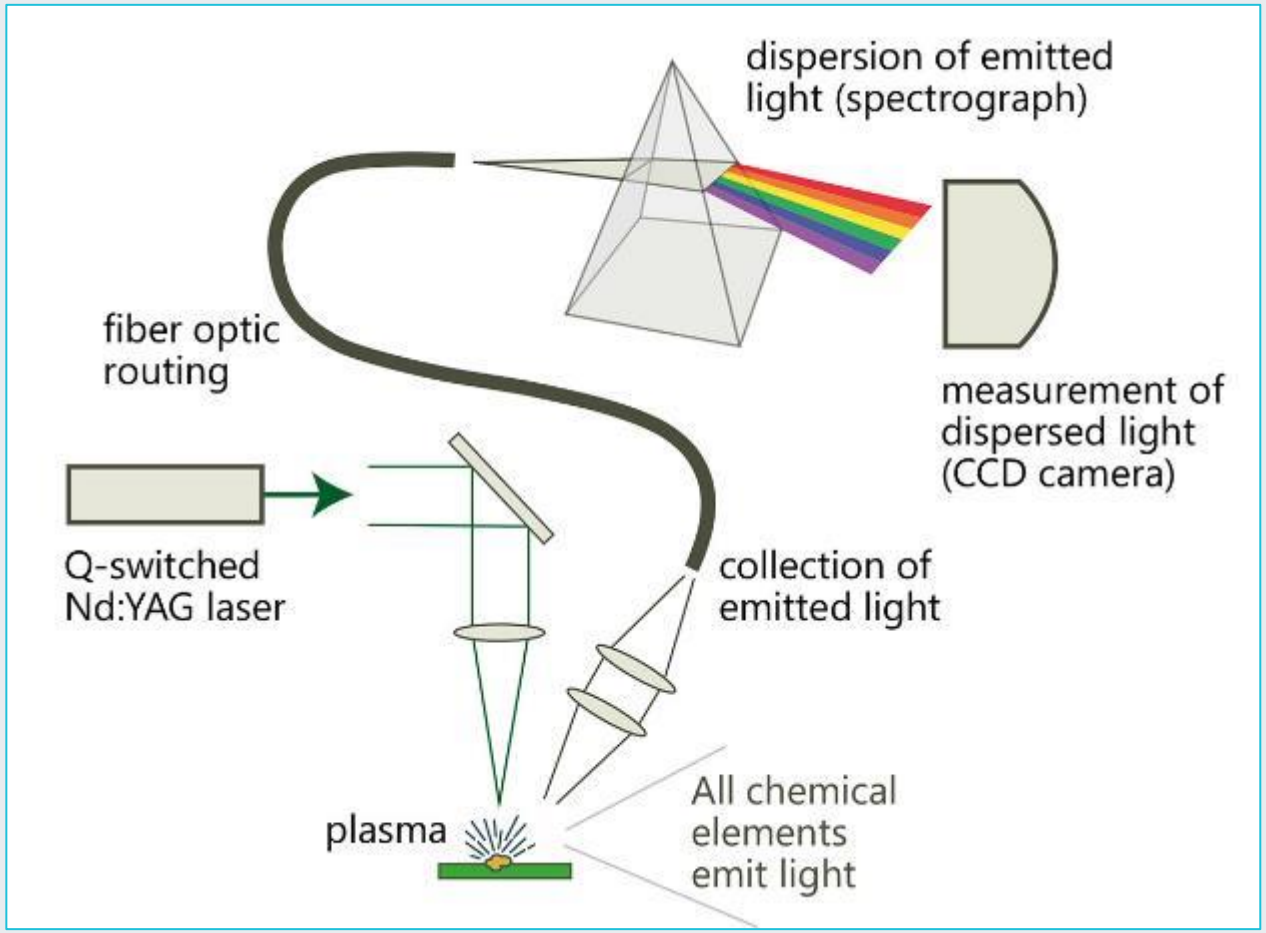
Sorting by Aluminum Alloy

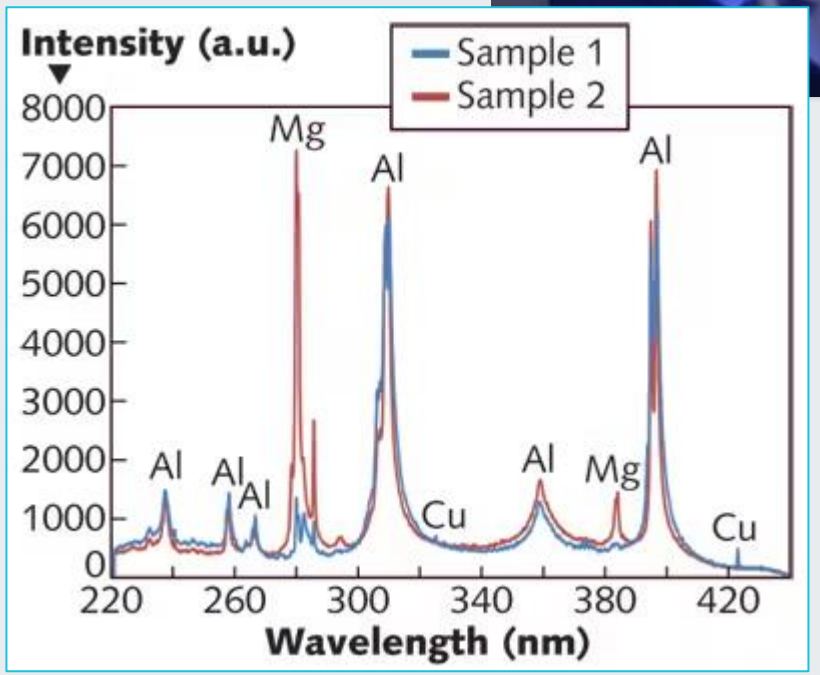
Sorting aluminium by alloy is of high importance



- The X-TRACT is a good sorting step in order to decrease Cu, Zn and partly Si
- This removes the 2.xxx and 7.xxx as well as the cast alloys high in copper
- In aluminium from car shredder a high content of Si typically remains
