

## Turning scrap into the sustainable future of the manufacturing

# Enabling the Circular Economy with AM

## **Our Value Proposition**

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



**f**∋nice

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

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





economy

## Metal is already recycled today...

# ...however, it is mostly done in an inefficient



# Traditional approach 1:15 150+ kg of CO<sub>2</sub>eq / kg

## f3nice approach

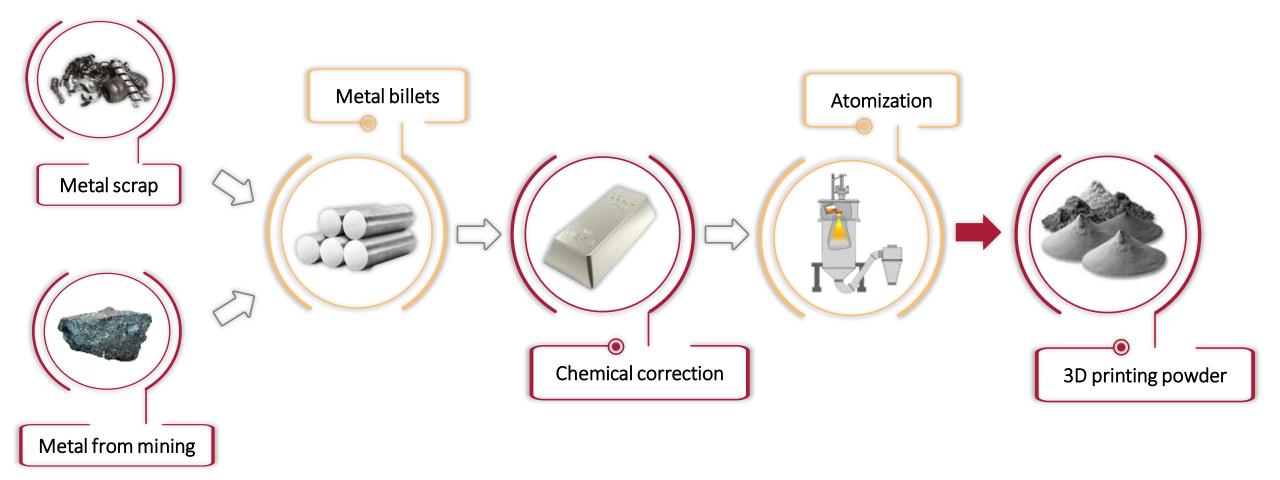
1:1

