Interreg Aurora

Co-funded by the European Union

Supply chain mapping and the implications of MAM-DeD for the Steelmaking Industry

by UiT – the Arctic University of Norway

Limited data on DED applications in the steelmaking industry is available. This document provides an overview of the steel industry in the program regions of Interreg Aurora; maps the supply chain; and discusses the implications of Metal Additive Manufacturing (MAM) and Directed Energy Deposition (DED) for steelmaking and the Sustainable Development Goals (SDGs).

Background

Steelmaking is the process of producing steel from iron ore or scrap. This involves multiple stages that transform raw materials into a durable, versatile metal used in a wide range of industries. The steelmaking process typically begins with the extraction of raw materials, such as iron ore, followed by processing in blast furnaces, where iron is produced. Crude iron is then converted into steel through either Basic Oxygen Furnaces (BOF) or Electric Arc Furnaces (EOF). Once the crude steel is produced, it undergoes further refining and post-processing to meet specific requirements for different applications, from construction to automotive manufacturing, and machinery production.

Iron ore is the primary material required for steelmaking and the rest of material are case-specific considering application needs and requirements. Fluxing agents are added to the blast furnace for removing impurities. Alloying elements are added to enhance steel properties. Once steel is produced, it can undergo coating to further improve its properties. Figure 1 illustrates a simplified overview of the steelmaking process.

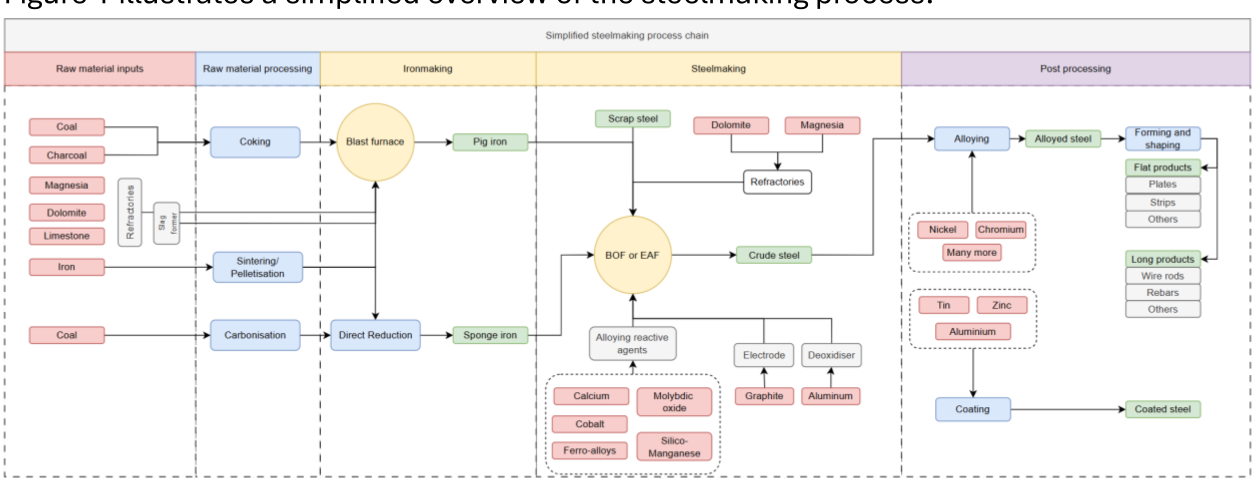

Figure 1 Steelmaking supply chain overview adapted from World of steel simplified steel industry supply chain model [1]

Supply Chain Mapping of steel production

The steel supply chain involves multiple players responsible for sourcing, producing, and distributing steel products globally. Managing the steel supply chain concerns three flows between these players:

- **Material Flow**: This includes the sourcing of raw materials, such as iron ore, and their movement through the chain, starting from the suppliers and flowing to the steel producers for processing.
- **Information Flow**: This encompasses the exchange of information, including procurement functions like generating purchase orders, which detail the volume and delivery schedules of raw materials essential for production.
- **Cash Flow**: The movement of capital within the supply chain, whether through credit arrangements or direct payments between entities.

The focus of this report is primarily on mapping the **material flow**. Understanding where raw materials are sourced from and how they move through the supply chain is essential for identifying the key players involved. This includes tracing the origin of iron ore extraction, production of the crude iron, and the subsequent steelmaking stages. Besides, mapping the material flow involves tracking how raw materials and finished steel are distributed among various entities. That is, the movement of iron ore and steel between Norway, Scandinavia, EU, and globally. Analyzing both local and international flows provides a better understanding of the supply and demand dynamics for iron ore and steel in the Interreg Region.

Iron ore extraction and trade in Europe

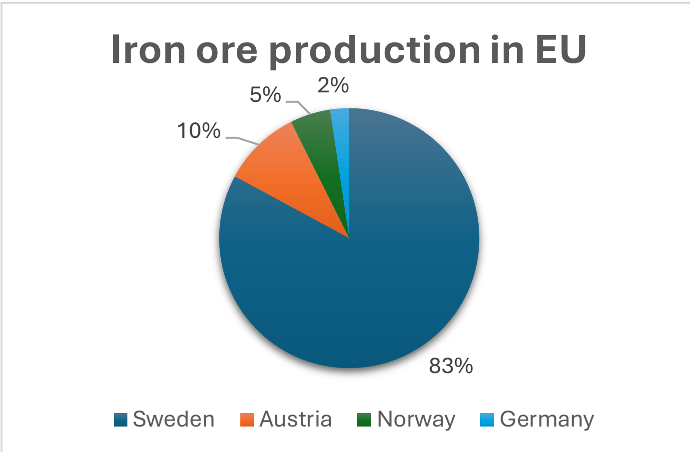

Figure 2 Iron ore production in EU

Table 1 Iron ore output EU

Location	Iron produced (m tonnes)	Exports	Imports	Consumption
Sweden	28.1	23.7	0	4.4
Austria	3.3	0	1.4	4.7
Norway	1.7	1.8	0	0
Germany	0.8	1.5	37.5	36.8
Total	33.9			

