

Address FOR FUTURE



WP2: Identification and Analysis

Result 1. National and International Level Additive Manufacturing Industry Strategic Framework

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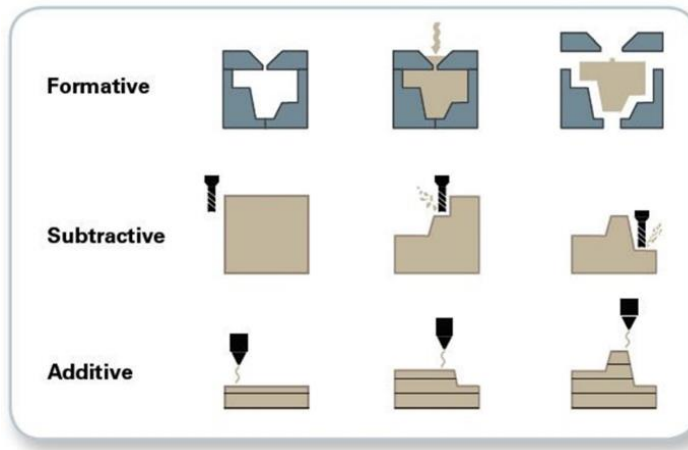
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1. INTRODUCTION

Additive manufacturing (AM) has caught the attention of industrial designers, manufacturers, and artists for decades. It has transformed its dominance from prototyping into actual manufacturing through these years.

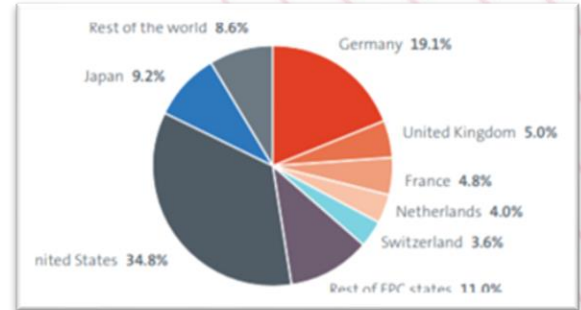
In the 1950s, the benefits of layer-wise manufacturing were considered more seriously. The chain of events from the 60s to 80s set the stage for the development of processes that used layer-by-layer material addition to produce 3D parts. Finally, AM started to be used in industrial applications with the invention of stereo lithography and registered the patent for it in 1984.



Additive manufacturing (AM) is the process of making 3D objects by adding material layer upon layer according to the computer design data (CAD). With the step up of industrial use of AM, several innovative AM technologies with different materials have been presented to the industry. After industrial applications started, AM has been regarded as Digital Manufacturing and it is one of the technological topics in Industry 4.0.

Besides several different technologies for addition of material to each sliced layer of CAD data, creates the need for standardization and re-skilling the technical personnel. As a result, ISO and ASTM cooperate for creating a common set of standards on AM. The cooperation of creation of standards on raw materials, processes and qualifications are continuing.

AM is also one of the key technologies to boost manufacturing capabilities particularly in critical industries such as aerospace, energy, medical, defence and die-mould. Furthermore, considering the current environmental crisis worldwide, using more sustainable technologies with minimized material waste, such as additive manufacturing, is inevitable in the future. Countries are competing in AM and related technologies since it is dramatically increasing market volume in last decade and it will be similar trend in next years.



Additive manufacturing patent map

The industrialization of AM has passed through different waves, yet it still manages an average yearly growth rate of 20% according to World Economic Forum report. Therefore, developed and developing countries especially from America, Europe and Asia continents have huge investments in additive manufacturing. Of course, those countries are investing on AM, based on well-planned strategies in different areas i.e., machinery, software, raw material, qualified skills.

Following this, many studies are continuing either technically or theoretically regarding AM technology. Also, the potential of AM to have a significant role in the future of manufacturing has been underlined again within the context of the COVID-19 pandemic.

Therefore, studying this technology and its processing methods and promoting them are essential to be ready for the future of work and production.

2. SCOPE

This report is the outcome of the first work package (WP) of ADDress For Future project. This report of this WP identifies national and international level additive manufacturing industry strategic framework. In this report not only the strategy of countries on AM is identified but also long-term technological and industrial roadmap which collects the major technological developments foreseen to happen in the following years is also determined. This is critical to ensure that future skills need in AM are identified in due time, thus guaranteeing that a skilful workforce is ready when industry requires it.

To ensure these perspectives on the long-term strategy, ADDress project has analysed a set of initiatives, institutions, encompassing networks, platforms, and research programmes at International, European, National and Regional levels. The aim is to clearly understand and

determine focus of the studies/areas/topics which are common, how they can promote new offerings and allow academicians, students, employees, and society in general to progress together with technological evolution.

3. AIM

ADDRESS For Future project aims to raise awareness of different participants (engineers, students, academicians, NGO's, governments) and increase expertise and awareness of business world about AM, bring entrepreneurs together with a common platform, therefore contribute to a society that is compatible with digital transformation, has a green deal approach and has increased inclusion.

In order to increase the competitiveness in the field of AM technologies in the European industry and also to customize the related products the following objectives are to be realized:

1. Ensuring the integration of Additive Manufacturing into the existing production ecosystem
2. Dissemination of technology by increasing the awareness and application level of the manufacturing industry regarding additive manufacturing technology
3. Development of the additive manufacturing ecosystem at national and international level by focusing on cooperation networks and human resources, sharing policies and good practices
4. Development of upskilling needs for Additive Manufacturing in VET and integration to training at different levels
5. Building up innovative training technologies in Additive Manufacturing for engineers, blue collar workers, academicians and NEET
6. Supporting start-up and spin-off companies operating for encouraging entrepreneurship in Additive Manufacturing industry.

Outcomes including the project results that will occur during and after the project are as follows:

1. National and International Level Additive Manufacturing Industry Strategic Framework.
2. Integration of Additive Manufacturing Curriculums into training organizations.
3. Additive Manufacturing Technologies Skill Map.
4. Work force Transformation Program Tools and Platform Design.
5. Partners with improved capacity through collaborations with the ability to act jointly, to increase the capacity of professionals and NGOs, to create and share new approaches.
6. Trainers who have gained new skills and metacognitive awareness to digitize educational contents.
7. Green awareness in design and production of AM products.
8. Academicians and technical professionals gained new skills for digital transformation.

4. METHODOLOGY

The report has been elaborated from comprehensive research, gathering all the information from governmental bodies to industry companies and training or education institutions that are currently focused on digital transformation and additive manufacturing but also those who are potential users. Determination of stakeholders is done with thorough study of project partners not only in their country but also the countries that assigned.

Through this study, new business models, value chain analysis, market volume development, strategies, policies, financial supports, market-related trends and expectations are analysed. This makes it possible to determine the focus issues and priorities among the stakeholders. The detailed activities carried out for the preparation of the report can be summarized as follows:

1. Literature review providing an overview of AM technologies,
2. Research on AM reports prepared by various EU Institutions and private companies,
3. Research on dedicated magazines,
4. Research of EU-funded projects,
5. In-depth analysis of AM strategies for EU countries,
6. Research of EU patents.

Tools like Google Patent, Web of Science, Science Direct and Scopus etc. are used.

The content of these detailed studies articulates into the following main sections:

1. Current state of art on metal AM technologies
2. Reports from various Institutions/Companies
3. Summary from EU Institutions dealing with AM
4. Reports from Magazines dealing with AM
5. Reports from EU funded projects

Analysis of the countries with a focus on the following main aspects:

1. Vision and Policies at national level,
2. Grants, projects, and patents,
3. Training and education systems considering universities, national competence centres and other public institutions,
4. Business and market,
5. Main challenges

A top-down approach is used for mapping and updating all relevant initiatives, thus consideration of policies, platforms, clusters, frameworks and associations addressing Additive Manufacturing and related areas (e.g. Advanced Technologies, industry 4.0 /digitisation, etc.) at International, European, National and Regional levels are done. Additionally, the most relevant worldwide technological roadmaps in the Additive Manufacturing field have been analysed and compared to identify most promising technological challenges and to develop the list of technological trends that can determine

the evolution of these technologies. The spotlight has been put on the trends with a direct influence on skills development.

An important phase of this WP is the survey study. An extensive survey analysis has been performed to monitor the needs of stakeholders for AM. The survey is prepared by the ADDRESS for Future project partners and the questions are prepared as multi-choice and open-ended types. The survey is delivered to the recipients via project web page (www.addressforfuture.com), social media, conference participation, one-to-one contacts etc.

During these studies, partners of ADDRESS project also take part in different events about AM all around Europe where dissemination of the project, gathering of information about the WP studies, survey study and networking is done. The survey has been presented as Appendix 2: Survey Results.

Those events are;

- Additive Manufacturing Conference, AMC Türkiye 2022 06-08 October
- EPMA World PM 2022 Congress & Exhibition, France 09-13 October
- I-AM 2022 International Additive Manufacturing Conference, Portugal 19-20 October 2022
- SAHA Expo Defence and Aerospace Exhibition, Türkiye 25-28 October 2022

5. CURRENT SITUATION

5.1 Introduction and Historical Background

Additive Manufacturing is building objects by successive addition of material. According to Definition by ASTM/ISO 52900 Standard, Additive manufacturing is “process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies”. Additive Manufacturing is not a single process or technology, but rather a combination of multiple different processes (i.e. ‘products’) embedded in one process.

Actually, the mother nature has been using AM even before the existence of humanity such as wasps while building their hives or scallops making their own shells.



Wasp hive (left), Scallop shell (right)

The first steps in the historical evolvement of Additive manufacturing can be considered as the 3D CAD (Computer Aided Design) systems in the 70s. In the 80s, the US automotive industry identified the need for augmented prototyping processes. Several "Rapid Prototyping" (RP) processes developed during the 80s and early 90s as below:

- Stereolithography (SLA, Charles Hall, 1986) – First Machine Sold in 1987
- Selective sintering (SLS, Deckard, 1989)
- Fabrication of components by layered deposition (Vannon D. Pratt et al. 1991)
- Apparatus and Method for Creating Three-Dimensional Object, Fused deposition modelling (FDM, Crump, 1992)
- Techniques for Three-Dimensional printing (3DP, Emanuel M. Sachs et al. 1993)
- Laminated Object Manufacturing (LOM, Feygin, Sung 1996)



(a) First 3D Printer designed by Charles Hall
(Source: 3D Systems)



(b) The first 3D printed part, 1983

It is important to distinguish between prototyping and Industrial AM as they both evolve in different directions as of today, although being all covered under the title of Additive Manufacturing. A prototyping process includes everything from concept idea to the delivery

of the physical prototype. Requirements are ad-hoc and settled by agreement between service provider and customer. On the other hand, an industrial manufacturing process consists of a series of sub-processes, with defined interfaces and specified requirements like consistency, predictability, traceability, and quality control with predetermined product requirements.

5.2 Technology

In its Research Report “The future of manufacturing in Europe” of 2020, the EU agency Eurofound (European Foundation for the Improvement of Living and Working Conditions) counts five game-changing technologies:

- Advanced Industrial Robotics (AIR)
- Additive Manufacturing (AM)
- Industrial Internet of Things (IIoT)
- Electrical Vehicles (EV)
- Industrial Biotechnology (IB)

The term ‘game changer’ reflects a belief that economically significant change comes in occasional bursts of innovation clustered around a core technology, with wide application throughout the economy.

Three of these, AIR, IIoT and AM are transversal technologies and they have potential application in practically all types of manufacturing.

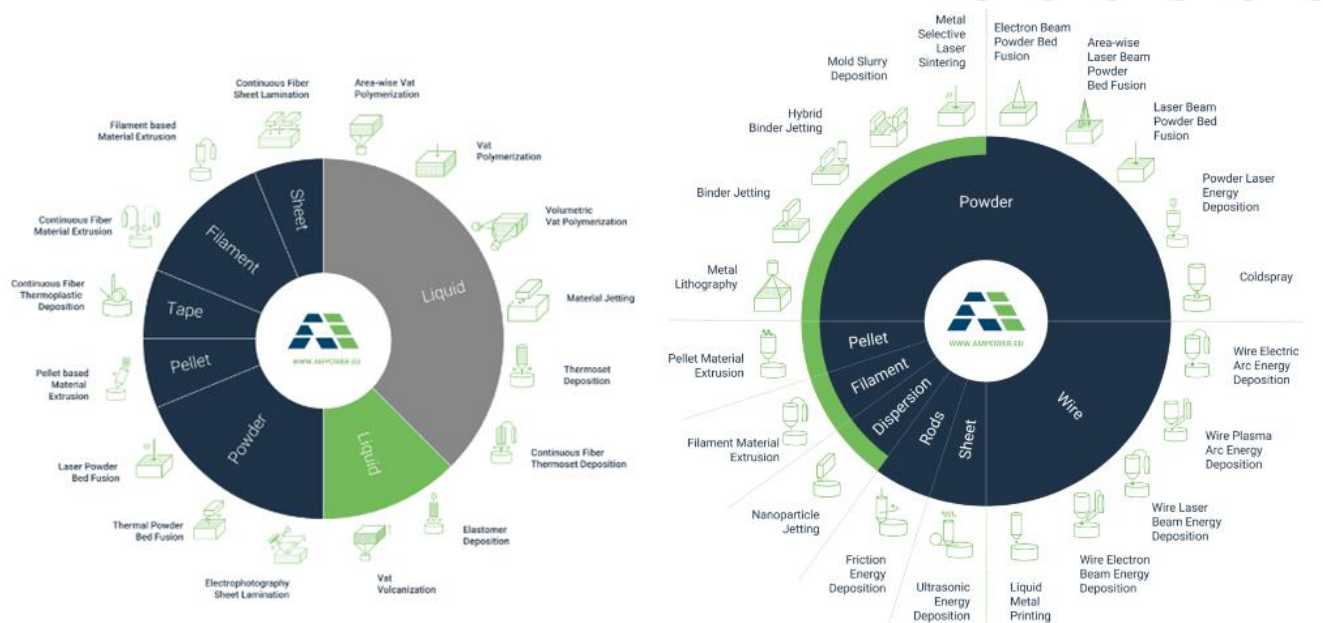
These three technologies cover the core production process, which could potentially lead to very high levels of labour productivity and a minimum of labour input in this part of the supply chain. On the other hand, the potential for an increase in labour productivity may lie more in the other stages, which typically have lower levels of productivity.

R&D	Design	Logistics (inward)	Production	Logistics (outward)	Marketing	Services
		Advanced industrial robotics				
		Industrial internet of things				
Additive manufacturing						

Potential application of three game-changing technologies along the value chain

Regarding Sustainability, AM can significantly reduce manufacturing waste by using just the right amount of material needed in the additive layer-by-layer product creation. This obviously has significant environmental benefits, and in the context of growing environmental concerns and related policies, it was identified by several of those interviewed as a potential driver for the adoption of these technologies in Europe.

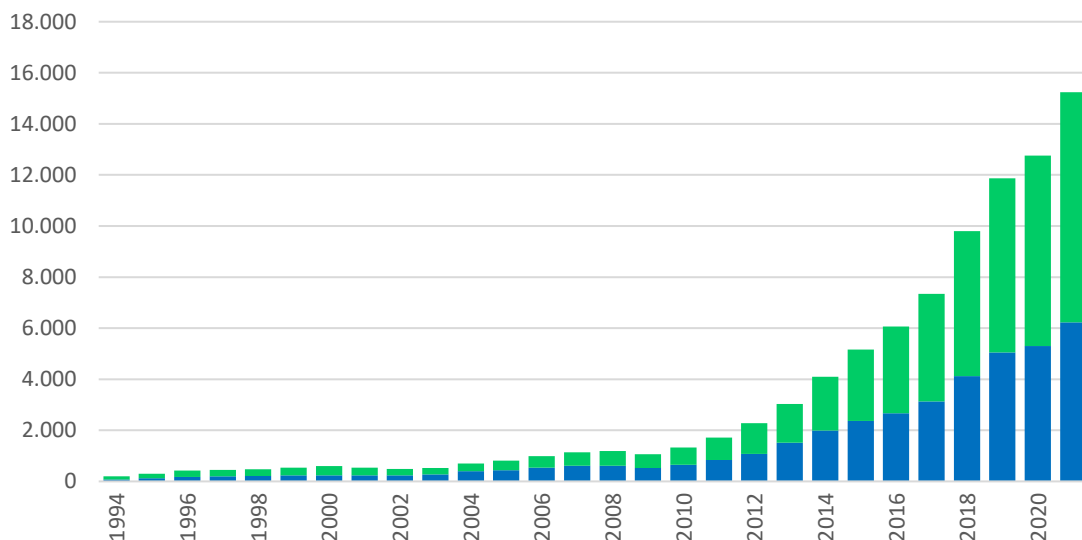
Metals and Polymers are the main materials used in AM. Thanks to latest developments in various AM methodologies, ceramics and metal matrix composites are also possible to be used in AM.



AM Technologies for Polymer and Metal Applications (Source: AMPOWER)

5.3 Market

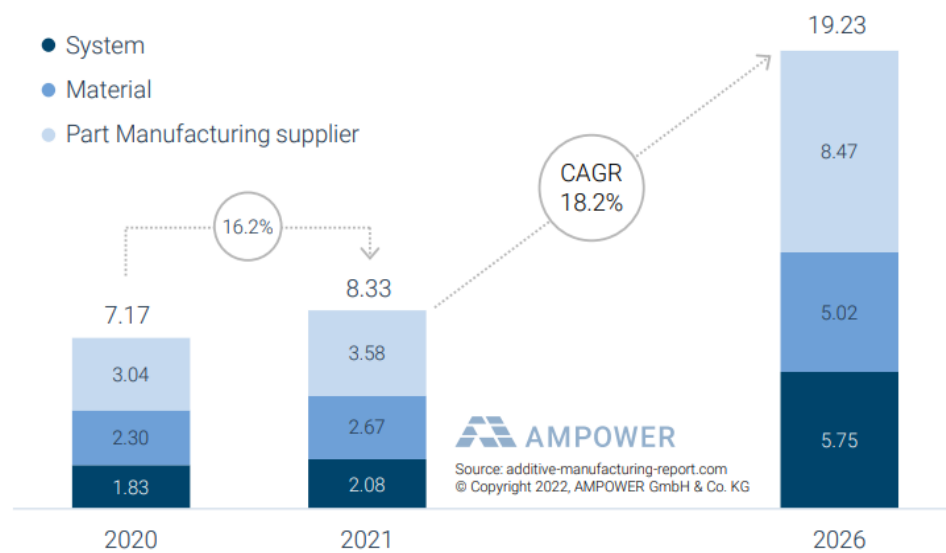
There are different estimations for the AM market size by different market researchers, but one thing they all agree on is the growth rate of the AM industry, which is much beyond the average of the entire industrial growth globally. According to Wohlers Report in 2021, the AM industry consisting of all AM products and services worldwide, grew 19.5% to \$15.24 billion.



Worldwide AM Revenues according to Wohlers Associates (in million \$)

The lower blue segment represents products, (\$6.23 Billion) while the upper green segment represents services (\$9.01 billion), Products include AM systems, materials, aftermarket products such as software and lasers. Services include revenues generated from parts produced on AM systems.

In another serious report from a European Market Research Company AMPOWER, in 2021 the global metal and polymer Additive Manufacturing market size is valued at EUR 8.33 billion including system, material and part manufacturing supplier sales. The polymer AM market accounts for about 70 % of the total volume and thus is about 2.5 times bigger than its metal equivalent.



Global AM Polymer & Metal Market (Source : AMPOWER)

While system sales revenues in both markets are at a similar level, material and part manufacturing suppliers are much more developed for polymers resulting in a larger share of revenue. The metal AM market alone is valued at 2.50 billion€ in 2021 with an expected CAGR of 25.5 % until 2026, while the polymer market is forecasted to grow with 14.4 % annually starting at 5.83 billion€ in 2021.

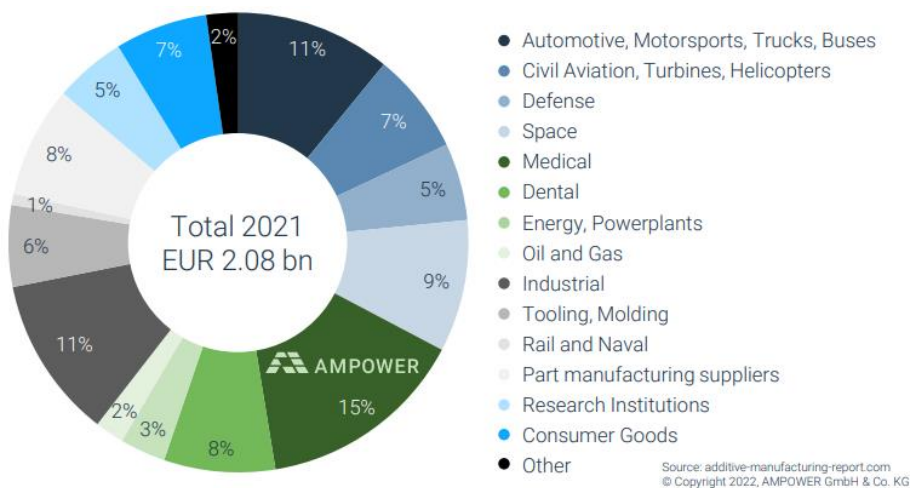
Both AMPOWER and Wohler's forecast a CAGR above 15% within the next five years in AM industry. This means that the demand for qualified labour force that is already in deficit for AM will be in a much more severe condition, unless additional educational & formational lines are constructed to fill in the gap.

5.4 Industries

As additive manufacturing technologies have advanced, 3D printed parts have moved decidedly outside the Research and Development arena and onto the production line. These pivotal processes are developing and producing concepts previously unattainable in the manufacturing world.

In 2021, the medical industry was again the system suppliers' prime customer. After about 19 % of the total system sales revenue share generated in 2020, they bought machines with a value of EUR 302 million in 2021 which accounts for 15 % with overall, a slight decrease in total sales.

During the starting of the pandemic in 2020, many systems were acquired to overcome supply chain issues to satisfy need for health care – a one-off effect. An example is the initial lack of nasal swaps for testing kits that was overcome on short notice by printing the parts. Once the conventional manufacturing chains were able to satisfy the demand, the need for printing these parts stopped.



Industry Distribution of AM System Sales Revenue (Source : AMPOWER)

Second largest customer groups come from the Aerospace and Defence. Aerospace companies were some of the first to adopt additive manufacturing.

Some of the toughest industry performance standards exist in this realm, requiring parts to hold up in harsh conditions. Engineers designing and manufacturing for commercial and military aerospace platforms need flight-worthy components made from high-performance materials. Both sectors make increasing use of Additive Manufacturing for supporting their development teams and production lines.

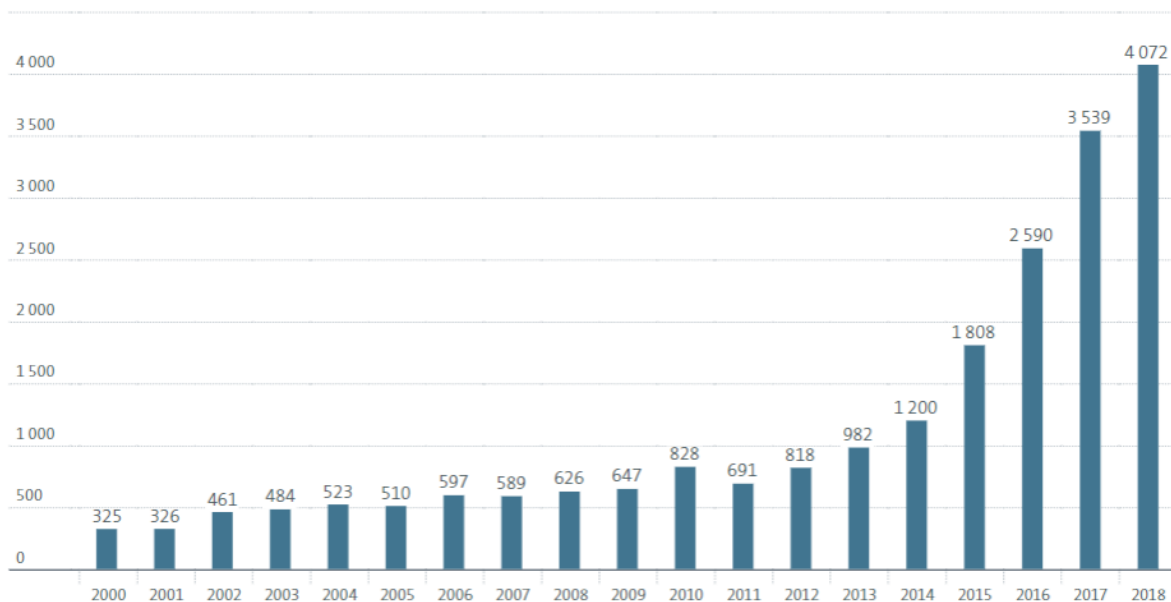
Much like aerospace, the automotive industry is always looking to innovate with newer designs; their products are also subjected to high speeds and harsh conditions. AM allows them to develop complex, high-quality parts that can withstand these conditions, offering improved safety. Rapid prototyping also improves vehicle quality, enabling automobile manufacturers to test things like water resistance and high temperatures. In addition, 3D printing allows for parts consolidation, reducing inventory, and enabling repair or maintenance to be done with a single part. And like in aerospace, AM technologies allow for lattice structures to be printed so car parts can be as lightweight and aerodynamic as possible.

