

# Erfaringer og strategi med 3D-printing og digitalt forsyningsnettverk i Equinor

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Head of Additive Manufacturing Centre of Excellence

# Digital Supply Networks and Additive Manufacturing

## On-Demand Manufacturing is the key



### Cost

- Reduce physical inventories
- Reduce cost related to long lead times
- Reduce maintenance cost
- Reduce production losses



### Sustainability

- Reduce CO2 emissions
- Reduce waste
- Reduce transport
- Increase lifetime of equipment
- Use recycled scrap metal



### Supply resilience

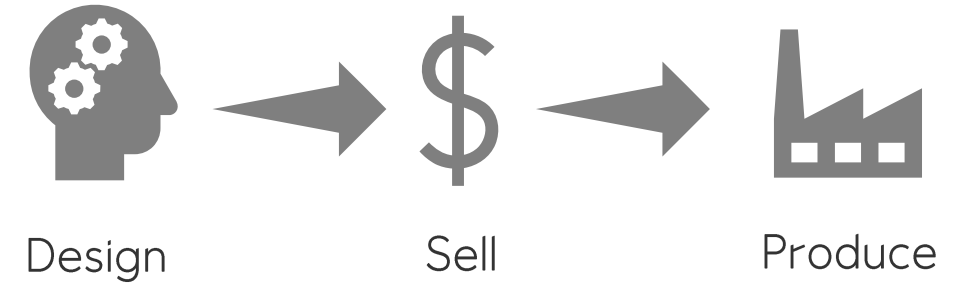
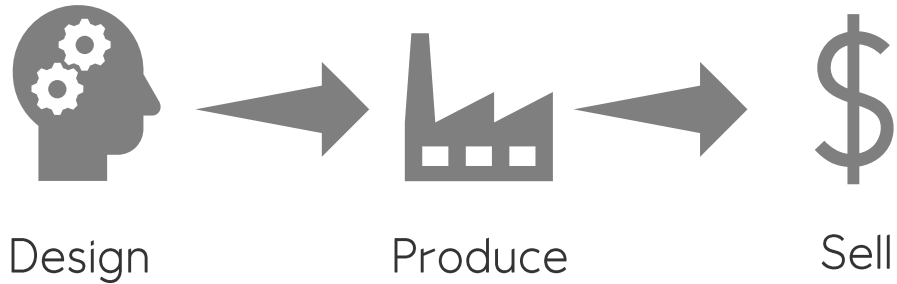
- Digital Inventory combined with local manufacturing and services
- Reduce delays
- Reduce need for crossing borders
- Use of local, recycled raw materials



### Local value creation

- Manufacturing of mechanical parts close to end user
- Change from centralised mass production to local on-demand manufacturing
- The digital is global, the physical is local