- LIBS Sorting can help to lower the Mg and Si level

LIBS Detection enables the Identification of Specific Elements in Aluminum Scrap:





https://en.wikipedia.org/wiki/Laser-induced_breakdown_spectroscopy

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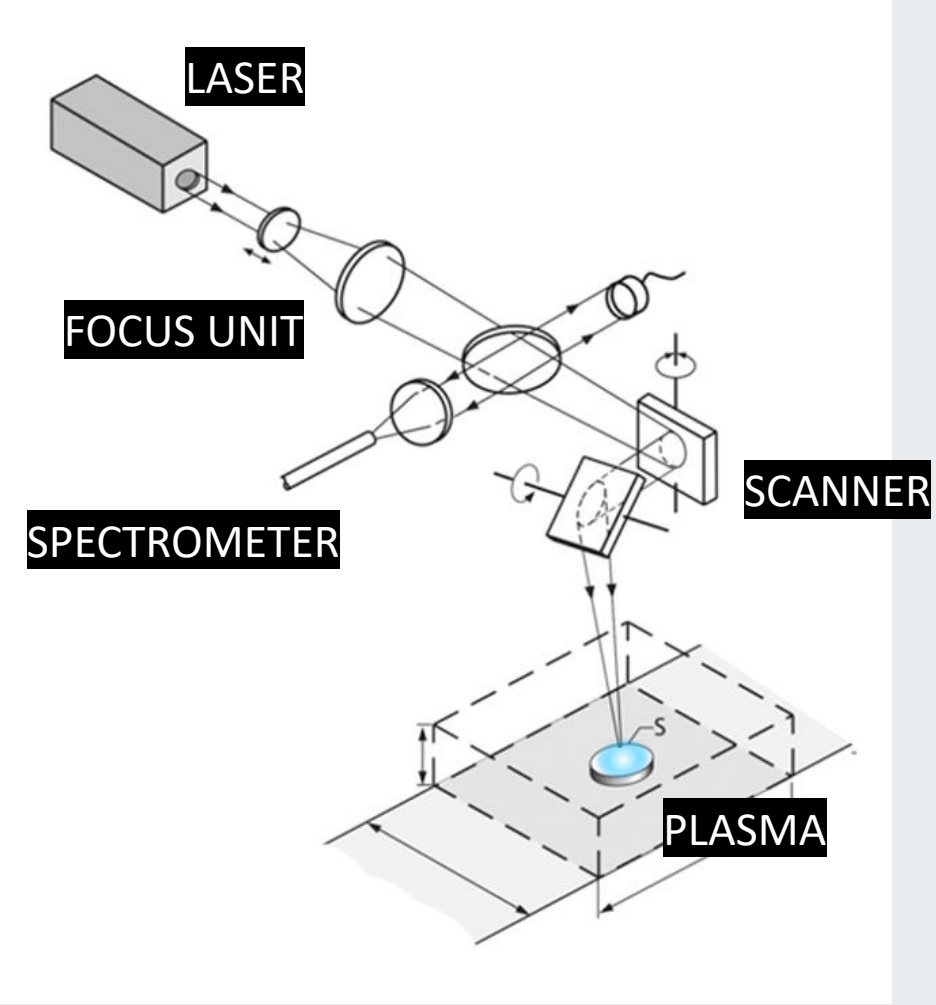
TOMRA has adapted the LIBS principle to Bulk Sorting of Scrap Materials:



https://www.parilas.eu/en/consortium.html

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 520 165 B1**

(12) **EUROPÄISCHE PATENTSCHRIFT**

(45) Veröffentlichungstag und Bekanntmachung des Hinweises auf die Patenterteilung:
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PCT/EP2003/006705

(22) Anmeldetag: **25.06.2003**

(87) Internationale Veröffentlichungsnummer:
WO 2004/003528 (08.01.2004 Gazette 2004/02)

(54) **VERFAHREN UND VORRICHTUNG ZUR DURCHFÜHRUNG DER EMISSIONSSPEKTROMETRIE**
METHOD AND DEVICE FOR CARRYING OUT EMISSION SPECTROMETRY
PROCEDE ET DISPOSITIF DE SPECTROMETRIE D'EMISSION


2022/11/17 10:37:49 THU
reolink
LIBS

AUTOSORT™ PULSE is the Sorting Machine fully Industrialized for processing Bulk Scrap Material Flows:

AUTOSORT® PULSE

- Conveyor Belt length 5.5m
- 2.5-3m/s conveyor belt speed
- Sorting width 1200mm
- Fits into an oversea container

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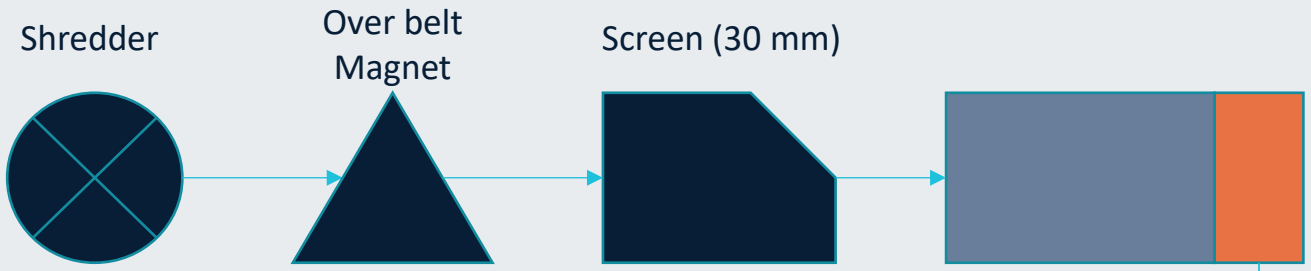
In a generic processing Flow, LIBS Detection requires some Pre-Processes:



<u>Results matching the industry requirements:</u>

- High throughputs that match industry standards
- High purities that enable direct scrap utilization in aluminum production.

5xxx

6xxx

Many Different Aluminum Scrap Materials can be sorted Utilizing LIBS Technology:

1) **Post-production (PPr)**
   - Stamping scrap
2) **Post-consumer (PCo)**
   - Zorba (Shredded NF-scrap)
   - Twitch (Floated fragmentizer aluminum scrap, from automobile shredders)
   - Taint Tabor (Clean mixed old alloy sheet aluminum)

1) Post production (car industry): Mostly a mix of 6 alloys (3*6.xxx and 3*5.xxx)

2) Post consumer: Mostly a mix of all series (1.xxx, 2.xxx, 3.xxx, 5.xxx, 6.xxx, 7.xxx, cast >5% Si)