Success of AM in the energy sector hinges on the ability to quickly develop tailored, mission-critical components that can withstand extreme conditions. Additive manufacturing's advancements in producing efficient, on-demand, lightweight components and environmentally friendly materials provides answers for diverse requirements and field functions.

Some key applications that have emerged from the gas, oil and energy industries include rotors, stators, turbine nozzles, down-hole tool components and models, fluid/water flow analysis, flow meter parts, mud motor models, pressure gauge pieces, control-valve components and pump manifolds. With the development of corrosion resistant metal materials for customized parts that may need to experience under-water or other harsh environments, there's no telling what major energy companies may accomplish with additive manufacturing.

5.5 Patent Data Analysis

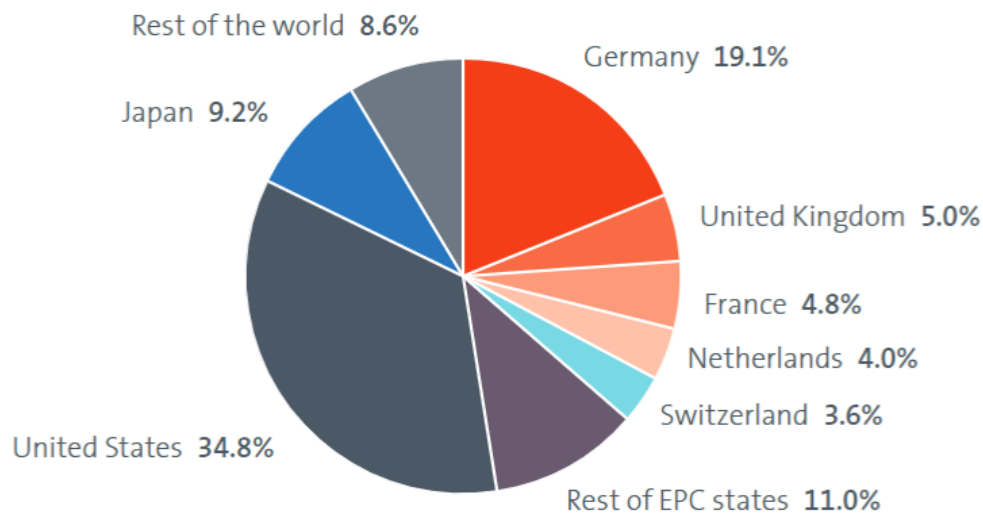
Innovation in AM has accelerated sharply in recent years, with more than 4 000 patent applications for inventions relating to AM filed at the EPO (European Patent Office) in 2018 alone. During the years 2015 to 2018, AM patent applications grew at an average annual rate of 36%, which is more than ten times faster than the average yearly growth of patent applications at the EPO in the same period (3.5%). New industrial applications of AM technologies account for the largest share of patent applications in AM so far (50%). Other patent applications are related to machines and processes (38%), innovation in materials (26%), and digital technologies (11%). Almost 23% of AM patent applications relate to two or more of these different technology sectors.



Patent applications in AM technologies at the European Patent Office

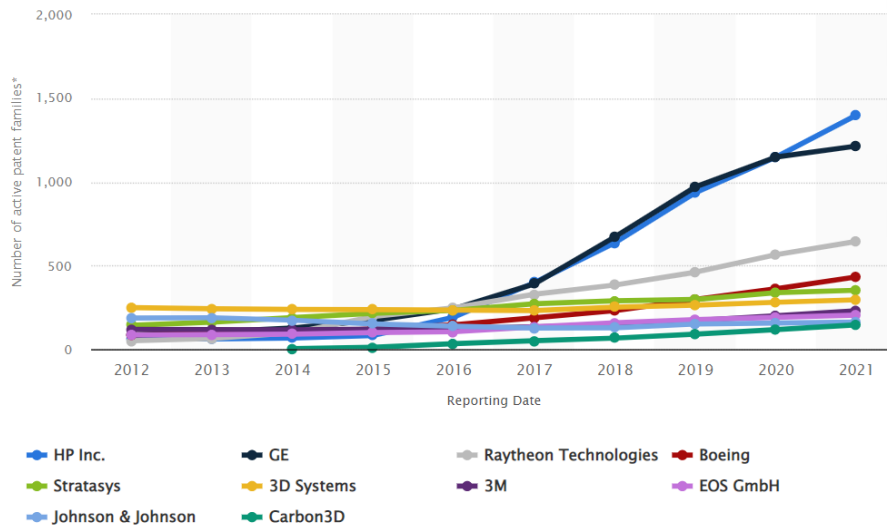
Industrial patent applications of AM technologies span a large variety of industries. The use of AM in the medical and health sectors has generated the largest number of patent applications since 2010, followed by the energy and transportation sectors. However, rapid growth of AM applications is also observed in areas such as industrial tooling, electronics, construction and consumer goods, and even in the food sector.

In terms of geographic distribution, Europe and the US have a strong lead in AM innovation, with 47% (Europe) and 35% (US) of all AM inventions for which a patent application was filed with the EPO since 2010. Europe's leading position is largely due to the performance of Germany, which generated 19% of all patent applications in AM. Outside of Europe, Japan is an important innovation centre for AM technologies (9%), while R. Korea (1%) and P.R. China (<1%) made relatively modest contributions.



Geographic origins of AM applications, 2010-2018 (Source: European Patent Office)

While two out of three patent applications in AM technologies were filed by very large companies with less than 1 000 employees accounted for 22% of applications. Individual inventors and small businesses with less than 15 employees generated 12% of patent applications in AM. These small companies are especially active in digital technologies and new application domains. Universities, hospitals and public research organisations were responsible for over 11%, mainly concentrated in new materials and application domains for AM.



Largest patent owners in additive manufacturing worldwide (Source: Statista)

5.6 Training and Education

AM applications are evolving continuously; accordingly AM training and education is always a critical issue to overcome. By ISO 52900, seven technologies are defined as the major technologies in AM. Besides different raw materials are being used with these technologies. The continuous evolving technology and raw material in AM create another burden for update of the training and education. It is important to understand the whole product lifecycle of the AM process in order to benefit from this technology. Due to this, several bodies; universities (e.g., MIT, METU, Gazi University), machine manufacturers (e.g. EOS, Desktop Metal, SLM) raw material manufacturers (e.g. BASF), service bureaus and related federations/organizations (e.g. EWF, ASME) are trying to support professionals, students and newcomers to AM technology with different alternative training and education alternatives.

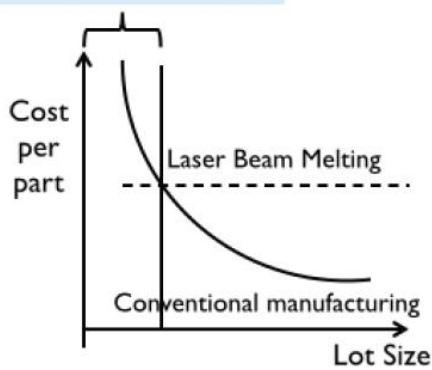
These are regular courses in universities and technical trainings organized by bodies stated previously. The training and education are presented in several medium, i.e. online trainings, hybrid trainings, face to face trainings. Several projects have been accomplished to foster training and education and skills in AM, e.g. SAM, 3DPrism, E3D+, CCLAIM, ADMIRE. Since there are several technologies and raw materials for AM, main obstacle on trainings are on practical side. It is important to create innovative solutions for theoretical and practical training and education and dissemination of this training and education to industry.

5.7 Limitations and Technological Barriers

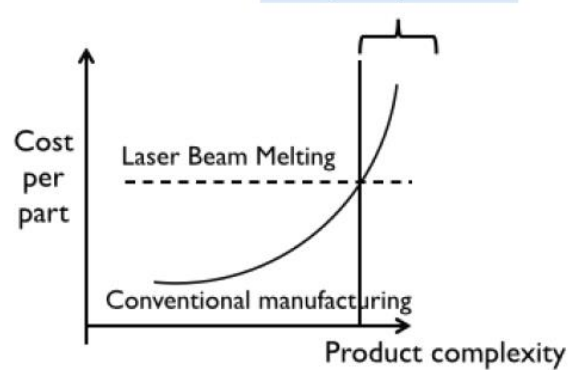
There are certain limitations to be aware of before taking full advantage of AM technologies. Most important technological barriers have been listed below, mainly for beam-based technologies like Powder Bed Fusion (PBF).

1. Part size: For PBF, the part size is limited to powder bed size, such as 250 x 250 x 250mm. Part sizes can be greater with DED processes. But, due to the low thickness of powder layers, it can be very slow and costly building tall or very large parts.
2. Part design: In the case of PBF, removable support structures are needed when the overhang angle is below 45°.
3. Production series: the AM processes are generally suitable for unitary or small series and is not relevant for mass production. Progress is made to increase productivity and the production of larger series. For small sized parts, series up to 25.000 parts/year.

Individualization for free



Complexity for free



AM enables part customisation and increased design complexity at no cost, compared with conventional manufacturing (Courtesy of Fraunhofer)

4. Material choice: Though many alloys are available, non-weldable metals cannot be processed by additive manufacturing and difficult-to-weld alloys require specific approaches.
5. Part properties: AM parts tend to show anisotropy in the Z axis (construction direction). Densities of 99.9% can be reached, there can be some residual internal porosities. Mechanical properties are superior to cast parts but inferior to wrought parts.

The severity of these barriers may differ in other AM technologies like Binder Jetting or Direct Energy Deposition (DED), but the list will be more or less the same for those AM methods as well.

5.8 Green Awareness and Sustainability of AM

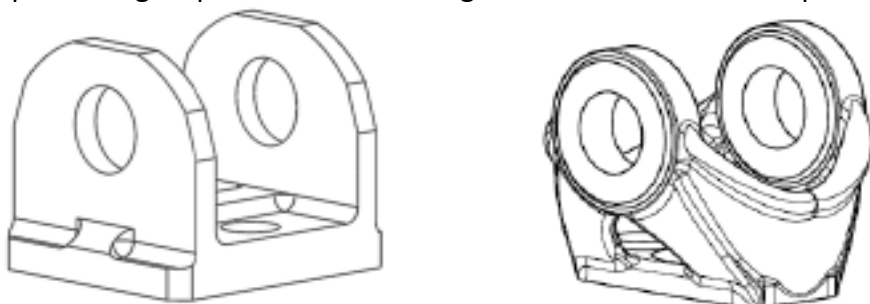
Additive manufacturing was not initially conceived of as a "green" technology. When the first AM machine was commercialized in 1986, the intent was to build parts and geometries that were impossible with subtractive techniques, not a manufacturing solution to reduce CO2 emissions. And in the three and a half decades that followed, AM has seen rapid development and progress. Emissions have not been optimized, of course, but initial steps toward this goal can be prioritized even without in-depth LCAs. The AM-specific energy and emission contributors are AM material production and AM part production, while the benefits of AM are seen in the product use phase.

		Raw materials production	AM materials manufacturing	Product manufacturing without post-processing
Energy demand	AM	M Metal AM: L-PBF Ingot production 100–400	AM powder atomization 10–30	AM printing process 50–100
	Conventional	M Aluminum die-casting Ingot production 50–100		Die-casting <10
		M Titanium aerospace part (machined) Ingot alloy production 300–400		Machining <10
		M Turbine blade production Ingot alloy production 50–100		Casting and machining <20
	AM	P Polymer AM Polymer synthesis and granule production <50	AM mat. conversion to powder, filament or resin <10	AM printing process 10–20
	Conventional	P Injection molding Polymer synthesis and granule production <50		Injection molding incl. heating, conveying, mixing, molding, ejection <5

Energy demand comparison [kWh/kg] in each manufacturing step
(Source: Roland Berger)

Almost all AM technologies require materials that have already undergone an additional processing step. The most relevant AM polymer material classes – polymer powders, filaments and resins – have previously been converted thermally or chemically, which requires energy and therefore adds a debit entry to their CO₂ emissions ledger. Similarly, metal AM materials such as metal powders and wires must first be atomized into particle-shaped powders or drawn into wires. The gas atomization of powders in particular consumes large amounts of energy before the material can be used in an AM machine.

Metal ingots are melted and dispersed by a hot, high-speed inert gas stream to form spherical powders of a certain particle size. These particles then need to be sieved to retain an optimal particle size distribution – producing large amounts of scrap powder in the process. Moreover, additive manufacturing requires long processing times, normally in the range of a couple of hours for polymers, though metal powder bed fusion parts can take up to a week. Processing also presupposes an inert gas atmosphere, electricity to heat the build room and machine operation during printing. The process gases themselves are obtained via gas separation, which is itself very energy intensive. In addition, AM fabrication is always followed by one or more post-processing steps that further enlarge the environmental footprint of the AM part.



Conventional Design vs Optimized design for AM with 47% weight reduction.

As a result, processing AM parts yields an energy disadvantage when comparing 1 kg of material in each process step of the production chain. However, the ratio changes for the example of a titanium aerospace bracket.

This part showcases the fact that, thanks to limited waste material compared with milling processes the reduction in material needed by AM more than makes up for the energy intensive AM material and AM production steps even before design is optimized. Parts can then be optimized by admitting more complex designs that reduce weight by only placing solid materials where they are needed most to guarantee mechanical properties and ensure the functionality of parts.

Besides topology optimization, another critical terminology in aerospace industry is “Buy-to-Fly ratio”.

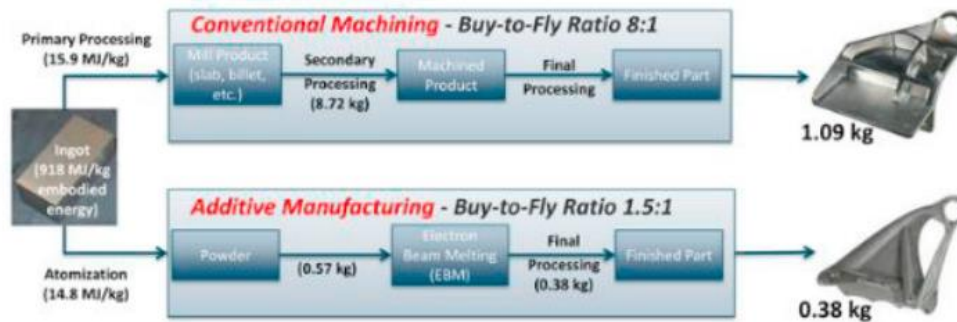
The term describes how much material is wasted in a manufacturing process; simply the ratio is weight of the raw material divided by the weight of the final component. For conventional metal manufacturing like milling the ratio is generally over 10, that is to say %90 of material should be machined creating the scrap. With AM, the paradigm is changed, the machining times and scrap ratio could be improved which supports the sustainability.

Moreover, AM converts complexity to simplicity; a final product composed of several components can be manufactured as a single final product. Several examples of these are available; GE has redesigned mid frame structure CT-7 for AM, consolidating 300 components to 1 and 7 assembly processes to 1. When product life cycles are examined, the benefit of AM on sustainability becomes clear.

In the Aerospace industry, the amount of scrap material generated in production is referred to using the buy to fly ratio, which is defined as the ratio of the weight of raw material used to manufacture the part to the weight of the final part. The typical buy to fly ratio for aircraft structural parts is reported to be 20:1, which means that for every kilogram of material that is flown on an aircraft, 19 kilograms are scrapped in the production process, resulting in many tonnes of scrap material from every aircraft that is manufactured.

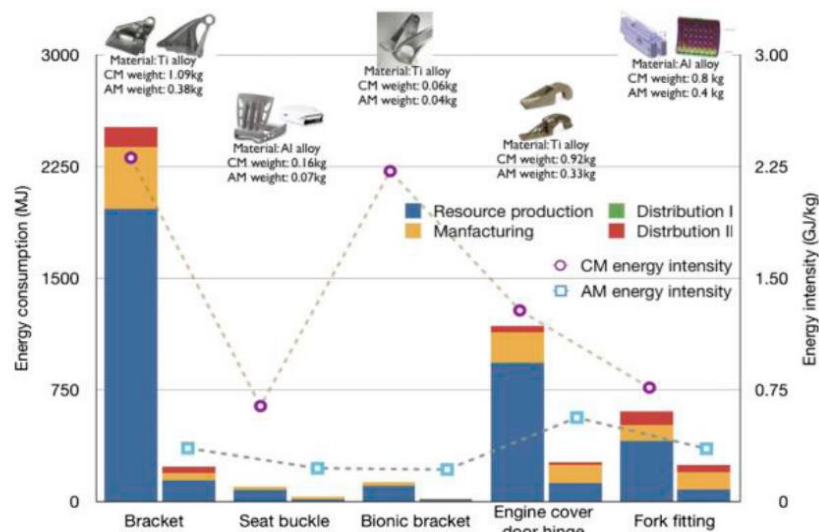
Of course, the scrap material can be recycled, but it has low value and cannot be used for aerospace applications. Another problem with machining from billet is the long lead time to procure the billets or forgings themselves, which can in some cases take more than a year.

The AM processes enable a high degree of freedom in product design and result in a substantial weight reduction, which leads to significant reduction in life cycle energy demand. The picture below shows an example of aircraft bracket design for conventional machining and EBM process.



The buy-to-fly ratio of the design for conventional machining is 8:1.

The major part of the raw material is converted to chips in conventional process route. Material and energy usage throughout the life cycle Energy consumption reduction in AM by design optimization. The additive manufacturing process route is quite different. The buy-to-fly ratio is only 1.5. Thus, the additive manufacturing has much lower material consumption. Below picture compares the energy consumption throughout the life cycle between additive and subtractive process routes. By optimizing the design, the mass of additive fabricated part can be significantly reduced.



6. ADDITIVE MANUFACTURING INDUSTRY STRATEGIC FRAMEWORK

6.1 Country List and Overview

This report summarizes AM strategies of 34 EU countries listed below. The report explores the outlines of the current situation, need analysis and the overview of the AM in these countries.

Governmental, institutional, and private sector analysis and technical reports on AM were reviewed and evaluated in detail. AM strategies of these countries are presented by considering based on politics, education, grants, projects, business, and challenges.

List of countries examined;

1. Albania	12. Germany	23. Malta
2. Austria	13. Greece	24. Montenegro
3. Belgium	14. Holland	25. North Macedonia
4. Bosnia Herzegovina	15. Hungary	26. Poland
5. Bulgaria	16. Iceland	27. Portugal
6. Croatia	17. Ireland	28. Romania
7. Czech Republic	18. Italy	29. Serbia
8. Denmark	19. Kosovo	30. Slovakia
9. Estonia	20. Latvia	31. Slovenia
10. Finland	21. Lithuania	32. Spain
11. France GCA	22. Luxembourg	33. Sweden
		34. Türkiye

6.2 Country Reports in EU

The report has been elaborated from comprehensive research, gathering all the information from those companies and training or education institutions that are currently employing Additive Manufacturing but also those who are potential users. All countries were examined under the report topics. Large-scale studies and country strategies could not be found in the research for some countries, which does not indicate that there are no efforts, but rather that resources are not easily available for a large-scale strategy or study on AM. The related reports and articles has been presented as Appendix 1: Reports and Articles about Additive Manufacturing.

6.2.1 Vision and Politics

ALBANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

AUSTRIA

Additive Manufacturing Austria (AM Austria) sees itself as a technology platform for supporting and networking the Austrian additive manufacturing scene. The technology platform officially started its activities on 23 February 2018 in the form of a founding convention at the BMVIT (Ministry of Climate Action and Energy) in Vienna and has already

gained 60 organisations as members in its first year of existence. In the course of 2018, intensive work was carried out on the strategy project "Roadmap Additive Manufacturing Austria", the aim of which was to develop a comprehensive and inter-institutional Austrian roadmap on the topic of "Additive Manufacturing in Austria". The roadmap was commissioned by the BMVIT and jointly implemented by the Montan Universität Leoben, ASMET and AIT with the participation of AM Austria.

BELGIUM

The AM industry is growing fast in Belgium and it is becoming an increasingly important pillar for the future manufacturing industry in fields of medical and automotive. It is also supported officially by the Belgium government in a national or regional base through communities and its three regions of Flanders, Wallonia, and Brussels.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

In Bulgaria on national level the AM is mentioned in the Digital Bulgaria National Program 2025 and "Strategy for the participation of Bulgaria in the fourth industrial revolution (Industry 4.0)" among others, as industrial strategy, and a new technological solution, which will play key role for the development of the society, economy and industrial manufacturing. There is no specific plan for the development of the AM though.

CROATIA

Investments on Advanced Technologies related to the Recovery Plan:

The Recovery Plan is the economic recovery of all the European Union Members States. In order to do so, every country scheduled its own National Recovery and Resilience Plan, where investments and reforms for research and innovation in the medium and long term are planned.

Smart Specialisation Strategy (S3)

The concept of "smart specialization" is a central part of the European Union policy framework to enhance innovation, competitiveness, and sustainable growth. Smart specialization strategies are national or regional innovation strategies that set priorities for building competitive advantages by developing and matching research and innovation strengths to business needs.

The S3 introduced a new sectoral approach to prioritize policy interventions by identifying thematic (strengthening research, technological development, and innovation) and sub-thematic priority areas (TPAs and STPAs). The official S3 document was adopted later with respect to the start of the EU financial perspective. This also delayed the use of European Structural and Investment Funds (ESIF) for research, development, and innovation (around HRK 6.74 billion). The S3 did not take root due to extensive delays in establishing appropriate sectoral governance bodies. However, the adoption of the S3 in Croatia was a milestone in the

development of the national innovation policy system, as stated in the report framing the Croatia S3 results. In recent decades, architecture and engineering have undergone their own digital revolutions; now, AM can bring digital flexibility and efficiency to manufacturing operations.

CZECH REPUBLIC

On a national level Czech Republic has 5 Digital Innovation Hubs (4 fully operational and 1 in preparation) covering various market domains (mining, construction, manufacturing (food products, textiles, chemicals, basic and fabricated metal products, electrical and optical equipment, machinery, electrical equipment), education and health) through a large spectrum of technology areas among which is the AM.

DENMARK

Most of the Danish companies actually using 3D printing for product development are found in electronics, plastic, glass and concrete industry as well as companies manufacturing electronic appliances. A large number among the 80 percent of companies that do not utilize 3D printing technology, have processes suitable for AM. Overall, this means that there is considerable potential to use the technology to make prototypes and improve products in Danish manufacturing industry.

Although more companies are adopting AM technology in Denmark recently, there is still a need to spread knowledge about how AM technology can be practically used in manufacturing companies and how the technology has the potential for more sustainable production. According to the Danish AM Report 2022, the most common barrier to implementing AM technology is that companies cannot see that it is relevant to their line of business.

ESTONIA

Unfortunately, there is not much information on AM in Estonia. According to research paper "Introducing Additive Manufacturing in Estonia" by Marek Jõelet and Lauri Kollo from Tallinn University of Technology, presented at Conference: NATO AVT-258 Additive Manufacturing for Military Hardware in 2016, quote "Additive manufacturing is a new technology for manufacturing parts in Estonian industry and has become available only recently."

FINLAND

Finnish companies are still on the process of mapping systematically possibilities for AM integration, and still have the opportunity to implement final production using AM. However, there is a need to invest in high-end industrial and research equipment in order to stimulate AM integration with existing production systems and provide Finnish companies a state-of-the-art testing platform. The common goal for Finnish companies is to digitalize manufacturing operation and supply chain while taking the advantages of AM as a manufacturing solution whenever feasible.

FRANCE

The future of AM is promising in France, and it is becoming an increasingly important pillar for the future manufacturing industry in fields of aerospace and automotive. It is also supported

officially by the French government in a national or regional base through departments and regions by the ministries of Labour, Education and Industrial Development.

Currently, there are an increasing number of use cases and demo business showing the benefits that AM can bring as mainstream manufacturing technology promoted by various initiatives. There are also several technological trends at material, technology, post-processing, ICT and quality assessment fields that will bring new innovations in the coming years to deal with current AM challenges and industrial needs in France.

GCA (GREEK CYPRIOT ADMINISTRATION)

Greek Cypriot Administration is the official government in South of Cyprus, with a population of 1.2 million habitants. Its main income is Tourism and Agriculture. There is only one university and one working on Additive manufacturing that are established after 2004, which is the date GCA has been accepted as a member of EU.

GERMANY

Germany is the largest additive manufacturing (AM) market in the EU and it offers substantial business opportunities to U.S. companies.