# Transformation in the supply chain

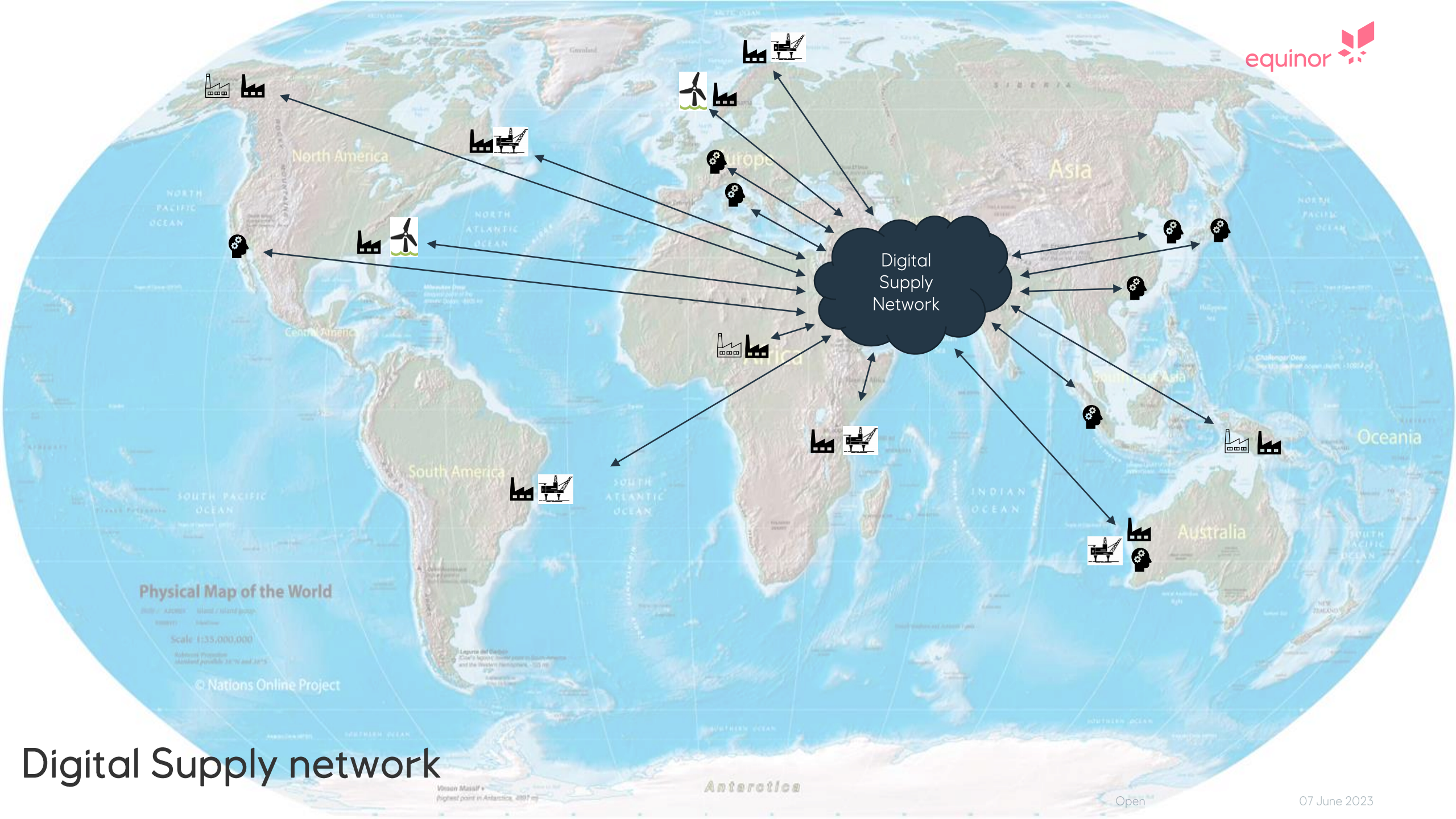


Source: f3nice



Source: IMI-CCI





Physical Map of the World

Scale 1:35,000,000

© Nations Online Project

# Digital Supply network

# Proposed clusters/ on-demand factories in Norway

Equinor supply bases:



- Hammerfest
- Helgeland (Sandnessjøen)
- Kristiansund
- Florø
- Mongstad
- CCB (Ågotnes)
- Dusavika (Stavanger)

Existing AM factories

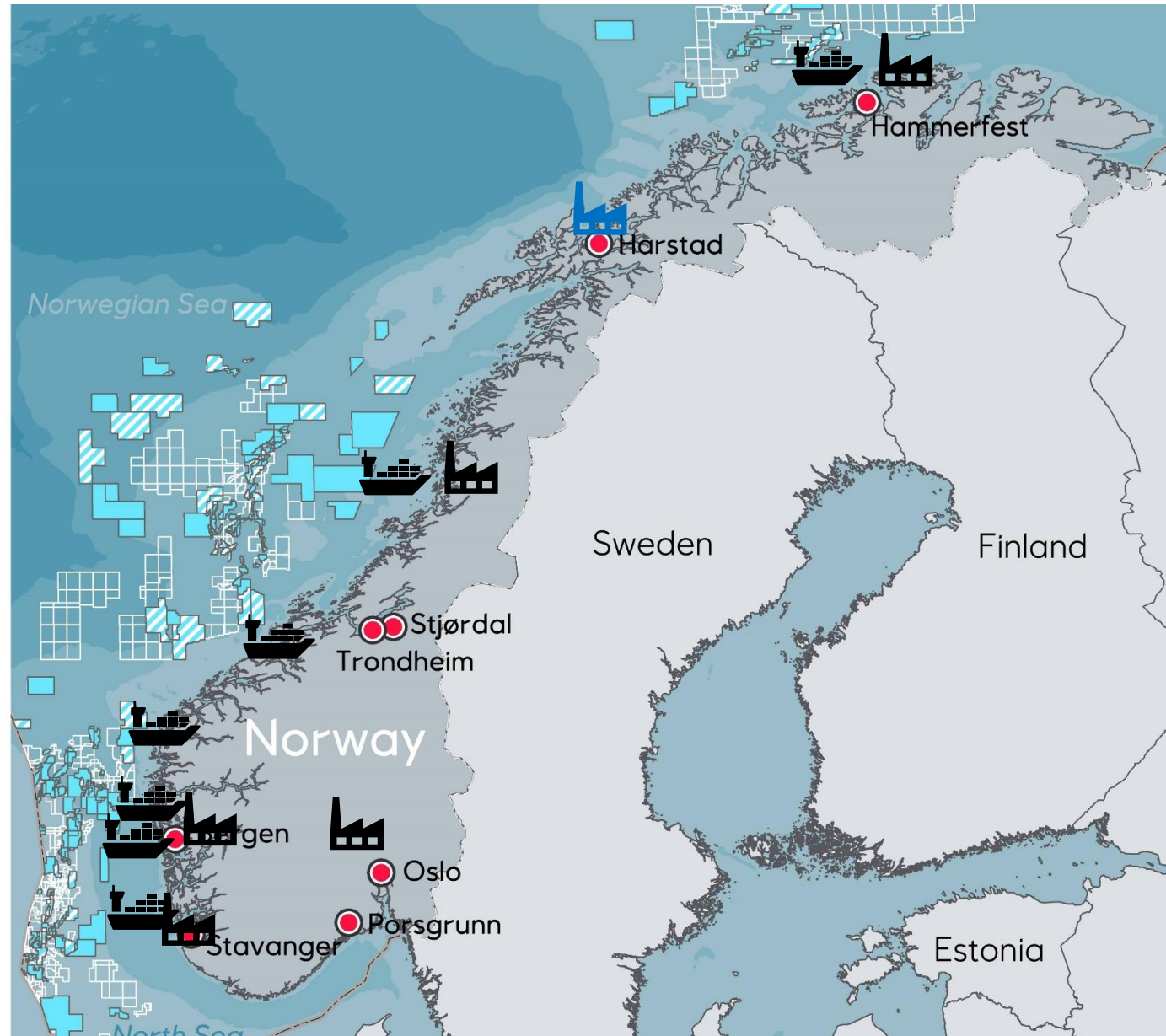


- Hammerfest
- Mo i Rana
- Stavanger
- Bergen
- Raufoss

Planned AM factories



- Dual use AM centre Bjerkvika (Harstad/Narvik)