Other EU countries iron ore consumption				
Location	Iron produced (m tonnes)	Exports	Imports	Consumpion
Belgium	0	0.2	7.4	7.2
Czechia	0	0	4.9	4.9
France	0	0	12.4	12.3
Italy	0	0	5.1	5.1
Netherlands	0	18.4	25.7	7.3
Poland	0	0.1	4.9	4.8
Romania	0	0.2	2	1.9
Slovakia	0	0	4.9	4.8
Spain	0	0.1	4.8	4.6

Other European countries iron ore production				
UK	0	0	6.4	6.4
Turkey	5.5	2.7	9.6	12.3
Bosni-Herz	1.3	0	0	1.3

The initial stage of steel production begins in the iron ore mines. Only a few countries within the EU produce considerable quantities of iron ore. Figure 2 illustrates the countries of the primary iron ore mines across the region. In addition to this, Table 1 provides detailed data on the volume of iron ore mined and exported by the leading producers within the EU. The data is collected from the world of steel 2024 report for the year 2022 [2].

Much of the iron ore produced in the EU is traded regionally, supporting the region's steel industry. Figure 3 and Figure 4 illustrate the distribution of iron ore imports and exports between the EU and global markets, indicating the key trade partners and routes.

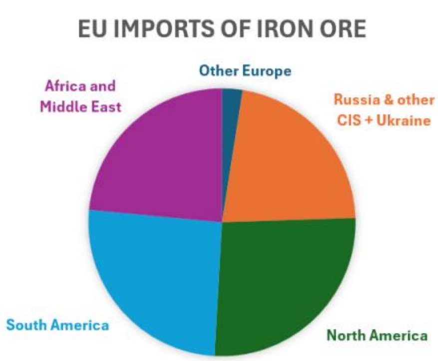

Figure 3 Imports of iron ore to Europe from the global market

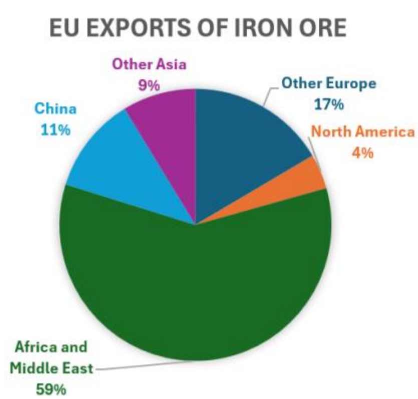

Figure 4 Exports of iron ore from EU

Steel production and distribution

Figure 5 presents the steel production volumes for Norway and EU member states, which is primarily produced using BOF and EOF. Table 2 provides more details on crude steel production, along with imports and exports of both semi-finished and finished steel products, measured in million tonnes.

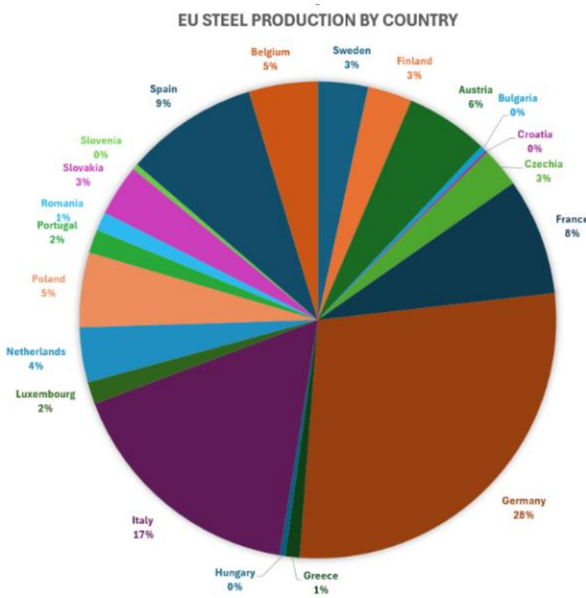

Figure 5 Steel production by Countries in EU

Table 2 Steel produciton, import and export of semi-finished and finished steel in EU and Norway (million tonnes)

Country	Crude production steel	Total imports (Finished and semi finished steel)	Total exports (Finished and semi finished steel)	Apparent consumption
Nordic				
Country	Prod	Import	Export	Consumption
Norway	0.69	0.831	0.552	0.97
Sweden	4.30	3.5	3.207	4.633
Finland	3.80	0.956	1.569	3.187
Denmark	0.00	2.7	1.091	1.612
EU				
Country	Prod	Import	Export	Consumption
Austria	7.13	3.46	7.03	3.565
Belgium	5.86	11.62	14.62	2.866
Bulgaria	0.49	2.06	1.10	1.449
Croatia	0.21	0.97	0.34	0.847
Cyprus	0.00	0.36	0.00	0.356
Czechia	3.38	6.86	4.14	6.113
Estonia	0.00	0.64	0.16	0.478
France	10.01	11.81	9.88	11.941
Germany	35.44	18.72	22.51	31.654
Greece	1.18	1.54	0.96	1.754
Hungary	0.48	2.40	0.77	2.101
Ireland	0.00	0.90	0.10	0.797
Italy	21.06	18.69	16.10	23.642
Latvia	0.00	0.38	0.13	0.248
Lithuania	0.00	0.89	0.26	0.638
Luxembourg	1.90	0.47	1.95	0.422
Malta	0.00	0.07	0.00	0.072
Netherlands	4.68	9.02	11.78	1.921
Poland	6.43	11.58	5.13	12.883
Portugal	2.04	3.28	2.45	2.862
Romania	1.62	4.56	2.10	4.082
Slovakia	4.38	3.06	4.56	2.879
Slovenia	0.53	1.64	1.09	1.085
Spain	11.44	10.17	7.83	13.771

For an understanding of the steel trade, we have analyzed the material flow in three main categories:

1. Imports and exports between Norway and EU
2. Imports and exports between the EU and the global market
3. Imports and exports between Scandinavia and EU.

