Turning scrap into the sustainable future of the manufacturing

LAYERS AHEAD

Enabling the Circular Economy with AM

Our Value Proposition

A sustainable and innovative process to transform *metal scrap* into *metal powder* for 3D printing

We are transforming metal making into a **circular economy**

Goal: lower the **carbon footprint** of our customers


Metal is already recycled today…
…however, it is mostly done in an inefficient

Traditional approach

1 : 15

150+ kg of CO_2eq / kg metal

Data calculated by LCA analysis on Inconel® material

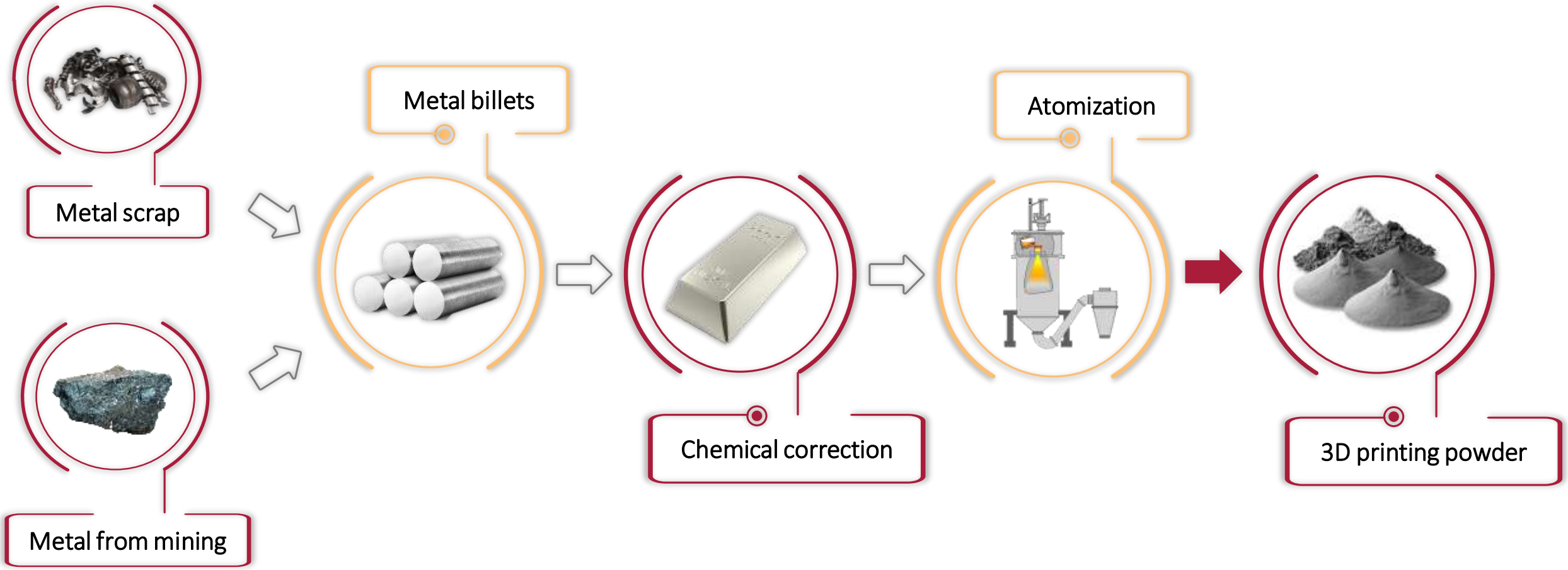
f3nice
LAYERS AHEAD

f3nice approach

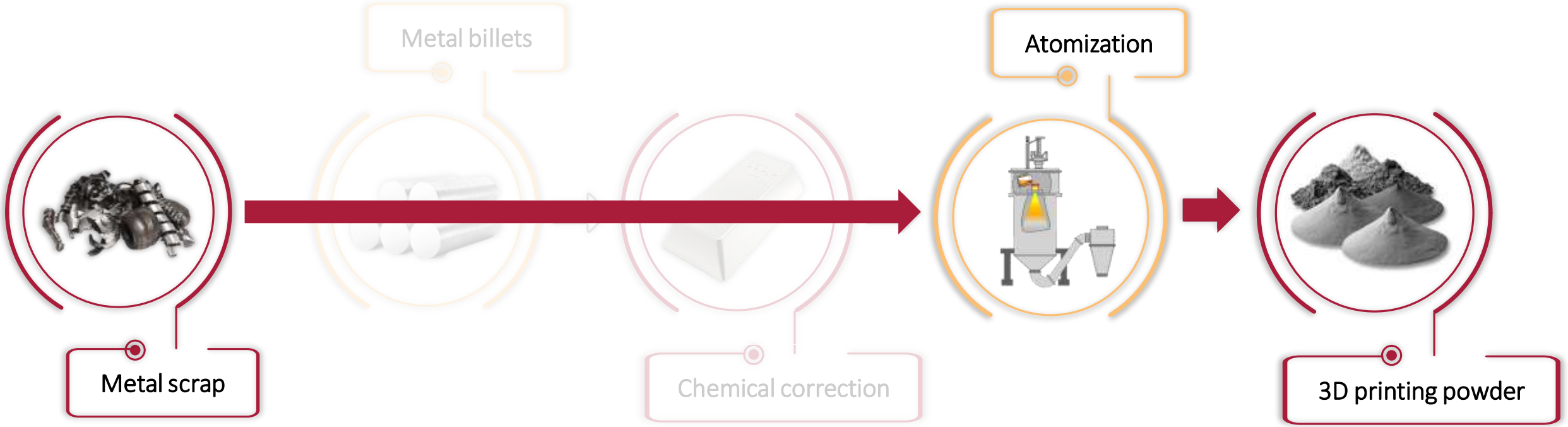
1 : 1

10+ kg of CO_2eq / kg metal

Data calculated by LCA analysis on Inconel® material

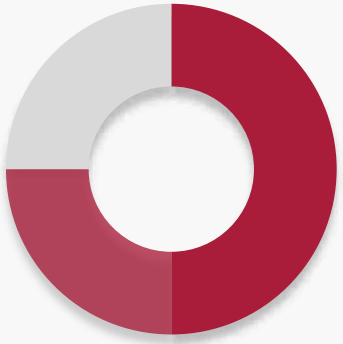


Conventional process



f3nice upcycling process

Our powder benefits



50 to

CO_2 saving

≈

50%

Energy saving

results by
in-house LCA analysis

up to 100% Metal scrap

Additional benefits of our solution

1

USING METAL SCRAP & OBSELETE PARTS

=

Less minerals mining and exploitation of natural resources

(CO_2 reduction)

2

LOCAL PRODUCTION

=

Less logistic and reduction of transport, boost of local economy

($ & CO_2 reduction)

3

FIXED PRICE

=

Less volatile towards market prices fluctuation

($ reduction)