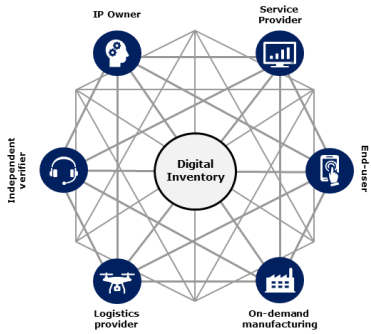




# Typical supply cluster



# Arenas for building the ecosystem



**US Oil & Gas Association**  
ADVOCATE FOR THE OIL & GAS INDUSTRY  
Since 1917



## Digital Inventory ICP

## Regional O&G organisations

## IOGP

## Accelerator programs

## AM Energy

## Regional AM organisations

Industry Collaboration Project for Global Implementation of DI

Equinor, TotalEnergies, Shell, ConocoPhillips, Vår Energi, Woodside and Fieldnode

May 2022 – September 2024

Invent and test new commercial models

Improve QA/QC

Fill DI with content

Digital Inventories

Build common understanding

Next phase target obstacles, e.g. standardisation

Challenge regulations

Collaboration with suppliers

Expert group

Overlays for current international standards gaps

Functional specification of a digital spare part

AM material datasheet Repository

Sustainability monitoring through new digital supply network

Accelerator programs for start-up companies

Stimulate startup companies which can have role in the DI network

International network for AM in the Energy industry

>330 members from all parts of ecosystem

3 sub-committees:

- Digital Value Networks
- Additive Mindset
- Materials and design for AM

Challenge framework

Organisation for acceleration of AM










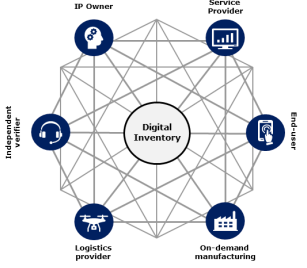
Membership

Build competence and share experience

Broad participation - all industries, research and universities

Reduce  
Environmental  
footprint

# Benefits of using AM in Equinor

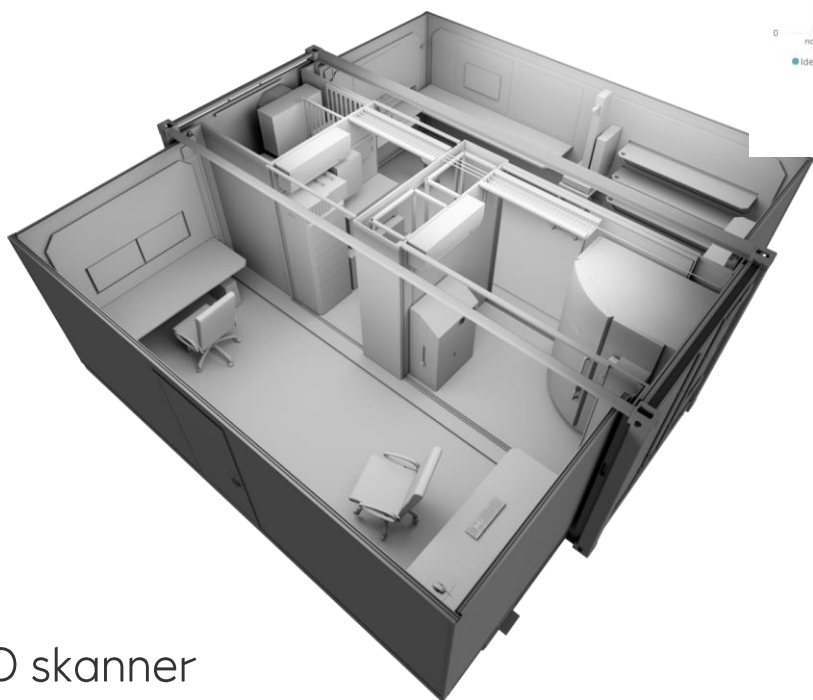
 <p>Reduce lead time</p>	 <p>Part repair</p>	 <p>On-site repair</p>	 <p>Obsolete parts</p>	 <p>Optimize function</p>
 <p>Visualization</p>	 <p>Reduce component cost</p>	 <p>Alternative materials</p>	 <p>Temporary fix</p>	 <p>Digital Inventory</p>