The use of additive manufacturing (AM) during the pandemic has shown global industry the capabilities of this new technology. Until two years ago, German firms mainly used AM for prototyping and proof-of-concept applications. In 2019, AM use was expanded. Today, German firms print replacement parts, unique single items or small batches of specialty items on AM equipment. The pandemic made more German firms realize how beneficial the use of AM was when it bridged the gap of broken supply chains. It also showed that AM can be used as a supplemental technology to traditional production methods.

GREECE

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

HOLLAND

Investments on Advanced Technologies related to the Recovery Plan:

Following an unprecedented crisis caused by the pandemic, the Netherlands' recovery and resilience plan responds to the need of fostering a strong recovery and making the Netherlands future-ready. The reforms and investments in the plan will help the Netherlands become more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transition. The reforms address bottlenecks to lasting and sustainable growth, while investments are targeted to accelerate the transition towards a more sustainable, low-carbon and climate-resilient economy, to maximise the benefits of the digital transformation and to strengthen economic and social resilience and the cohesion of the Single Market."The plan involves 4.7 B€, 48% of which will support climate objectives and 26% of which will be devoted to support digital transition.

Smart Specialization Strategy (S3)

A smart specialisation strategy (S3) is a substantiated prioritisation for investments in innovation in a certain Region. This strategy clarifies the strengths and the opportunities for economic, innovation and knowledge advancements within the Region.

The RS3 creates the relationship with entrepreneurial activities and available infrastructure and points out where the critical mass is located in the Region.

The RIS3 is a requirement for all European Regions that want to make use of the European Fund for Regional Development (ERDF) in the period 2021-2027. With particular reference to East Netherlands RIS3 investments will be devoted to some specific industry-related areas, among which:

- Smart Industry and Industry 4.0: “modernising the (manufacturing) industry by further automation of production through robotisation and digitalisation.”
- New, sustainable and advanced materials: “the development and application of new materials, products and processes, and testing them in prototypes and pilots. This may concern lighter materials, more sustainable materials or functional materials.

HUNGARY

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

ICELAND

The government is funding a test facility for R&D. New materials and AM production processes are being developed in this centre, especially for metal products to create a world leading R&D centre.

IRELAND

Investments on Advanced Technologies related to the Recovery Plan:

Ireland will receive approximately €915 million in grants from the Recovery and Resilience Facility. These grants will be used to support investments between now and mid-2026. A further set of grants will be allocated to each Member State in 2023, taking into account economic developments between now and then. The overall objective of Ireland’s National Recovery and Resilience Plan (NRRP) is to contribute to a sustainable, equitable, green and digital recovery effort, in a manner that complements and supports the Government’s broader recovery effort.

Smart Specialization Strategy (S3)

“Smart Specialisation is an innovation policy concept developed by the European Commission which aims to boost regional innovation, contributing to growth and prosperity by helping and enabling regions to focus on their strengths.

This will promote broader benefits, including innovation-driven growth in regions and the promotion of sustainable growth models. Ireland’s Smart Specialisation Strategy will embrace

a regional approach to addressing Ireland's Research, Development, and Innovation (RD&I) challenges. It will provide a 'bridge' between regional and national innovation strategy building and decision making, bringing coherence to RD&I planning for the benefit of enterprise and advancing the RD&I agenda regionally and nationally." Investments will be devoted to some specific industry-related areas, among which;

- Digitalisation and digital transformation
- Green transformation for enterprise
- Innovation diffusion
- International collaboration on RD&I
- Improving the national or regional enterprise research and innovation system

ITALY

Investments on Advanced Technologies related to the Recovery Plan:

The Recovery Plan is the economic recovery of all the European Union Members States. In order to do so, every country scheduled its own National Recovery and Resilience Plan (PNRR), where investments and reforms for research and innovation in the medium and long term are planned. The plan will provide an overall fund of approximately €209 billion for the country articulated into several missions: roughly €60 billion for the green transition (M2), €40 billion for the digitalization, innovation and tourism (M1), €30 billion for research (M4), €25 billion for sustainable mobility (M3), €15 billion for health (M6). AM technologies will play an important role in all those missions.

The national PNRR is in close relation with the National Plan for Scientific Research (PNR 2021-2027) which is specifically oriented to the research's politics, based on the regional situations, providing lines of intervention focusing on research and innovation. It is aimed at guaranteeing the coordination of the research at a European, National and Regional level.

Smart Specialisation Strategy (S3)

The Smart Specialisation Strategy (S3) aims at identifying research, development and innovation priorities, known as the key enabling technologies, which complement the resources and capacity of a territory to plan sustainable growth paths in the medium and long term, with particular focus on the industry sector. Investment priorities are identified based on the territory's excellence, and on any limits or constraints to be managed, and, consequently, ad-hoc policy initiatives are generated to implement research, technological development and innovation policy interventions.

The S3 2014-2020 [33] plan provides general directions at the national level, while the subsequent regional S3 2021-2027 plans provide more detailed directions at the regional level. In this regard, among the most advanced regional Research and Innovation Strategies for Smart Specialization (2021-2027), the one presented by the Emilia-Romagna region is here analysed more in detail. Additive Manufacturing (AM) is considered an important key enabling technology which leads throughout the digital and ecological transitions.

Industry 4.0 brought with it a technological revolution, together with manufacturing, logistics and social revolution. The whole revolution has guided knowledge advancement and increased efficiency.

The AM manufacturing process has a direct impact on the robotic, aerospace, and manufacturing sectors, such as on the development, fabrication, and characterization of advanced materials. Now, Industry 5.0 is emerging on a global and European level, introducing customization and user experience into innovations and new solutions: the AM is a promising manufacturing process in the nearly future, making possible the transition from mass production to mass customization, by exploiting the intelligent manufacturing, using Deep Learning, Machine Learning and Artificial Intelligence technologies.

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

Latvia has developed several strategic plans and policy documents for the integration and development of Industry 4.0. such as the National Development Plan of Latvia 2021-2027, National Industrial Policy Guidelines 2021-2027, Digital Transformation Guidelines for 2021-2027, Guidelines for Science, Technology Development and Innovation 2021-2027 and other binding strategies and guidelines, e.g., Research and Innovation strategy for Smart specialization of Latvia, Implementation strategy of Platform “Industry 4.0”, Cyber Security Strategy, Guidelines for the Development of Education for 2021-2027 “Future Skills for the Future Society”.

LITHUANIA

In Lithuania, there are some attempts to integrate the innovation ecosystem of the Lithuanian manufacturing sector into the European innovation ecosystem and the Digital Innovation Hub (DIH) network, which is a support tool for boosting business competitiveness through the use of digital technologies to improve business or production processes, products and services has been operating in Lithuania since 2012.

LUXEMBOURG

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

MALTA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

MONTENEGRO

The government has used AM during Covid for medical purposes and produced health equipment and is aware of the possibilities gained with AM.

NORTH MACEDONIA

Government is currently using AM for preservation of cultural and geographical heritage.

POLAND

Investments on Advanced Technologies related to the Recovery Plan: The Recovery Plan is the economic recovery of all the European Union Members States. In order to do so, the country scheduled the National Recovery Plan (NRP) under the Recovery and Resilience Facility (RRF).

The National Recovery Plan (NRP) is a comprehensive document that sets out the objectives for rebuilding, and the creation of Poland's socio-economic resilience following the crisis caused by the COVID-19 pandemic. It includes proposals for reforms and investments that will help Poland to restart developments. The NRP constitutes the basis for benefiting from the Instrument for Reconstruction and Enhancing Resilience.

The expected effects of the National Recovery and Resilience Plan include the impulse for the development of domestic companies, technological modernization of the economy and improvement of the quality of life of Polish citizens. Poland will have approximately EUR 60 billion at its disposal from this. It aims primarily to introduce reforms enabling to establish digital and green economy, resilient to shocks and potential future crises.

The Plan consists of six components, including five thematic ones:

- Resilience and competitiveness of the economy
- Green energy and reduction of energy intensity
- Digital transformation
- Efficiency, accessibility and quality of the health care system, green, smart mobility

And one institutional:

- Improving the quality of institutions and conditions for implementing the National Recovery and Resilience Plan.

The aims of the National Recovery and Resilience Plan include: strengthening the potential for economic growth, creating jobs, increasing the economic and social resilience of the state, offsetting the effects of the economic and social crisis, and strengthening economic, social and territorial cohesion. It will include reforms and public investments in areas, such as innovations, education, infrastructure, transport, new technologies, energy, and building. The Ministry of Economic Development proposes to cover projects in the areas of innovation, digitalization, green economy, circular economy, energy, and thermal upgrading, which are prepared in dialogue with representatives of Treasury companies, companies, experts and voivode ship authorities. The recommendations regarding the need for environmental and digital transformations have been particularly strong [78]. Poland will be supported by an estimated €23.9 billion in grants and €11.5 billion in loans. Projects implementing climate goals and green transition will account for 42.7% of the value of the NRP. The second key area of reform is the digital transition, 20.85% of the NRP funds will be allocated to projects related to this area.

Additive Manufacturing (AM) is promoted with these NRP funds, being an instrument leading to digital and green transition.

PORTUGAL

“Portugal 2020” aims to bridge the gap between funding and research and development activities, as for example in the development of metal AM activities in Portugal.

In 2014 the creation of the Portuguese Additive Manufacturing Initiative (PAMI) took place. The main objective of this partnership is the development of skilled labor to achieve an improvement in competitiveness and innovation in Portugal.

ROMANIA

There are investments to AM with start-ups mostly. Most of these investments are done in dental sector with metal PBF systems.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

The government is supporting AM for space projects. Currently AM is integrated in the space industry.

SLOVENIA

There are R&D studies on both polymer and metal systems supported by the government.

SPAIN

Some of the main programs and politics related to R&D in Spain are summed up:

- Estrategia Nacional de Innovación (E2i)
- Estrategia Española de Ciencia y Tecnología y de Innovación 2013-2020
- Plan Estatal de Investigación Científica y Técnica y de Innovación 2017-2020

SWEDEN

Investments on Advanced Technologies related to the Recovery Plan:

Sweden has requested a total of €3.2 billion in grants under the RRF. The Swedish plan is structured around five components: green recovery; education and transition into work; meeting demographic challenges; expansion of broadband and digitalisation of public administration; and investment for growth and housing. Projects in the plan cover the entire lifetime of the RRF until 2026, with a strong concentration of projects in the first three years of implementation. The plan proposes projects in six of the seven European flagship areas. Following the unprecedented crisis caused by the COVID-19 pandemic, Sweden’s recovery and resilience plan responds to the need of fostering a strong recovery and making Sweden future-ready. The reforms and investments in the plan will help Sweden become more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions. To this end, the plan consists of 15 reforms and 12 investments. They will be supported by €3.3 billion in grants. 44% of the plan will support climate objectives and 21% of the plan will support the digital transition.

Smart Specialization Strategy (S3)

The main institutions responsible for smart specialisation in Sweden are the Swedish Agency for Economic and Regional Growth (Tillväxtverket) and the National Innovation Council, as a high-level forum chaired by the Prime Minister. The Council has defined digitalisation, life sciences and environment, as well as climate technology, as crucial areas in order to effectively address the societal challenges.

TURKEY

Turkey's policy framework about additive manufacturing (AM) has been formed as a result of detailed field studies and analyzes of a comprehensive policy bundle created in broadly attended meetings, research projects and field surveys. Five comprehensive AM strategy reports prepared by Governmental Departments and private institutions have been appeared in last 6 years. These reports introduce the current situations and predictions of AM market, opportunities and treats, global and local trends, and economical perspective of AM in global and Turkey. Additive Manufacturing strategies and attempts have been planned and directed by State Ministries, Universities, private sectors, and non-profit organizations. Turkish authorities in AM Strategy planning and directing;

- Ministry of Industry and Technology
- Ministry of National Education
- Presidency of Defence Industries
- Strategy and Budget Department
- Council of Higher Education (YÖK)
- The Scientific and Technological Research Council of Türkiye (TUBITAK)
- Regional Industry Chambers
- Private Sectors
- Foundations and Associations

AM Report Title	Publishing Year	Institution
Additive Manufacturing Technologies Roadmap	2020	Presidency of the Republic of Türkiye - Presidency of Defense Industries
Additive Manufacturing Technologies with the Opinions of Industry Representatives from Our Country Sectoral Overview	2021	Technology Development Foundation of Türkiye IDEAPORT
Paradigm Change in Manufacturing: Additive Manufacturing and 3D Printing	2019	Presidency of the Republic of Türkiye Strategy and Budget Department
Aluminium alloy Powder production pre-feasibility report for Istanbul	2021	Istanbul development Agency, Ministry of Industry and Technology of Türkiye
Additive Manufacturing Technologies and Aviation Applications: Sector Evaluation Report	2016	STM Defense Technologies and Engineering Inc.

Ministry of Industry and Technology announced Technology Road Map for 2023 has been released in 2019 and AM is assigned one of the focuses/key technologies. The Ministry launched the HAMLE program where the SMEs and other technological companies are granted for the investment and research projects in the development of Additive Manufacturing and related Technologies like machines, equipment's, systems, powder, laser units and optic systems etc. Ministry and European Union funded Additive Manufacturing and Design and Hybrid Modelling Centres within the scope of the Competitive Sectors Program and train SMEs.

Ministry of National Education announced an agreement that Coşkunöz Education Foundation (CEF) gives AM Education to High School Students, undergraduate and graduate students. The Ministry also urges to open 3D Printing and 3D Design Training Courses to be given to Vocational and Technical High School students.

Presidency of Defence Industries organized an AM conference in November 2018 and brought all the firms, universities, and representatives from institutions. 38 companies, 3 research centers and 28 universities attended the conference. 270 attendees in total joined the group meetings and discussed the current and future topics of AM to be critical for Turkey's AM strategy. The conference concluding report released in 2020 to cover the comments of the group meetings, global and local AM situations, prioritization analysis of AM, acquisition plan, and general overview of AM technologies. Presidency of Defence Industries also give grants research projects in AM and support universities to increase PhD thesis in AM.

Strategy and Budget Department of The Presidency of Türkiye released an overview report in the name of 'Paradigm Change in Manufacturing, Additive Manufacturing and 3D Printing' in 2019. This report is the most exclusive report in Türkiye on AM. The report summarizes the current situation of the global and local AM market size using 2017 values.

The report also discussed the trends and expectations from AM and influences of AM to new business models, skills, production volume, and trades. Turkish AM policies, markets, players, and stakeholders are evaluated in detail. The opportunities and treats in different industries of AM are explained in the report. Finally, policy recommendations are stated in the end of the report. Although this report includes all the necessary details of AM in Türkiye, the only contradiction is that the report may not be considered since AM technology is a fast-growing technology and therefore the comments, data and the remarks for AM may would most probably be out-of-date. Strategy and Budget Department also gave a huge grant to Gazi University to establish a National Additive Manufacturing Technologies Application and Research Centre (EKTAM).

Technology Development and Foundation of Türkiye published an AM report called Developing Technologies in the Future Production: Additive Manufacturing Technologies in 2021. The report simply briefs the local AM sector with the vision of the industry representatives who evaluate the current situation of AM and trends, future opportunities, and treats.

Council of Higher Education (YÖK) launched a PhD Program called New Generation Manufacturing Technologies: 3D Printing and also announced that the Additive manufacturing is the Focus Topic in research and education in the action plan of YOK Universities-Industry cooperation development report. YOK also has 'Research Universities Support Program' which has been started and proposed research projects in Additive Manufacturing have been granted in the Universities.

Universities are mated according to their research potentials and infrastructure in different subjects and 'Additive Manufacturing' is one of these subjects. Universities are urged to open new academic positions for researchers who are having PhD degree in Additive Manufacturing.

The Scientific and Technological Research Council of Türkiye (TÜBİTAK) is a managing department that decides and leads the policies in science and technological research. TÜBİTAK has a policy to initiate technology transfer in advanced Technologies and there are several calls in Additive Manufacturing. TUBİTAK has granted 1004 - 'Center of Excellence Support Program' and EKTAM in Gazi University which has been selected one of the Centres in Additive Manufacturing. Additive Manufacturing' is one of the technological topics which are used to select the graduate students to be granted for scholarship. TUBİTAK also granted International Companies having R&D Centres in Turkey. GE is one the companies took a grant to establish Additive Manufacturing Center in TUBİTAK 1515 program: Pioneer R&D Laboratories Support Program.

Turkish Additive Manufacturing Association (TAMA) founded in 2018 with 11 university academics from Turkish Universities. TAMA then has opened this association to Turkish researchers to be part of it and informed. An international conference on additive manufacturing (AMCTURKEY) was firstly organized by TAMA in 2019 and then AMCTURKEY has been organized yearly. TAMA also organizes seminars, project days and other educational activities in additive manufacturing. An International refereed journal called as Journal of Additive Manufacturing was firstly formed and published in 2021.

Another non-profit organization is Coşkunöz Education Foundation (CEF) has been initiated certified additive manufacturing training programs to engineers and technical staff. CEF is giving a program full of content from the definition of additive manufacturing, materials, technologies, practice, and expert meetings.

6.2.2 Training and Education

ALBANIA

AM is integrated in institutes with 3D scanners to preserve historic culture and art pieces. They are currently using these technologies only in applications which cannot be accomplished with traditional methods. Also, there are some projects to print on textiles and this can only be done with AM.

AUSTRIA

AM Austria offers an overarching platform for the merger and professional exchange of all companies, universities and research institutions involved in the value chain of additive manufacturing in Austria. The focus is on joint work on the further implementation of additive manufacturing in the industry.

BELGIUM

KU Leuven is pioneering in Additive Manufacturing (AM) since 1990. Research on AM was initiated at the Mechanical Engineering Department of KU Leuven. Initially, research focused on the production of polymer parts for rapid prototyping purposes. This led to the foundation of 'Materialize', the first spin-off company of the AM-group, which is known today as one of the key players in additive manufacturing of polymers and software development for AM.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

Leader in providing AM education in Bulgaria is the Technical University of Sofia.

CROATIA

Several universities have developed projects on AM technologies, such as the following ones:

- Faculty of Mechanical Engineering and Naval Architecture, Zagreb
- University North, Koprivnica
- University of Rijeka
- The EOS company has promoted educational programs, being a leading supplier of responsible manufacturing solutions via industrial 3D printing technology, focused on plastic materials. EOS: "Additive Minds Academy: Become an Industrial 3D printing expert now" offers educational programs for all level of expertise. In cooperation with renowned partners, Additive Minds Academy has developed a comprehensive online training program to optimize onboarding processes and accelerate the knowledge build-up at the forefront of additive manufacturing innovation.

CZECH REPUBLIC

The overall awareness of industrial additive manufacturing in Czech Republic is not sufficient. Universities have not yet responded to the emerging need of industry for graduates with knowledge not only of additive manufacturing technologies, but also with knowledge of process and technological parameters, knowledge of software tools, CAD modelling for the creation of structured parts, simulation tools such as topological optimization, etc.

DENMARK

MADE – Manufacturing Academy of Denmark is the Danish Cluster for Advanced Manufacturing which is a non-profit association of companies, higher-education institutions and other knowledge providers, including Research Technology Organisations (RTOs).

ESTONIA

The Tallinn University of Technology in Estonia has an important role in introducing AM to the Estonian industry, since it acquired the first metal AM machine in the region.

FINLAND

FIRPA (Finnish Rapid Prototyping Association) promotes additive manufacturing information in Finland, acting as an independent source and distributor of information in all areas of additive manufacturing and as an impartial channel for the transfer of know-how in the manufacture of the latest material.

FRANCE

There are various universities and training centres in France about AM. EC Nantes, University of Paris and CESI offers MS degree programmes for engineering graduates. Vocational programmes are also available by training centres like AFPMA and Materialia, especially in the eastern part of the country.

GCA (GREEK CYPRIOT ADMINISTRATION)

The CUT (Cyprus University of Technology) is the only public university in Cyprus with a Mechanical Engineering Department and additive manufacturing facilities.

GERMANY

A particular focus in Germany is industrial applied research by Germany's world-leading institutes at the Fraunhofer Society across the country. As of January 2021, Fraunhofer had 74 institutes and research institutions throughout Germany. Most of the organization's 28,000 employees are scientists and engineers. Its annual research budget in 2020 was EUR 2.8 billion, with EUR 2.3 billion being generated through contract research.

GREECE

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

HOLLAND

Several Universities and competence centres are currently dealing with AM technologies, both at the teaching and research levels.

- University of Twente: Within the university, multiple faculties joined forces and initiated the Twente Centre of Excellence in Additive Manufacturing (TEAM). The goal of this cooperation is facility sharing cooperation, synchronisation of research goals, definition and execution of joined research projects, facilitation of bachelor and master assignments and the initiation of partnerships with industry.
- TU Delft: STW-M2i: STW-M2i (High-Tech Materials - Additive Manufacturing) is a project that combines high-tech materials and additive manufacturing (AM) technologies. The project focuses on innovation in material science and manufacturing processes. Additive manufacturing is a method where material is deposited layer by layer, unlike traditional manufacturing techniques.
- Eindhoven University of Technology: 3DCP provides the potential to increase the productivity and reduce the environmental impact of the Architecture, Engineering and Construction (AEC) industry. The 3DCP research group addresses the scientific challenges to develop the technology towards safe and sustainable structural applications of 3D printed concrete.”
- University of Groningen: There is a project in university for in-depth understanding of the relationships between processing parameters, final microstructure and properties of the products in successful application of LMD in large scale additive manufacturing. The aim of this project is to obtain a novel structure-property relationship for large metal components made layer-by-layer with laser powder deposition.
- Utrecht University: 3D Printing and Biofabrication Summer School has been implemented.
- Vrije University Amsterdam: In addition to the normal size 3D printer, the University Library also has a larger printer to create more bulky objects. Anyone with a good and feasible idea can submit a request for the creation of a 3D object.
- University of Amsterdam: There are studies on 3D Printing of Biomaterials.
- Materials Innovation Institute has also some studies related with AM.

HUNGARY

Short seminars to get started in Additive Manufacturing are available, but there is a lack of more comprehensive trainings. (<https://www.nobleprog.hu/en/cc/3dprinting>)

ICELAND

Institutions are manufacturing with AM, mostly metal and medical products. There is also some research for hybrid productions.

IRELAND

Several Universities and competence centres are currently dealing with AM technologies, both at the teaching and research levels.

- Trinity College Dublin: The research interests of STAM (Science and Technology in Advanced Manufacturing) include large scale collaborative research projects, the applications and development of manufacturing techniques such as cold spray, 3D printing in novel materials including metals and polymers, as well as research into grinding, forming, high speed machining and joining, and the development of strategies inside the topic area of Industry 4.0.
- There are important activities in Additive Manufacturing for Medtech in Ireland.
- Stryker Ann Grove Facility: Stryker advances its global additive manufacturing leadership with new facility at Ann Grove, creating capacity for 600 additional jobs. Stryker applies additive manufacturing, also known as 3D printing, to an array of healthcare innovations, with a special emphasis on the manufacture of specialized medical devices.
- Dublin City University: There is 3D Printing & Additive Manufacturing research centre.
- Technological University of the Shannon: There is Materials Research Institute in the university.
- University College Dublin: There is a center called i-FORM - SFI Research Centre for Advanced Manufacturing.
- University of Limerick: Additive Manufacturing team at the University of Limerick is offering 3D Printing services to research bodies and industry.
- Atlantic Technological University: Additive Manufacturing Design, Methods, and Processes have been studied in the university.
- University of Galway: The I-Form Advanced Manufacturing Research Centre was established by Science Foundation Ireland (SFI) to deliver high-impact research in advanced manufacturing. The Centre is particularly focused on additive manufacturing (3D printing), combined with the use of digital technologies in manufacturing.
- South East Technological University: There is a bachelor of Science in Additive Manufacturing.
- Irish Manufacturing Research. "IMR's goal is to Demystify, Derisk and Deliver emerging technologies and new knowledge to enable industry to succeed at the cutting edge of advanced manufacturing.

ITALY

Universities

Several Universities are currently dealing with AM technologies, both at the teaching and research levels. AM technologies is standing out in different academic courses among the degree courses related to industrial and mechanical engineering, whereas first hints about AM are presented within some courses related to architecture and design degree courses.

The following ones are the Italian universities dealing with AM:

- University of Bologna: The studies aim to push advancements in the knowledge of several AM technologies within different university departments, such as

- structural, mechanical, and metallurgy ones. It is focused on Wire-and-Arc Additive
- Manufacturing and Laser Powder Bed Fusion methods. The aim is the definition of the geometrical and mechanical characterization of 3D printed metal elements using these technologies, together with studies on optimized elements by means of optimization algorithms.
 - University of Florence: In the university, there are some studies like system for repairing through AM.
 - Politecnico of Milan: The research team developed some projects and patents on AM. The research group is working on the characterization of the 3D printing process, with a focus on the reduction of flaws during the printing process, as well as a device for removing flaws in situ during the additive printing of metal parts.
 - Politecnico of Turin : The research line for AM aims to design and develop new materials and components in a number of sectors, including aerospace, biomedical and industrial ones. The objective is to develop a basic material study by controlling and exploiting the particular microstructural features introduced by AM technologies.
 - University of Padua: The research projects are meant to define design tools and methodologies to develop components with a local variation of the properties, from mechanical and geometrical characterization to conductivity, aiming to realize innovative high-tech elements.