The data for flow (1), representing trade between Norway and the EU, is collected from SSB statistics and includes iron and steel articles from SITC code 67 [3]. Flow (2), which covers EU-global trade, focuses on crude steel data obtained from the World Steel Association [4], [5]. Lastly, flow (3), between Scandinavia and the EU, uses Eurostat data [6] and, similar to flow (1), covers SITC code 67 iron and steel.

Global steel flows

A significant portion of steel produced in the EU is distributed and consumed within the region. Notably, **93 million tonnes (Mt)** of crude steel are traded within the EU, reflecting strong intra-regional demand [2]. Despite this, the EU remains an active player in the global steel market, engaging in substantial trade beyond its borders. Figures 6 and 7 illustrate the flow of steel imports and exports between the EU and the global market. Table 3 provides a summary of the data presented in these figures.

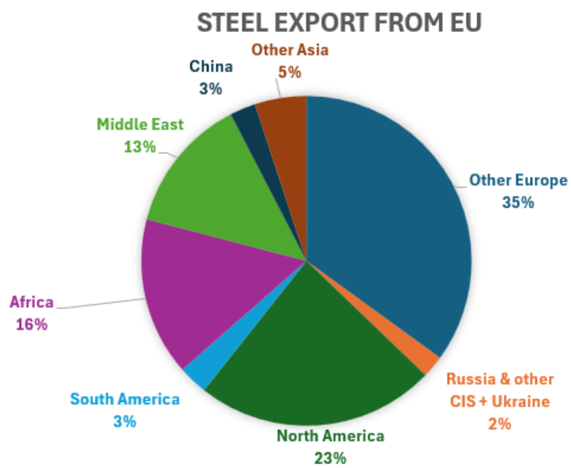

Figure 6 Export of Steel from EU

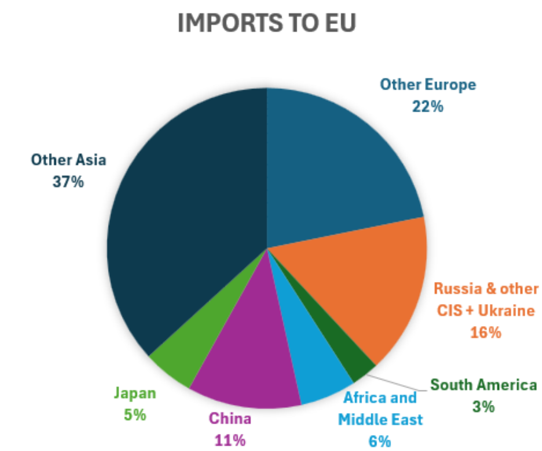

Figure 7 Import of steel in EU

Table 3 Detailed data for Steel flows between EU and the global market

Exports from EU		
From	To	Amount (mt)
	EU	93.1
	Other Europe	9.7
	Russia & other CIS + Ukraine	0.6
	North America	6.5
	South America	0.8
EU	Africa	4.3
	Middle East	3.7
	China	0.7
	Japan	0
	Other Asia	1.4
	Oceania	0.2
Total		121

Imports to EU		
From	To	Amount
EU		93.1
Other Europe		8.5
Russia & other CIS + Ukraine		6.3
North America		0.1
South America		1.1
Africa and Middle East	EU	2.2
China		4.5
Japan		2
Other Asia		14.3
Oceania		0.2
Total		132.3

Norway's steel flows

According to world of steel, Norway produced around 690,000 tonnes of steel in 2023 [7]. Norway does not produce crude steel using BOF furnaces and the country's only steelmaker is Celsa Armeringsstål using EOF technology, primarily recycling steel scrap [8]. As a result, Norway largely depends on imports to meet its steel needs.

The data for Norway's trade flows is sourced from **SSB (Statistics Norway) Table 08809** [3], **External trade in goods, by commodity group (one- and two-digit SITC) and country/trade/region/continent 1988 - 2023** which covers all imports and exports of iron and steel under **SITC Group 67**. The analysis of trade between Norway and the EU27 nations is shown in Table 4, Figures 8 and 9.