Reduce cost

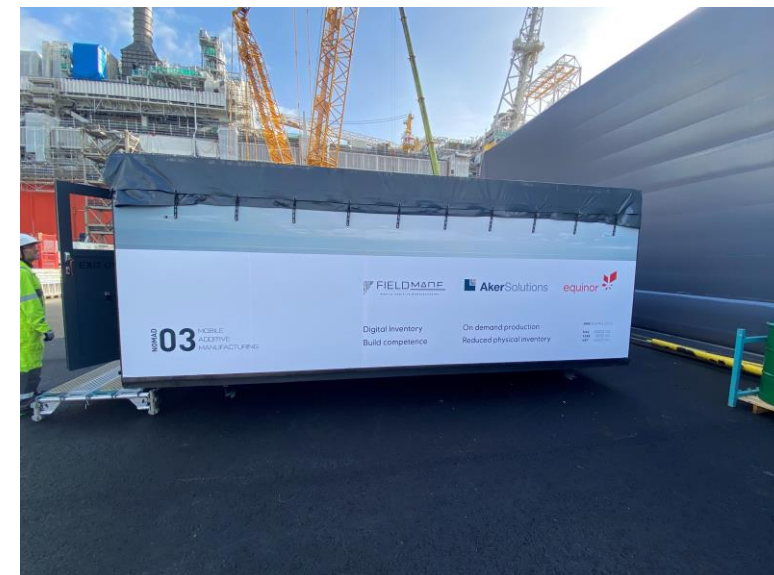
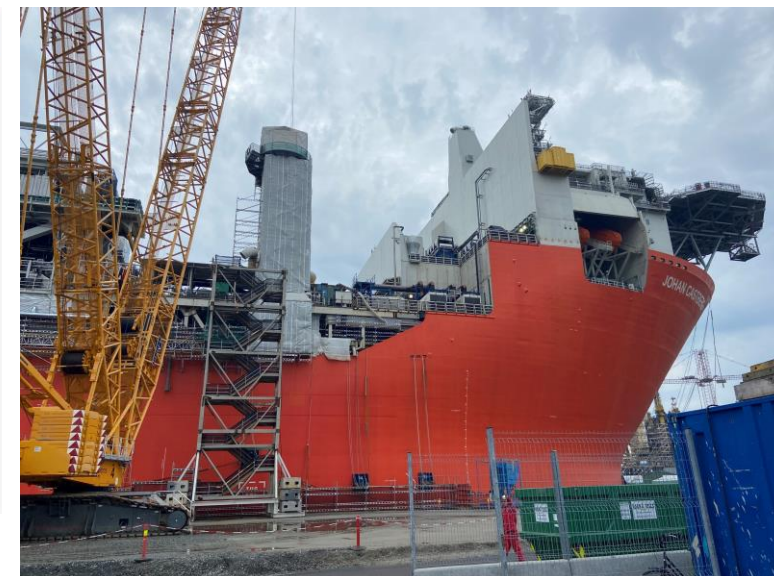
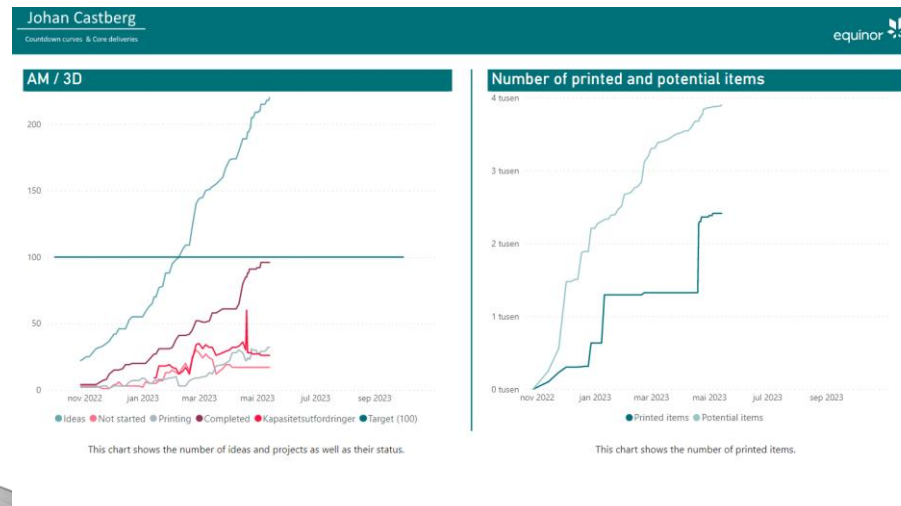


# 3D print microfactory at Johan Castberg

October 2022 – September 2023

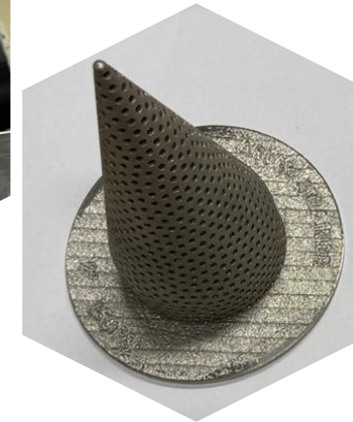


3D skanner  
 3D printer – composite  
 3D printer - metal



# 3D print microfactory during commissioning Johan Castberg

- Type of cases:
  - Tools
  - Support
  - Prototypes
  - Efficiency measures
  - Improved functionality
  - Missing parts/long lead time
  
- Success criterias:
  - Preparations
  - Build competence
  - Involve own organisation and suppliers
  - Availability



Using 100% recycled metal powder

# Quality and standardisation – Additive Manufacturing

ASTM/ISO – General top-level standards

- Terminology, data format, test methods, design guides, safety, test artifacts etc.

ASTM/ISO – Material or Process category standards

- Feedstock, process/equipment, finished parts

ASTM/ISO – Material, process and application specific standards

- Feedstock, process/equipment, finished parts
- Aerospace, medical, automotive etc

DNV-ST-B203 & API 20S – O&G application specific metal AM standards

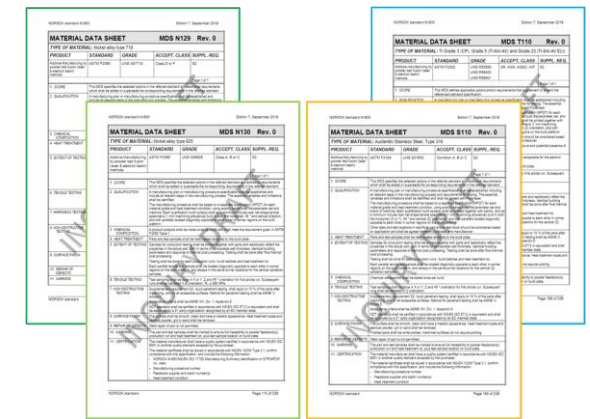
- Quality management of additive manufacturing and additively manufactured metal parts
- Test, inspection and QA/QC protocols for qualification, certification and production