Competence Centers

In 2018, eight national competence centers were established within the Industry 4.0 plan: CIM 4.0 Competence Industry Manufacturing 4.0 (Turin, Italy), MADE – Competence Center Industry 4.0 (Milan, Italy), BI-REX – Big data Innovation-Research Excellence (Bologna, Italy), ARTES 4.0 – Industry 4.0 Competence Center on Advanced Robotics and enabling digital Technologies & Systems 4.0 (Pisa, Italy), SMACT Competence Center (Padua, Italy), MediTech Competence Center I 4.0 (Naples, Italy), STRAT 4.0 – Security and optimization of Strategic Infrastructure Industry 4.0 (Genoa, Italy), CYBER 4.0 – Cybersecurity Competence Center (Rome, Italy).

The competence centers are public-private partnerships, which organize orientation and training activities on Industry 4.0 for companies, supporting them in the actualization of innovation projects, industrial research and experimental development, in order to manufacture new products, realize new processes or services by means of advanced technologies in Industry 4.0 field. AM technology is one of the topics presented during the training courses.

The National Research Council (CNR) and National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) are public national research institutes, they offer AM technologies and competencies within their laboratories. Italian space agency The Italian Space Agency invests in AM, as shown by the project “Portable On-Board Printer 3D”, to fabricate plastic objects directly on the International Space Station (ISS).

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

- PLM Group (e.g. Training in Solidworks)
- Riga Stradins University (e.g. <https://www.rsu.lv/en/rsu-courses/foundations-3d-printing-fk068>)
- Vidzeme University of Applied Sciences (e.g. 3D graphic course)

LITHUANIA

There is only InTechCentras as an AM training center, the research has been found.

LUXEMBOURG

- 3D Print (Workshops)
- Université du Luxembourg
- Digital Learning Hub (short course)
- Université Populaire Belval

MALTA

Short seminars to get started in additive manufacturing are available, but there is a lack of more comprehensive trainings. Nevertheless, University of Malta has been involved in some AM research projects.

MONTENEGRO

There are studies on optimizing filament usage with FDM printers due to high consumption during covid.

NORTH MACEDONIA

Materials are currently being developed for AM. Also, supply chain problems are solved via AM and digital inventories.

POLAND

- Institute of Non-Ferrous Metals (IMN) in Gliwice: it is a research centre of the Polish non-ferrous industry. The services provided cover: R&D targeted for the development of new technologies, optimisation of industrial processes, modernisation of production lines, construction of equipment, measurement and analytical services.
- Materialise: the company offers a variety of training courses and seminars to assist users in optimizing their use of AM software and workflows within their everyday work. Topics are related to an overview of 3D printing, metal 3D printing, design for

- AM adopting polymers and metal. Moreover, they offer various courses to assist users with optimizing their use of Materialise software.

PORTUGAL

There are a couple of training center especially based on universities.

- Inegi
- ISICOM
- Universidade de Aveiro
- Universidade de Coimbra
- Politécnico de Leiria
- Universidade do Minho
- Universidade do Porto

ROMANIA

Training programs are currently in development both from private institutes and universities.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

Materials are currently being tested and parameters are worked on. There is interest and a lot of initiatives on AM.

SLOVENIA

AM is used for R&Ds, topology optimized products and prototyping. Also, service bureaus are available for production and post processes in metal and polymer.

SPAIN

- AIDIMME
- Comillas Pontifical University's ETSI-ICAI
- EDDM
- IMH
- ITECAM
- Lortek
- Laboratorios 3D
- MasterD
- Universidad de Burgos
- Universidad del País Vasco
- Universidad Politécnica de Madrid

SWEDEN

Several Universities and competence centres are currently dealing with AM technologies, both at the teaching and research levels.

- Lund University: Design for Additive Manufacturing
- Linköping University
- KTH Royal Institute of Technology
- Linnaeus University
- Uppsala Universitet
- University West
- Mid Sweden University
- Örebro University
- Chalmers University
- Umeå University
- Luleå University of Technology
- Swedish Arena for Additive Manufacturing of Metals
- Additive Manufacturing Application Center

TURKEY

Additive manufacturing needs some engineering skills such as technical drawing, computer aided drafting and design, basic material science and computer programming. Therefore, most of the educational and training programs in Türkiye are exist in universities. AM courses are generally opened as undergraduate technical selective course or graduate courses. However, AM has also been thought in Manufacturing Processes courses as an individual chapters at undergraduate level. AM courses which are exist in the universities program.

University	Course Name	Level
METU	3D Printing and Additive Manufacturing	Undergraduate
Yıldız Technical University (YTE)	Additive Manufacturing	Undergraduate
Bursa Uludağ University	Additive Manufacturing Graduate Program	Graduate
Eskişehir Technical University	Additive Manufacturing Methods	Graduate
Düzce University	Additive Manufacturing	Undergraduate
İstanbul Technical University (ITU)	Additive Manufacturing Process and Design	Undergraduate
Marmara University	Additive Manufacturing Technologies	Graduate
Sakarya University	Additive Manufacturing Technologies	Graduate
Sivas Science University	Metal Additive Manufacturing	Graduate
Çankırı Karatekin University	Additive Manufacturing	Graduate

6.2.3 Grants

ALBANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

AUSTRIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BELGIUM

Digital Wallonia's regional Industry of the Future programme has helped coordinate the work of 37 partners (professional and sector-specific federations, research centres, clusters, etc.) to ensure the digital transformation of industry in Wallonia.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

CROATIA

From 2018 to 2020, Mikrotvornica, within the project 3DPrintaj.com, implemented 755 3D printers in libraries and public schools in Croatia. Through a partnership with IRIM – Croatian Makers, they joined the STEM revolution in Croatia, which is directly funded by Google. Its goal is to transform public libraries into digital maker spaces in the region.

CZECH REPUBLIC

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

DENMARK

AM-LINE 4.0 is a project by Danish Technology Institute with a duration of four years, which launched in 2018. The project aims to ensure that Danish industrial companies receive the necessary knowledge to exploit the great potential of 3D print production of metal items. A new demonstration and knowledge center for industrial 3D printing in metal will make it attractive for smaller Danish companies to use 3D printing in their production.

ESTONIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

FINLAND

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

FRANCE

Materialia is a competitiveness cluster dedicated to materials and processes, with its headquarters in Metz and a branch in Charleville-Mézières. Even though it operates throughout the Greater East region (Région Grand Est) of France, its location is also national. CIMES is the French competitiveness cluster dedicated to Manufacturing and Productive performance and efficiency. Strategic stakeholders in the French innovation system, present

in a large number of economic sectors, competitiveness clusters are associations that bring together innovative companies of all sizes and training and research actors, around collaborative projects, by relying on the assets and know-how present at the local and regional levels. CIMES supports and grants eligible start-ups in France.

GCA (GREEK CYPRIOT ADMINISTRATION)

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

GERMANY

In 2015, the BMBF launched the “Additive Manufacturing – Individualized Products, Complex Mass Products, Innovative Materials (ProMat_3D)” funding initiative. In 2017, the BMBF announced the “Line Integration of Additive Manufacturing Processes” program with the aim of achieving further industrialization of the technology and serial production within the framework of the High-Tech Strategy. Germany offers optimal conditions for start-up companies developing new additive manufacturing technologies thanks to a plethora of universities and research institutions that conduct 3D printing research or access to the technology. Venture capital funds, such as leading German venture capital firm AM Ventures, are increasingly investing in disruptive and globally leading additive manufacturing start-ups.

In Germany 3D Printing is supported by a number of R&D programs at the EU and German federal levels. Commission of Experts for Research and Innovation (EFI) first identified additive manufacturing as a key technology in 2015. Since then, a number of programs have been established by the Federal Ministry of Education and Research (BMBF) and the Federal Ministry for Economic Affairs and Energy (BMWi).

Germany Trade & Invest informs about Germany’s research excellence in the additive manufacturing industry and provides market information and service support to companies seeking to establish a business in Germany.

GREECE

Some institutes are available which provide services, technological solutions, training etc. for AM.

HOLLAND

Public and private grants have been provided, as the following ones:

- Government grant: 1.73 B€ Smart Industry (2017)
- Government grant: 134 M€ (2016)
- Private grant: 4M€ Issued by BOM Brabant Ventures to AM_Flow (Amsterdam)
- Private grant: 14M€ Issued by Highlands Beheer BV to Additive Industries (Eindhoven)

HUNGARY

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

ICELAND

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

IRELAND

Public grants have been provided, as the following ones:

- Government grant: 2.1 M€ Human Capital Initiative Pillar 3
- Government grant: 18.5 M€ Science Foundation Ireland
- Government grant: 500 M€ Disruptive Technologies Fund
- Government grant: 4.3 M€ Science Foundation Ireland

ITALY

The government grants in AM have been provided by means of the National Recovery and Resilience Plan (PNRR) and supplied by the national competence centres.

National Recovery and Resilience Plan (PNRR) is organized into six missions (thematic areas) which are necessary to plan interventions. Then, the missions are articulated into areas of interventions to plan specified actions, composed of investments and reforms devoted to the development of key enabling technologies, both for academic (M2 “Green Revolution and Ecological Transition”) and private research (for companies, M1 “Digitalization, Innovation” and M4 “From research to companies”), encouraging interaction between research and manufacturing worlds. Grants provided by the Plan have been allocated to establish:

- 5 national research centers: Grants have been invested in research activities,
- 11 innovation ecosystems at a local level,
- 49 research and innovative technology infrastructures,
- Research partnerships based on interdisciplinary, holistic, problem-solving approaches.

All of these are oriented toward a research advancement within the thematic areas, therefore also focusing on AM.

The national competence centres are in charge of the publication of calls for proposals (or grants) in AM, such as applied research projects industry 4.0 (CIM 4.0), support for projects on innovation, industrial research and experimental development (MADE) with a project contribution of 50% of costs incurred up to €100K, support for projects on research, development and innovation (BI-REX) [37], call for ideas (ARTES 4.0 and SMACT).

The European Commission has planned a new project, Integradde, related to AM, due to its direct impact on the digital transition. In particular, grants for the development of Intelligent data-driven pipeline for the manufacturing of certified metal parts through Direct Energy Deposition process) will be provided. The Italian company “Prima Industry” is part of the consortium, working in the field of industrial laser systems and sheet metal working machines.

Primo Space Fund is the first Italian venture capital fund, it is specialized in the space tech industry. Their aim is to invest in those solutions constituting the space infrastructure, technologies enabling the space industry.

EUREKA! Venture SGR manages Eureka! Fund I – Technology Transfer: Investments are focused on proof of concept, seed and early-stage deals in spinoffs and startups steaming out from Italian Universities and Research Centres. Ideas and companies backed by Eureka! Fund have a competitive advantage that stems from cutting-edge proprietary technologies and innovations in materials science & engineering with a clear and unique vision of intellectual property rights.

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

Financial support is provided through the National Recovery and Resilience Plan, Business Incubators, Innovation Motivation Programme, Start-up support programmes and other programs.

Some of the projects have been funded by:

- European Regional Development Fund
- Commercialization Reactor Fund
- Latvijas nacionālais attīstības plāns 2020

LITHUANIA

The aim of EcHoLas is to enable a semi-professional production of digital reflection holograms by the application of the two main technologies (diode laser-based modules as laser light sources for the holographic printer devices and chemical-free development of freshly printed holograms). Within the project an economic holographic laser printer with all required components and accessories will be developed, which is expected to have a global impact on the digital hologram market.

Project funded by:

- Horizon 2020's SME Instrument.
- "Industrial Digitization LT" of the 2014-2020 European Union Funds Investment Action Program.
- The Manufacturing Innovation Valley in Vilnius provides a platform for small manufacturers, start-ups, technology developers, and researchers to carry out manufacturing activities, create digital innovations and prototypes, and test their innovative ideas. It will offer the right facilities, manufacturing equipment, and expert advice in around 20 different technological areas.
- The Manufacturing Innovation Valley project is implemented by UAB Pažangios inovacijos. The project is co-financed by the European Regional Development Fund under the call for Digital Innovation Hubs No. 01.2.1-LVPA-K-857-01.

LUXEMBOURG

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

MALTA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

MONTENEGRO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

NORTH MACEDONIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

POLAND

The Polish Government is pushing development and investment in new technologies, such as additive manufacturing, that will drive Poland's economy to the next level, and there are grants and other resources available to support innovative R&D. The amount of innovation investment in Poland has an approximate value of \$7.6 billion, and more than 300 R&D centres have been created in the past few years.

The Polish Government provides several incentives to support advanced manufacturing and industrial transformation through tax incentives and a robust grant system to support research and innovation in manufacturing. These projects have a budget of \$163.6 million and are supervised by the National Center for Research and Development (NCBR) and the Polish Agency for Enterprise Development (PARP).

Specific European Projects within the Smart Growth Operational Program 2014-2020 also be dedicated to innovative projects.

During the period of EU funding for 2014-2020, almost 89,000 Polish companies received funding for innovation and almost 8000 R&D projects have been started. Since the new perspective has been launched for the years 2021-2027, €76 billion will be allocated for innovation, entrepreneurship, digitization, infrastructure, environmental protection, power engineering, education, and social causes.

The European Funds planned for 2021-2027 a fund of €25 billion in the aviation sector to recover. Funds in the automotive and aerospace sectors are planned because the growth in these two sectors is heavily reliant on the development of advanced technologies and will drive demand for the latest in automation and additive manufacturing in Poland.

PORTUGAL

There are two programs founded in the research.

- Compete 2020
- Portugal 2020

ROMANIA

There are some institutes which intent to educate and support people, organizations, and companies for AM.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVENIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SPAIN

There is one project funded by: Programa Cervera.

SWEDEN

Public grants have been provided, as the following ones:

- Government - Swiss-Sweden Innovation Initiative: 78 M€
- Government - Digitalization of Supply Chain in Swedish Additive Manufacturing (DiSAM): 7MSEK
- Government - Additive Manufacturing for the Life Sciences 32 MSEK

TURKEY

Additive manufacturing has been defined as one of the future technological topics in Manufacturing and the Turkish government announced several grant programs which include AM as a special section. Those grant programs aim to encourage the universities, SMEs, and companies to initiate technological research on AM and to develop AM technologies.

The main purpose in such programs is to create AM ecosystem in Turkey and to increase the capabilities in AM technologies from machinery to software development.

Governmental and private sector Grants on AM:

Grant Name	Supplier	Users
HAMLE Program	Ministry of Industry and Technology	Companies and SMEs
Infrastructure Establishment of AM Research Centers	Strategy and Budget Department	Universities
National Funds for Industry	TUBITAK TEYDEB	SMEs and Companies
National Funds for Academic Researchers	TUBITAK ARDEB and BIDEB	Universities and Research Centers
Yakut	Presidency of Defense Industry	TUSAŞ Engine Industry (TEI)
Electron	Presidency of Defense Industry	TUSAŞ Engine Industry (TEI)

Presidency of Defense Industry	TUSAŞ Engine Industry (TEI)
Lift-up projects	Turkish Aerospace
Horizon 2020	EU
Erasmus +	EU
Technology Entrepreneurship and Commercialization	Development Agencies of Ministry of Industry and Technology
Industrialization	Presidency of Defence Industry
	Industry, Universities and Research Centres
	University Students (undergraduate and Graduate level)
	Universities and Industry
	Universities and Industry
	Industry, Universities and Research Centres
	Industry, Universities and Research Centres

6.2.4 AM Business

ALBANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

AUSTRIA

A study carried out by the JKU Linz confirms Austria's excellent position and international competitiveness in the AM market. Although few nationally coordinated AM programs have been set up so far in Austria, an active industrial and scientific community has emerged in recent years. The community ranges from material suppliers to system manufacturers and from designers to end-users.

BELGIUM

Currently, there are quite a good number of big companies like Materialise and an increasing number of use start-ups such as Aerosint. There are also several technological trends at material, technology, post-processing, ICT and quality assessment fields that will bring new innovations in the coming years to deal with current AM challenges and industrial needs in Belgium.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

There are several companies in Bulgaria, working in the field of AM. One of them “B2N Additive manufacturing ecosystem” draws attention with its activities in the field. The company is organizer and initiator of the annual event “Additive Days” - Balkan forum for additive manufacturing, which aims to facilitate the better understanding of the role 3D printing must play in different areas such as engineering, medicine, business, science, education, architecture, design, fashion, etc.

CROATIA

Several large and medium size companies are dealing with AM.

GE Additive: it is a world leader in metal additive design and manufacturing. It is specialized in developing Powder Bed Fusion (PBF) machines for the AM of metal parts. The AddWorks team at GE Additive applies practices and methodologies to solve technical and business challenges. They operate in the following sectors: aerospace, military and defence, medical, industrial manufacturing, automotive and space.

Mikrotrvornica : Croatian-based company that combines a wide range of additive and digital manufacturing technologies resulting in prototypes and product batches. The company has implemented two brands:

Modax Machines: They are a line of modular machines that enable the production of parts using both FDM/FFF 3D printing technology and CNC milling on the same machine simultaneously. The project is co-financed by funds from the Innovative Concept Verification Program (PoC) by HAMAG-BICRO.

3DPrintaj.com: It is a platform to share 3D printing knowledge with people in Croatia, through educational programs, technical “knowledge base” and valuable blogs. It is a place where purchase 3D printers, materials and accessories.

CZECH REPUBLIC

The field of additive manufacturing has been developed at the application level in the Czech Republic by several companies for about 15 years. This is primarily the field of polymer processing. The actual development of polymer 3D systems by Czech companies has been implemented only in the last few years. Thanks to European finances, the Czech Republic has entered a period of investment in infrastructure both at the state and corporate level. Metal additive manufacturing technologies are installed at two university workplaces and several large companies.

DENMARK

Most of the Danish companies actually using 3D printing for product development are found in electronics, plastic, glass and concrete industry as well as companies manufacturing electronic appliances. A large number among the 80 percent of companies that do not utilize 3D printing technology, have processes suitable for AM. Overall, this means that there is considerable potential to use the technology to make prototypes and improve products in Danish manufacturing industry.

ESTONIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

FINLAND

Additive Manufacturing in Finland has been concentrated on large bulk pieces and prototyping services, whereas production in other countries such as Germany, UK or other European countries focus more on small series production of complex and special parts for aerospace and automotive industry. Nevertheless, there is a potential for growth of AM applications in traditional OEMs, especially in manufacturing applications from which complete new products and processes can be innovated.

The AM ecosystem in Finland has been built upon the research activities of the universities, VTT, and the output of the few service bureaus that have emerged.

To complement metal AM, machine shops are being employed to provide final machining for printed component. As more service bureaus have emerged, knowledge of metal AM has spread and ordering of the first metal prints has become more easily accessible to companies new to this manufacturing technology.

FRANCE

France is a mature market in all segments of the AM sector: 3D printers, materials & consumables, on-demand manufacturing services, files storage, software for 3D and post-processing activities. In 2019, France ranked 4th in Europe in the additive manufacturing (AM) sector after Germany, Italy and the U.K. The additive manufacturing sector in France represented a turnover of approximately 489 million Euros/USD 575 million – and 3% of the global additive manufacturing market.

GCA (GREEK CYPRIOT ADMINISTRATION)

Two companies are detected (A.Kirmitsis Ltd and M.D. Upstruct Additive Manufacturing Limited) that work as a service provider. By the support of EU fundings, two institutes of Research and Education has been established since 2004, and there has been certain initiatives on Additive Manufacturing. Besides from these no AM activity is detected in Greek Cypriot Administration.

GERMANY

In 2020, the German additive manufacturing sector listed turnover of EUR 1.6 billion, with above average growth rate in recent years. Around one in three large German industrial companies currently use 3D printing. For patent applications submissions, Germany is in the first place in EU. ¼ of all additive manufacturing companies worldwide are located in Germany. EUR 1.6 billion industry turnover in Germany – with above average growth rate in recent years.

Before, less than 50% of German firms used AM. Nowadays, more German companies than ever before are aware of AM capabilities. There is a clear trend towards additional AM in Germany. German firms are active on the global AM market, and some are major global players. They contribute nearly 50% of all European AM patents. Due to its high-tech market, Germany is a ready playing field for AM, offering the strongest AM market potential among all European Union countries. In addition, its central location makes it a natural hub for supplying neighbouring countries. The majority of German firms prefer to make their products

in-house on their own AM printers rather than ordering them from an outside AM service provider.

The German market offers a strong potential to U.S. manufacturers of AM equipment and materials. Several U.S. exporters have very successfully established their AM business in Germany. AM solution packages can make it easier for a first-time local AM user to adopt the new technology. Hence, some U.S. companies have partnered with a local firm.

GREECE

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

HOLLAND

Several large and medium size companies are dealing with AM.

- **Luxexcel:** Luxexcel Group is the Inventor of Printoptical Technology. The patented 3D printing process is a digital technology specially developed to make functional optics. The “one-step-CAD-to-Optic” process enables the manufacturing of smooth 3D-printed optical components with no post-processing required. It allows the users to upload a file to be designed and the product is sent back in 5 days. Binary Lighting, Oligo, and Baretech are among its customers.
- **Additive Industries:** Additive Industries is a developer of SLM 3D printer. The company offers products such as MetalFAB1, MetalFAB-420, MetalFAB-420 autoloader, MetalFab-450, and MetalFAB-600. It can be used in the aerospace, automotive, and energy sectors.
- **AM-Flow:** The company is provider of AI-powered industrial 3D printing systems. It offers end-to-end solutions for industrial additive manufacturing, including 3D part recognition, digital manufacturing, sorting conveyor, packaging, product handling, and identification systems. It also develops an autonomous robotic system for business monitoring and management. It provides software for product and process automation.
- **DiManEX:** DiManEx offers a one-stop-Shop industrial printing of (spare) parts service for various verticals. It allows for digital supply chain optimization and enables the ability to print any part anywhere in the world with the same quality and commercial standard. They identify the parts and find an industrial printer match for the part to be produced and securely stores & monetizes on the designs. They also perform quality control and data analytics. Their partners include Oceanz, TNO and 3D Makers Zone.
- **MX3D:** The company is provider of industrial 3D printers that use robotic arms. It develops a multiple axis 3D printing tool, an industrial robot equipped with advanced welding machine and software to control it. It will print metals and resins without support in the mid-air.
- **Aectual:** Aectual is a provider of 3D-printed flooring systems. It provides robotic 3D printers and software tools to produce smart building products. It uses the Actual 3D printer to provide a customized 3D printing floor with a terrazzo infill.
- **Printr:** Printr develops an ERP cloud system for 3D printer management. Its streaming device called ELEMENT connects to the 3D printer via USB turns. The user can stream

all STL files or Gcode generated from any slicing software directly to the printer either locally or through their FORMIDE account, which is an end-to-end ecosystem for makers, schools and offices where one can manage multiple printers and projects. Its availability on every major (mobile) platforms makes it easy to connect to the 3D printers from anywhere.

- Addoptics: Addoptics is a manufacturer of polymer optics using additive manufacturing. It claims to offer manufacturing service for prototyping and batch production of custom optics providing lenses for smartphones and lighting.
- Manometric: The company is provider of 3D printed braces and orthotics. The offerings include 3D Software, 3D hand scanner, and slicing software. The brace is created using 3D Scan and 3D Print technique and is made of a combination of flexible and hard plastic.
- 3D By Flow: 3D By Flow developed portable 3D printer based on FDM technology which can print multi-material. It is foldable and has exchangeable extruders which can support filament and pastes of PLA, ABS, PET, laybrick, wood, biorubber , bronze, silver, glassclay, ceramic, silicon, edible materials and bio- and recycled plastics. It has the feature of auto calibration also.

HUNGARY

The main field of the Hungarian AM companies is the manufacturing of printers.

Company Inventory:

- Craftbot
- Freedee
- Pab Engineering
- 3D Parade

ICELAND

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

IRELAND

Several large and medium size companies are dealing with AM.

- MCOR: Provider of industrial 3D printers. Its colour 3D printers use materials, like standard office paper, inkjet colours, and water-based adhesive. It has developed software that enables its users to add colours, textures, logos, and maps to the 3D files. It has applications in the engineering, educational, medical, art, forensic, and archaeological sectors.
- WAZP: Wazp is developing platform for designers to present and sell their designs, for 3D printer owners to have presence in platform for customers. It is trying to simplify supply chain of 3D printable products from designer to 3D printer shop to customer. They had successful Kickstarter campaign for "We Grow" jewellery collection.
- Love & Robots: Love and Robots, previously FabAllThings, is a Dublin-based 3D Printing company that uses cutting edge high-precision printers to create custom objects in four categories namely smartphone cases, jewellery, coasters, and clocks. It is an

online design community in which crowdsourced product designs are either manufactured and delivered to customers or downloaded and printed by customers itself.