4

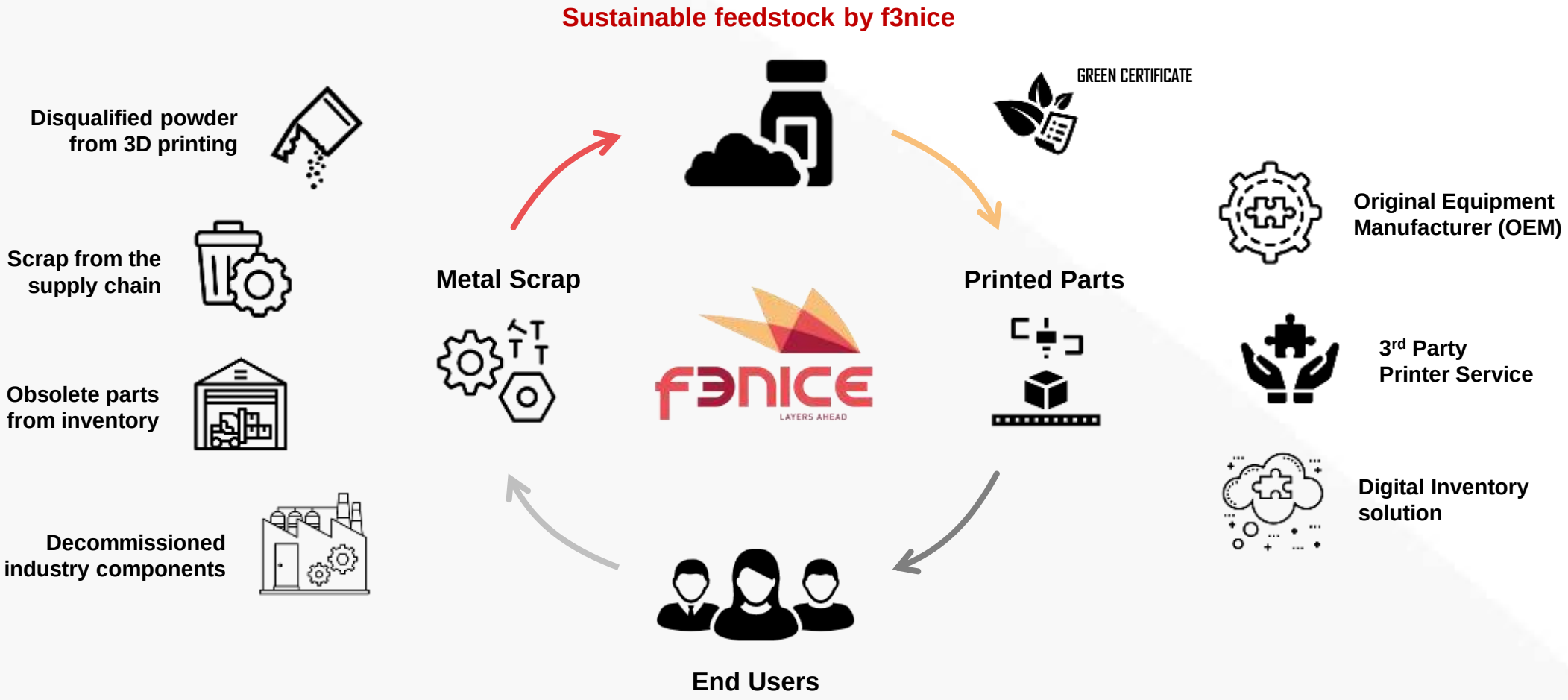
RESILIENT & SUSTAINABLE

=

Strategic solution to tackle the Supply Chain disruption

($ reduction)

f3nice in the Value Chain



f3nice process: step by step

Overview: production steps and added value

Scrap collection & preparation

Our Role

- Collecting scrap material
- Checking and sorting
- Cleaning and preparation

Powder atomization

- Recipe for the scrap mix
- Powder atomization
- Sieving and packing

Powder characterization

- Providing powder samples
- Iterating on the production
- Leading R&D activities

Printing & testing

- Powder for qualification
- Licensing f3nice powder
- CO_2 savings: LCA analysis

1. Scrap sorting

Metal scrap collected from different sources (Equinor on the left, Shell on the right)

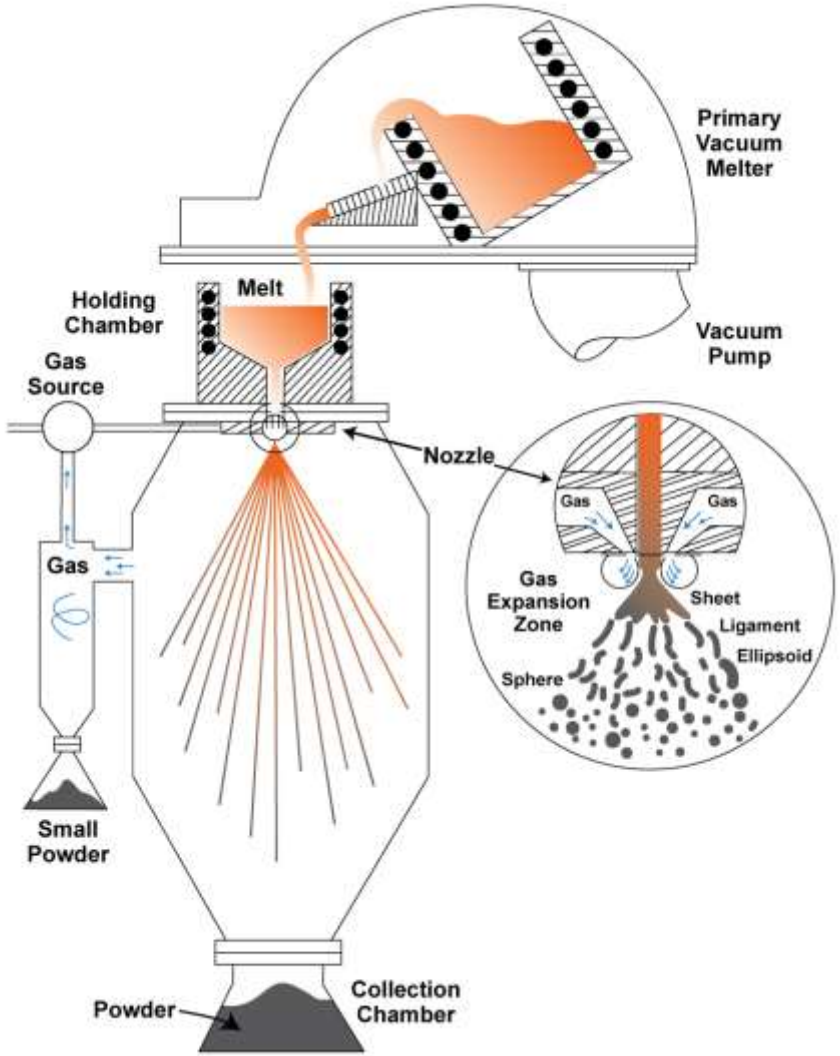
1. Scrap preparation

Metal scrap ready to be atomized

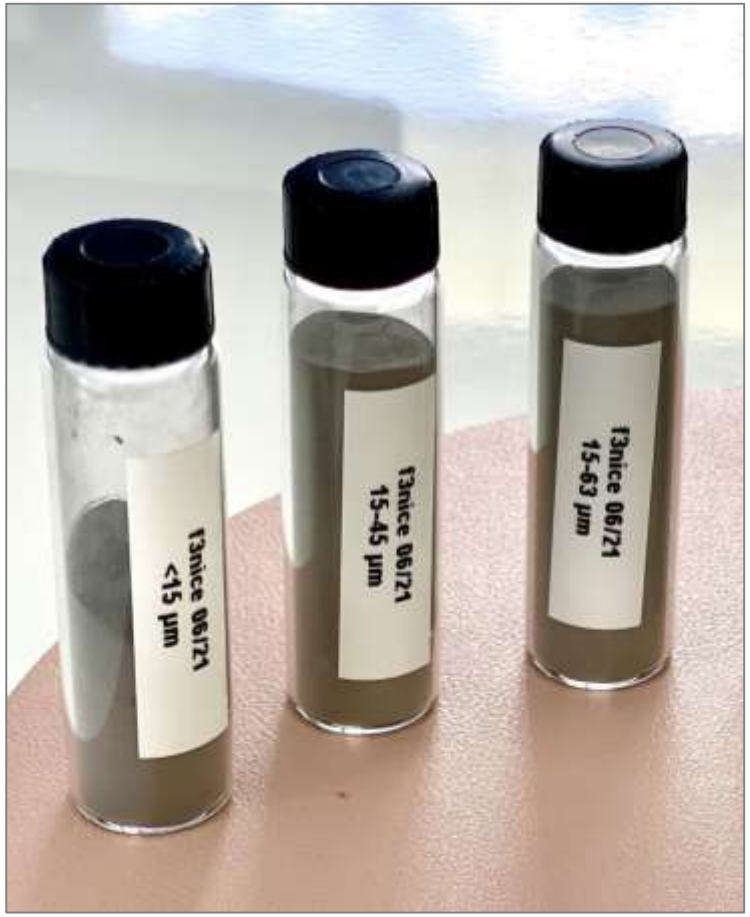
2. Atomization: how it works

Gas Atomization processes

- Scrap is **molten down** by EM induction
- Liquid metal **is sprayed** to be transformed into **powder**
- Atomization occurs – preferably – in **inert gas atmosphere**
- Different technologies can be used depending on materials
- Vacuum Inert Gas Atomization **(VIGA)** as top-tier technology