2018: In-house qualification of Titanium swan-neck using existing ASTM F3302 ++



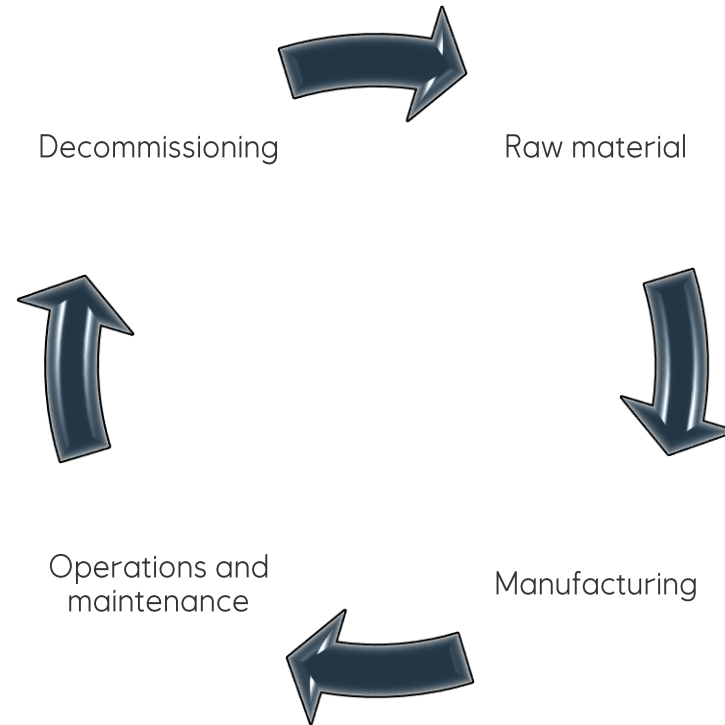
Examples of alloy 718 nozzle holder, impellers in Ti Grade 5 and alloy 625, and hydraulic block in alloy 625 following DNV-ST-B203