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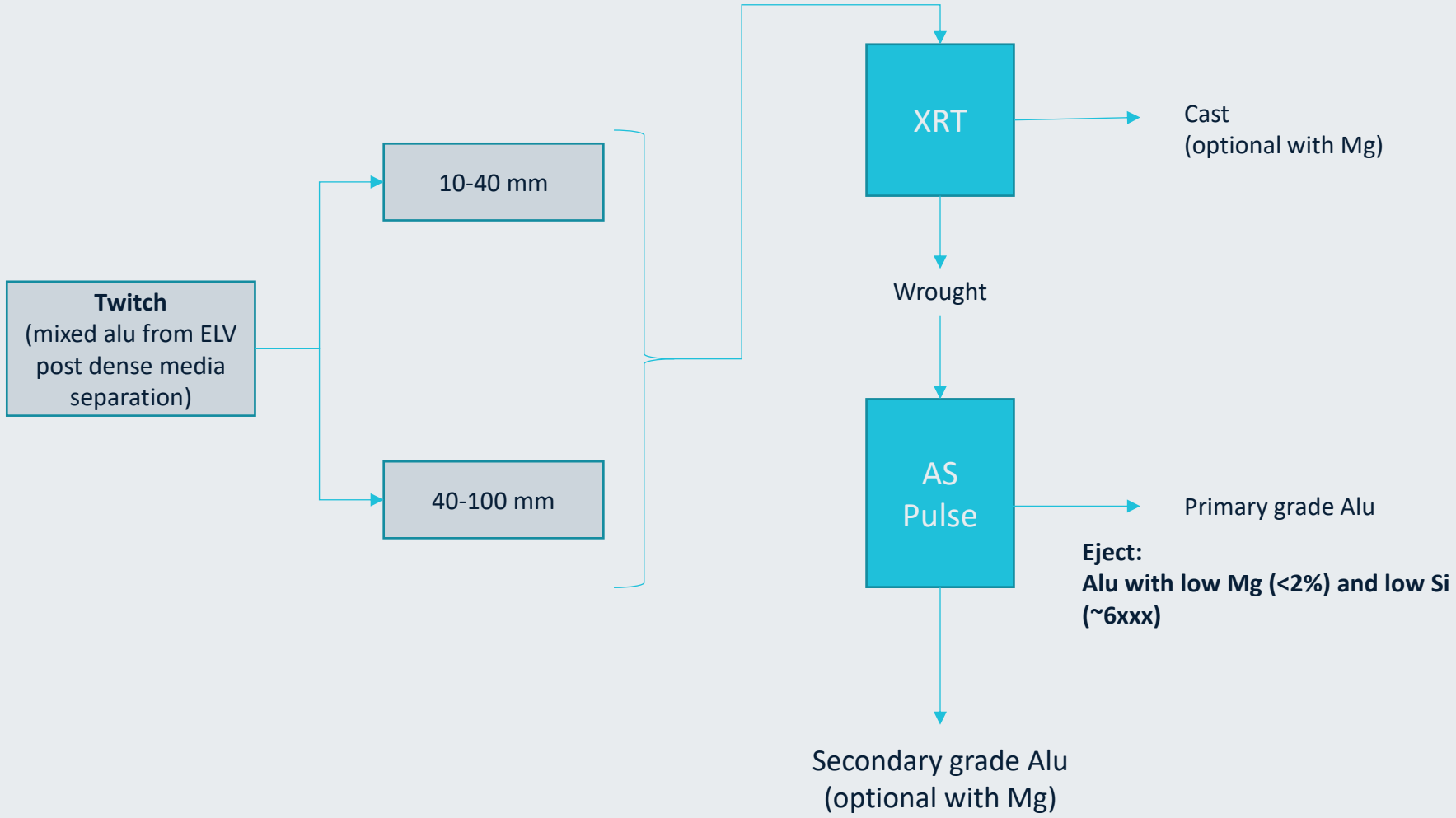
Post Consumer Scrap Applications