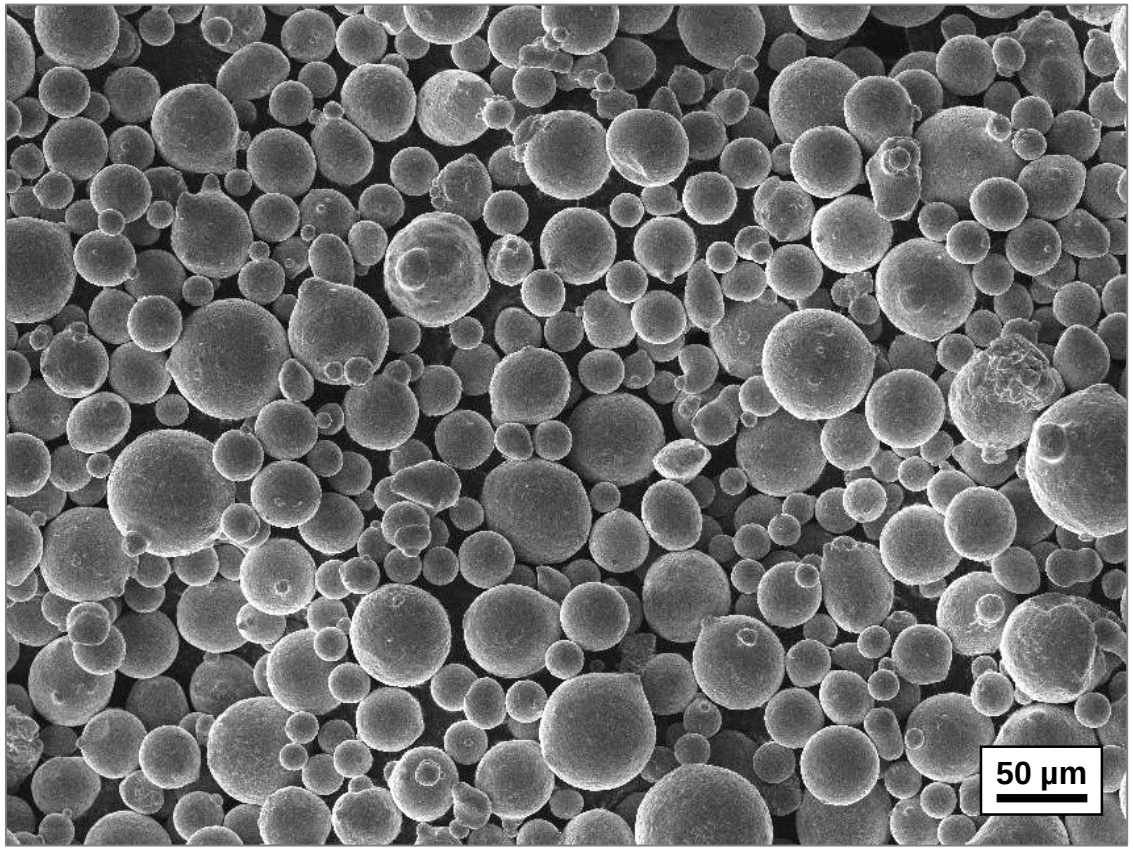


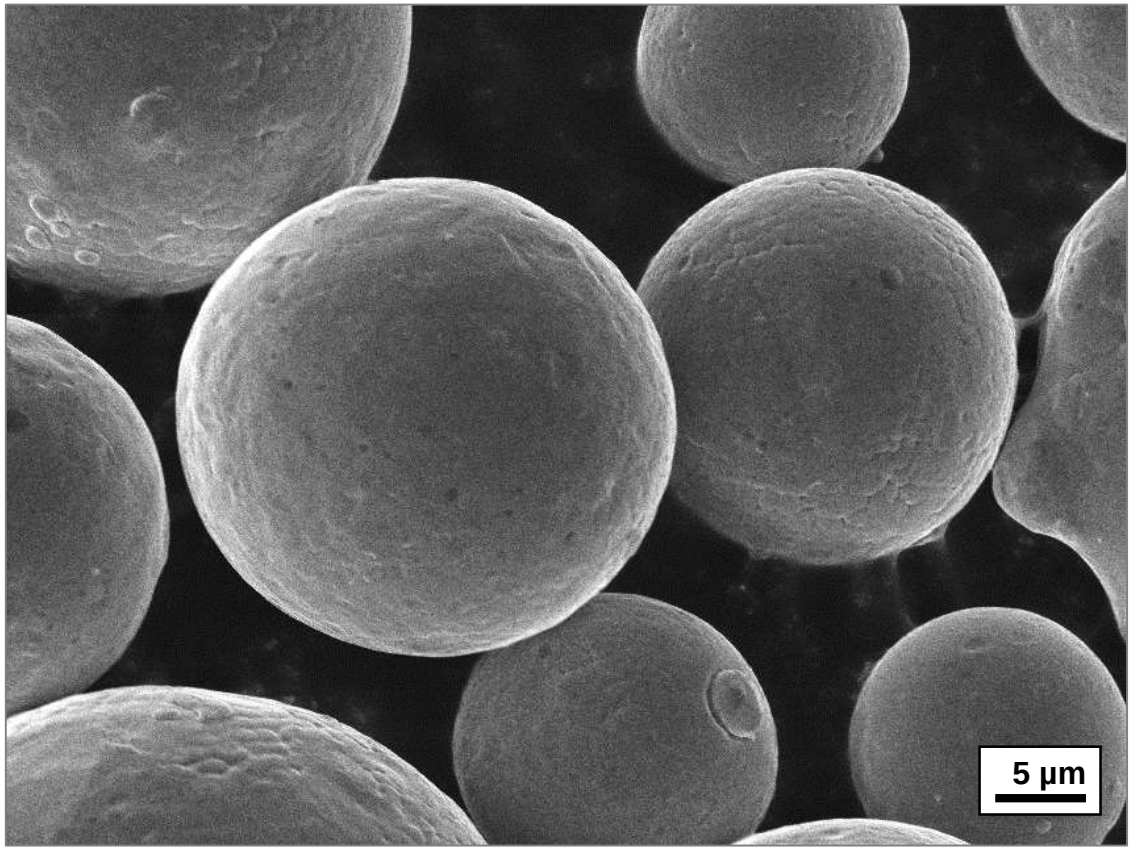
2. Powder production: sieving



316L SS powder after atomization & sieving

3. Powder characterization





SEM microscope images on virgin powder at different magnifications

3. Powder Material Certificate

Certificate of Conformance

Document number: [redacted]

Document description:
Inspection certificate to [redacted]

Product: Inconel 718
Specification(s): NA

Lot ID: PK0201
Heat ID(s): HT00241, HT00242

Customer Order Reference: [redacted]
Customer: [redacted]

Consignee: As customer

BS EN 10204:2004 Type 3.1 Certificate
QMS to ISO9001:2015 & EN9100:2018
Certificate No.: FM 725778

Condition of supply:
Supplied to internal ISO9001:2015 and EN9100:2018 approved QMS.