10+ kg of CO<sub>2</sub>eq / kg



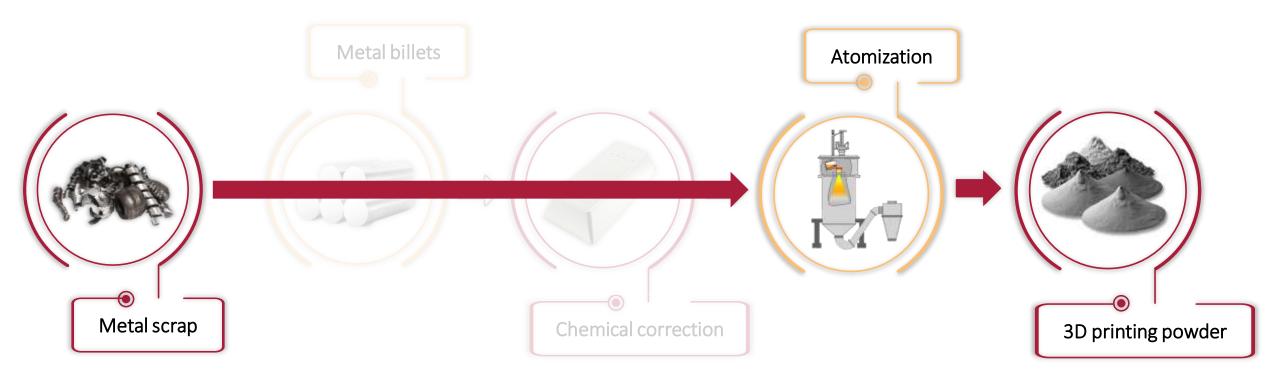






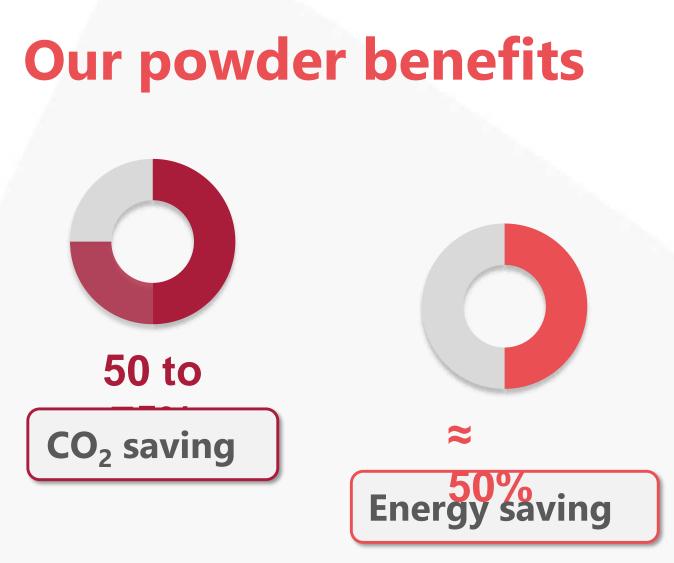
## Conventional process



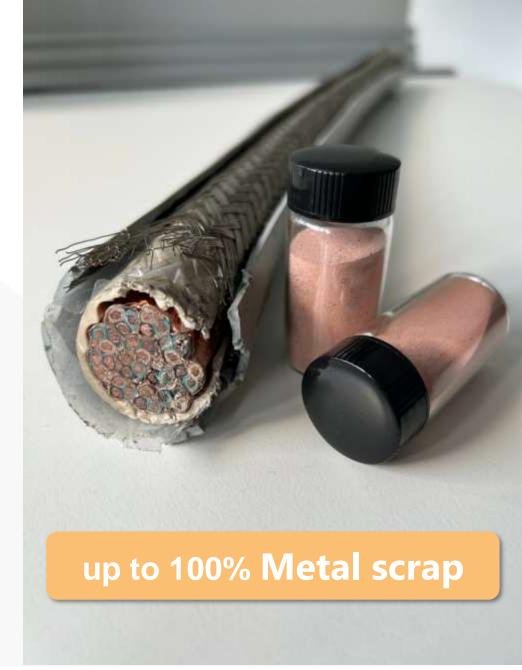


### f3nice upcycling process











## **Additional benefits of our solution**

#### USING METAL SCRAP & OBSELETE PARTS

#### LOCAL PRODUCTION

#### FIXED PRICE

#### RESILIENT & Sustainable

#### =

Less minerals mining and exploitation of natural resources (CO<sub>2</sub> reduction) Less logistic and reduction of transport, boost of local economy (\$ & CO<sub>2</sub> reduction)