- **Advant Medical:** Advant Medical is a medical device contract manufacturer with expertise in additive manufacturing, injection moulding, product development, and packaging solutions. Its product offering includes Neurovascular, cardiovascular, peripheral vascular, orthopedics, clot management, stent and balloon packaging (dispensers). The company also offers services for rapid prototyping, pilot manufacturing, injection moulding.
- **IMAR:** Offers 3D printing, scanning, data analytics and IoT application development services.

ITALY

Several large and medium size companies are dealing with AM, as the following ones:

- **Beam It:** the company has a high level of specialization in metal AM components.
- **Guidetti Technology:** the company provides its knowledge on welding and the equipment composed of 3D printer (Delta system), Fronius technology and a 6-axis robotic arm to the customers, demonstrating the advantages correlated to the adoption of AM technologies.
- **Caracol AM:** the company has developed a lightweight and compact extruder, which can process a wide range of polymers and composite materials in pellet form.
- **Juno Design:** the company offers from 3D modelling up to prototype realization with high-performance 3D printers.
- In 2021, a study conducted by the first Observatory on Additive Manufacturing promoted by Messe Frankfurt Italy, SPS Italy and Formnext revealed the following information; material jetting and powder bed fusion attest to their established positions among the AM technologies, the focus is on polymers and metal materials among the ones available, the outcomes are primarily used for prototyping, necessity to embrace the AM advantages.

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

Latvian AM companies work in the sectors of aeronautic, consulting, low volume/batch production of plastics parts, molds, production of 3D printers, R&D, wire for AM, 3D printing, 3D prototyping. FDM, Polyjet and SLS are the AM technologies used by these companies.

Company Inventory:

- Additive Technology Group (ATG)
- AM Craft
- Baltic 3D
- Mass Portal
- Materize
- PLM Group

- SMW Aerospace
- SMW Engineering
- 2AM

LITHUANIA

Lithuanian AM companies work in the sectors of consulting, prosthetic-orthopedic devices, prototyping, 3D modeling, 3D printing, 3D scanning. Binder Jetting, DMLS, FDM, MJF, SLA, SLM or SLS are the AM technologies used by these companies.

Company Inventory:

- Acatia
- Amera Labs
- APC Tooling
- Inorega
- InTechCentras
- ManuValley
- Ortho Baltic Implants
- Reklamos 4
- Smart Factory
- Wryedge
- 3D Creative
- 3D Prototipai

LUXEMBOURG

Luxembourger AM companies work in the sectors of consultancy, large scale additive manufacturing, prototyping, and provider of materials for AM, software or 3D Printing. DMLS, FDM, MJP, SLA, SLM, SLS are the AM technologies used by these companies.

Company Inventory:

- AM4AM
- AirTech
- Anisoprint
- Luxinnovation
- Ricoh
- Saturne Technology
- 3D Print

MALTA

Maltese AM companies work in the sectors of consultancy, mass manufacturing, product design and development, prototyping and R&D. FDM, SLA or SLS are the main AM technologies used by these companies.

Company Inventory:

- Full Circle 3D
- Invent 3D
- Magigoo
- MECB EU Projects

MONTENEGRO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

NORTH MACEDONIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

POLAND

Several large and medium size companies are dealing with AM.

Materialise: The company is now entirely focused on certified Additive Manufacturing, boosting production, engineering, R&D, sales and software. Company development related to the construction of the 3D printing Competence Center for SLS technology. They offer a platform of software solutions and digital manufacturing services. They work in aerospace, automotive, eyewear, 3D printing, architecture, art and design, medtech, consumer goods, machinery and equipment.

Poland continues to grow as a manufacturing power in Europe, and there is increasing demand for new and innovative manufacturing technologies. In 2021, industry production was 14.8% higher than in the previous year. The Polish Government launched its Industry 4.0 Platform in 2019, in order to increase the innovativeness of Polish companies, sharing information about 4.0 processes and developing competencies in areas such as robotics and automation. According to the European Investment Bank (EIB) Investment survey 2021, most Polish firms in the manufacturing sectors (56%) have implemented at least one advanced digital technology.

PORTUGAL

Portuguese AM companies work in the sectors of aerospace, consultancy, automotive, industrial tools/molds, materials and consumables provider, medical/dental, printer provider or prototyping. DLP, FDM, LPBF, MBJ, Polyjet, SAF, SLA or SLS are the AM technologies used by these companies.

Company Inventory:

- Adira
- AM Cubed
- Beeverycreativ
- Blocks
- Centimfe

- Codi
- Dimlaser
- Fan3D
- GLN
- Hypermetal
- WeAdd
- Xpim
- 3D Ways

ROMANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVENIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SPAIN

Spanish AM companies work in the sectors of consultancy, dental, post-processing, printer provider, prototyping, R&D, testing, 3D modelling, 3D printing, 3D scanning.

Binder Jetting, DMLS, FDM, MJF, SLA, SLM or SLS are the AM technologies used by these companies.

Company Inventory:

- | | | |
|---------------|-----------------------------|--------------------|
| • Aciturri | • Bronymec | • Egile |
| • Addibeba | • CAF Digital Manufacturing | • Entredsd |
| • Addilan | • Catec | • Excelencia-Tech |
| • Addimen | • Ceit | • Fagor Automation |
| • Addvance 3D | • Cidetec | • Gaiker |
| • Aenium | • Citd | • Hervel |
| • AIDIMME | • Createchmedical | • Hiperbaric |
| • AIMEN | • Delaser | • Ibarmia |
| • Aimplas | • Delteco | • Iddo |
| • Azterlan | • Dlyte | • Ideko |
| • BCN3D | • Dynamical 3D | • Idonial |
| • Bezzier | • Eceleni | • Ikor |
| • Boloberry | | • Indart3D |

- Industrias Alegre
- Inter alloys
- Intermaher
- IT 3D Group
- Izadi
- Laboratorios 3D
- Leartiker
- Leitat
- Lortek
- Madit
- Maflow
- Maqcenter
- Maquinser
- Materialise
- Mause3D
- Mecanizados Aranda
- Meltio
- Moso 3D
- MTorres
- Naitec
- Navantia
- Nippon Gases
- Optimus 3D
- Polifluor
- Prima Power
- Print 3D Solutions
- Quipplan
- Renishaw
- Samylabs
- Sariki
- Scan 3D Print
- Sicnova
- Tecnia
- Tekniker
- TheSteel Printers
- Tknika
- Technical Marine Bureau
- Triditive
- Trimek
- TUmaker
- Undo Prototipos
- Verot
- Zayer
- Ziknes
- 3D Incubator
- Pixel Sistemas

SWEDEN

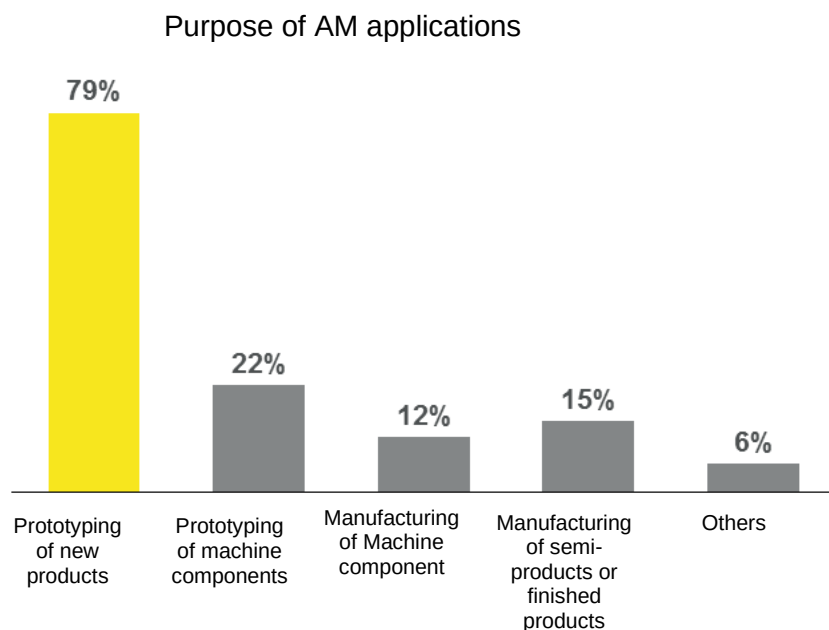
Several large and medium size companies are dealing with AM.

- Cellink
- Volumental
- Wematter
- Arcam
- Anatomic Studios
- Aim Sweden
- Zyyx 3D Printer
- Volvo Construction Equipment
- Valinge Innovation Sweden
- Things
- Exmet
- Acron
- Digital Mechanics
- 3D Burrito

Among all the wide-ranging AM-relevant strengths that reside within Sweden, the undisputed leadership that the country has provided in terms of materials development in general, and global powder production in particular, is most striking. The country garners an impressive 25% of the global metal powder market share because of the niche specialization areas of Swedish powder producers such as Carpenter Powder Products, Erasteel, Höganäs, Sandvik and Uddeholm, combined with the substantive support in terms of materials research and development that they derive from the considerable domain expertise available at Swedish universities and institutes. Nonetheless, the predominant focus so far has been on ferrous powders and little of the powder production has been dedicated to AM.

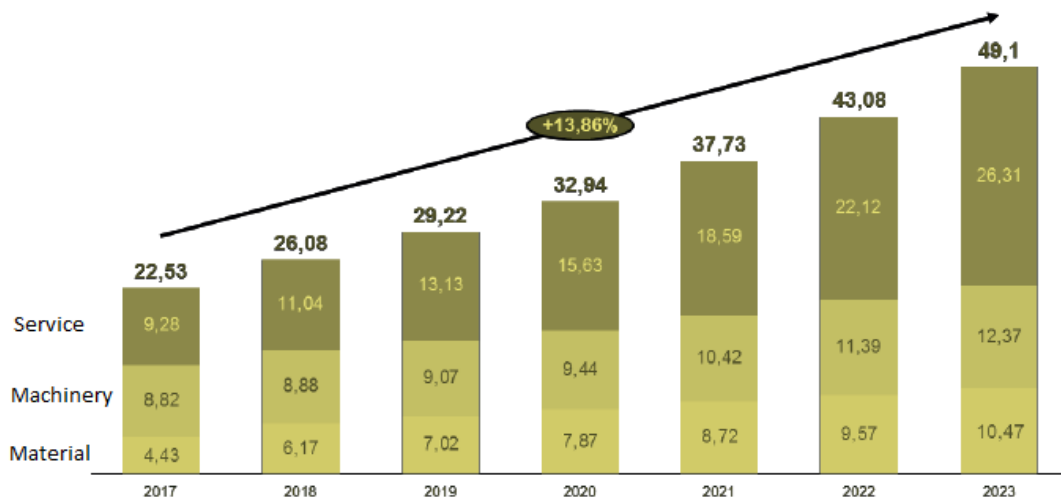
TURKEY

Additive manufacturing technologies has been used in different sectors: medical, dental, defence, aerospace, machinery, automotive, electronic, polymer and others. Among them, medical and dental are the most mature sectors to use AM in their products, such as implants and some of the medical and dental prototypes. Aerospace sectors is highly popular in Turkey in last decades and the leading companies in these sectors have huge investment on AM both machinery and skilled persons. Defence companies have very much interest on AM however those companies have some reluctance on AM since AM part sizes and material varieties are limited. Automotive industry is still being suspicious about AM due to production time and rates. Nevertheless, all the sectors are having a knowledge about AM and they have an intention to use and make investment on AM in near future. The utilization of AM in the sectors shown below. Although still prototyping is having majority of percentage, direct manufacturing of new semi and final products are increasing.



AM Market in Turkey are generally directed by international AM companies. Most of the Turkish AM companies are having partnership with the global AM companies and supplying AM systems and products to the sectors in Turkey. Although, there are some attempts on private sectors, the effect of these ventures is limited and needs time and more investment. However, Turkish AM market is highly vibrant, eager, and fast growing. Seven years prediction of AM Market in Turkey.

Turkish AM sector is primarily consisting of service, machinery and material.



Additive Manufacturing Market Prediction 2017-2023 (million USD)

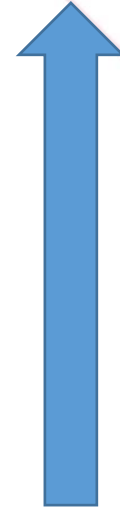
The sector is primarily using AM technology for prototyping and manufacturing of new products. Therefore, polymeric AM machines and technologies are highly used in Turkey. Particularly, jewellery sector uses DLP method to manufacture wax patterns.

Defence and automotive industry use FDM and SLS both for prototyping and functional parts. Powder bed processes and machines uses metal powders and aerospace, and defence companies prefer to use this method for functional prototypes and machinery components to be tested and used. WAAM and DED methods are rarely used in the industry due to lack of commercial machines and applications.

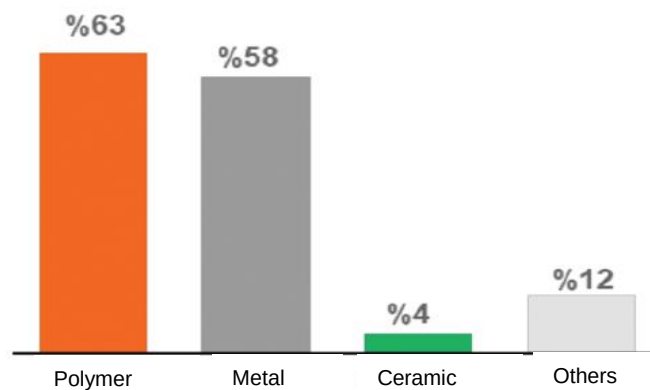
Although BJ has great potentials in some sectors like casting, it has very limited practical use in the sector. Table gives an order of usage of AM technologies in Turkish AM sectors.

Order of Usage Rate of AM Technology

Fused Deposition Modelling (FDM)
Selective Laser Sintering (SLS)
Direct Light Processing (DLP)
Stereolithography (SLA)
Laser Powder Bed Fusion Processes (L-PBFP)
Electron Powder Bed Fusion Processes (E-PBFP)
Wire Arc Additive Manufacturing (WAAM)
Directed Energy Deposition (DED)
Binder Jetting (BJ)
others



AM machines use raw materials in different forms, filament, powder, and resin. Polymers are produced in the form of resin, filament, and powder form and most of the AM raw materials used in the AM machines in Turkey is polymers. Metals are also produced in the form of powder and wire. Powders are used in PBFP and DED machines and the wire is only used in WAAM. Metal is the second most used material in the sector. Ceramic is only produced in the form of powder and processed with binders in AM. Ceramic materials are used very limited in the sector. Table seen below shows the overall percentage of materials usage in AM sector of Turkey.



6.2.5 Projects and Patents

ALBANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

AUSTRIA

Many ongoing research activities, such as the lead project 'addmanu', the initiative 'AM for Industry' from the plastics and mechatronics cluster in Upper Austria, and the insights that arose from the Additive Manufacturing Austria road map on behalf of the BMK, show the immense potential that is made accessible through a cooperative national approach.

BELGIUM

The STREAM consortium consists of industrial partners from different segments of the AM value chain: material producers, AM-technology companies, software developers, companies with post-processing & functionalization expertise and end-users of different market segments (aerospace, medical, PVC-products). The latter are very important to define the required AM.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

In Bulgaria there is a National initiative - Bulgarian association for development of knowledge in CAD/CAM/CAE&PLM technologies 3C ACADEMY, financed under EU programs.

CROATIA

The following AM project has been developed:

INEX-ADAM (INcreasing Excellence on Advanced Additive Manufacturing): this project has received funding from the European Union's Horizon 2020 research and innovation.

programme. The overall goal of this project is to enhance networking and reduce technology deficiencies in UNIZAG FSB by significantly strengthening the excellence and innovative capacity for research in the field of Additive Manufacturing (AM) within the Centre of Additive Technologies (CATEh), which is an integral part of the University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture (UNIZAG FSB). Several institutions from different European countries have participated in it; AIDIMME, Lund University in Sweden, The Austrian University of Mining, Brunel University London in England

CZECH REPUBLIC

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

DENMARK

AM-LINE 4.0 is a project by Danish Technology Institute with a duration of four years, which launched in 2018. The project aims to ensure that Danish industrial companies receive the

necessary knowledge to exploit the great potential of 3D print production of metal items. A new demonstration and knowledge center for industrial 3D printing in metal will make it attractive for smaller Danish companies to use 3D printing in their production.

ESTONIA

As part of efforts to digitise European industry, the Smart Industry Centre (SmartIC) is advancing research in smart production by combining R&D efforts from Tallinn University of Technology (TalTech) and the University of Life Sciences (ULS) in Tartu, Estonia. With new, innovative labs at both universities, the project has enhanced the country's stake in smart manufacturing research and increased its global competitiveness.

FINLAND

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

FRANCE

France AM industry mainly participate in EU projects of Horizon, Erasmus+, Marie Curie programmes. Big companies like Safrane, Addup and Renault profit those projects as well as research centres like CEA, CETIM and IRT. Start-ups are participating indirectly in these EU programmes via regional clusters like Materaila, CIMES and EMC2.

GCA (GREEK CYPRIOT ADMINISTRATION)

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

GERMANY

The BMWi in Germany supports a variety of projects – including SAMPL and ADD2Log – as part of the “Digital Technologies for the Economy (PAiCE)” technology competition. Both funding lines are aimed at consortia of medium sized companies and research institutions. The BMBF also provides support to the “Zwanzig20” Agent3D consortium located in the Dresden region.

GREECE

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

HOLLAND

Several projects are dealing with AM technologies.

- **Grade2XL:** Grade2XL is a joint development programme aligning partners along the value chain to foster the rapid development of WAAM materials and process. Grade2XL will deliver multi-material products of superior quality and performance. The high printing rate of WAAM, combined with the ability to control material properties down to the nanoscale, will enable building strong and durable engineering structures.
- **3DMed:** 3DMed aims to improve affordability and large scale accessibility of medical treatment using 3D printed devices. This goal will be achieved by increasing the TRL of state-of-the-art 3D printing technologies for medical applications and integrating them into a streamlined, fast, cost-effective software platform for use in routine clinical practice.

- InShaPe: The aim of the recently launched EU project InShaPe is to further develop metal-based additive manufacturing. The improved manufacturing process is based on a high-performance optical module with programmable intensity distribution and AI techniques to determine the optimal beam shape for the target object, determined for example by the material type and geometry. InShaPe also develops an innovative process monitoring and control system for quality analysis that integrates multispectral imaging, i.e., simultaneous observation of light of different wavelengths into the area of additive manufacturing. Since 2015, the AM patents registered in the Netherlands are more than 1.700 Patent.

HUNGARY

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

ICELAND

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

IRELAND

Several projects are dealing with AM technologies.

- AERIALIST - Advanced Aircraft Noise Alleviation Devices using Metamaterials
 - Implementing Additive and Cold Spray Techniques for the smart manufacturing of valve components (IMPACT)
 - The Development of Cold Spray towards the Next Generation of Additive Manufacturing
 - New compositions and microstructure evolution of High-entropy alloys for the next generation 3D-printing
- Since 2015, the AM patents registered in Ireland are 148.

ITALY

Several research projects on AM have been developed in the last few years by universities and competence centres:

- University of Florence: RetroFix – MANUNET III project
- University of Bologna: ACMEC – Additive manufacturing and Cyber-physical technologies for the MEchanics of the future

AMAC research group (University of Bologna):

- AUTOR3DICOLARI – towards autonomous construction of gridshell through AM,
- POC – Mobile 3D printer compatible with WAAM technology,
- AGRIAM – DED arc manufacturing of highly customized functional injection moulds,
- SHARKY – Worker-centric programming tools for free designing of lightweight aluminium-based products
- ADDress – Address for Future

Polytechnic of Milan:

- Amatho
- Burner 4.0
- Made 4.0 SIADD
- SAM

National Competence centres:

- CIM 4.0: “ADI”, “AMC”, “BLAPO-FREE” (€40K funds), “RICROCO” (€40K funds), “SCAM” (€20K funds), “SIMPADD”,
- MADE 4.0: “EXO3AGE”, “PASSO” ,
- BI-REX 4.0

Since 2015, the AM patents developed in Italy are 38.

The Italian Space Agency have developed the project “Portable On-Board Printer 3D”, in which a completely automatized 3D printer was brought to the International Space Station (ISS), to test the fabrication of plastic objects, representing the first step toward a digital and automatized objects production directly on ISS.

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

There are some studies seen below;

- Modification of Al-Mg-Sc alloys for further use in 3D printing (Additive Manufacturing) in the form of wire, testing of the obtained material, obtaining properties
- Electromagnetic processing during solidification of nano-particle strengthened light alloys for additive manufacturing
- Experimental 3D printer with integrated software customized for prosthetic printing
- 3D Printing filament from recycled plastic
- FDM and SLS industrial 3D printing technology applicability in serial manufacturing of aircraft interior parts Development of 3D printable aircraft interior parts compliant with EASA safety standards
- Solving the needs of the aviation industry by integration of 3D industrial printing solutions into existing supply chains
- Addressing aerospace industry needs for industrial 3D printing integration into existing supply chain
- Digitally controllable plastic parts manufacturing by building an automated production line with industrial 3D printers.

LITHUANIA

There are some studies seen below;

- 3D print training modules for electric-electronic teachers in vocational high schools
- Demand-driven additive manufacturing upskilling in RIS countries
- VETRIANGLE - Promotion of Web-based Learning via Vocational Education Training Triangle
- 3DP - Training in 3D Printing To Foster EU Innovation & Creativity

LUXEMBOURG

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

MALTA

There are some studies seen below;

- 3DP – Training in 3D Printing to foster EU Innovation & Creativity
- Additive manufacturing of high-pressure hydraulic seals

MONTENEGRO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

NORTH MACEDONIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

POLAND

Several projects are dealing with AM technologies.

AM technologies are primarily explored in the aerospace sector. Some projects on AM have been developed:

- AMgAvio: Magnesium-based alloys processed with SLM technology for aeronautical applications, funded by the Polish National Centre for Research and Development (PNC R&D), coordinated by Wroclaw University of Science and Technology.
- AMpHOra: Additive Manufacturing Processes and Hybrid Operations Research for Innovative Aircraft Technology Development, funded by NCBiR, coordinated by Wroclaw University of Science and Technology.
- InnsLOT: Development of innovative additive manufacturing method for the production of complex thin-walled, nickel-based aircraft engine components, funded by Polish National Centre for Research and Development (PNC R&D), coordinated by Wroclaw University of Science and Technology
- ReCover: Layers and coatings with rhenium, its compounds and alloys properties, areas and methods of application, funded by the Polish National Centre for Research and Development (PNC R&D), coordinated by Nicolaus Copernicus University.

- TiSPHERO: Manufacturing of spherical powders from scraps for special applications, funded by KIC RawMaterials, coordinated by IMN.

Other projects on AM have been developed;

Manufacturing plant of the future, 3M's Super-Hub in Wroclaw: It has a highly automated production and supply chain, modern safety and security measures controlled by drones. 3M SuperHub plant is the largest 3M manufacturing center in Europe, producing within safety and industry, transportation and electronics, healthcare, and consumer solutions fields. The company is introducing innovative solutions in the areas of broad automation and digitalization that leverage big data and artificial intelligence (Industry 4.0) to optimize processes for reduced energy and water consumption, waste reduction and carbon footprint both at 3M plants and in supply chains in collaboration with consumers.

PORTUGAL

There are some studies seen below;

- ADD.Additive – Add additive manufacturing to Portuguese industry
- Additive cooling
- Add Milling to Additive Manufacturing
- ADMIRE – Knowledge alliance for Additive Manufacturing between industry and universities.
- BAMOS – Biomaterials and Additive Manufacturing: Osteochondral Scaffold innovation applied to osteoarthritis
- CLAIMM – Creating Knowledge and skills in AM.
- DESTINE – European DESign TechnIciaNs IEague
- PAMI – Portuguese Additive Manufacturing Initiative
- PRINT-AID – Multidisciplinary European training network for development of personalized anti-infective medical devices combining printing technologies and antimicrobial functionality
- SAM – Sector Skills Strategy in Additive Manufacturing
- SAMT SUDOE – Spread of Additive Manufacturing and advanced materials technologies in plastic processors and mould industries

ROMANIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

SOSA space related projects are implementing about AM.

SLOVENIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SPAIN

There are some studies seen below;

- ALFA – Study of new solutions for the AM industry
- AMable – AdditiveManufacturABLE
- Ampere – A Model-driven development framework for highly Parallel and EneRgy-Efficient computation supporting multi-criteria optimisation
- APEM-AM
- Bio3D – Research on additive manufacturing solutions of biomaterials for biomedical products
- Bioprintia – Industrial investigation of new technologies for the customized treatment of osteoarticular pathologies of the knee by Artificial Intelligence and cellularized implants generated by 3D printing
- Cardiopatch – Cardiac Regenerative Medicine and 3D printing applied to Myocardial Infarction treatment
- Cardioprint – Advanced multifunction 3D biofabrication for the generation of computationally modelled human-scale therapeutic cardiac tissues
- CAxMan – Computer Aided Technologies for Additive Manufacturing
- CEFAM – Strategic program for the catchment of excellence in the additive manufacturing of metal materials
- CLLAIM – Creating knowLedge and skills in Additive Manufacturing
- COMSENSO – WAAM Additive Manufacturing technology assisted by sensorized multimaterial laser
- CUSTODIAN – Customized photonic devices for defectless laser-based manufacturing
- DAAMAS – Development of wire Arc Additive Manufacturing processes for Aeronautic large Structures
- DESTINE – European DESign TechnlcialNs IEague
- EWIRA – Design and manufacture of AM parts for critical flight application
- I4MS – ICT Innovation for Manufacturing SMEs
- Nemarco – New manufacturing routes (for NiCrSiFeB alloys) to replace cobalt in aircraft components
- NINFA – Research for the development of aerospace solutions with new methods of evaluation, design and inspection in additive manufacturing adapted to the entire supply chain
- OPTIFLY3D – Research on the integration of adaptive design and topological optimization with advanced manufacturing technologies for the generation of high-requirement aeronautical components
- PROTECTOR – Development of the process of high-level protection for the manufacturing of metal materials by hybrid technology LMD-CNC
- Readi – Network of Excellence in Additive Manufacturing
- SAM – Sector Skills Strategy in Additive Manufacturing

- Triankle – Innovative personalized collagen- and gelatine- based implants manufactured with 3D technology for patients suffering from osteoarticular diseases
- Validdantenness – Validation of the additive manufacturing of antennas for aerospace applications
- Vet in 3D – Promote innovation and opportunities among VET operators
- 3D2Act – Fostering Industry 4.0 and 3D Technologies Through Social Entrepreneurship: An Innovative Program for a Sustainable Future

SWEDEN

Several projects are dealing with AM technologies.

- 3D-Action: 3D-printing for the next generation of product and production solutions 16 MSEK.
- MANUELA: Additive Manufacturing Using Metal Pilot Line. 15.6 M€.
- ProThin: Robust additive manufacturing of components with thin walls and narrow channels.
- Establishment of the Application Center for Additive Manufacturing MSEK.
- National testbed for SME in additive manufacturing 1.5 MSEK.
- DREAM – Data dRiven process control in mEtal Additive Manufacturing.
- DiDAM - Demonstration of Infrastructure for Digitalization enabling industrialization of Additive Manufacturing.

TURKEY

Turkish government and private sectors support different sorts of projects in AM technologies. Ministry of Industry and Technology and TUBITAK has been announced several projects calls for private sectors, universities, and research centres in AM technologies. These project calls are classified based on the needs and the requests from the sectors. The project topics are innovative technological areas in AM, such as machinery, software, hardware, sensors, control and optical equipment's etc.

Besides, EU funded Pre-Accession Assistance (IPA) projects are also exist and there several IPA projects funded in AM Technologies.

The list of IPA projects Ministry of Industry and Technology, Competitive Sectors Programme

Project Title	End Recipient of Assistance	Location
DiMAP – Direct Digital Manufacturing Platform	Sabancı University	İstanbul
ALUTEAM: Joint Research Center for Digital Transformation of the Aluminium Industry	Fatih Sultan Mehmet University	İstanbul

Smart Technologies Design, Development and Prototyping Centre (STEDEC)	Konya Karatay University	Konya
Eskisehir Design and Innovation Centre (EDIC)	Anadolu Teknoloji Araştırma Parkı San. ve Tic. A.Ş	Eskişehir

National Patents registered in last two years*

Patent No	Patent Title	Patent Holder
2022/012724	Additive Manufacturing Production And Risk Costs Calculation System And Method	Norm Eklemeli İmalat Teknolojileri Anonim Şirketi
2022/005269	Additive Manufacturing Machine Blowing Unit	Ermaksan Makina Sanayi Ve Ticaret Anonim Şirketi
2021/021555	Method Of Heating The Powder Layer In Powder Bed Fusion Additional Fabrication Machines	Sentes-Bir Metalurji Kimya Enerji Üretim Ve Geri Dönüşüm Teknolojileri Sanayi Ticaret Anonim Şirketi
2021/020076	Additive Manufacturing Method With Spraying	Tahir Soyugüzel
2021/019677	Quick-Change Multi-Size Additive Manufacturing Table System	Alper Canbolat, Bayram Berk Tanrisevdi
2021/017773	Thermal Management System Of Static Mixer Made With Traditional Or Additive Manufacturing	Bursa Uludağ Üniversitesi
2021/004413	Additive Manufacturing Method For 3d Printing With Metal Or Ceramic Additives Using Photopolymer And 3d Printer Using This Method	T.C. Erciyes Üniversitesi
2020/22131	Metal Filler Additive Manufacturing Method With Direct Energy Input	Coşkunöz Kalıp Makina Sanayi Ve Ticaret Anonim Şirketi
2020/19776	Development Of 3d Metal Additional Molds For Making Glass Products	Merkad Makina Kalıp Sanayi Ve Ticaret Limited Şirketi

* The whole list can be obtained from the web site <https://www.turkpatent.gov.tr/arastirma-yap?form=patent> by typing 'Eklemeli İmalat or üretim'. There will be more than 50 results will be appeared.

6.2.6 Challenges in AM

ALBANIA

Currently, government is not actively supporting the transition to AM from traditional. Much research regarding AM technologies needs to be done via companies and government for the correct integration to AM in Albania.

AUSTRIA

In Austria, to this end, efforts are being made to strengthen and disseminate additive manufacturing across the entire interdisciplinary value chain, involving all key stakeholders and interfaces for effective activities at national and international level.

BELGIUM

Belgium suffers from qualified labour force in AM either as blue collar or white-collar employees. To overcome this problem, strict rules of immigration from non-EU countries has been excluded for AM engineers and other critical proficiencies like medicine and software development.

BOSNIA HERZEGOVINA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

BULGARIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

CROATIA

The reported information shows the limited public and private grants in AM, which lead to a minor number of projects devoted to this field. Moreover, a lack of AM specialist's results in fewer companies devoted to AM technologies, and a lack of educational courses for employers and students.

CZECH REPUBLIC

The Czech Republic Industry 4.0 initiative SWOT analysis points the absence of own know-how in the field of additive manufacturing applications as a threat.

ESTONIA

Estonia, as a small country, there are only a few large international corporations and most of the engineering companies employing mechanical manufacturing are SME's (< 100 employees). This in turn means a significant investment in new and unknown technology carries high risk. It is therefore crucial for the engineers and decision-makers to get acquainted with AM to learn the capabilities of the technology and to gain confidence for its implementation within their manufacturing process.

FINLAND

The challenge for Finnish AM industry is to coordinate a national innovation strategy to help organisations to attract EU funding instruments to develop new technology and applications. To some extent, development activities in Finland have created new start-ups focused on AM. However, this has been limited to AM service providers that incorporate new machines to

process basic materials, development of consumer level material extrusion technologies, and small companies that provide all kind of services related to consulting basic AM services.

FRANCE

The main challenge for AM industry in France is language. The system of education for English is poor in the country causing a difficulty for integration to the global AM value chain whereas English is the main language of AM business.

GCA (GREEK CYPRIOT ADMINISTRATION)

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

GERMANY

The main challenges in Germany:

- Education and training
- Strengthening industry
- Standards
- Definition of research topics
- Research: Facts and figures, profiles and showcases
- Strategy: Positioning and internationalization

The pandemic strongly impacted global economies, including Germany. The German government forecasts German economy to reach pre-pandemic levels by 2022. It can be expected that its economy will start to pick up in the second quarter of 2021, likely to trigger increased demand, also for AM equipment.

GREECE

Profitability of products produced with AM is lower than traditional manufacturing. Another problem is the lack of certification for AM materials. Institutes cannot replace or integrate AM to their production lines due to standardizations. Finally, design knowledge for AM is not at the proper level for productions to be feasible.

HOLLAND

The reported information shows that the potential of AM technologies is recognized by the government and private companies, resulting in public and private grants. The funds have been adopted to promote education and training, as well as research projects, aiming to push the boundaries of the current knowledge about AM technologies (training of AM specialists, and knowledge advancement in AM processes and materials).

HUNGARY

There are some reportings emphasized integration of the AM technology in the industrial sector beyond the production of printers.

ICELAND

AM is still considered to be a new and developing manufacturing method.

IRELAND

Although AM was first used commercially in the mid-1980s to produce concept models, design or functional prototypes and visualization tools, more recent advances in printer and material technology have enabled AM to expand to applications such as factory tooling, spare parts and end-use products. AM is currently used primarily for low-volume parts production, but it is also slowly becoming a valued part of production processes more generally. And yet, a recent study found that 63 percent of enterprise AM users deploy the technology for prototyping, while only 21 percent use AM for items that cannot be made with any other manufacturing technology.

ITALY

As reported in the study conducted by the Observatory on Additive Manufacturing [46], the first obstacle to the massive adoption of AM technologies is represented by the lack of sufficient knowledge and specialists with adequate specific training about AM technologies, materials and processes. The big challenge is the possibility of training investments within specific laboratories, with the consultancy of universities and other research institutions.

KOSOVO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

LATVIA

Challenges have been reported in the following areas;

- Support the introduction of innovative solutions in companies.
- Encourage the cooperation between the companies and educational institutions.
- Development of specific AM training courses.

LITHUANIA

Challenges have been reported in the following areas;

- Support the introduction of innovative solutions in companies.
- Fostering the development of training in the 3D printing skills proficiency among students, youth, and adults.

LUXEMBOURG

Challenges have been reported in the following areas;

- Consolidating the current use of AM technologies in the Luxembourg industry.
- Development of specific AM training courses.

MALTA

There is a clear interest in fostering the development of training in 3D Printing since the main objective of the Erasmus+ project 3DP is to increase the 3D printing skills proficiency among students, youth and adults from Romania, Poland, Spain, Italy, Lithuania and Malta.

MONTENEGRO

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

NORTH MACEDONIA

Material variations are not enough to integrate into manufacturing completely. Comparisons with traditional production in cost and final quality are not enough.

POLAND

While Poland is ripe for seizing opportunities in advanced manufacturing, the country does need to overcome some obstacles that may hold Polish industry back (e.g., specific regulations and a lack of technological standards, shortages of experts in the field, limitations of existing digital technologies, and a reluctance to adopt new solutions). There is also a need to introduce ethical and legal standards for the use of artificial intelligence and robots; such standards are being discussed at the EU level. However, recent analysis indicates that Poland has much potential in industrial automation and manufacturing technology.

Opportunities include:

- Additive manufacturing equipment
- Sensors and instruments
- Electric motor and actuators
- Electrical relays and industrial control equipment
- Material handling equipment
- Industrial robots
- Machine tools for cutting metal and forming metal pieces
- Machine tools parts
- Tools for manufacturing applications
- Welding and soldering equipment
- Plastics and rubber manufacturing equipment
- Industrial molds

There are also good prospects for IoT, advanced analytics, virtual reality, augmented reality, and general innovative solutions as the key elements toward the development of Industry 4.0 in Poland.

PORTUGAL

- Standardization and material specification
- Build volume development
- Speed of production
- Reproducibility and repeatability
- Surface quality improvement
- Process understanding & certification
- Suppliers' certification
- Engineering development
- Awareness of technology
- Training of professionals
- Supply chain optimization

ROMANIA

The biggest problem is lack of standardization in AM. Companies cannot integrate AM to their current production lines.

SERBIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVAKIA

Large-scale studies and policies in the field of additive manufacturing have not been achieved.

SLOVENIA

More R&D is needed to properly adapt to AM.

SPAIN

- Technical limitation to achieve the required properties in the final product.
- Speed and volume of the production.
- Certification of the parts and final products.
- Integration of AM in other manufacturing methods.
- Cost of raw materials, machines and/or transport.
- Change in the way of thinking regarding the design.
- Necessity of post-processing.
- Industrial property, taxation, and security of the manufactured products.

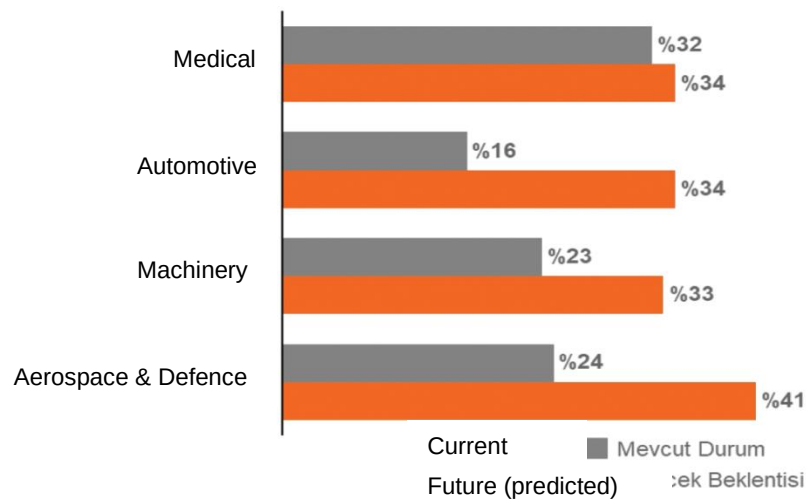
SWEDEN

The strong materials technology position of Sweden can be a game changer both when it concerns tuning of existing materials as well as developing completely new materials to meet emergent AM needs. This can serve as an ideal foundation to undertake a concerted effort to evolve strategies for rapid material development for metal AM applications at a competitive cost, using best practices from the powder technology field.

Since both powder bed and blown powder technologies use powder as raw material, such an effort is integral to addressing the pressing need to augment the AM materials' portfolio to yield new functionalities and expand the application spectrum. Inspiration for this can be drawn from Sweden's well-known success in the medical sector, which was fuelled by extensive research devoted to the development of new types of materials and allied processes specifically for dental and medical device segments. As a specific example, a similar focus on the development of aerospace relevant light alloys for AM has the potential to not only establish a niche but also lead to other spin-off applications. Overall, the Swedish strength in powder technology is, therefore, a key enabler for the industrialization of AM.

TURKEY

Maturity level of AM is a measurement of how AM is used, applied, and understood in the design and manufacturing of products using AM. There four sectors are leading in such measurement and there are: Medical, Automotive, Machinery and Defence & Aerospace. In the figure below, the current and predicted maturity level of sectors in percentage can be



Current and predicted future maturity level of AM in different sectors in five years

Additive manufacturing technologies need high-technology machines and high-quality materials. Machined and material suppliers are generally from abroad and imported with foreign currencies.

Due to high rate of exchange rates of USD and Euro, the overall cost of such machines and materials cannot be afforded by SMEs and entrepreneurs who are willing to invest on AM. In addition, the number of companies which are familiar with AM is still limited and therefore AM service companies are having difficulties to sustain their business. The most demand is coming from aerospace companies, but the number and capacity of such companies are very less, and these companies make investment in their own AM facilities and contact abroad AM suppliers. Thus, AM ecosystem cannot be strengthened and getting demands to grow up and enlarge their business capacities.

Skilled persons in terms of engineers, technician, operators, and hardware/software engineers are still needed in AM sector. Consciousness in AM and application capabilities of AM are not yet understood well in many SMEs.

Raw materials particularly in powder form are under special restrictions in importing and transportation. Metal powders production needs high technological machineries, and one or two companies are existing in this area. The most used metals powders especially Ti-6Al-4V and other superalloy powders cannot be produced locally and imported. The lack of production of such powders increases the lead time of the products and overall cost.

Laser is highly critical technology in AM since most of the AM machines uses laser as a heat source. A laser system used in AM machines is a combination of laser resonator, beam profiler, galvo scanner, lenses, cooling units and other equipment's. Although there are some private attempts to develop and produce domestic laser system brand, those lasers cannot be used in AM machines.

Also, lenses, optical apparatuses, software, and hardware, as well as gas systems cannot be supplied domestically and therefore investors are not willing to put money on AM machinery or system development.

Turkish government put an excellent intention to promote private sector, research centres and universities on the development and use of AM. The government gave grants to established national research centres, laboratories, and research projects. Although such ventures increase the maturity level of AM, the dependency in the aforementioned technologies still continues.

Conclusion of The Reports

Additive Manufacturing (AM), also known as 3D printing, is a process of building objects by adding material layer by layer based on a 3D model. It is a combination of various processes embedded in one. While humans have been using AM unknowingly for centuries, the formal development of AM began with the advent of 3D CAD systems in the 1970s.

In the 1980s and early 1990s, several rapid prototyping processes were developed, including Stereolithography (SLA), Selective Sintering (SLS), Fused Deposition Modeling (FDM), and Laminated Object Manufacturing (LOM). These processes laid the foundation for the growth of AM technologies. Initially, AM was primarily used for prototyping, but it has now expanded into industrial manufacturing with defined interfaces and specified requirements.

AM is considered one of the game-changing technologies in manufacturing, along with Advanced Industrial Robotics, Industrial Internet of Things (IIoT), Electrical Vehicles (EV), and Industrial Biotechnology (IB). These technologies have the potential to significantly improve labor productivity and transform various industries.

The market for AM has been growing rapidly. According to the Wohlers Report 2021, the global AM industry, including products and services, reached \$15.24 billion in 2020, with a growth rate of 19.5%. The market is divided into products (AM systems, materials, software, etc.) and services (revenues generated from parts produced on AM systems). The polymer AM market is about 2.5 times bigger than the metal AM market.

AM has found applications in various industries. The medical industry is one of the prime customers, followed by aerospace and defense, automotive, and energy sectors. AM allows

meet industry performance
the production of lightweight

The European Patent Office
ns in 2018 alone. Industrial
technologies are the main areas
the largest number of patent

and advancement of AM
raw material manufacturers,
ion programs. However, the

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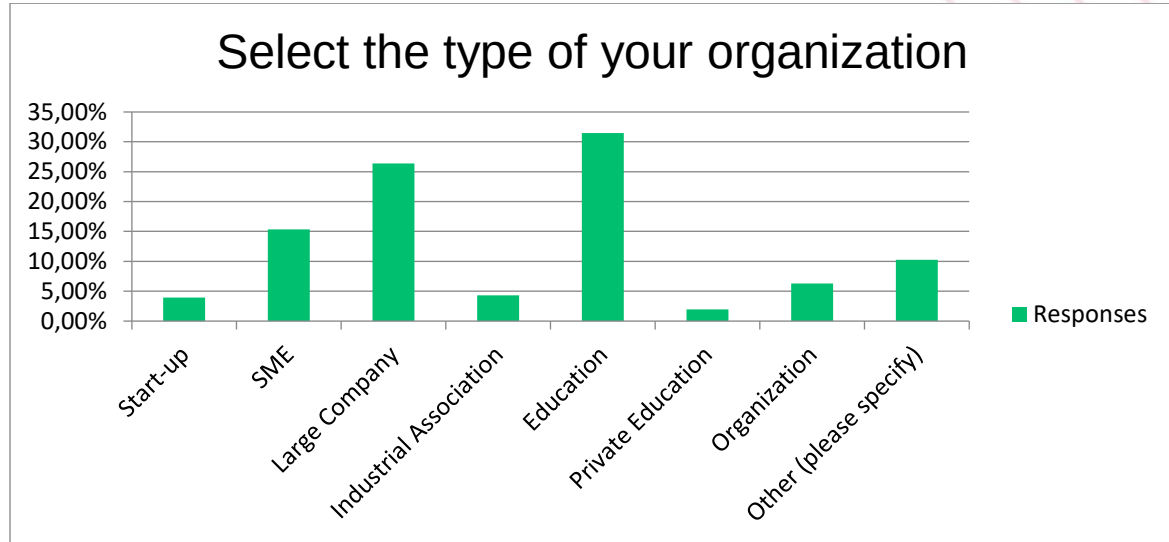
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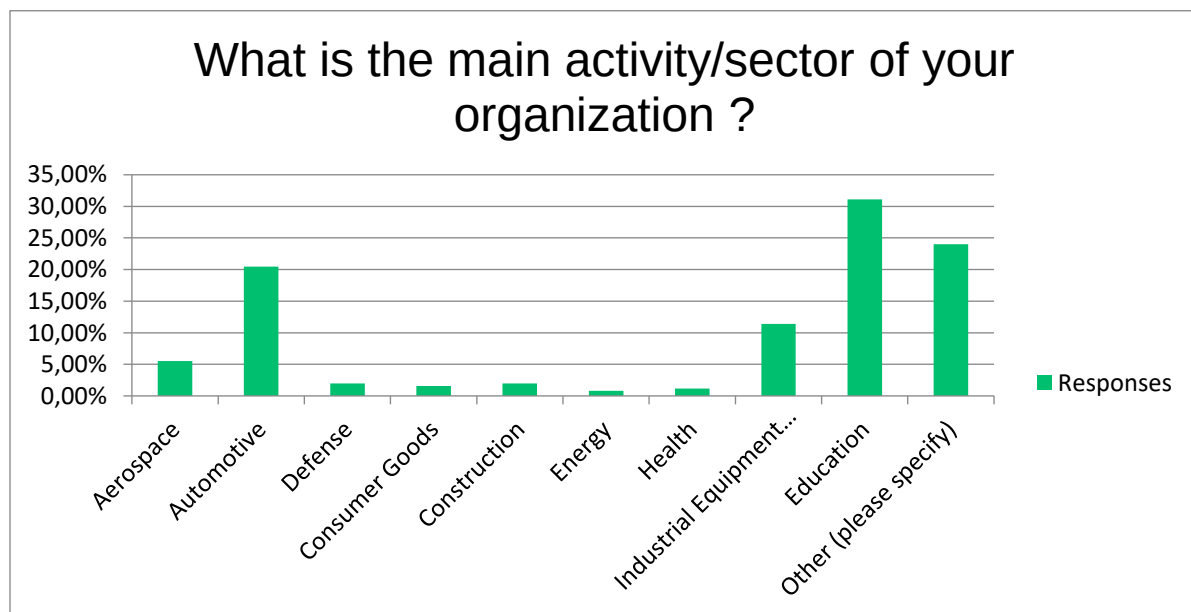
and advancement of AM
raw material manufacturers,
ion programs. However, the

Q: Select the type of your organization



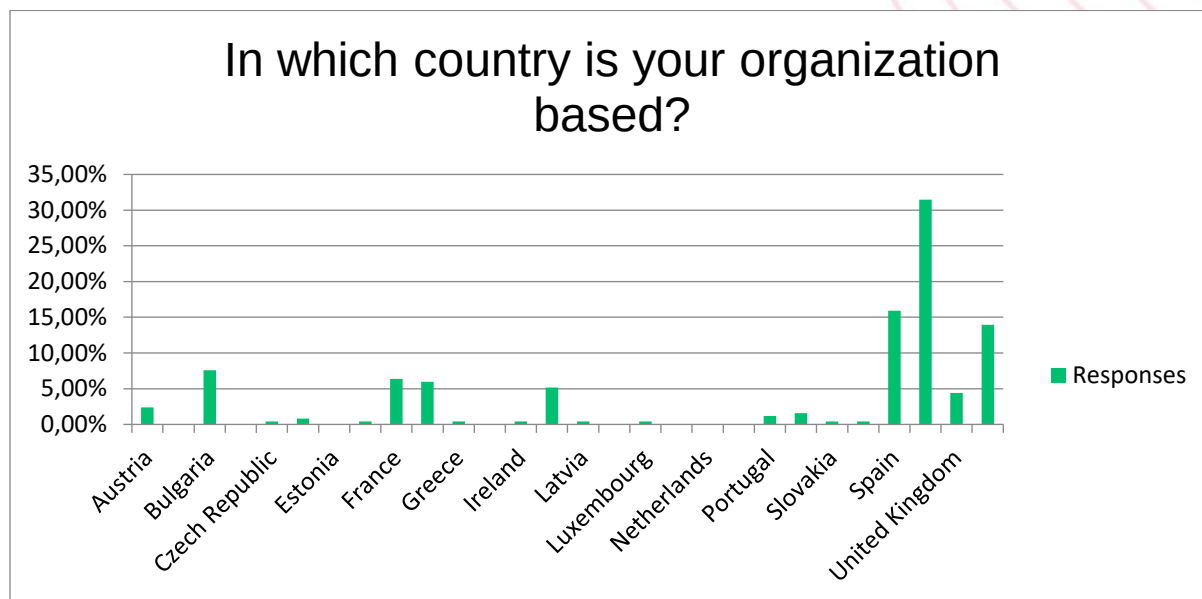
It is obvious that the technology is being followed by large companies and education institutions. Education institutions; this is because the network of the project partners composition; half of the partners are education and training institutions. Large companies; this is because the investment requirement on AM is high considering other technologies. It is interesting to see the third biggest share is on the SME, this shows the potential.