Product Chemistry

E	M	R	E	M	R	E	M	R	E	M	R	E	M	R
Al	1	0.45	Cr	1	18.6	Mn	1	0.09	Ni	1	54.5	Ta		NR
B	1	0.003	Cu	1	0.05	Mo	1	3.03	O	3	<0.01	Ti	1	0.93
C	2	0.03	Fe	1	17.1	N	3	0.007	P	1	0.007	V		NR
Ca		NR	H		NR	Nb		NR	S	2	<0.003	W		NR
Co	1	0.05	Mg		NR	Nb+Ta	1	4.95	Si	1	0.11	Zr		NR

E = Element
M = Method
R = Result
NR - Not Reported

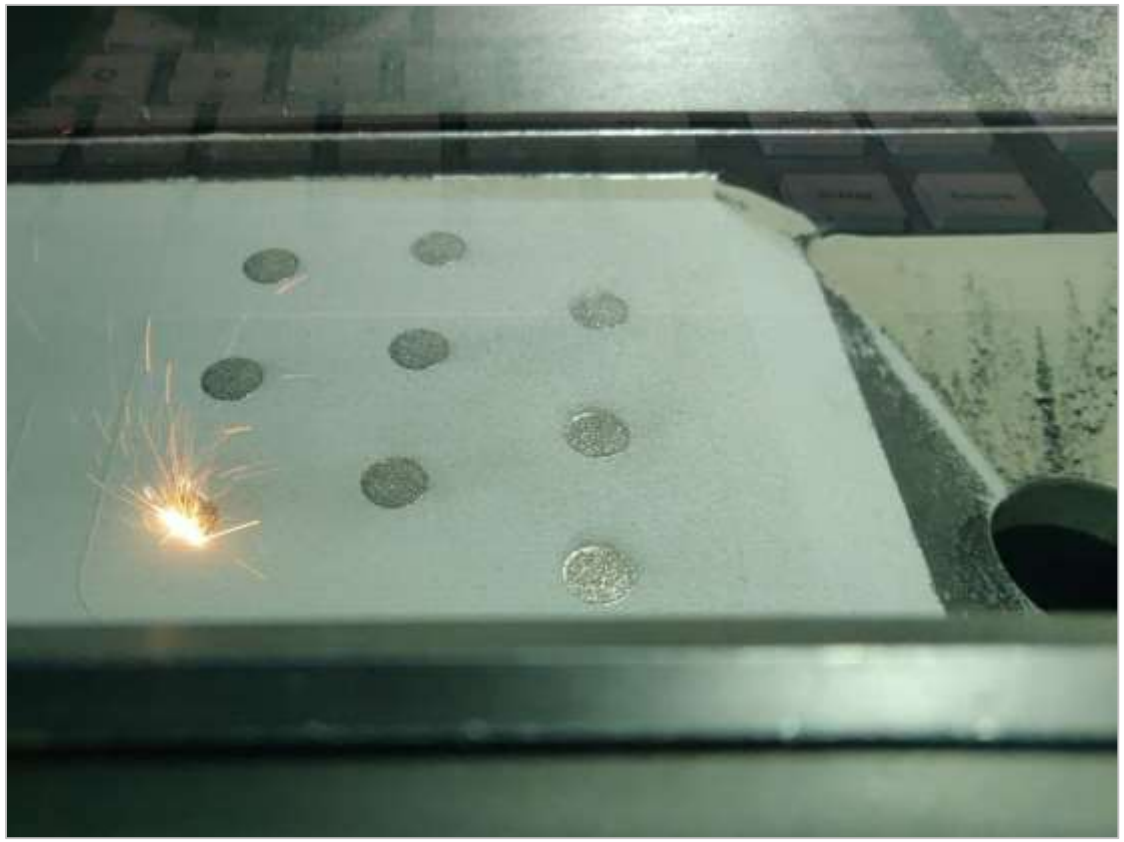
M	Type	Std	Source
1	ICP-OES	Supplier	ELE
2	Combustion	Supplier	ELE
3	Fusion	Supplier	ELE
4	"	"	"
5	"	"	"

Physical Characteristics

Test	Test Std.	Procedure	Sample ID	Measure	Result	Unit	RT (°C)	Comments
Flowability	ASTM B213	LPM-SOP-L002	LPM-SAM-00844	Time to flow	15.6	s/50g	25	
PSD-Laser	ISO 13320	LPM-SOP-L003	LPM-SAM-00844	D10	23.2	µm	25	
PSD-Laser	ISO 13320	LPM-SOP-L003	LPM-SAM-00844	D50	36.0	µm	25	
PSD-Laser	ISO 13320	LPM-SOP-L003	LPM-SAM-00844	D90	55.5	µm	25	
PSD-Sieve	ASTM B214	LPM-SOP-L004	LPM-SAM-00844	+63	0.0	wt%	25	
PSD-Sieve	ASTM B214	LPM-SOP-L004	LPM-SAM-00844	+53	0.0	wt%	25	
PSD-Laser	ISO 13320	LPM-SOP-L003	LPM-SAM-00844	-20	3.9	vol%	25	
PSD-Laser	ISO 13320	LPM-SOP-L003	LPM-SAM-00844	-15	0.0	vol%	25	
Tap Density	ASTM B527	LPM-SOP-L008	LPM-SAM-00844	T_0	4.5	g/cm³	25	

Material Certificate for the Sustainable Powder by f3nice

4. Printing and testing: LB-PBF



Printing of specimens and parts in LB-PBF systems (Concept Laser by GE and M290 by EOS)

4. Printing and testing: L-DED

Printing of specimens in the L-DED machine (LASERTEC Hybrid by DMG Mori)

Life Cycle Assesment (LCA)

LCA: how to

LCA framework…

…and steps

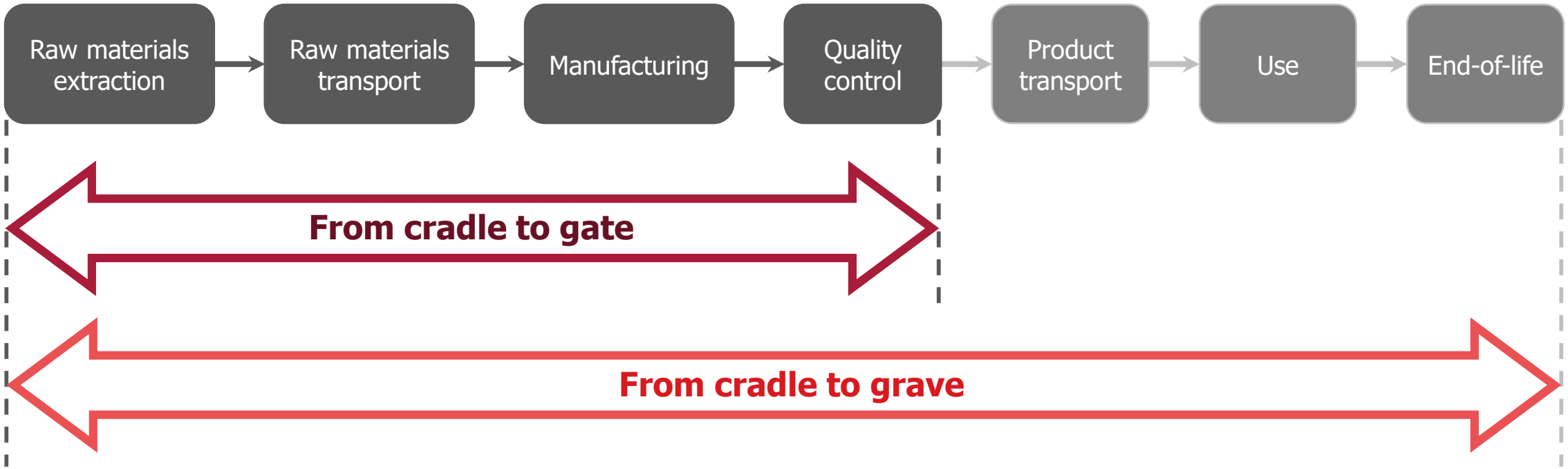
- UNI EN ISO 14040:2006
- UNI EN ISO 14044:2006