2020: NORSOK M-630 Ed.7 – 4 PBF metal MDS'es based on ASTM product standards



# AM and sustainability



Design



# DESIGN OPTIMIZATION



Reduce weight

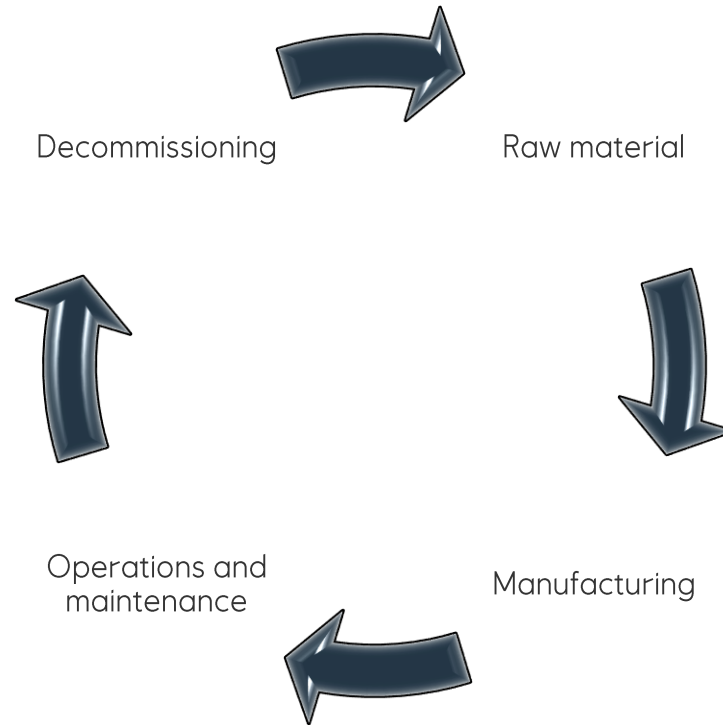


Improve efficiency of pumps

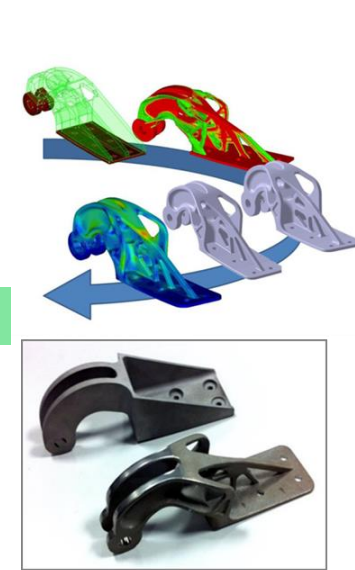


Improve efficiency of turbines

# AM and sustainability



Design



Reduced waste



Reduced Transport





# Sustainability in manufacturing

1a. Traditional part with design based on machining

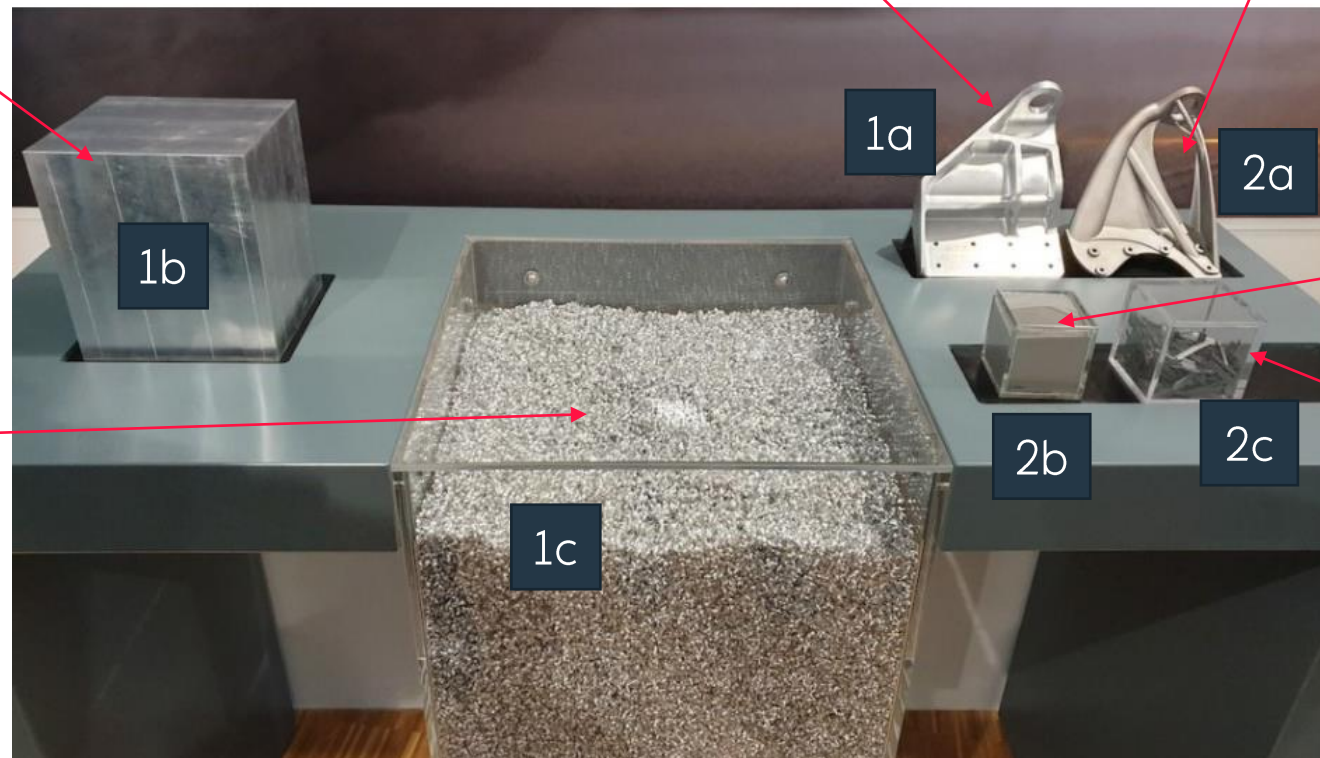
2a. Optimised part with same strength and function, based on generative design and metal 3D printing

1b. Amount of metal needed to produce part 1a with traditional manufacturing

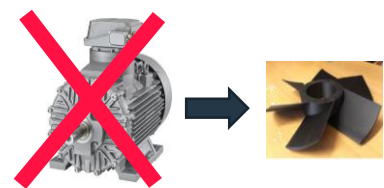
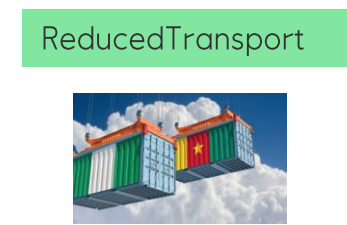
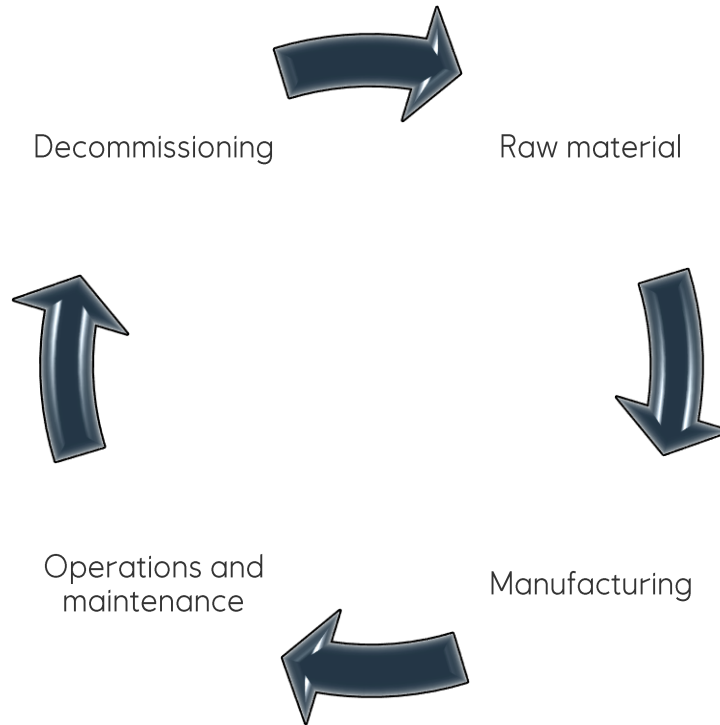
2b. Amount of metal powder needed to 3D print the new part