Post-Consumer Scrap, Example #1 – Twitch

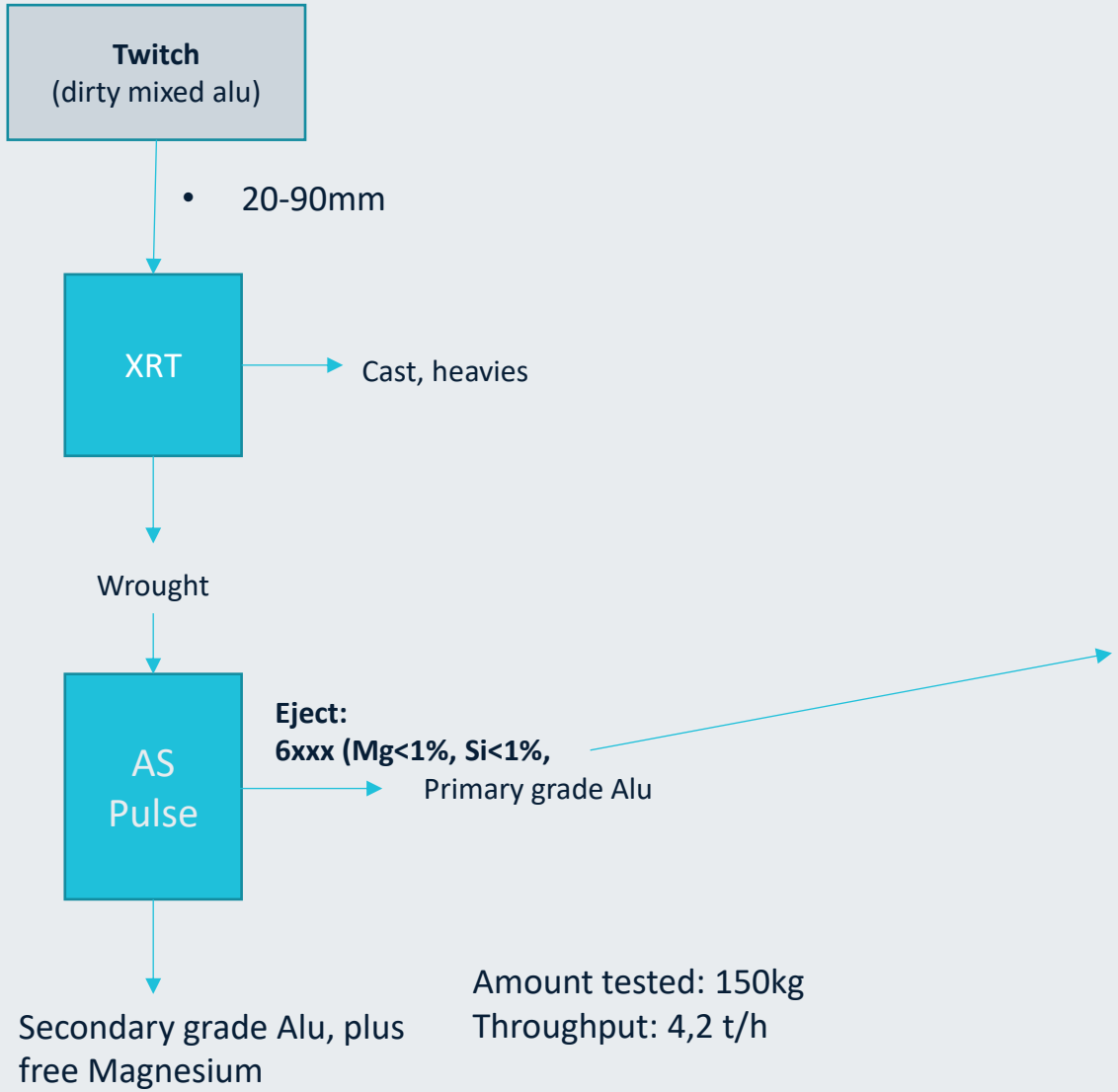
- Aluminium from the auto shredder process was sorted in two steps: X-TRACT and LIBS
- The materia was processed in two grain sizes:
  - 10-40 mm
  - 40-100 mm
- The AUTOSORT *Pulse* extracted all alloys with low Mg and low Si

Example #1 – Set Up and Results



Melt Analysis		
	10-40mm	40-100mm
Cu	0,05%	0,03%
Zn	0,04%	0,06%
Fe	0,28%	0,3%
Mg	0,3%	0,4%
Si	0,5%	0,5%
Mn	0,1%	0,15%

Post-Consumer Scrap, Example #2 – Twitch



Amount tested: 150kg
Throughput: 4,2 t/h

- Goal is to produce a premium quality with specifications:
  - Si<1%
  - Mg<1%
  - Zn<0,7%
- Targets are reached well within specs

	TOMRA LIBS	
Elemento	6xxx LIBS+XRT	Resto LIBS+XRT
Si	0,50%	2,1%
Fe	0,3%	0,3%
Cu	0,05%	0,05%
Mn	0,15%	0,2%
Cr	0,0090%	0,03%
Mg	0,4%	4,0%
Zn	0,01%	0,03%
Ti	0,02%	0,03%
Ni	0,004%	0,004%
Pb	0,005%	0,01%
Otros cada	-	-
Humedad	0,00%	0,00%
Orgánicos	2,4%	4,0%
Hierro libre	0,4%	0,40%