LCA analysis: goal&scope

Goal: Comparative LCA analysis between the conventional and f3nice processes for the production of metallic powder

Type of analysis: Cradle-to-gate, no info about use and end-of-life of the powder

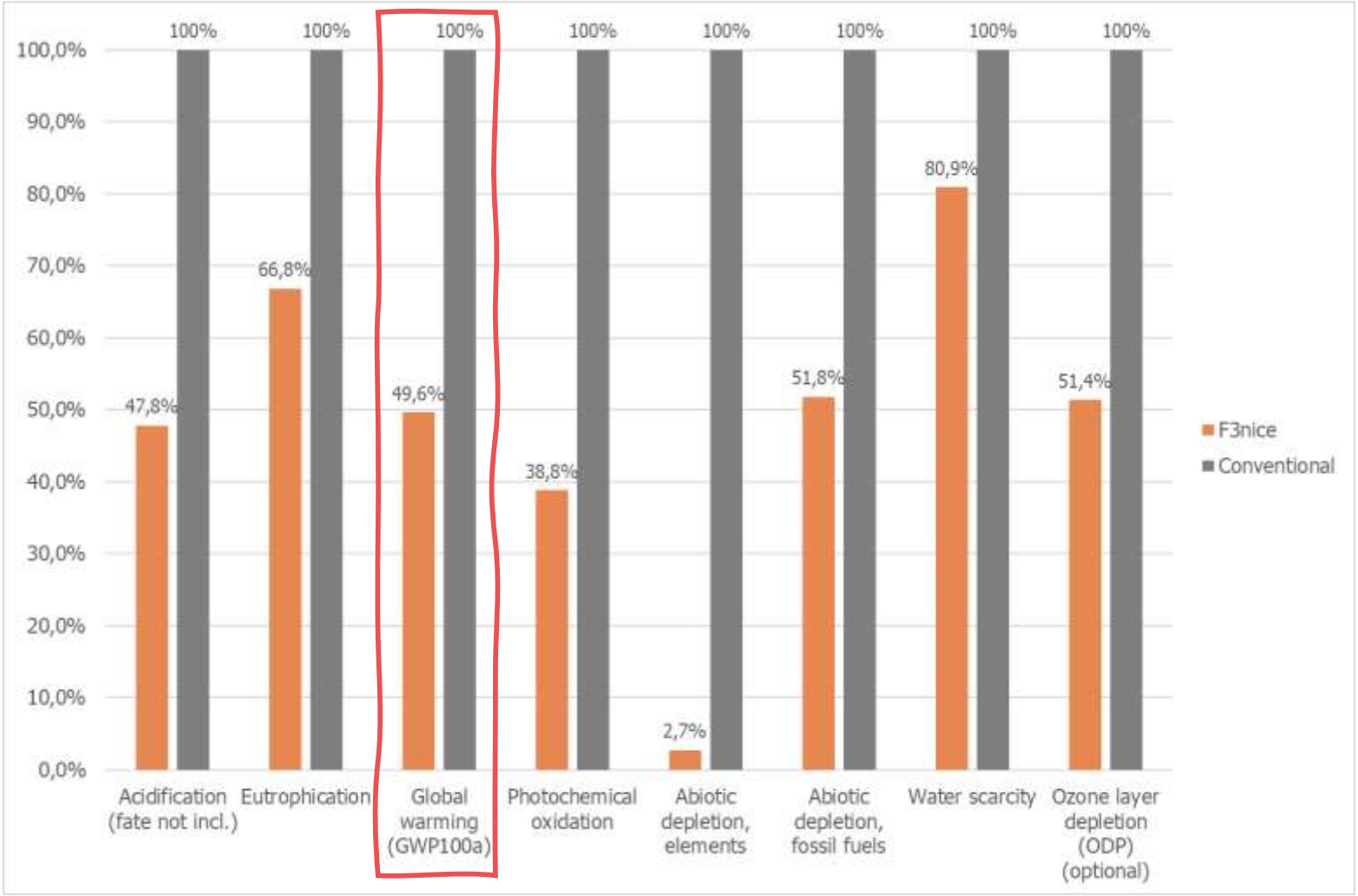
Functional unit: 10 kg of powder (1 jar)



LCA analysis: comparative results

SS316

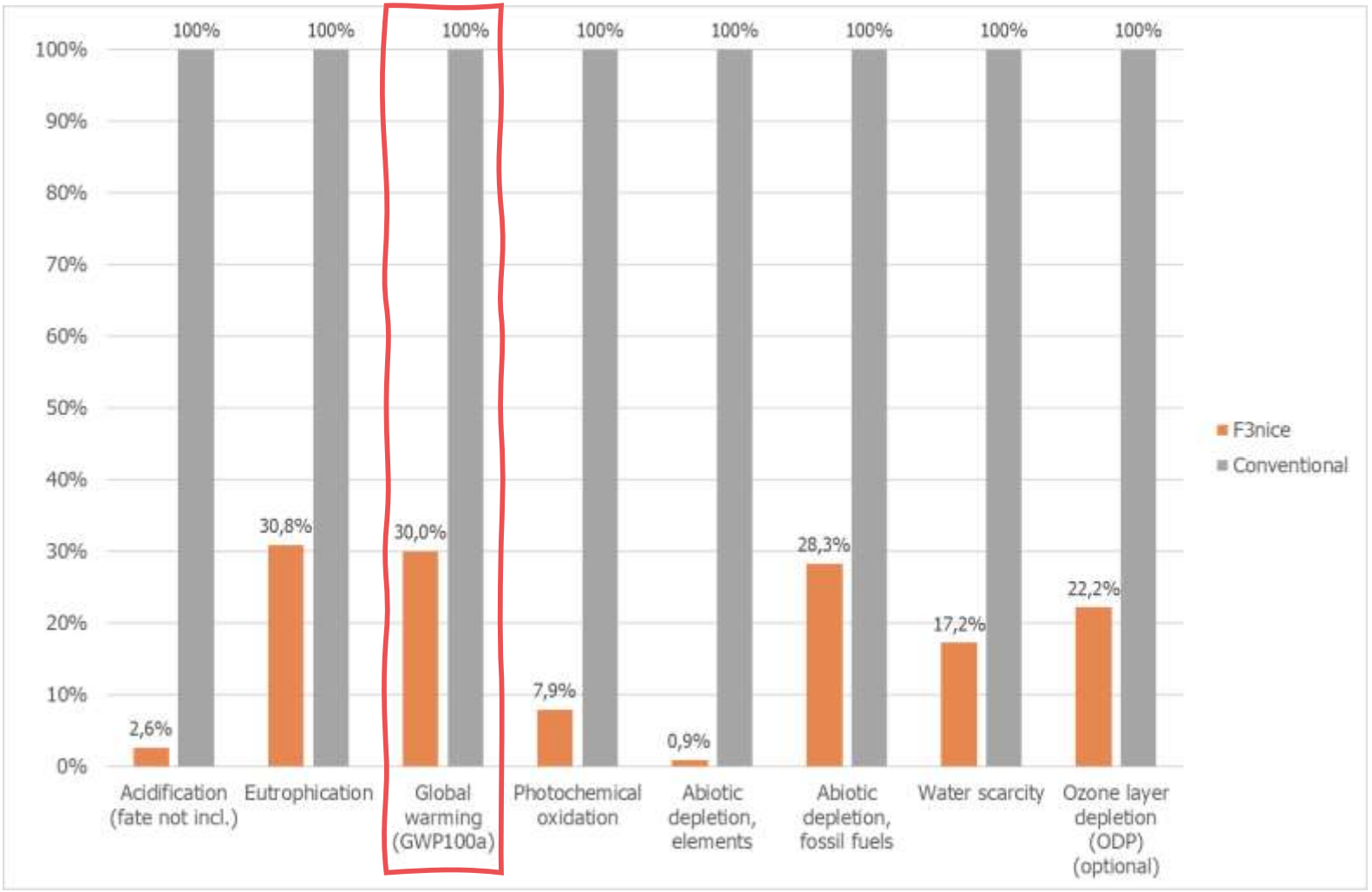
The f3nice process allows an **50%** reduction in CO_2eq emissions for the production of SS316 powder