#### =

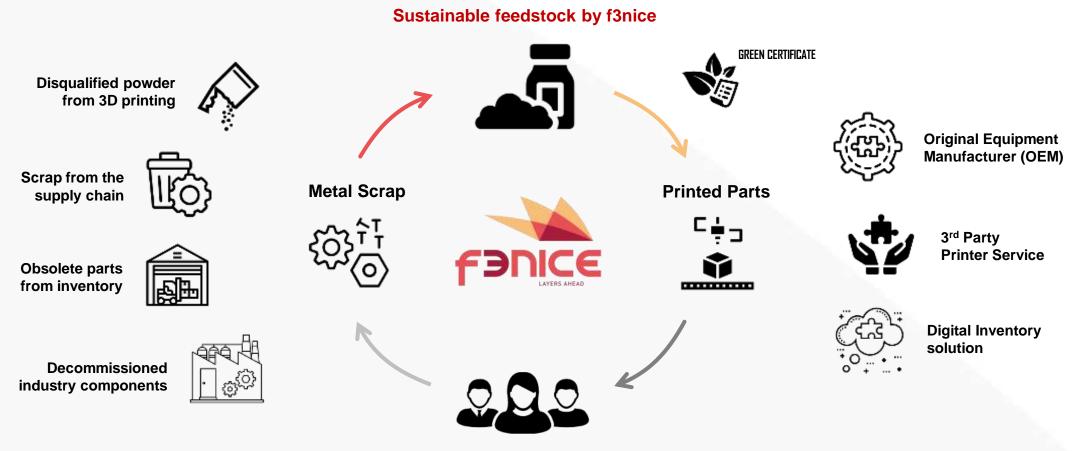
Less volatile towards market prices fluctuation (\$ reduction)

#### 

Strategic solution to tackle the Supply Chain disruption (\$ reduction)



## f3nice in the Value Chain



End Users





## f3nice process: step by step

## Overview: production steps and added value

Scrap collection & preparation

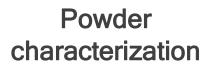


- Our Role
- Collecting scrap material
- Checking and sorting
- Cleaning and preparation

Powder atomization



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





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

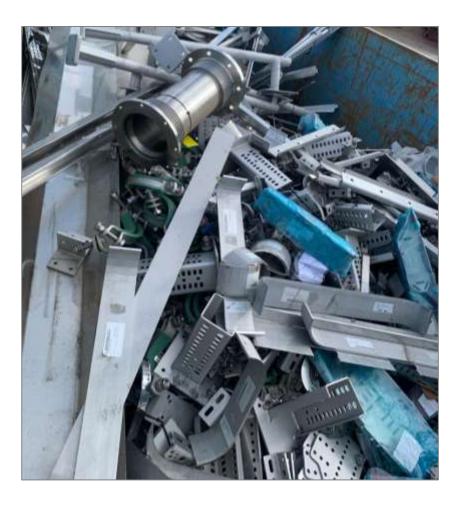
#### Printing & testing



- Powder for qualification
- Licensing f3nice powder
- CO<sub>2</sub> savings: LCA analysis