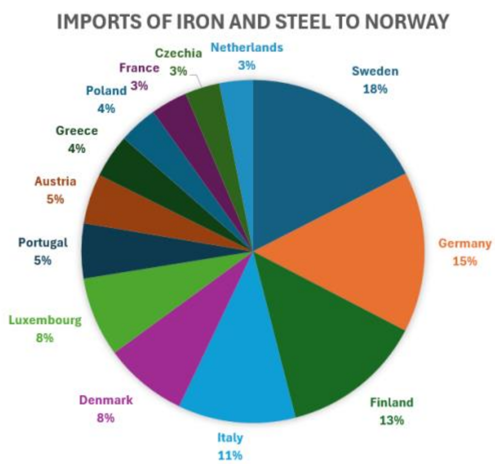

Figure 9 Iron and steel imports to Norway from EU

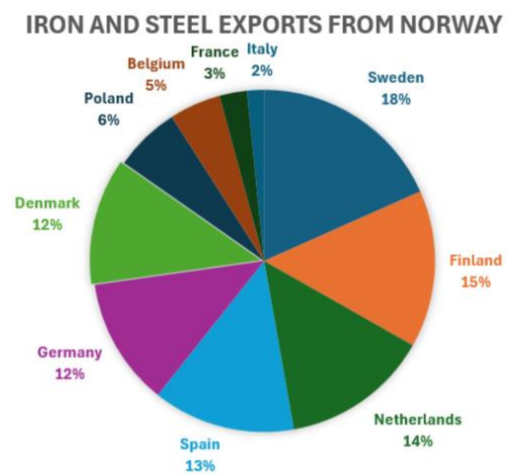

Figure 8 Iron and steel exports from Norway to EU

Table 4 Steel flows between Norway and EU

Countries	Tonnes	Countries	Tonnes
Sweden	101812	Sweden	186879
Germany	88203	Finland	151423
Finland	77927	Netherlands	142662
Italy	64498	Spain	137180
Denmark	45769	Germany	123013
Luxembourg	43733	Denmark	121798
Portugal	30219	Poland	63356
Austria	27353	Belgium	49564
Greece	23960	France	26542
Poland	21299	Italy	16228
France	20150	Latvia	8831
Czechia	19023	Greece	6061
Netherlands	18366	Slovakia	4009
Lithuania	15844	Lithuania	2387
Spain	13504	Estonia	1482
Slovakia	6168	Romania	842
Belgium	5611	Austria	258
Romania	3924	Portugal	233

Scandinavian steel flows

The final part of this mapping analysis flows between Norway, Sweden, Denmark, and Finland, and the EU27 nations. This analysis does not consider exports from Scandinavia to non-EU markets. The Eurostat Detailed Database, more specifically, the "**EFTA Trade Since 1995 SITC Database"** and the "**EU Trade Since 1999 SITC Database"** is used to compile the required data. This includes statistics under **SITC Code 67 (Iron and Steel)** for the year 2023, which considers both imports and exports between the Scandinavian countries and EU countries. Table 5 provides a breakdown of the total trade volumes (in tonnes and kilotons) from Scandinavia to every EU country, while the accompanying pie charts (see Figure 10 and Figure 11) illustrate the top 10 imports and exports partners.

Table 5 Iron and steel trade flows between Scandinavia and EU

Imports of Iron and steel to Scandinavia			Exports of iron and steel from Scandinavia		
From	Tonnes	kt	To	Tonnes	kt
Germany	1691287.3	1691.2873	Germany	1537674.7	1537.6747
Austria	219889.7	219.8897	Austria	46960.9	46.9609
Greeze	26633.7	26.6337	Greeze	8536.3	8.5363
Romania	22860.9	22.8609	Romania	59051.3	59.0513
Bulgaria	5656.8	5.6568	Bulgaria	15609.6	15.6096
Spain	210902.9	210.9029	Spain	417278	417.278
Lithuania	185228.9	185.2289	Lithuania	75461.2	75.4612
Latvia	33683.8	33.6838	Latvia	83704.4	83.7044
Poland	257118.8	257.1188	Poland	660854.5	660.8545
Netherlands	608648.8	608.6488	Netherlands	892187.6	892.1876
France	269359.4	269.3594	France	184797.3	184.7973
Italy	354005.4	354.0054	Italy	617214.8	617.2148
Belgium	293861.1	293.8611	Belgium	169467.5	169.4675
Czech	116581.9	116.5819	Czech	97265.6	97.2656
Hunagry	7367.3	7.3673	Hunagry	33153.8	33.1538
Estonia	58043.6	58.0436	Estonia	153941.1	153.9411
Ireland	2640.9	2.6409	Ireland	7214.1	7.2141
Slovenia	6463	6.463	Slovenia	15508.6	15.5086
Portugal	46362.8	46.3628	Portugal	37730.5	37.7305
Slovakia	58134.5	58.1345	Slovakia	45299.2	45.2992
Croatia	5600.6	5.6006	Croatia	2339.4	2.3394
Cypros	13	0.013	Cypros	52.5	0.0525
Malta	0	0	Malta	36	0.036
Luxembourg	219498.8	219.4988	Luxembourg	606.9	0.6069

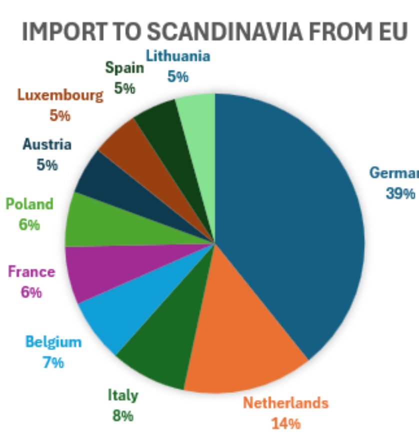

Figure 10 Import of Iron and steel to Scandinavia from EU

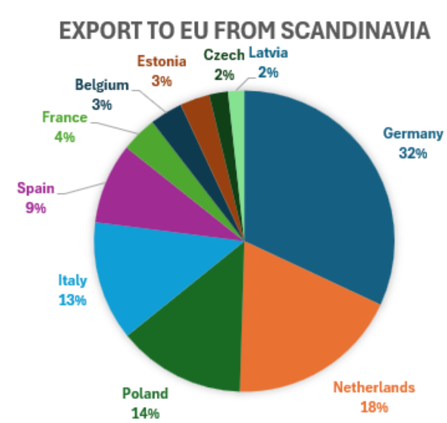

Figure 11 Export of steel and iron Scandinavia to EU

What are the supply chain implications for steelmaking?