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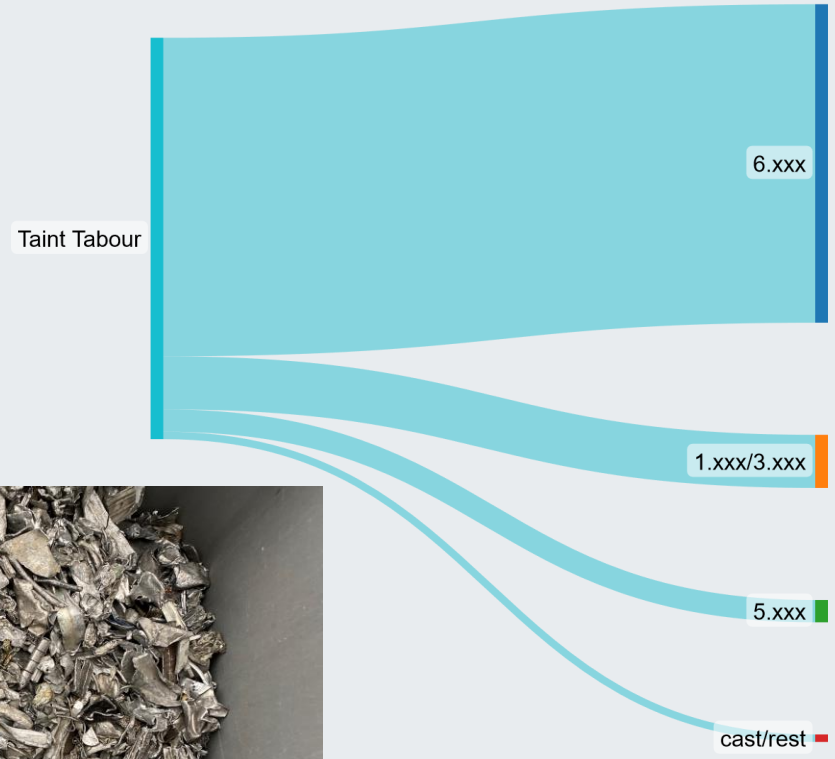
Example #3 – Taint Tabor

- The machine produced the groups 6.xxx, 5.xxx, 3.xxx and cast in 4 steps
- Recovery of 6.xxx has to be increased, as below 90%
- The more groups are defined the better the purity and recovery results will become

	Alloy group	Pur	Rec.	Throughput (tph)
Step 1	**6.xxx**	97,5%	81,1%	3.8
Step 2	**5.xxx**	97,7%	92,8%	3.9
Step 3	**3.xxx**	89,1%	83,2%	4.3
Step 4	**cast**	91,0%	47,0%	3.5