# 1. Scrap sorting





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



## 1. Scrap preparation



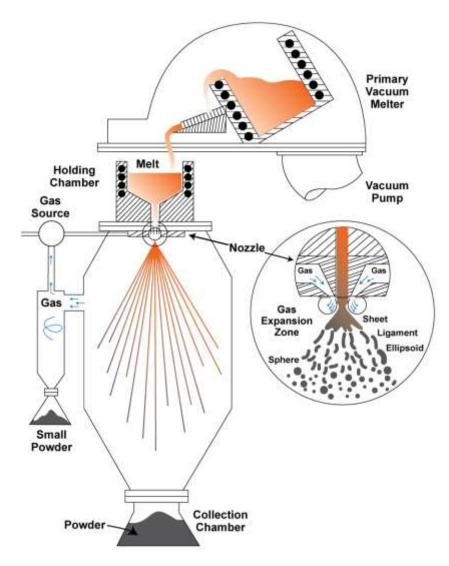
Metal scrap ready to be atomized



## 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





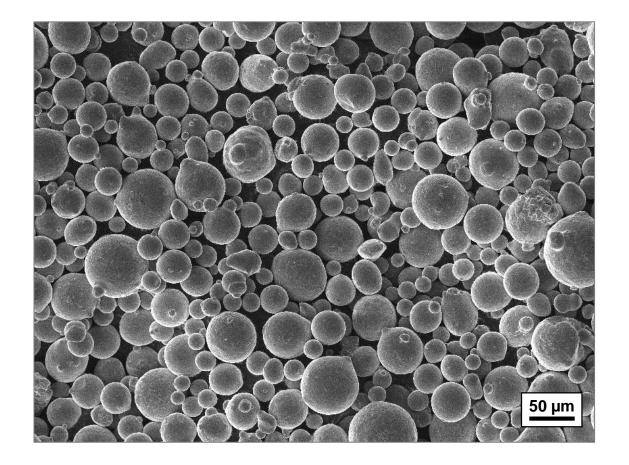
## 2. Powder production: sieving

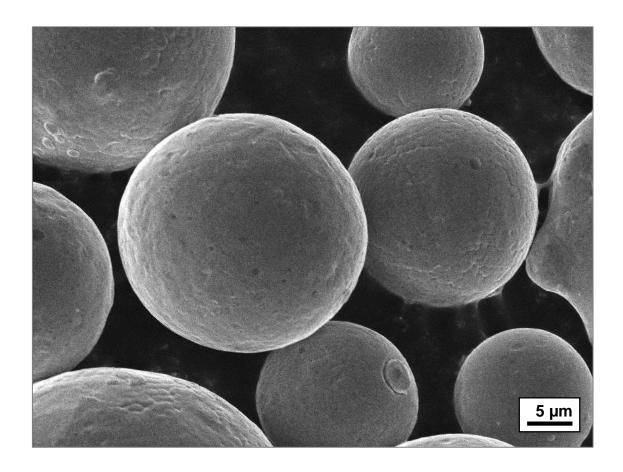


316L SS powder after atomization & sieving



## 3. Powder characterization





SEM microscope images on virgin powder at different magnifications



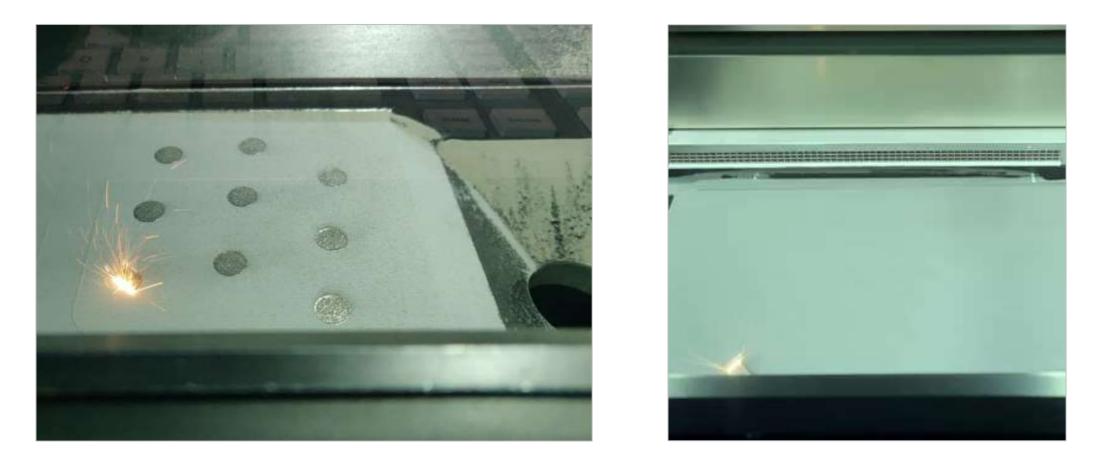
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Material Certificate for the Sustainable Powder by f3nice