DED utilizes the concept of cladding and welding processes and is defined as “an additive manufacturing process in which focused thermal energy is used to fuse materials as they are being deposited” [9]. There are mainly two feedstock forms in DeD: wire and powder; machine chips is possible is rather niche. The main two feedstocks can be used separately, or by combining them to increase deposition rate. Powder is the most commonly used material. DED do not have the same high requirements for material when compared with Powder-bed Fusion (PBF), where particle requirement is 50-150 μm [10] as opposed L-PBF 10-60 μm [11]. Figure 12 provides an overview of the DED methods, feedstocks and heat sources.

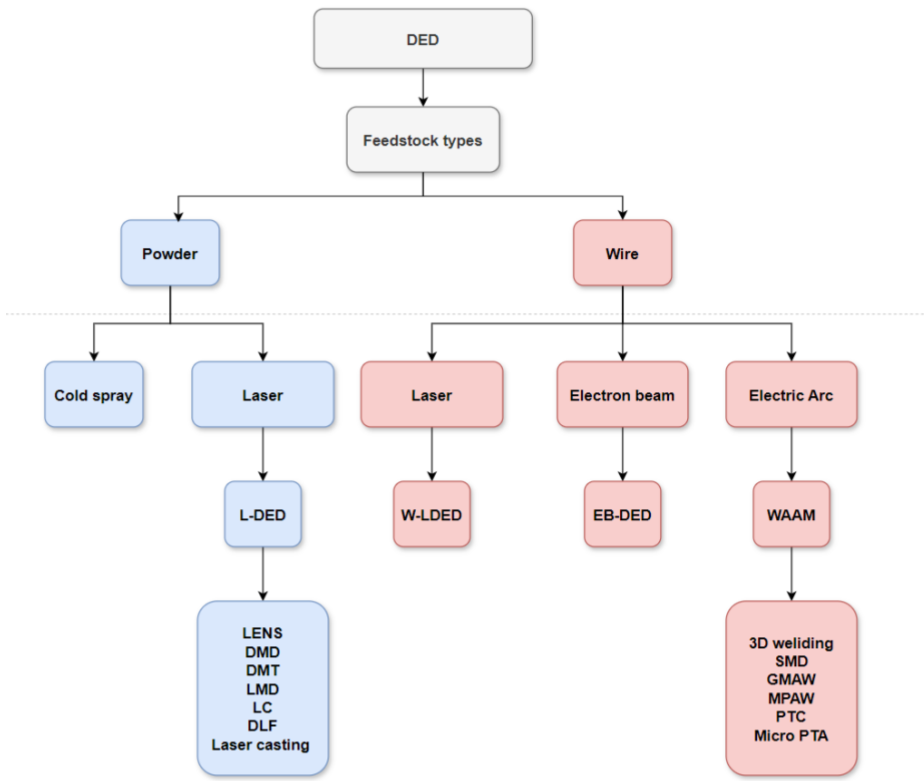

Figure 12 DED process overview

DED Stakeholder analysis

Figure 13 provides an overview of the main stakeholders in a DED-based supply chain. The process begins with raw material preparation, followed by traditional steelmaking and the post-processing stage. The raw material suppliers provide either wire or powder.

Additional stakeholders include Original Equipment Manufacturers (OEMs), which supply and integrate the DED printers. Other essential suppliers include consumables providers (e.g., shielding gas) and the component suppliers. Besides, DED machines require maintenance and various components, such as nozzles, substrate plates, lenses, optics, and cooling systems to operate efficiently.

The next stage is manufacturing, where the steel products are printed. Following the printing process, the products often require post-processing. While DED produces strong, durable parts, these parts may have a lower surface quality, needing post-processing. Further steps may include the removal of support structures, heat treatment to relieve residual stresses, and techniques to improve hardness and enhance mechanical properties.

Software and technology providers are critical stakeholders in the DED supply chain. These providers deliver essential software and control systems to manage the DED process, regulate material deposition, and ensure part quality.

The final stage involves the distribution of DED-manufactured parts to end-users. The end users are the final recipients of products or services produced in the steel supply chain; they drive demand and influence technological advancements. The customers may differ from those of traditional steelmaking. While the most prominent application of DED is for repair purposes [12], the technology also extends to areas such as surface cladding, fabrication of functionally graded materials, and more (see [10]). DED has been widely used in aerospace [10], automotive, marine, railway transport, energy, to defense industries [12].

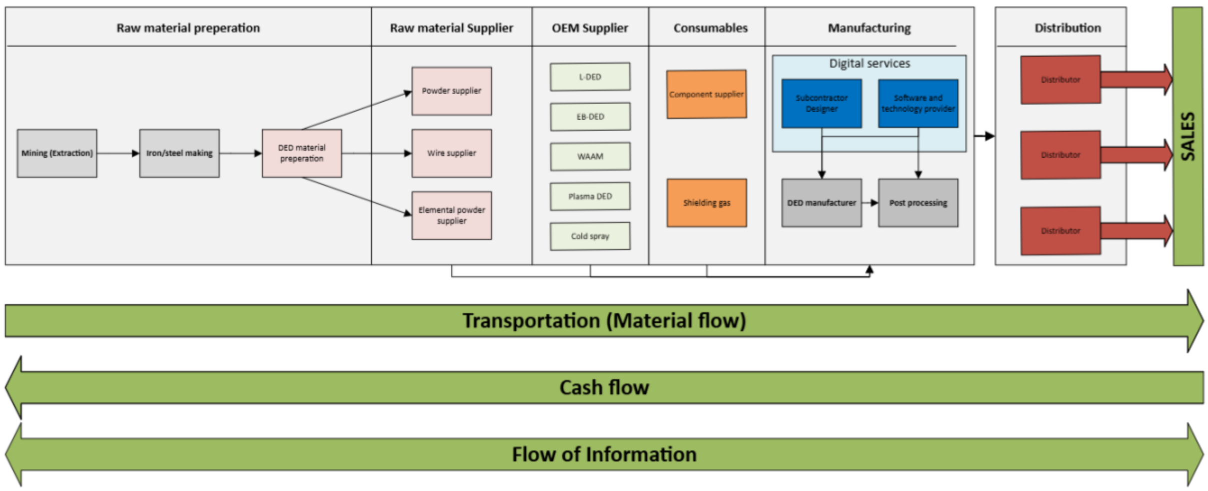

Figure 13 DED-based supply chain

How material flow in DED-based supply chains differs from traditional steelmaking?