Q: What is the main activity/sector of your organization?



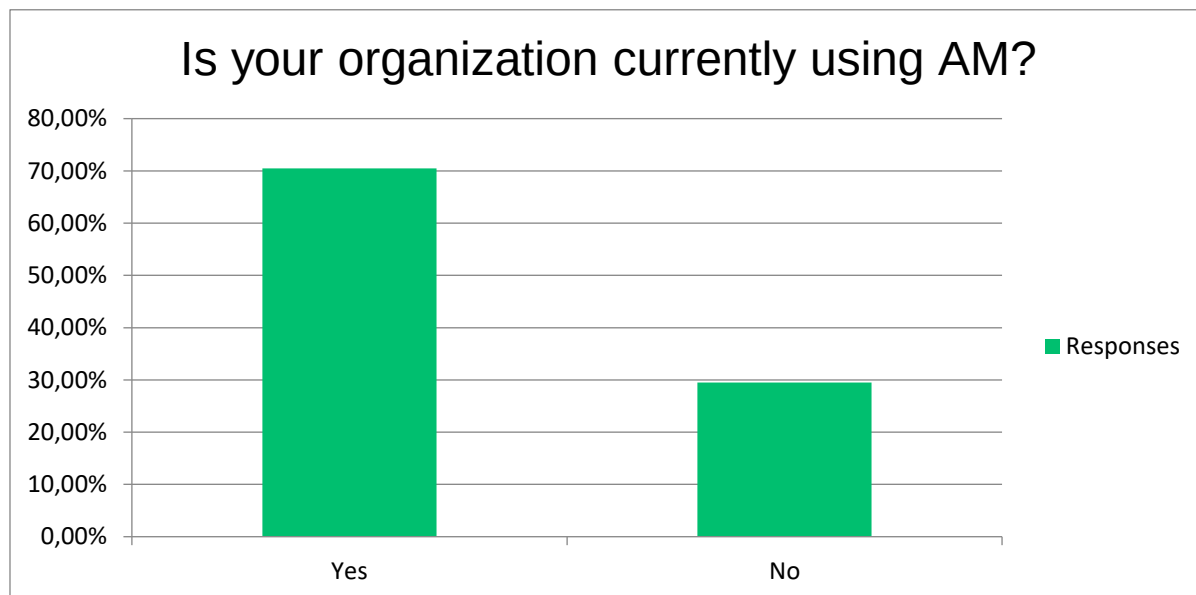
The composition of survey results again reveals the network of partners. It is interesting to see "other" as the second most marked answer. Other; Rolling Stock Manufacturing, Metal / Alloy powder Producer, Additive manufacturing, Research, Nuclear, AM Service Bureau

Q: In which country is your organization based?

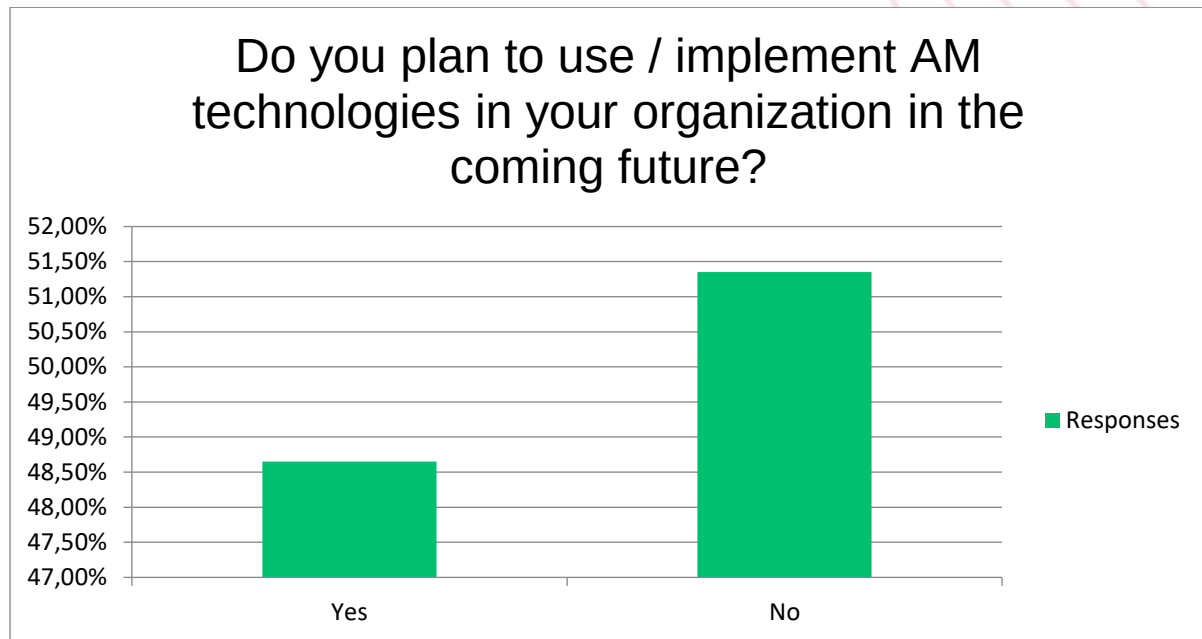


The composition of survey results again reveals the network of partners. It is interesting to see "other" as the third most marked answer.

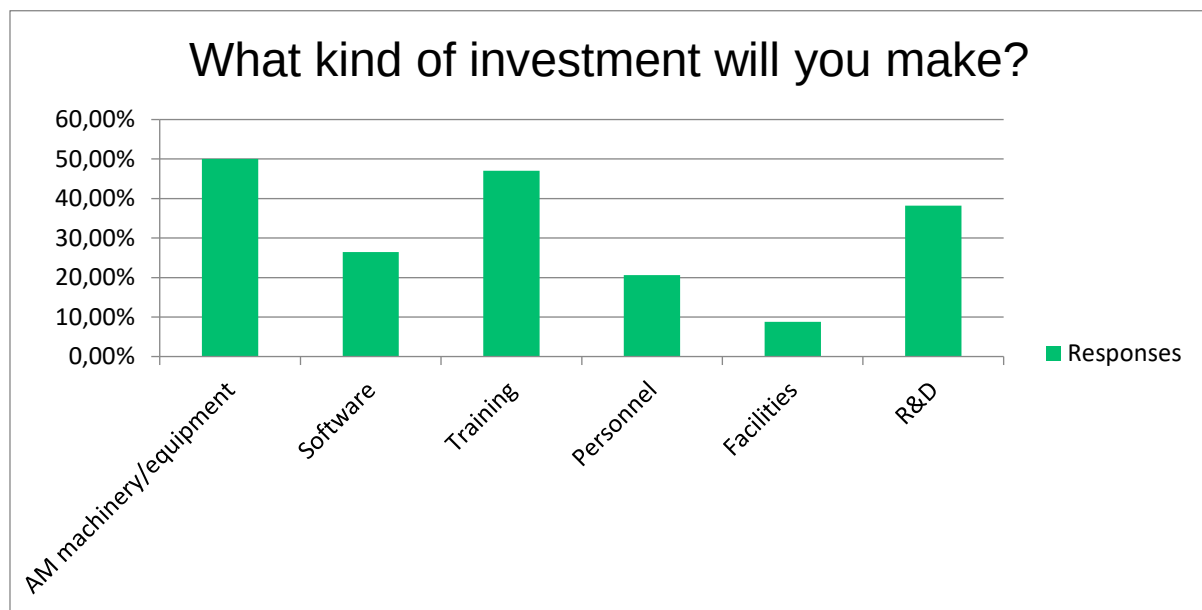
Q: Is your organization currently using AM?



Q: Do you plan to use / implement AM technologies in your organization in the coming future?

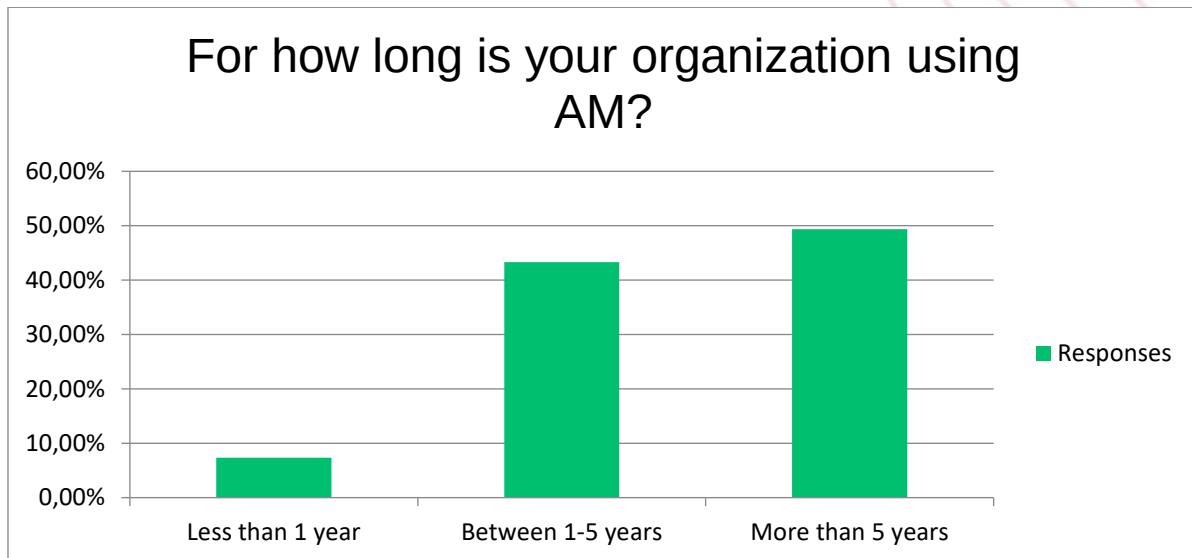


Q: What kind of investment will you make?



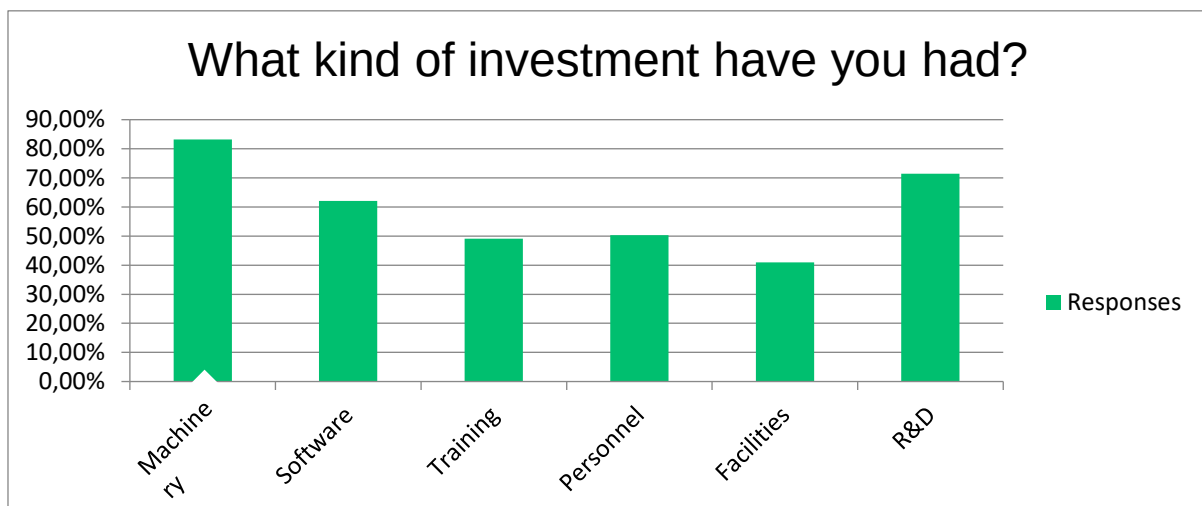
It is seen by the responds to this question, training is the second investment that is required by the survey respondents. Also, it is indicative that nearly %20 percent of the respondents stated "personnel investment". Both in fact indicates the qualification about AM is critical.

Q: For how long is your organization using AM?



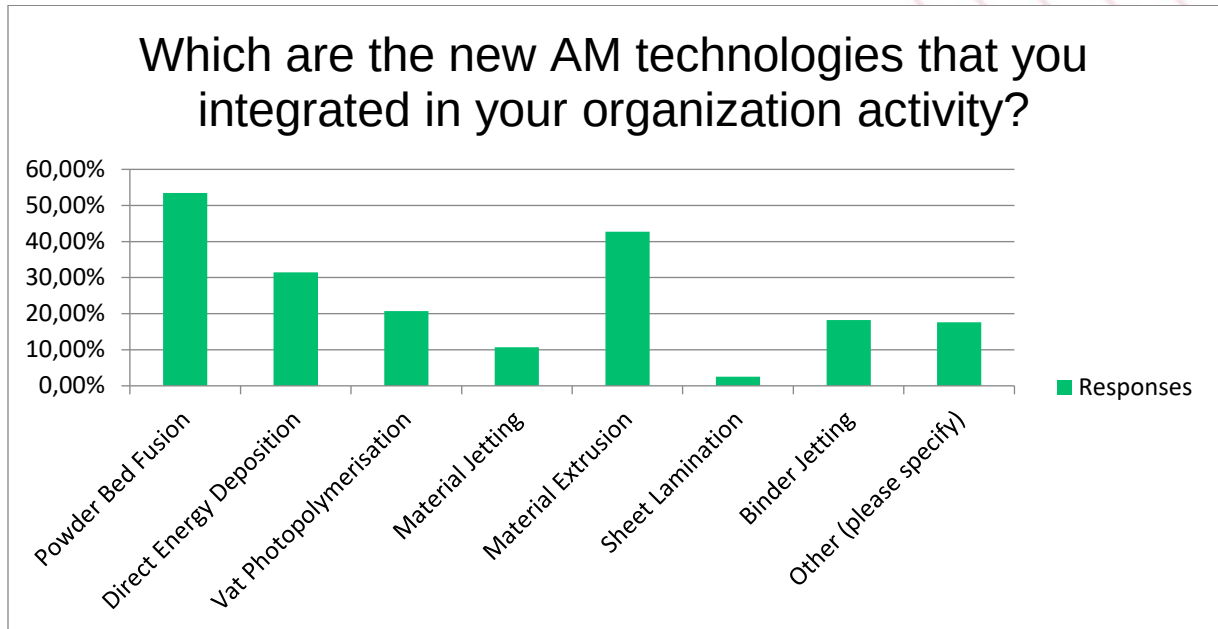
Survey respondents are users of AM technology in fact more than 5 years is nearly 50%. But still they will invest training and personnel as stated in the previous graph.

Q: What kind of investment have you had?



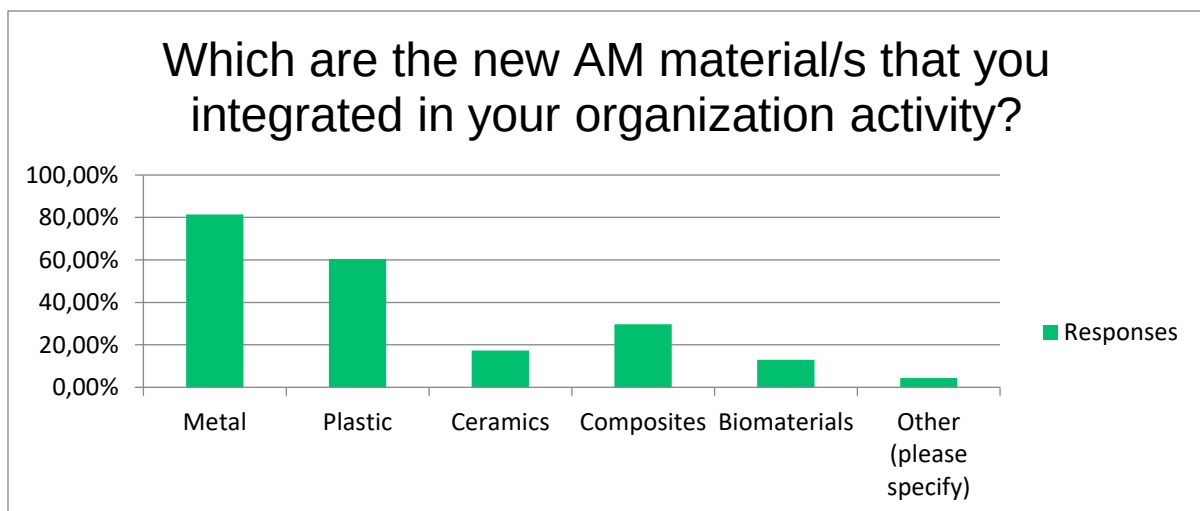
The respondents' 50% had already made investment on training. Still, they urge for training as responded to previous question for future investment.

Q: Which are the new AM technologies that you integrated in your organization activity?



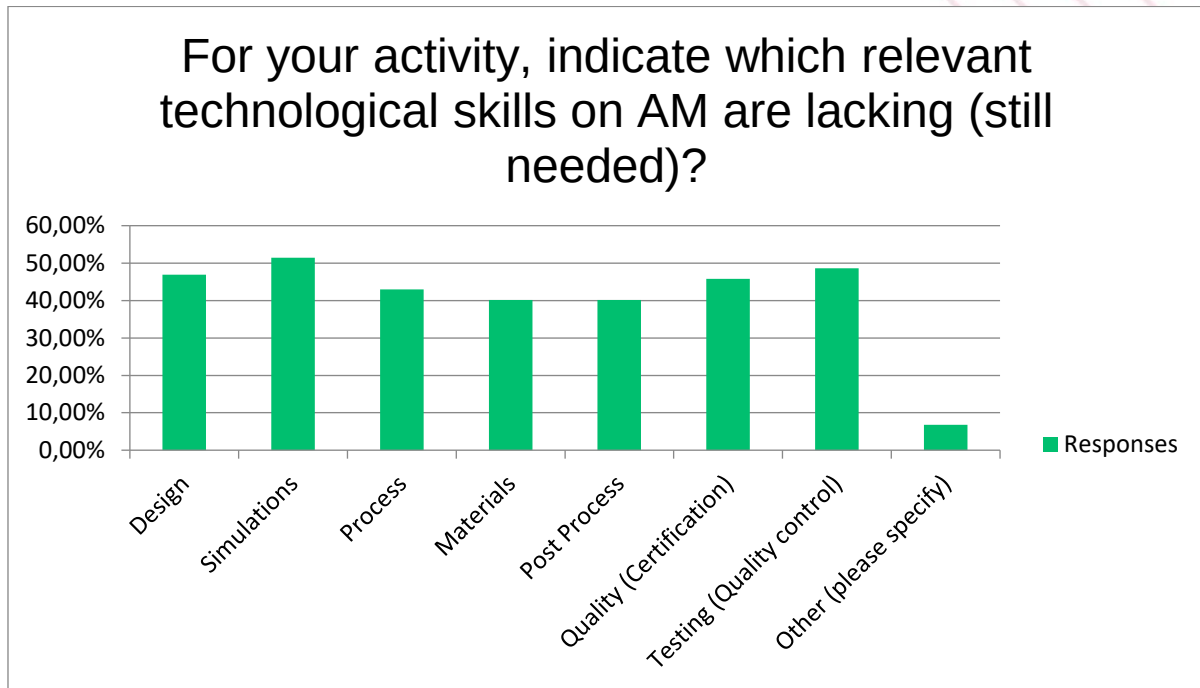
This shows the maturity of technology among the respondents. On average two response for each respondent, meaning two different technologies for each respondent.

Q: Which are the new AM material/s that you integrated in your organization activity?

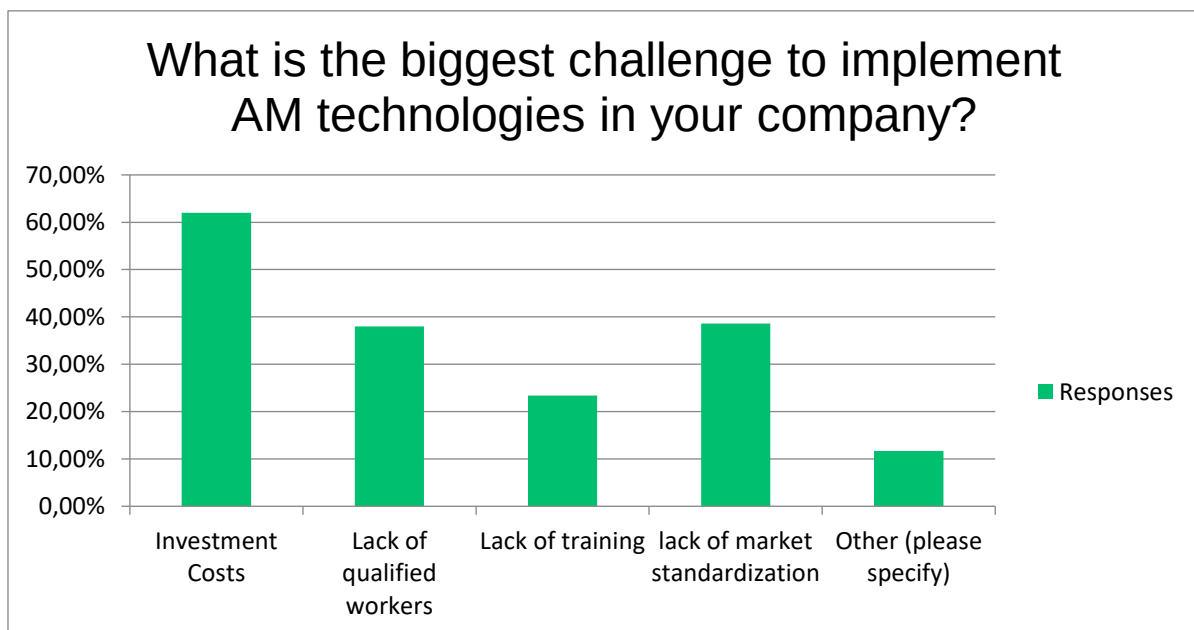


Twice the number of respondents; two different materials are integrated.

Q: For your activity, indicate which relevant technological skills on AM are lacking (still needed)?

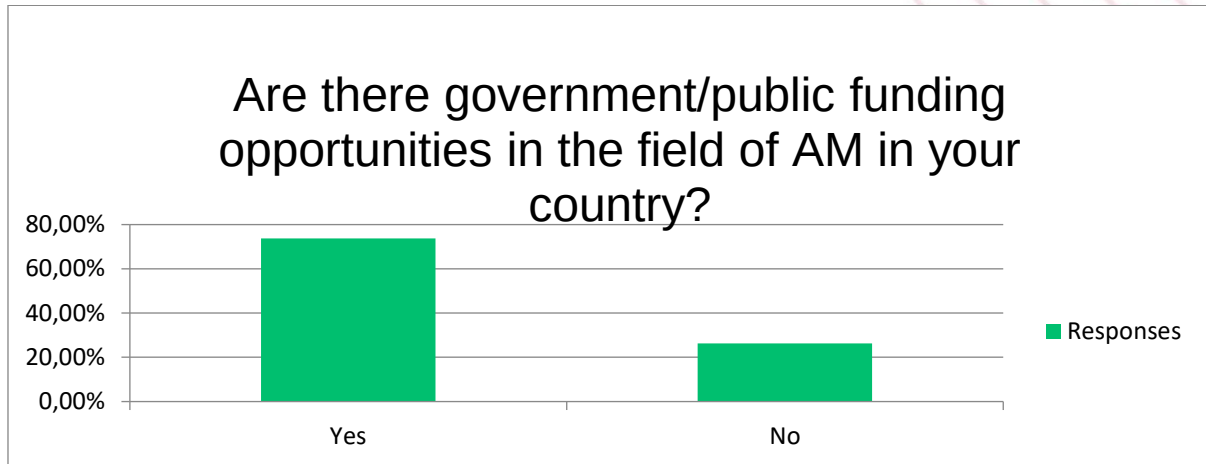


Q: What is the biggest challenge to implement AM technologies in your company?