## 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



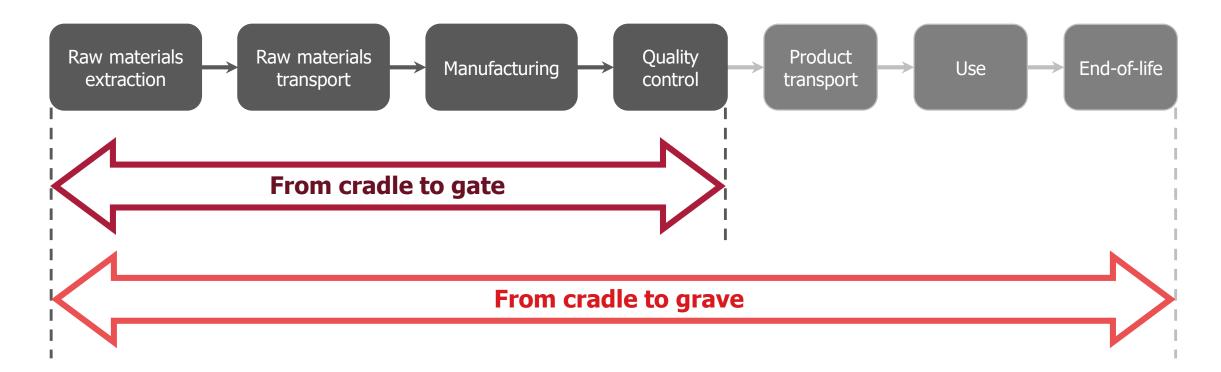


## LCA analysis: goal&scope

**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)

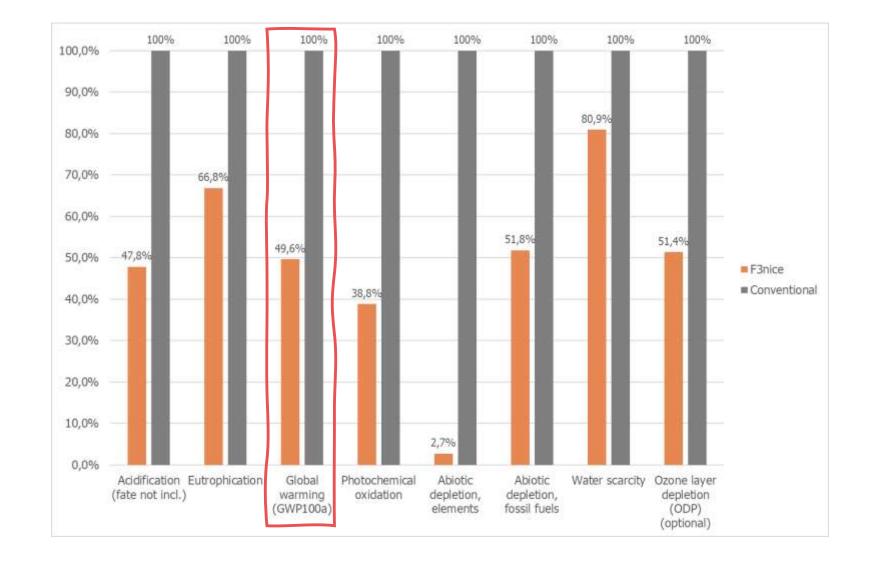




# LCA analysis: comparative results

## SS316

The f3nice process allows an **50%** reduction in CO<sub>2</sub>eq emissions for the production of SS316 powder