LCA analysis: comparative results

Inconel 718

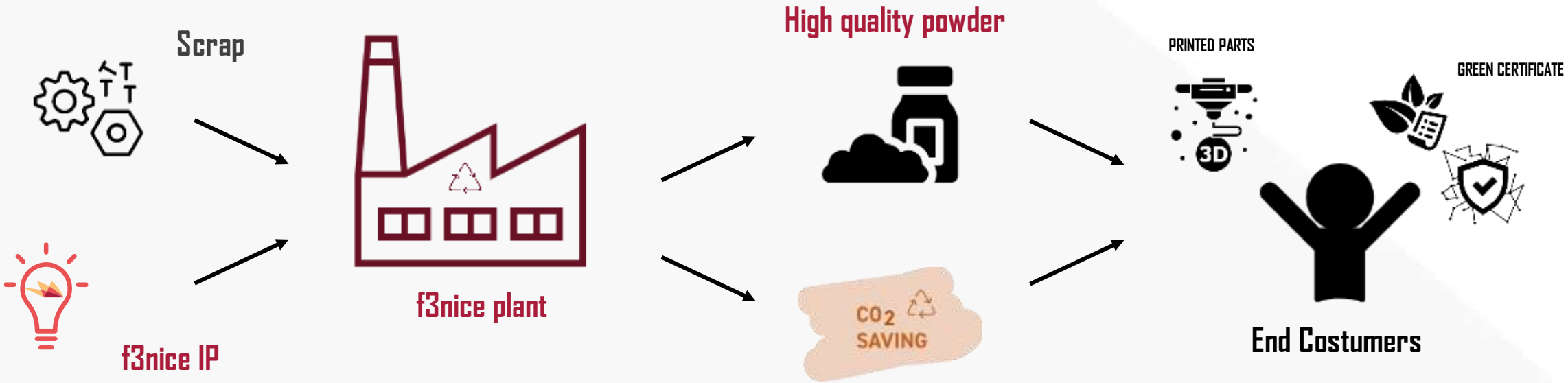
The f3nice process allows an **70%** reduction in CO_2eq emissions for the production of Inconel 718 powder



Ultimate goal: exploiting the savings

Proprietary software by f3nice to calculate & track the **CO_2** and **energy savings**

- Efficient reuse of the metal scrap by exploiting our patent-pending process
- **Real time Life Cycle Assessment** to assign specifics savings to each batch of powder
- **Transferring savings** as token/certificates to be converted **into carbon credits**



Joining the f3nice Ecosystem

Full potential of our ecosystem

1

Selling to the printer market

Providing sustainable powder to your company

2

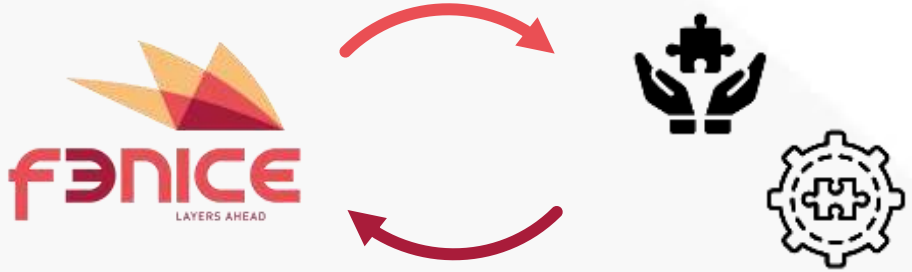
Closed loop with **target End User**

We retrieve your scrap, and we give you powder back to feed your needs

3

From powder to powder

We can recycle exhausted powder from AM



Joining our Ecosystem

Call to Action

- Providing **valuable material** to be converted **into powder** by f3nice
- **Efficient reuse** of **internal scrap** and **obsolete spare parts**
- **Exploring UX Cases** to be addressed trough **metal 3D printing**
- **Qualification** and **implementation** of **parts** produced from f3nice powder
- Relevant synergies with **local partners** to **forge the Ecosystem**

f3nice@f3nice.com

f3nice.com

A story of collaboration

Phase 1: De-risking

- **Qualification of f3nice powder** in controlled environment

Phase 2: Recycling & Printing

- Scrapping of **obsolete spare parts** to be converted into powder
- **Powder production** and **printing**

Phase 3: Field Testing

- **Printing** and **testing** of **UX Cases**
- **Life Cycle Assessment (LCA)**

1. Scrap collection and preparation

Copper retrieved from Sub Sea electrical cables

Retrieving and processing

- Metal scrap from **conventional sources**
- **Obsolete spare parts** from physical inventories
- **Disqualified powder**
- **Sorting** and **separation** of metals
- **Cleaning** and **processing**
- **Preparation** of the **"recipe"** as the input for the atomization

2. Powder production: atomization

Scrap Metal in crucible before Atomization

Atomization of metal powder

- **Lab-scale atomization** of **2 – 10 kg** of powder
- **Industrial atomization** up to **500 kg** of powder per batch
- Steel and Inconel powder for the **O&G** and **energy industry** (e.g., hydrogen)
- Titanium and other materials for **medical** and **aerospace**
- Further materials **under development**

3. Powder characterization

Sustainable powder by f3nice

Checking powder properties

- **Sampling of powder** depending on metal alloys, particle range, etc.
- **Characterization** of the different **powder products**
- Evaluation of the main properties
- **Comparison** with **industrial powder** and **relevant benchmark(s)**
- **Collaboration** with **universities** and **labs** for testing and R&D activities