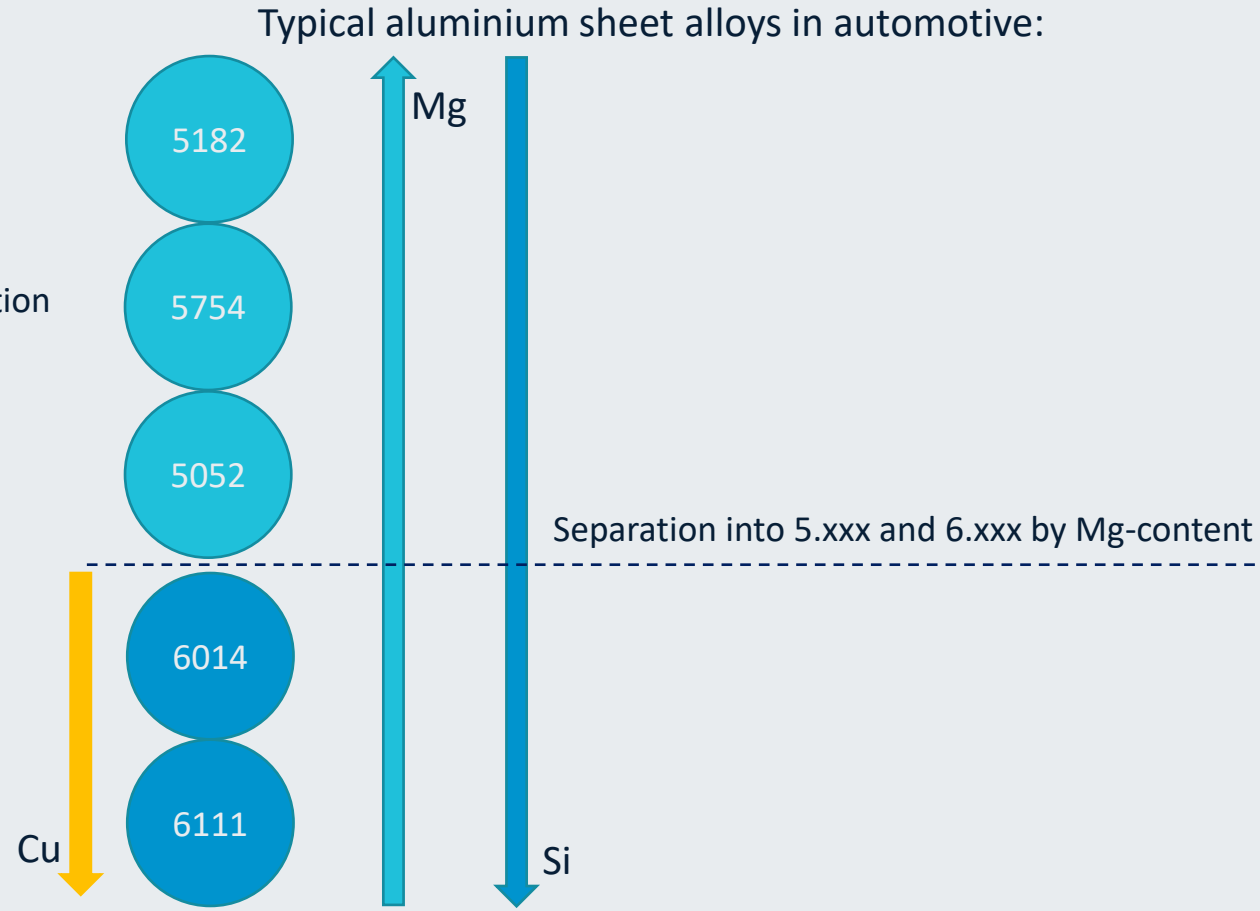


Post Production Scrap Applications

In the Car Manufacturing Process, different Aluminum wrough alloys are utilized for different Components:

- Production scrap from cars as a first sorting task for the AUTOSORT PULSE
- Separation of two main alloy groups (5.xxx and 6.xxx)
  - Mg in 5.xxx roughly > 2 %
- Scrap is completely clean: no lacquer, dirt or organic
  → plasma on the surface easy to create
- Separation of different alloy kinds within the groups is still under investigation

Al-Legierung	Si	Fe	Cu	Mn	Mg	Cr	Zn
5052[1]	0,25	0,40	0,10	0,10	2,2-2,8	0,15-0,35	0,10
5182[1]	0,2	0,3	0,15	0,2-0,5	4,0-5,0	0,1	0,25
5754[1]	0,40	0,40	0,10	0,50	2,6-3,6	0,30	0,20
6014[1]	0,30-0,6	0,35	0,25	0,05-0,20	0,40-0,8	0,20	0,10
6451[2]	0,60-1,0	0,40	0,40	0,05-0,40	0,40-0,80	0,10	0,15
6111[2]	0,60-1,1	0,40	0,50-0,90	0,10-0,45	0,50-1,0	0,10	0,15



[1]DIN EN 573-3, Dezember 2013
[2]www.matweb.com

Researchproject KANAL

Kreislaufsystem für funktionales **A**luminium-**N**euschrottrecycling aus der **A**utomobilproduktion mittels **L**aserinduzierter Plasmaspektroskopie

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

Projektträger Jülich Forschungszentrum Jülich

Projectpartner:

Gerhard Lang Recycling GmbH, TOMRA Sorting GmbH, Jeanvré Ingenieure, Hochschule Pforzheim, German Car Manufacturer, Novelis Deutschland GmbH

Researchproject KANAL

- Funded as part of the German Federal Ministry for Economic Affairs and Climate Action’s (BMWK) lightweight construction technology transfer program (Technologietransfer-Programm Leichtbau)
- Development of an end-to-end process chain for new aluminum scrap from automotive production, from the point of origin, through identification and sorting, to the smelter or semi-finished product manufacturer and reuse in lightweight automotive componentsTrennung vermischter Aluminium Neuschrotte in die Legierungsgruppen 5xxx und 6xxx
- The central technical step is the separation of the new scrap using LIBS technology through the provision of AUTOSORT® PULSE sorting technology by TOMRA Sorting GmbH
- Support from associated partner companies from the automotive and aluminum industries - including Novelis Germany

Gefördert durch:

Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Conclusion and Outlook

- For Decarbonization Purposes, the Aluminum Industry will require more and more clean scrap inputs with as little ‘mixed’ alloys as possible.
- These scrap materials today are scarece or do not exist.
- Scrap treatment processes need to be adapted to create necessary scrap qualities for recycling.
- Downcycling of valuable alloys can be prevented by the right processing technology

OUTLOOK:

- More and more scrap processing will be implemented
- Scrap sorting by alloy group (inter-alloy) will be possible
- Scrap sorting within a specific alloy group (intra-alloy) is today already possible for specific materials and will be further developed in the future.