Figure 14 illustrates the material flow within the traditional steel supply chain and outlines the primary areas where DED is typically applied. It is important to note that material flows in each process is influenced by a wide range of factors.

In the traditional steelmaking, the final steel products are used in machining, welding, forging, and other applications, each of which has a unique set of processing stages. In DED, the specific technology (e.g., powder or wire DED) and the intended operational environment determine the material flow within the supply chain. As shown in the figure, the primary change originates from the transformation of crude steel into powders or wire suitable for DED.

For producing powder for DED, one can distinguish between powdered alloys and elemental powders [10].

- Powdered alloys
    - Starts with an alloyed ingot followed by its atomization (gas, water, plasma atomization process) to obtain the powder fit for DED
- Elemental powders
    - The process of DED can be used itself for the manufacturing of alloyed components. Each material needed (in its element powder form) is added to the melt pool in correct proportions to arrive at the final composition of the alloy.

- Wire
    - in DED the wire is created through wire drawing a process that transforms bulk materials into thin, uniform wires. These are often the same or similar to those used in welding and conform to the same standard. You can often source wires from existing suppliers and use existing supply chains.

After the initial stages, both wires and powders need to undergo post processing and quality control to ensure that the feedstock are suitable for DED. For powder material, additional steps include Sieving drying and dehydration, blending and homogenization, surface treatment/passivation, powder packing (inert gas or vacuum packaging).

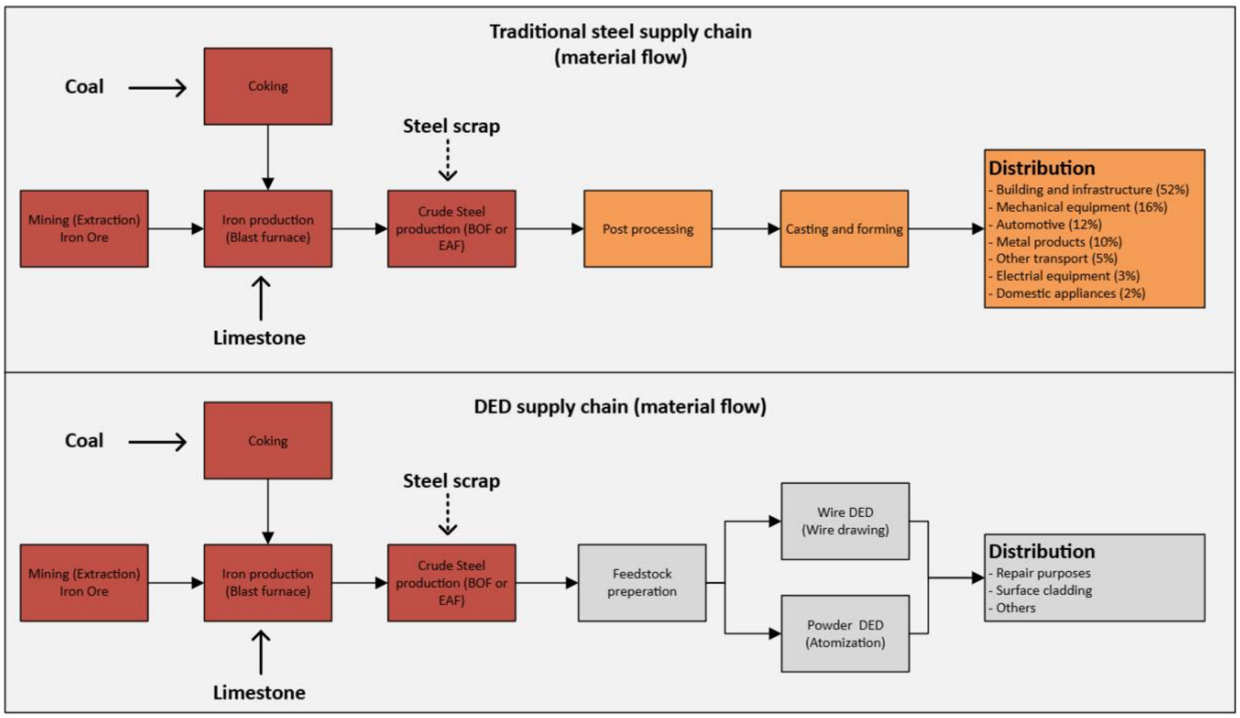

Figure 14 Traditional steel supply chain (material flow) versus DED

The major Nordic actors in DED

The final part of this report includes an overview of the supply chain actors in the region. The scope includes:

1. Steel production companies. I.e., those that produce steel through BoF or EOF.
2. MAM competences in the programme region (Norway, Sweden, and Finland).