4. Printing and testing

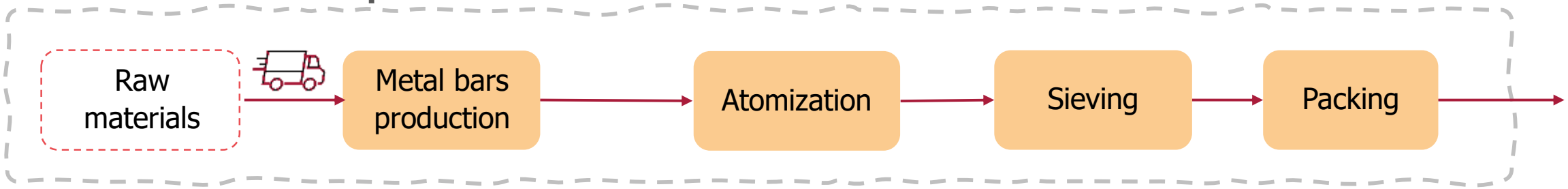
Printing of pressure components

Printing with f3nice powder

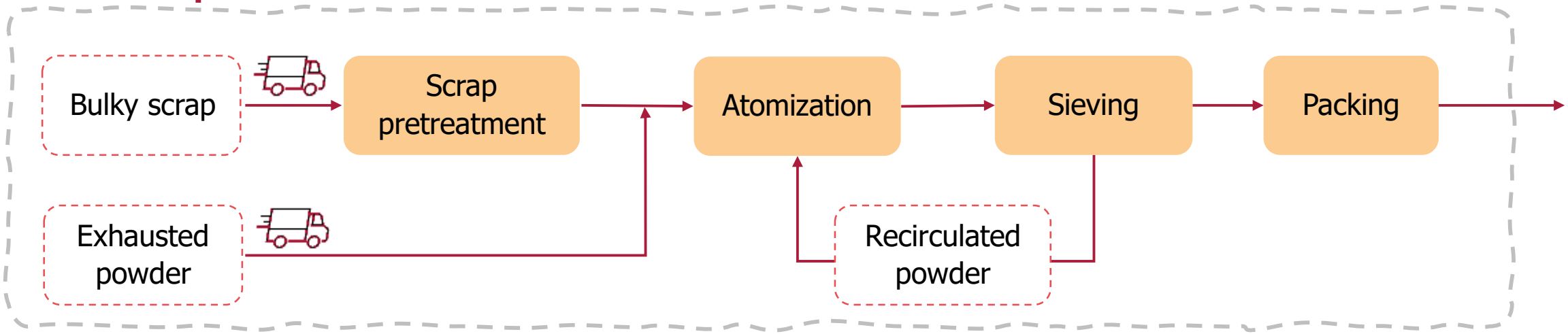
- Using different 3D technologies to print f3nice powder
- Printing by **Laser Beam Powder Bed Fusion (LB-PBF)** technology
- Printing by **Laser Direct Energy Deposition (L-DED)** technology
- Production of specimens and coupons
- **Printing** of **critical components** (e.g., pressure-containing parts)