1c. Amount of scrap metal after machining

2c. Amount of scrap metal after 3D printing, mainly support material

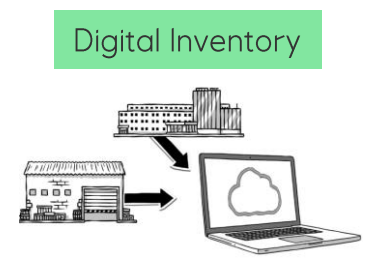


# AM and sustainability

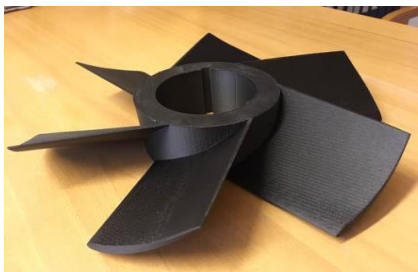


Extended lifetime

Improved function



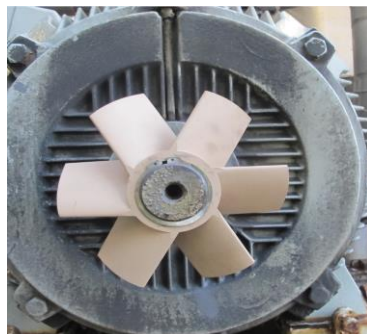
# Operations and maintenance



1. Erstatte vifte ved bruk av AM, og karbonforsterket nylon.

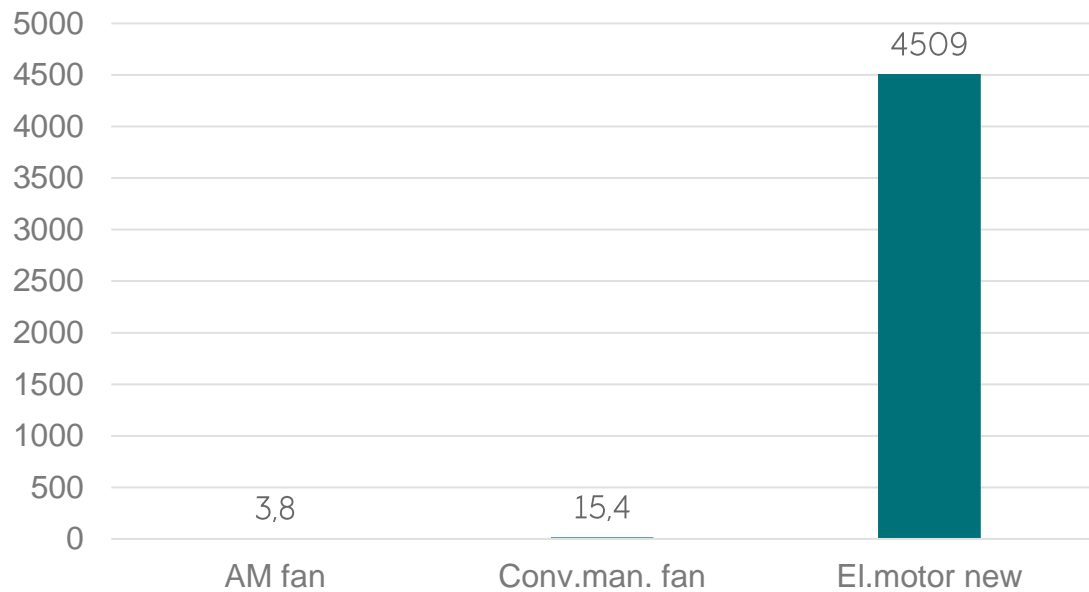


2. Erstatte vifte ved bruk av tradisjonelle produksjonsmetoder, og aluminium.



3. Erstatte hele elektromotoren

GWP kg



Source: Hege Botnen, Jennifer Oyaga, Ruben Lindseth

# Inventory



Equinor:

- 27bn in physical inventory
- 80% will never be used
- Digital inventory and on-demand manufacturing

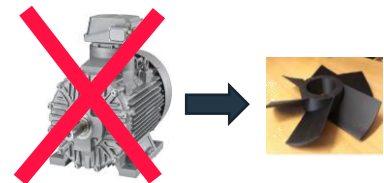
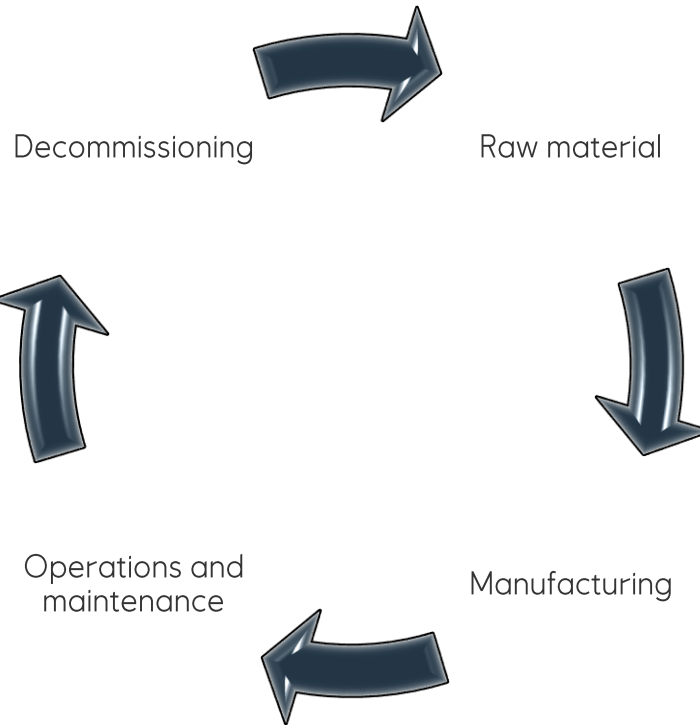
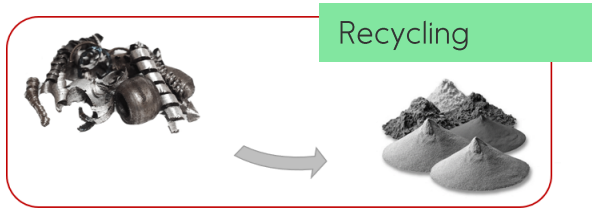
Source: Aidro and Hege Botnen