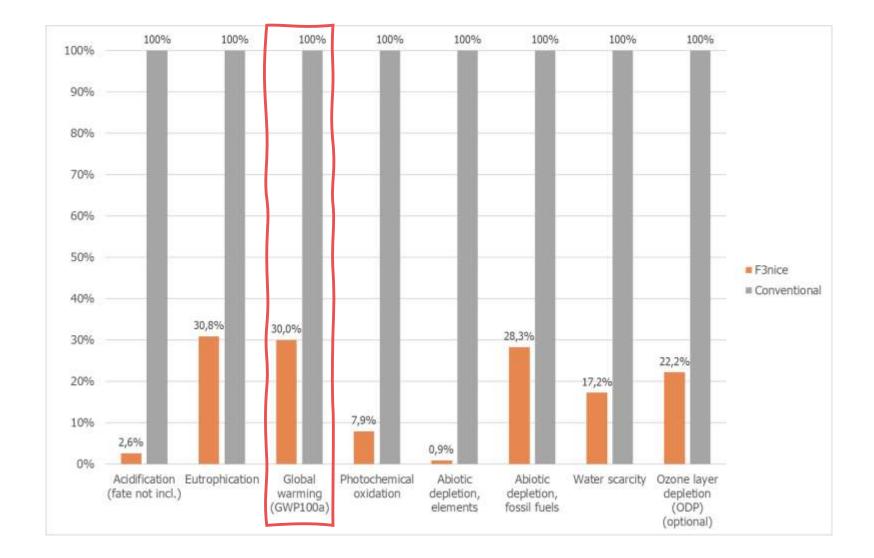




# LCA analysis: comparative results

## Inconel 718

The f3nice process allows an **70%** reduction in CO<sub>2</sub>eq emissions for the production of Inconel 718 powder





# **Ultimate goal: exploiting the savings**

#### **Proprietary software** by f3nice to calculate & track the **CO<sub>2</sub>** 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