Overview of iron and production plants in Sweden, Finland and Norway				
Location	Nominal iron capacity ('000 tonnes/year)	Nominal crude steel capacity ('000 tonnes/year)	No. of furnaces	Furnace types
Sweden				
SSAB - Luleå	2555	2300	1	BF/BOF
SSAB - Öxelösund	1550	1500	2	BF/BOF
Avesta		500	1	EOF
Bjorneborg		95	1	EOF
Hagfors		120	1	EOF
Hofors		500	1	EOF
Sandviken		200	1	EOF
Smedjebacken		480	1	EOF
Finland				
SSAB Raahe	2600	2600	2	BF/BOF
Tornio	.	1300	2	EOF
Imatra	.	360	1	EOF
Norway	.	.	.	.
Celsa Armeringsstål	.	770	1	EOF

Figure 15 Iron and steel production plants in Nordic countries[13], [14]

Finland			
Organization	**Location**	**Website**	**Capabilities/Focus**
Manufacturers			
HT Laser Oy	Finland	https://htlaser.fi/en/home/	L-PBF manufacturing
3D Formtech Oy	Finland	https://3dformtech.fi/en/	L-PBF manufacturing
3DStep Oy	Finland	https://www.3dstep.net/	L-PBF manufacturing
Materflow Oy	Finland	https://www.materflow.com/en/	L-PBF and other AM (metals & polymers)
Amexci Oy (Finland)	Finland	https://amexci.com/	L-PBF manufacturing and development
Valmet Oy (internal use)	Finland	https://www.valmet.com/	L-PBF for in-house production
Lillbacca Powerco Oy/FINN POWER	Finland	https://finnpower.fi/	Likely L-PBF manufacturing
Delva Oy	Finland	https://delva.fi/en/	Metal AM parts (exact process not specified)
SME Elektro-Group Oy	Finland	https://smegroup.fi/	Metal AM production (details not specified)
EOS (Research center Turku)	Finland	https://www.eos.info/	AM technology provider with local presence

Universities and research institutions			
VTT Technical Research Centre of Finland	Finland	https://www.vttresearch.com/en	Industrial 3D printing R&D, various AM processes
University of Oulu	Oulu	https://www.oulu.fi/university	L-PBF & WAAM research, materials & processes
Savonia UAS	Finland	https://www.savonia.fi/	WAAM & L-PBF, applied research and education
LUT University	Lappeenranta	https://www.lut.fi/	WAAM, laser wire DED, L-PBF research
Tampere University	Tampere	https://www.tuni.fi/	WAAM & L-PBF research, materials & processes
University of Turku	Turku	https://www.utu.fi/	L-PBF & DED research and education
Engineering services (design or other digital services for MAM)			
Elomatic Oy	Finland	https://www.elomatic.com/	Engineering, AM design
Etteplan Oy	Finland	https://www.etteplan.com/	AM design and consulting
Mecaplan Oy	Finland	https://mecaplan.fi/en/	Mechanical & AM design
Reminet Oy	Finland	https://reminet.fi/en/	Engineering services, AM
Ajatec Oy	Finland	https://www.ajatec.fi/en/	Product dev. & AM design
Clusters & competence centers			
DIMECC / FAME	Finland	https://fame3d.fi/	AM ecosystem builder, competence network
3D metal printing machine Importers			
Vossi Oy	Finland	https://www.vossi.fi/teknologiat/3d-tulostus/	Importer/distributor of AM systems
Fenno3D Oy	Finland	https://fenno3d.fi/	3D printer importer/distributor
Beijer Oy	Finland	https://beijers.fi/en/business-areas/	AM machine/tool importer
Apricon Oy	Finland	https://www.apricon.fi/en/products/trumpf/additive-production-systems/laser-metal-fusion/	TRUMPF AM systems
Evomax Oy	Finland	https://www.evomax.fi/machinery/	Machinery & AM equipment importer
Protech Lahti Oy	Finland	https://www.protech.fi/	Nordic subsidiary, AM systems distributor
Ekval Oy	Finland	https://www.ekval.fi/lang-EN	Machine tools & AM equipment

Sweden

Organization	Location	Website	Capabilities/Focus
Universities and research institutions			
Chalmers University of Technology	Gothenburg	http://www.chalmers.se/en/centres/cam2	Metal AM research (PBF-LB), materials, process optimization
Dalarna University	Borlänge, Dalarna	https://www.du.se/materialstechnology	Characterization of powders, microstructure-property relations
Jönköping University	Jönköping	www.ju.se	Materials & Manufacturing, product development, design for AM
Karlstad University	Karlstad	www.kau.se	PBF-LB, new materials, process monitoring
KTH Royal Institute of Technology	Stockholm	https://www.kth.se	AM alloy design, material characterization, AM education
Linköping University	Linköping	https://liu.se/forskningsomrade/konstruktionsmaterial	Structure-property relations, thermomechanical testing
Luleå University of Technology	Luleå	www.ltu.se	Laser DED, high-speed imaging, design for AM, topology optimization
Lund University	Lund	https://www.innovation.lth.se/	Electron beam melting, economics of AM, mechanical testing
Mid Sweden University	Östersund	www.miun.se/sportstech	Powder materials, process development, AM education
RISE (Research Institutes of Sweden)	Mölndal/Jönköping	www.ri.se	AM materials & production, DED, EBM, BJT, process simulation
Swerim	Kista	https://www.swerim.se/en	Powder materials, additive manufacturing processes, characterization
Uppsala University	Uppsala	https://www.uu.se	Material characterization, AM for life sciences, NDE/NDT
University West	Trollhättan	www.hv.se	Metallurgy (Ni-based superalloys, Ti, DuplexSS), full DED AM line
Örebro University	Örebro	www.oru.se	Material characterization, digitalization, business modeling
Clusters & competence centers			
AMEXCI AB	Sweden	https://amexci.com/	AM competence center owned by Swedish industry, focusing on metal AM development and acceleration
RISE	Sweden	www.ri.se	National research institute with AM expertise
Swerim	Sweden	https://www.swerim.se/en/	Industrial research institute for metals & AM