LCA analysis: system boundary

conventional process

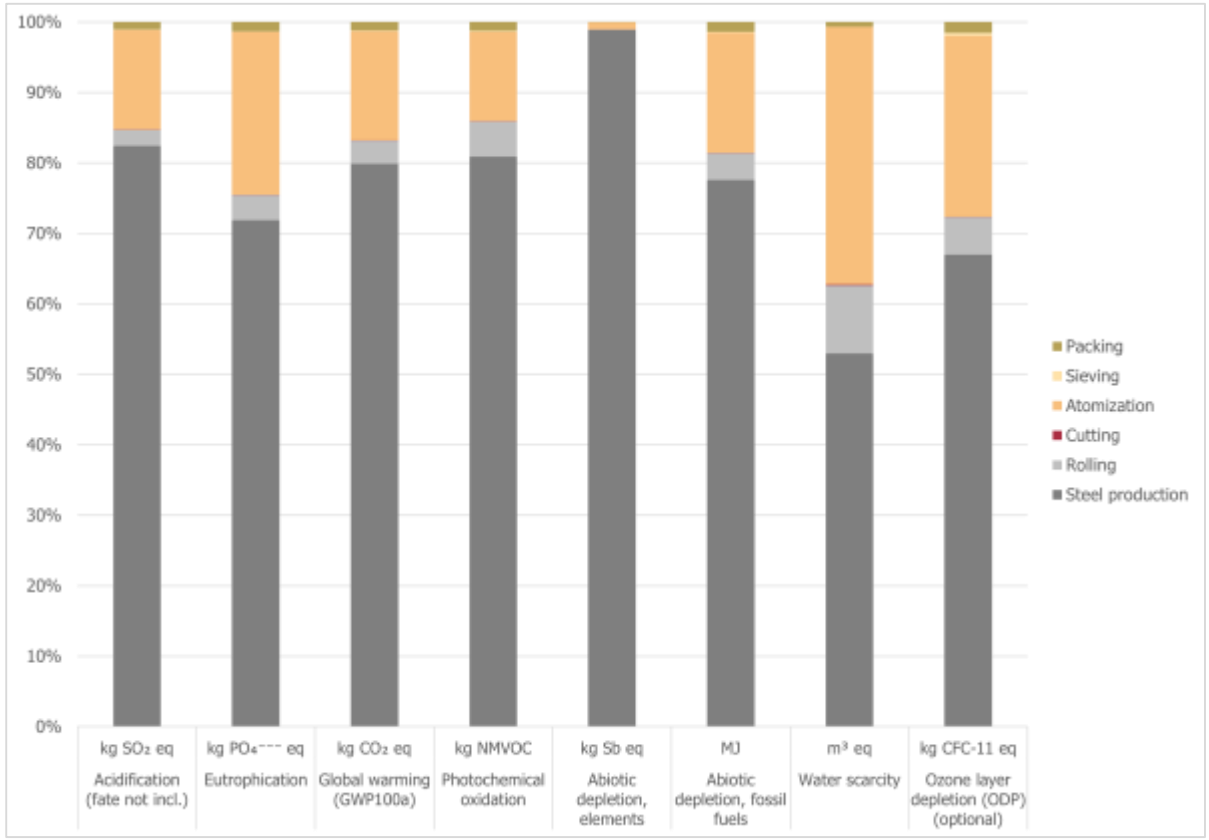


f3nice process

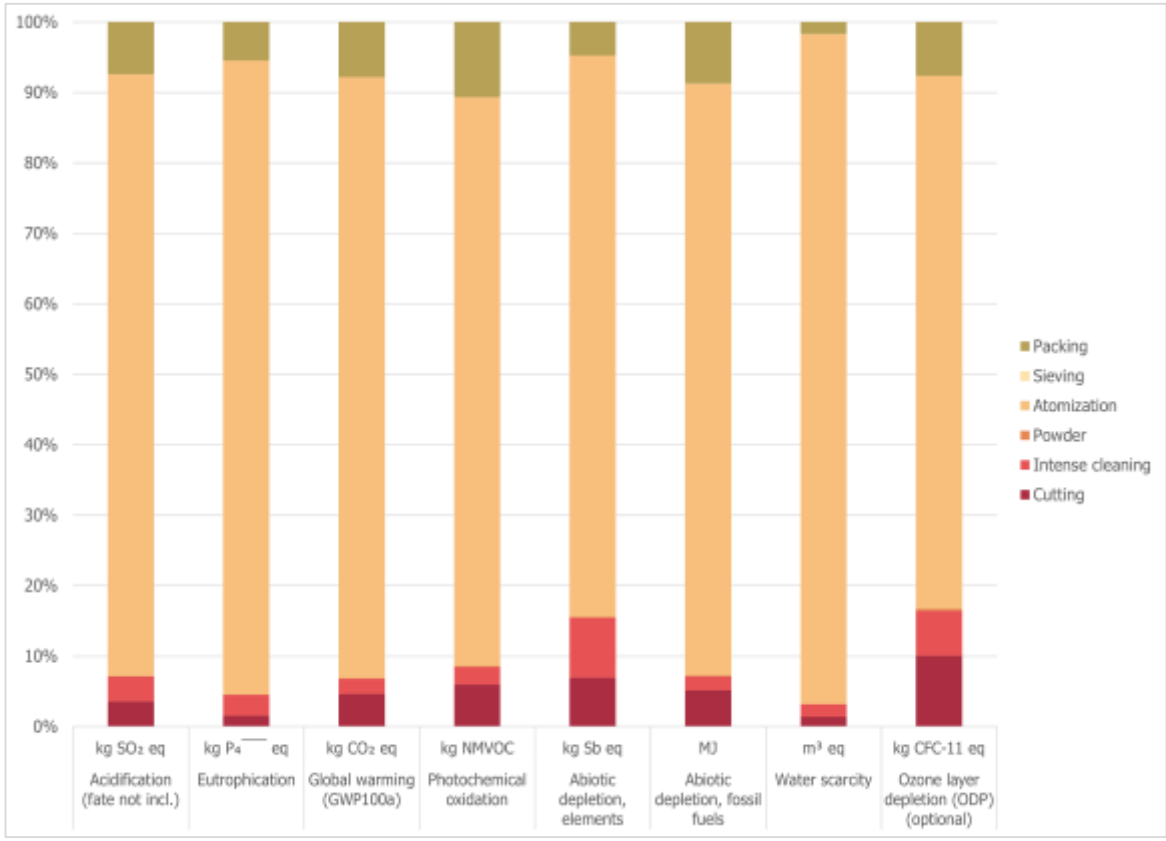


LCA analysis: results – SS316

conventional process



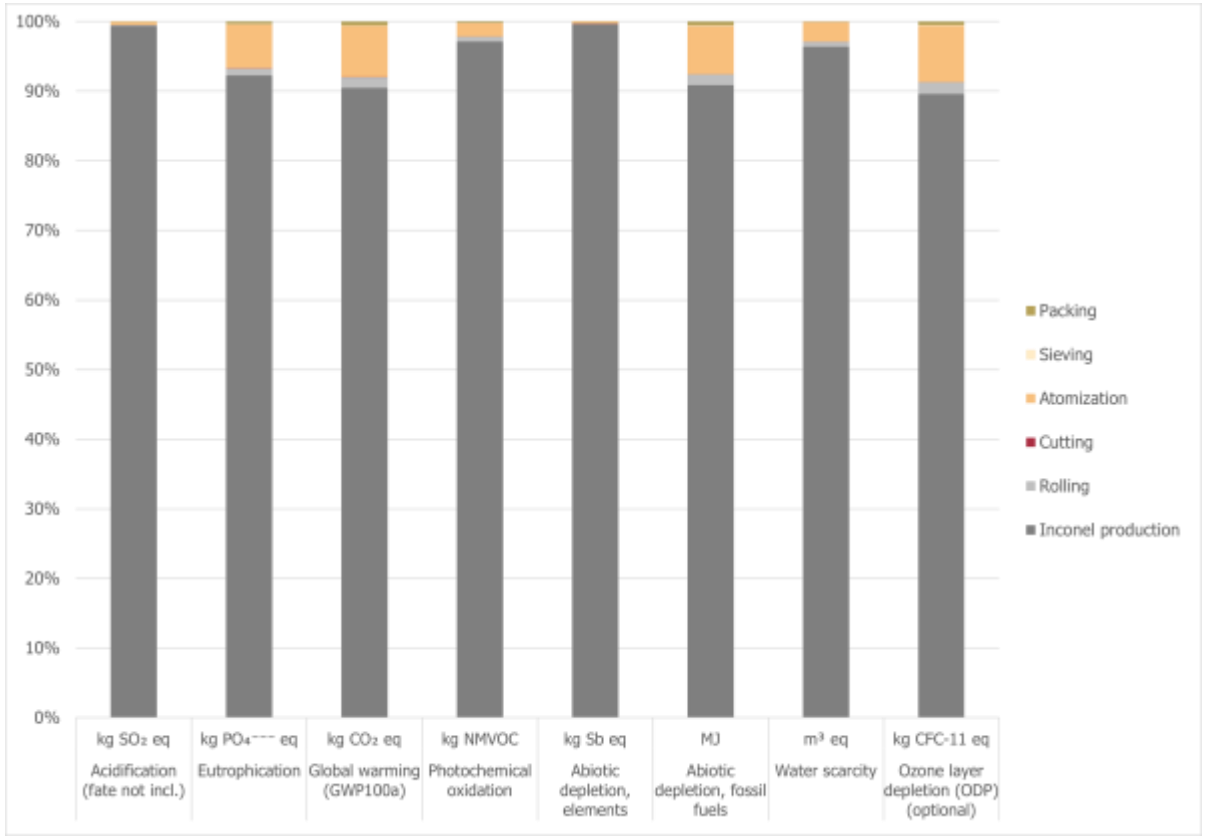
f3nice process



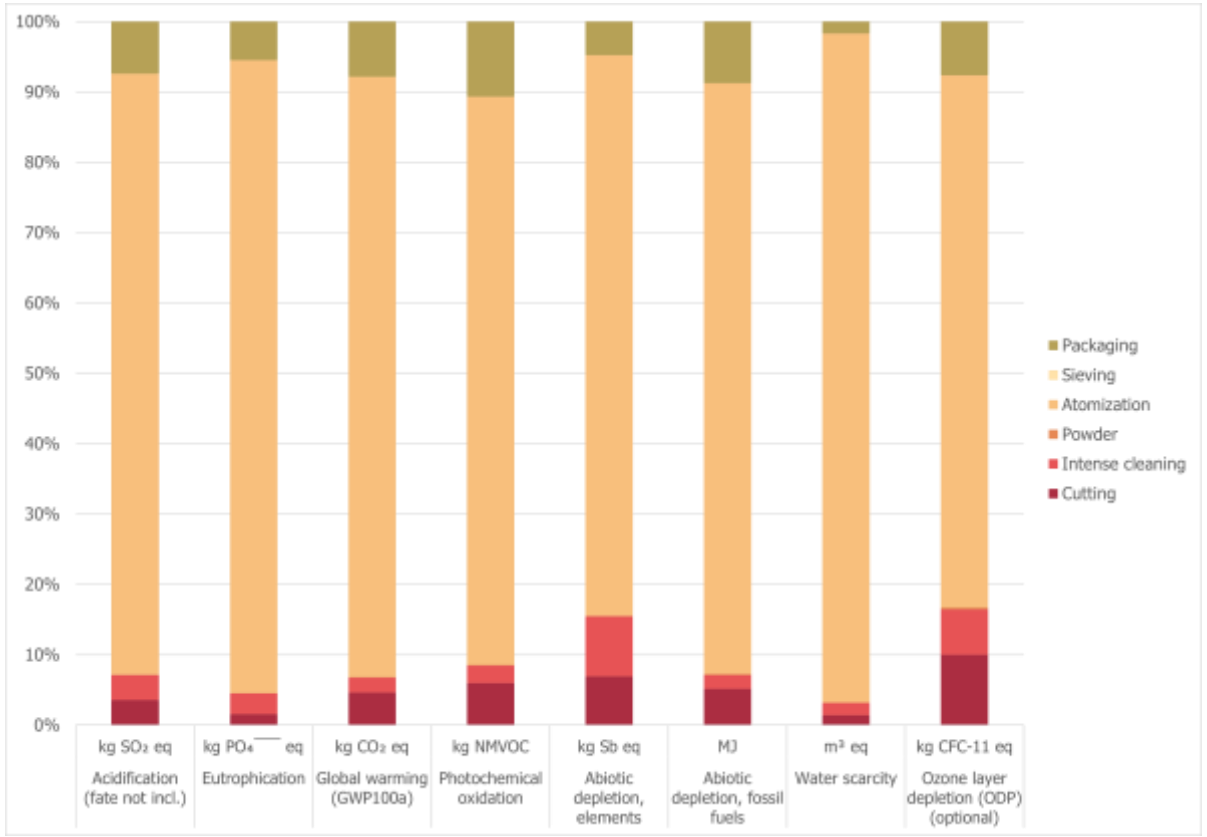
The results reported above have been detailed for each step comprised in the analysis.

LCA analysis: results – Inconel 718

conventional process



f3nice process



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Team

Matteo Vanazzi
CTO & Co-founder

Luisa E. Mondora
CEO & Co-founder

Philip Hansteen
COO & Co-founder

Torgeir Hamre
Business Developer

Chiara Caelli
Sustainability Analyst

Andrea De Paoli
Project Manager

Mattia Cabrioli
R&D Manager

Lorenzo Toso
R&D Technician

Our products

*All powder types available in particle sizes for different AM applications

STAINLESS STEELS

- AM 316L
- AM F51 (2205 DSS)
- AM F53/F55 (2507 SDSS)
- AM 17-4PH

NICKEL ALLOYS

- AM 625
- AM 718
- AM H-X

TITANIUM ALLOYS

- AM Ti64 (Ti6Al4V or Ti Gr.5)
- AM Ti (Ti Gr.2)

COPPER ALLOYS

- AM Cu