#### Selling to the printer market

Providing sustainable powder to your company





#### Closed loop with target End User

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





#### From powder to powder

We can recycle exhausted powder from AM

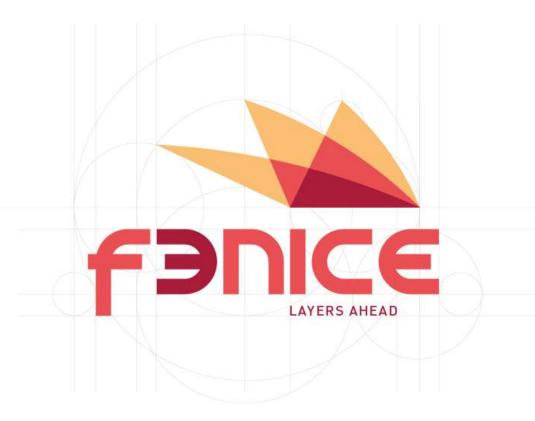




## Joining our Ecosystem

#### **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)

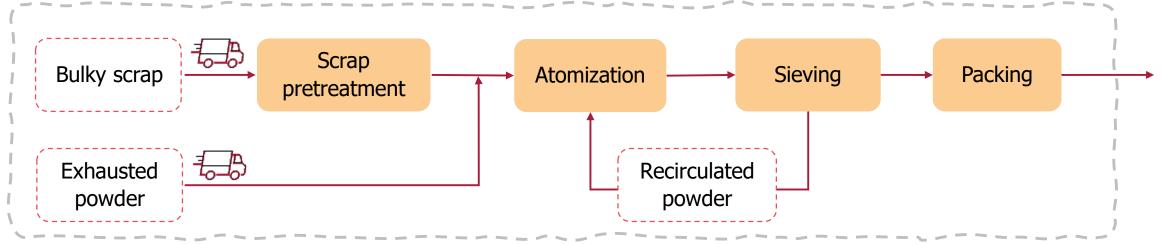


# LCA analysis: system boundary

### conventional process

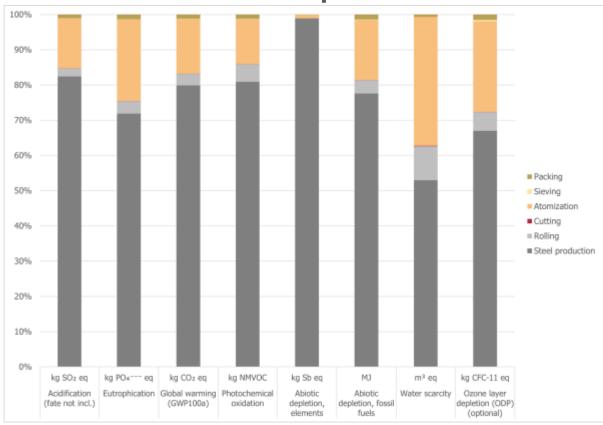


## f3nice process

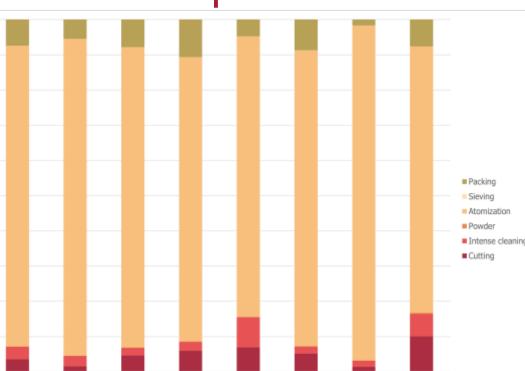




## LCA analysis: results – SS316



## conventional process



kg Sb eg

Abiotic

depletion,

elements

MD

Abiotic

depletion, fossil

fuels

kg CFC-11 eq

Ozone layer

depletion (ODP)

(optional)

m<sup>3</sup> eq.

Water scarcity

kg NMVOC

Photochemical

oxidation

f3nice process

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

100%

90%

80%

70%

60%

50%

40%

30%

20%

10%

0%

kg SO<sub>2</sub> eg

Acidification

(fate not incl.)

kg P4 eq

kg CO2 eq

(GWP100a)

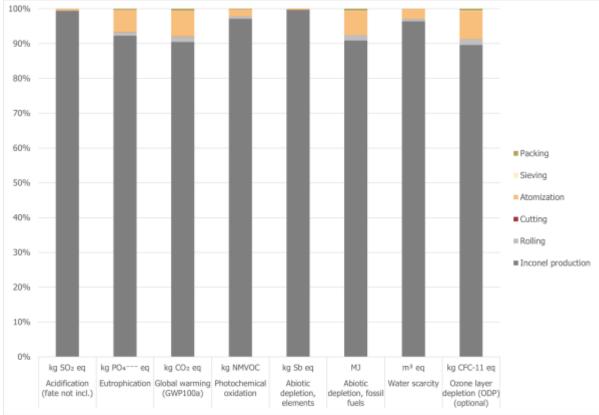
Eutrophication Global warming

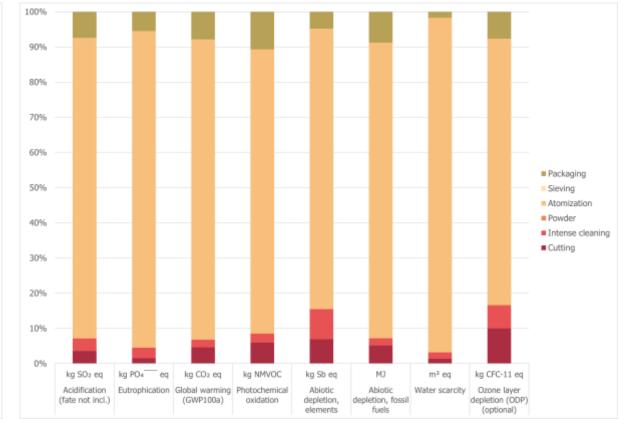


## LCA analysis: results – Inconel 718

## conventional process

f3nice process





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



## Team



Matteo Vanazzi CTO & Co-founder

	POLITECNICO MILANO 1863	
-		

Valland



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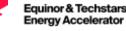
Luisa E. Mondora CEO & Co-founder

Valland	techstars_			
POLITECNICO	UNIVERSITY OF			
MILANO 1863	CAMBRIDGE			



**Philip Hansteen** COO & Co-founder

BABSON College	d all	London Business School
equinor *		or & Techsta y Accelerato





Mattia Cabrioli R&D Manager







Lorenzo Toso **R&D** Technician





**Torgeir Hamre** 

**Business Developer** 

N.

moreld flux



Chiara Caelli Sustainability Analyst















## Our products

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