Internal

08 December 2022

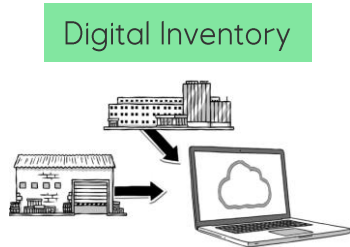


# AM and sustainability



Extended lifetime

Improved function



Reduced Transport



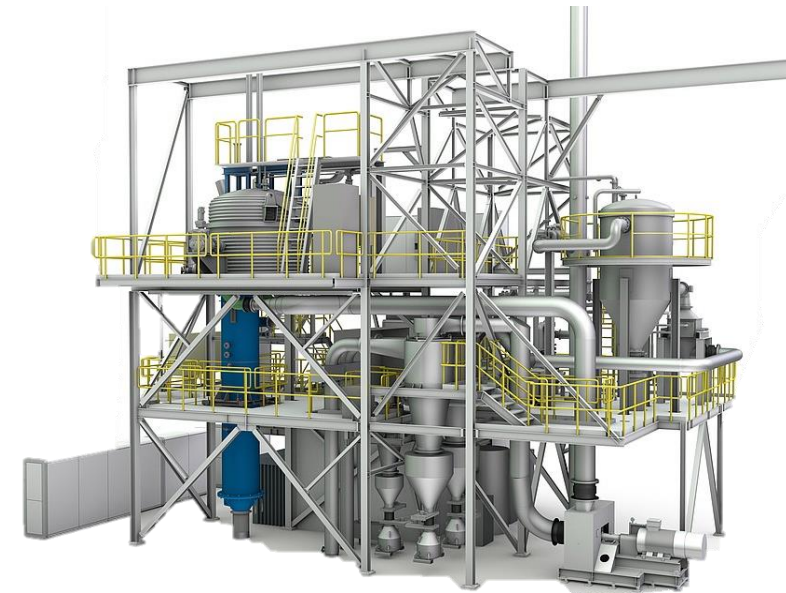
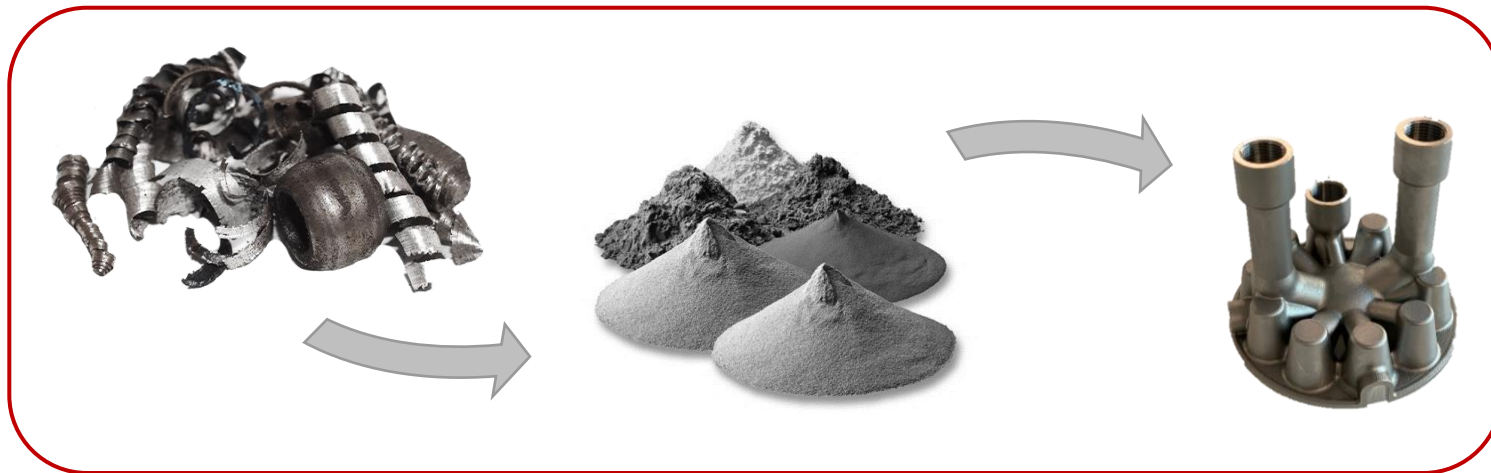
# Recycling

Source from scrap metal: **100%**

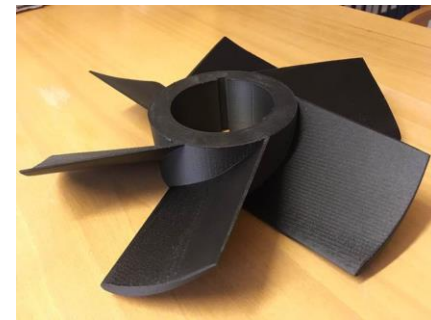
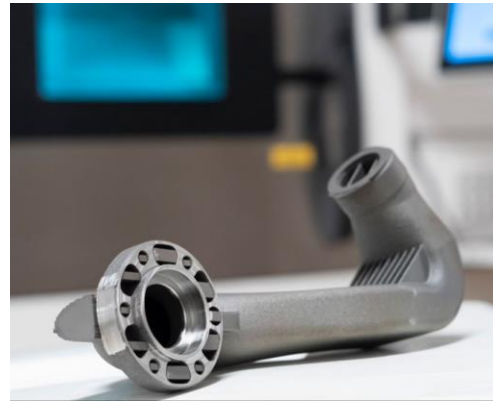
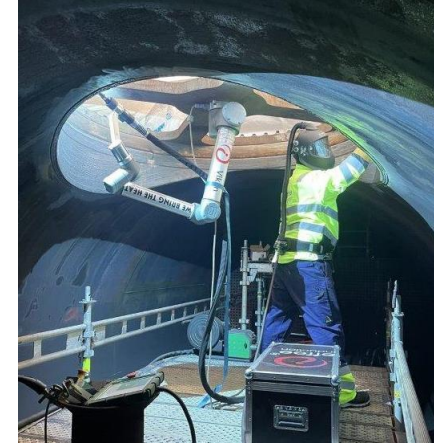
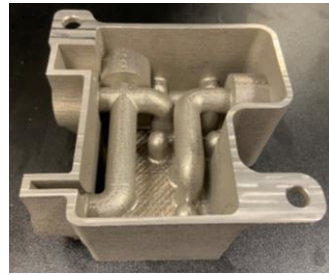
CO<sub>2</sub> emission savings: **90-96%**

Energy Savings: up to **78%**

**circular  
economy  
ecosystem**









# Equinor Additive Manufacturing and Digital Inventory strategy

Brede Lærum May 2023

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