www.tomra.com

CASE STUDY Aluminum recycler in Italy:

Input material:

Aluminium profiles & sheet
Taint/Tabor

Contaminations:
Zinc, brass attachments or inclusions
Some free heavy metals
Very little castings, Zamac (zinc alloy)
Plastics, non-metals

Contamination level only few %

Input content of zinc ~0,5-1% Zn

Centro Rottami sr

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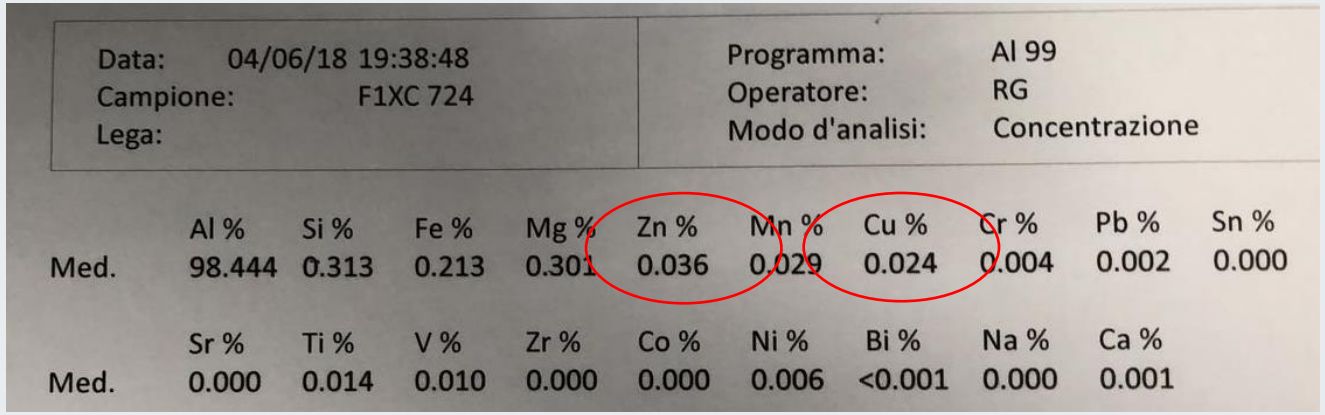
www.centrorottami.com

CASE STUDY - Product quality suitable for direct use in Aluminum Production Process

- **Zinc** < 0.04 – 0.05%
- **Copper** < 0.04 – 0.05%



Data:	04/06/18 19:38:48					Programma:	Al 99			
Campione:	F1XC 724					Operatore:	RG			
Lega:						Modo d'analisi:	Concentrazione			
	Al %	Si %	Fe %	Mg %	Zn %	Mn %	Cu %	Cr %	Pb %	Sn %
Med.	98.444	0.313	0.213	0.301	0.036	0.029	0.024	0.004	0.002	0.000
	Sr %	Ti %	V %	Zr %	Co %	Ni %	Bi %	Na %	Ca %	
Med.	0.000	0.014	0.010	0.000	0.000	0.006	<0.001	0.000	0.001	

Added value:

- Sell at 95% of LME
- For example: Price-Delta = **€ 300 / ton**
  (depends on actual market conditions)
- Aluminum scrap used for remelting; production of extrusion billets.

Losses:

- Fines 0-5mm (3-5%) – sold as dross/slag to slag recycler
- 8-10% in waste, ferrous, stainless etc.
- 1-2% aluminum into ejected contaminants

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CASE STUDY - Aluminum remelter Italy

INDINVEST

Aluminum Foundry & extrusion plant

- Two tilting furnaces, double chamber
- 5 presses
- 48.000 tons per year of produced extrusion profiles

Mainly 6060 alloy:

- Similar to primary quality
- Fe < 0.24%
- Zn < 0.045%
- Mn < 0.04%
- Cu < 0.03%

CASE STUDY - Benefits for Indinvest

Prior to using sorted scrap produced by Centro Rottami XRT:

- Secondary scrap **~ 20%** of total
- Primary ingots **~45%** of total
  - Price + € 250 > secondary scrap

+ € 1.5M

Since using secondary scrap produced by Centro Rottami XRT

- Secondary scrap **~ 45%** of total
- Primary ingots **~30%** of total

- Energy / gas consumption: **65 m^3/ton**

- 6%

- Energy / gas consumption: **60 m^3/ton**

- Cleaning of furnaces due to 'dirty scrap'

+ € 1.0M

- Furnace doesn't need cleaning as a result of using clean scrap
  - **Increased production by 2%**

TOMRA