Norway

Organization	Location	Website	Capabilities/Focus
Manufacturers			
Norsk Titanium	Hønefoss, Norway	https://www.norsktitanium.com/	Wire-based additive manufacturing (RPD) of titanium aerospace components
Fieldmade AS	Oslo, Norway	https://fieldmade.no/	On-demand AM manufacturing (metal & polymer), spare parts, portable AM units
Tronrud Engineering	Hønefoss, Norway	https://tronrud.no/	MAM services (DMLS), including design, production, and post-processing, utilizing advanced 3D printing technologies (EOS machines)
Nordic Additive Manfuacturing (NAM)	Raufoss	https://www.nordicadditive.no/	Norwegian startup that combines traditional manufacturing with AM techniques, specializing in LMD.
3D Production	Norway	https://www.3dproduction.no/	Large-scale metal AM in titanium, Inconel, aluminum, and tool steel.
Årdal Maskinering AS	Norway	https://www.aardal.as/am/	Hybrid manufacturing (DED + CNC machining) of metal parts; equipped with a Mazak Integrex i-500 AM hybrid machine.
3D Construction	Larvik, Norway	https://3dconstruction.no/	Large-scale metal 3D printing/welding, including carbon and stainless steel, as well as concrete.
Universities and research centers			
SINTEF	Norway	https://www.sintef.no/	R&D in materials, process development for AM, industrial projects. They operate both machines for research and industrial purposes.
NTNU	Trondheim	https://www.ntnu.no/	Engages in R&D in metal AM processes, materials development, and process optimization.
UiT	Narvik	https://uit.no/startsida	Research on MAM with several metal 3D printers including, PBF and metal material extrusion machines
UiS	Stavanger	https://www.uis.no/nb	Research in mechanical design, production, and materials science.
IFE (Institute for Energy Technology)	Norway	https://ife.no/	Advanced materials and manufacturing research, including MAM as part of broader energy and material innovation projects.

Clusters & competence centers			
Aibel	Harstad	https://aibel.com/	AM pilot competence center opened October 2024
Norwegian AM cluster	Norway	https://norwegianam.no/	Established in 2022. Cluster organization promoting AM adoption, collaboration, innovation in Norway
Future materials	Norway	https://www.futurematerials.no/	Norwegian innovation cluster specializing in advanced materials technologies, including MAM.
Mechatronics Innovation Lab (MIL)	Grimstad, Norway	https://mil-as.no/en/	National center for innovation, pilot testing, and technology qualification. They offer facilities and expertise in AM
PRO Barents	Norway	https://probarents.no/	Regional innovation and development entity in Northern Norway. They foster collaboration, competency building, and AM adoption in Northern Norway's industries
Engineering services (design or other digital services for MAM)			
Additech AS	Norway	https://www.additech.no/	Design engineering and in-house quality printing
Capnor AS	Norway	https://www.capnor.com/	Digitization services including 3D scanning, modeling, and design engineering
Meisle	Norway	https://meisle.no/	Provides design services and 3D printing for industrial applications.
Ivaldi group	Norway	https://www.ivaldi.com/	Provides digital inventory services and enables on-demand 3D printing production through a global manufacturing network.
Other notable companies			
Equinor	Norway	https://www.equinor.com/	Works extensively with MAM, and participated in several projects fostering increased used

What are the possible implications for pursuing the Sustainable Development Goals?

In September 2015, countries adopted the SDGs to address global challenges such as poverty, inequality, climate change, and environmental degradation. MAM has the potential to contribute to pursuing some of these goals through changing manufacturing processes and fostering innovation. MAM can have both direct and indirect impacts on all 17 SDGs, but the following list highlights the most relevant implications.

3 GOOD HEALTH AND WELL-BEING

Good health and well-being = Advanced medical solutions

Healthcare is one of the early adopters of MAM. The technology significantly enhances the medical industry by producing customized and critical parts. MAM enables the creation of customized medical implants and prosthetics tailored to individual patients, improving health outcomes. The ability to produce complex, biocompatible structures enhances the quality and accessibility of medical care.

8 DECENT WORK AND ECONOMIC GROWTH

Decent work and economic growth = New skills and jobs

The adoption of MAM creates demand for a skilled workforce proficient in digital manufacturing techniques. This shift opens new employment opportunities and stimulates economic growth in both the production stage and product development stage [15].

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Industry, innovation and infrastructure = Industry transformation

MAM are at the forefront of industrial innovation, enabling the development of complex geometries and customized solutions that traditional manufacturing cannot achieve. By enhancing manufacturing capabilities, they contribute to building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

11 SUSTAINABLE CITIES AND COMMUNITIES

Sustainable cities and communities = Infrastructure resilience

MAM are at the forefront of industrial innovation, enabling the development of complex geometries and customized solutions that traditional manufacturing cannot achieve. By enhancing manufacturing capabilities, they contribute to building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Responsible consumption and production = Minimized waste

MAM allows for material to be added only where needed, significantly reducing waste compared to subtractive manufacturing methods. This efficiency leads to more sustainable consumption of resources and minimizes environmental impact by reducing the need for raw material extraction and waste disposal.

13 CLIMATE ACTION

Climate action = Reduced carbon footprint

By optimizing designs for weight and performance, MAM reduces the energy consumption of products considerably during their lifecycle, particularly in sectors such as aerospace and automotive where lighter and optimized parts lead to fuel savings and lower greenhouse gas emissions. Additional localized production reduces the carbon footprint associated with transportation in global supply chains.

17 PARTNERSHIPS FOR THE GOALS

Partnerships and goals = Collaborative innovation

The development and implementation of MAM often involve collaboration between governments, industry, and research institutions. These partnerships accelerate technological advancements and facilitate the sharing of knowledge and resources.

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