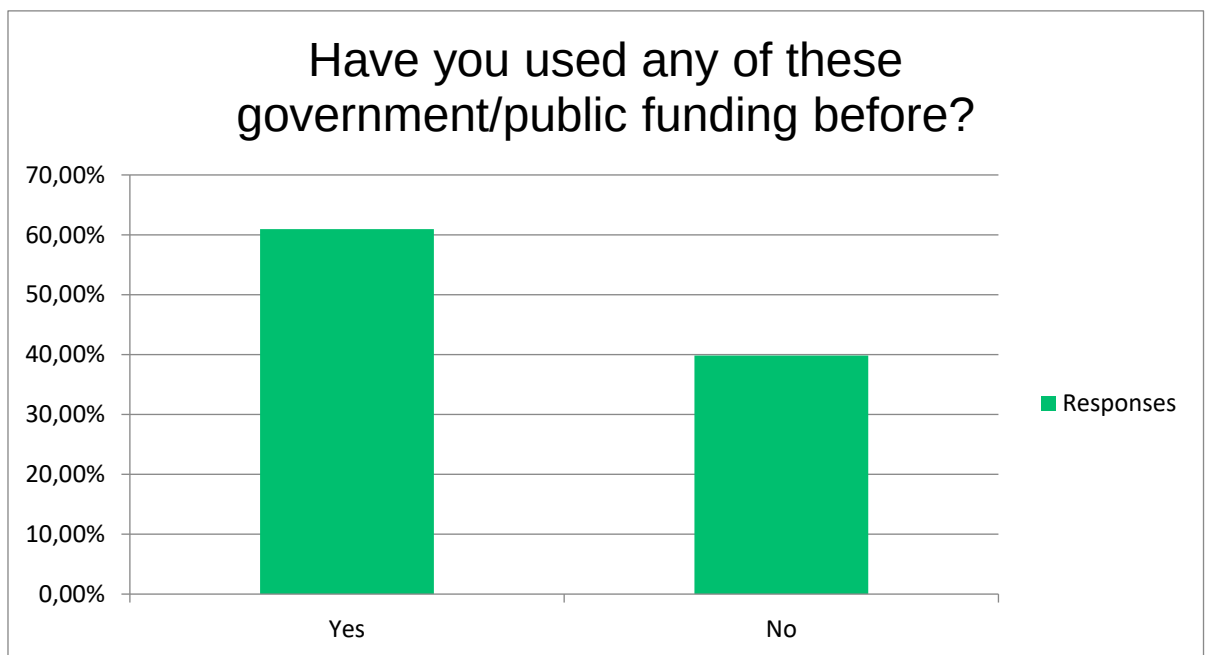
As expected, first issue is investment costs. The followings are lack of qualified worker and lack of market standardization.

Q: Are there government/public funding opportunities in the field of AM in your country?



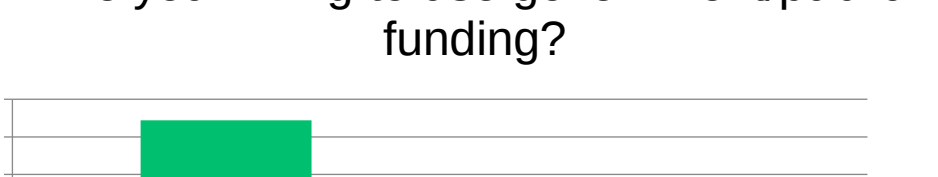
It is clearly observed that, there are fundings for the future of technology. This could be a solution for the biggest challenge on implementing AM.

Q: Have you used any of these government/public funding before?



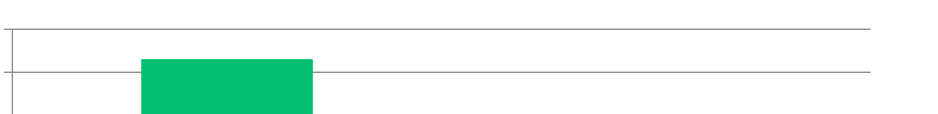
Nearly %60 have already used the funding. But still there are nearly %40 who has not used any funding.

Are you willing to use government/public funding?

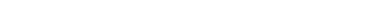
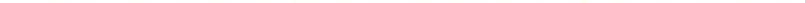


Response	Percentage
Yes	95,00%
No	5,00%

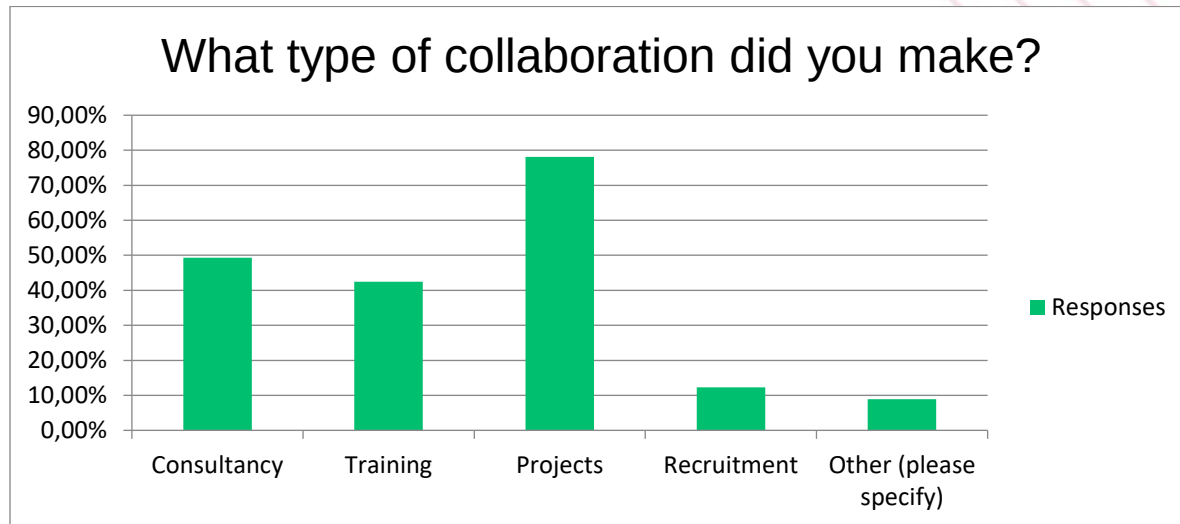
Do you collaborate with universities/research institutions/laboratories about AM technologies?



Response	Percentage
Yes	85,00%
No	15,00%

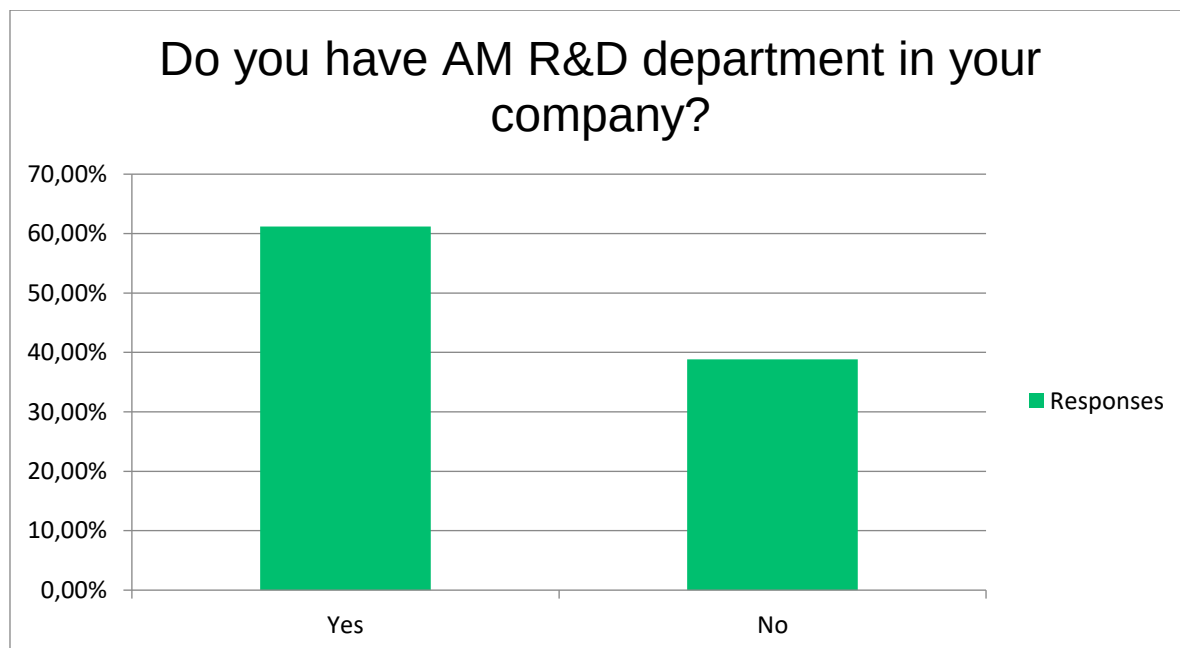



Q: What type of collaboration did you make?

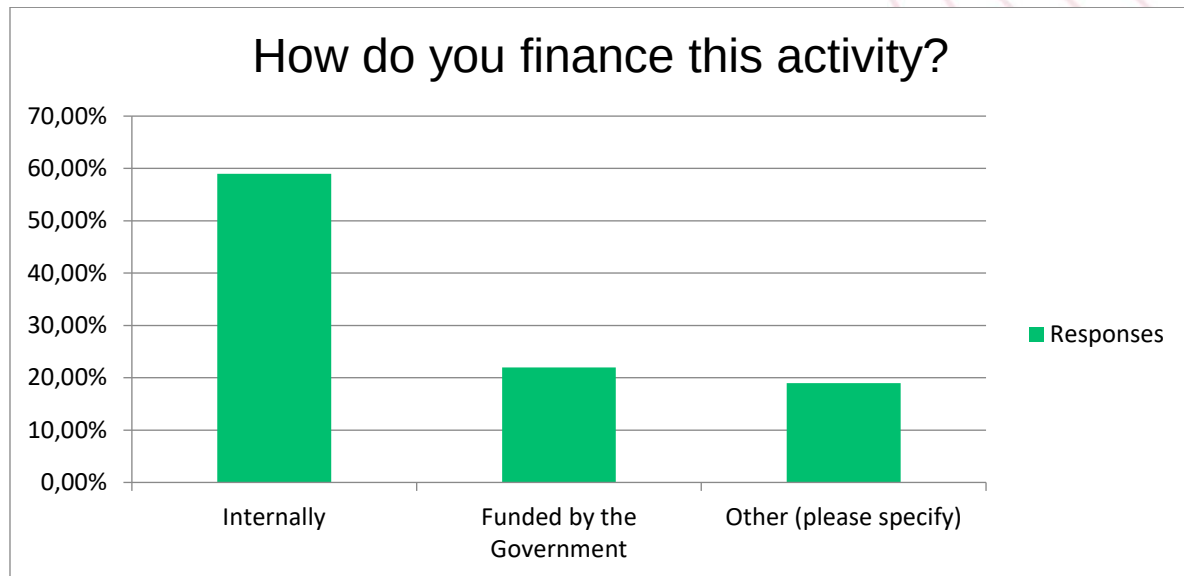


Every respondent gives two answers on average. The main activity is observed to be project collaboration with universities. But also, consultancy and training are the following subjects.

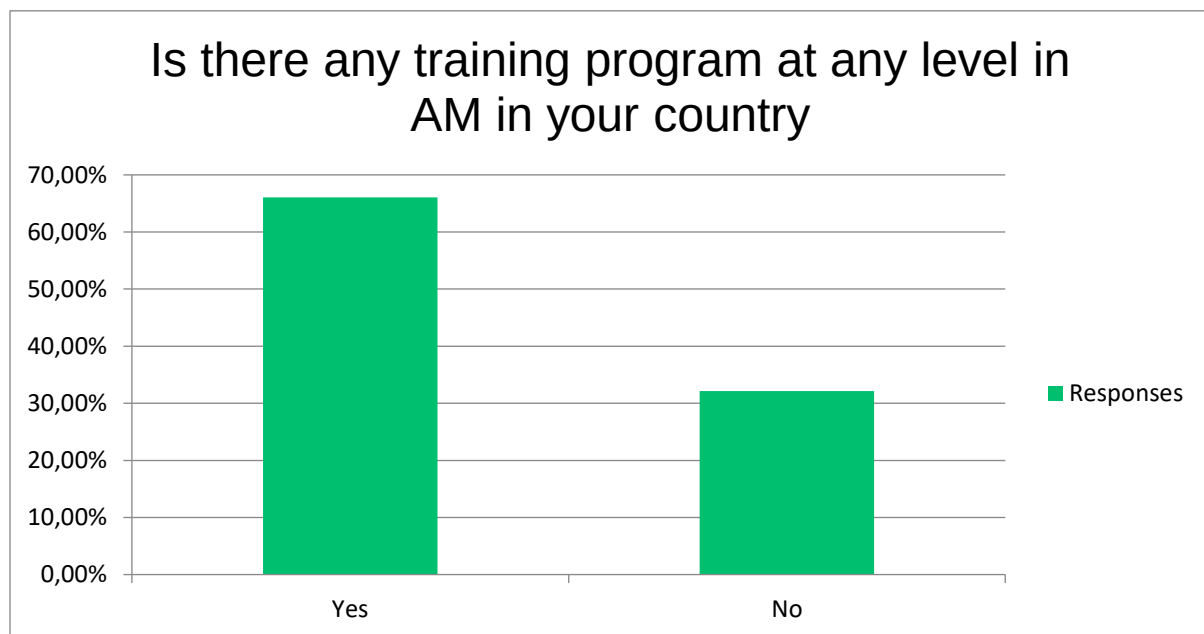
Q: Do you have AM R&D department in your company?



Q: How do you finance this activity?

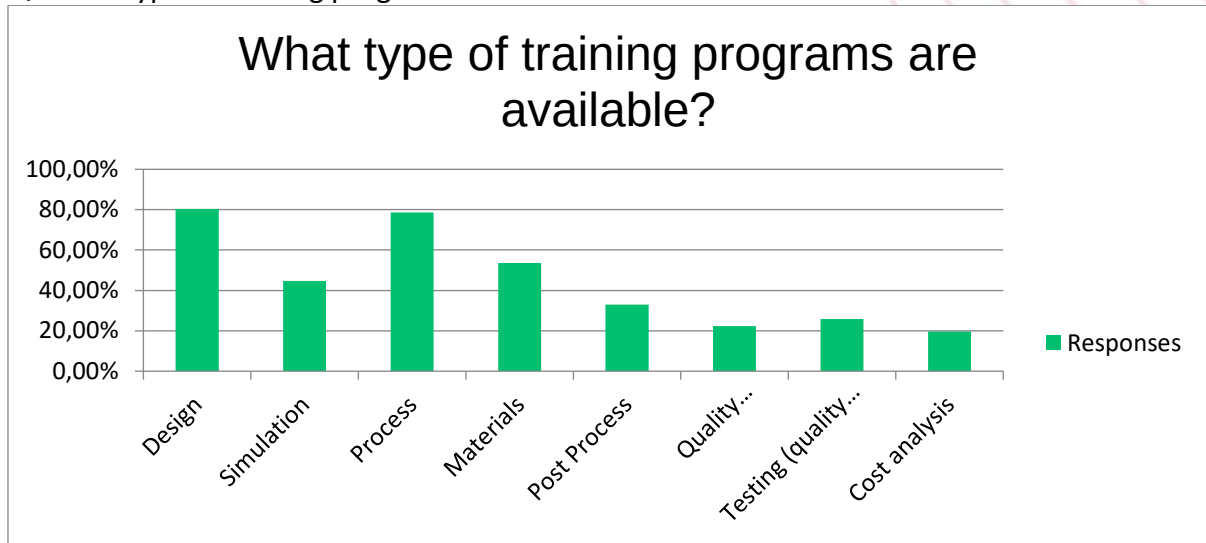


Q: Is there any training program at any level in AM in your country?



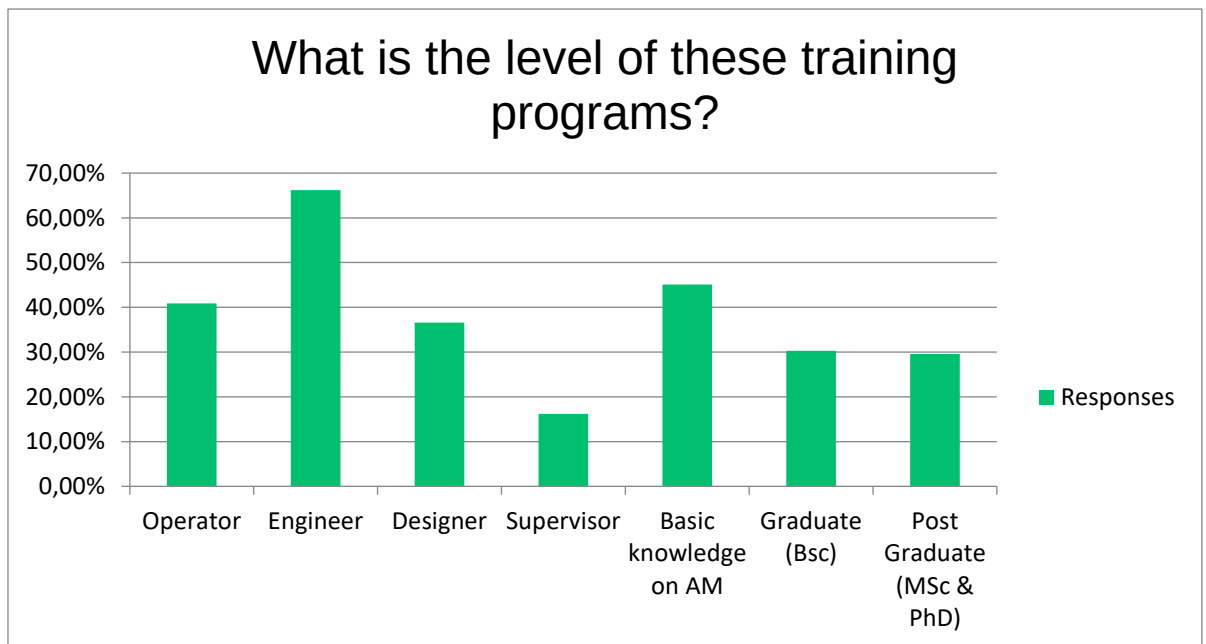
The survey respondents need improving the skills on AM. %65 responding as "yes" indicates their search on this. More than %30 states "no" which clearly shows the need.

Q: What type of training programs are available?



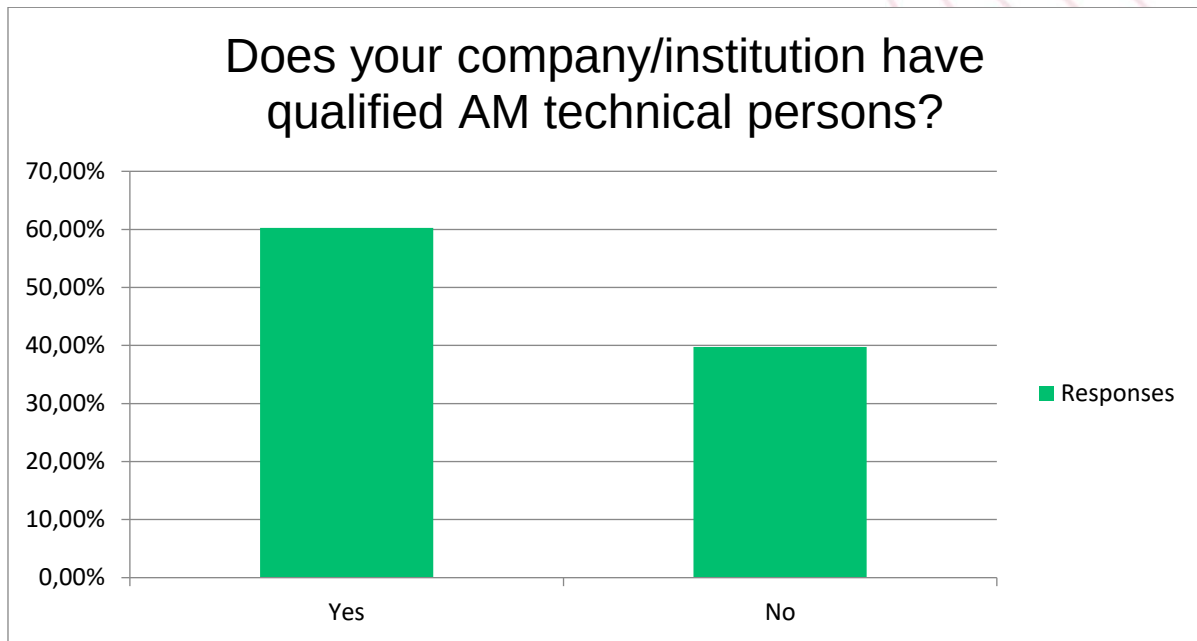
When skills needs and available training programs available are evaluated together, it shows that although there are programs available, the need for skills are still lacking.

Q: What is the level of these training programs?



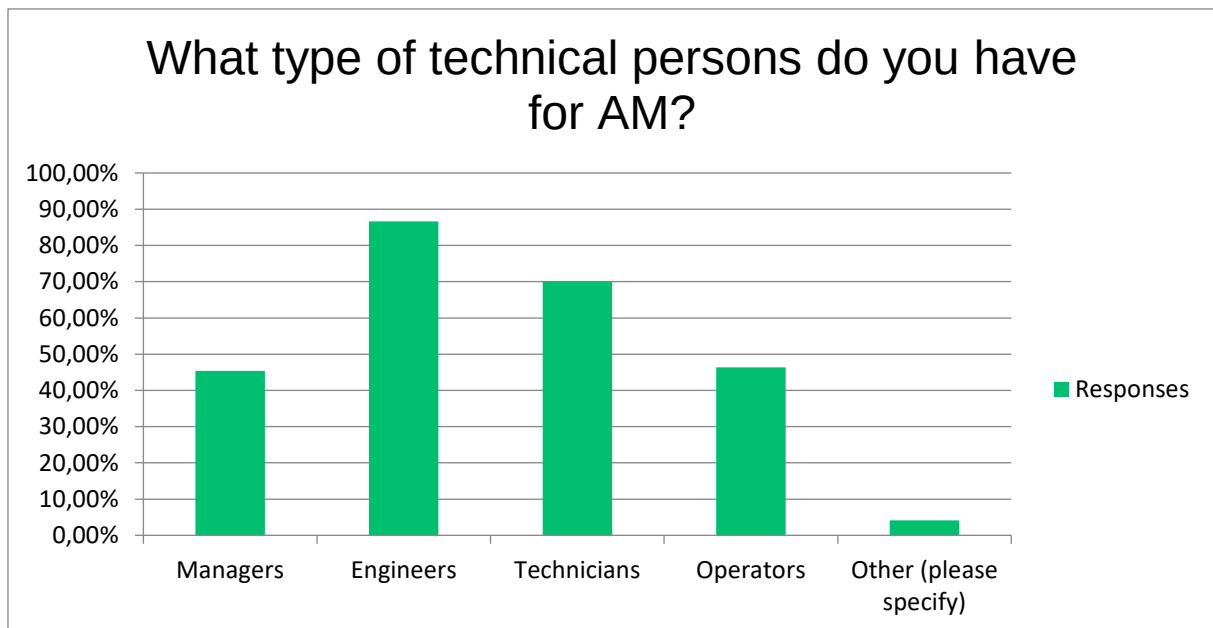
While examining the AM strategy of the countries, the subject of education was mentioned in detail. It has been observed that there are different educational orientations for different specialties. However, it has been observed that there is no established basic standard.

Q: Does your company/institution have qualified AM technical persons?

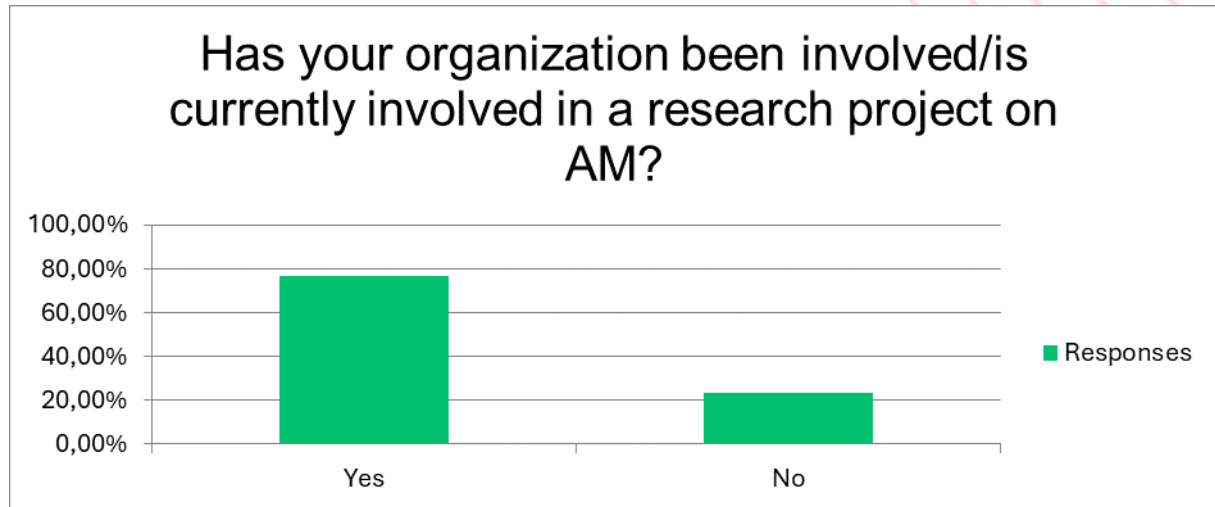


Nearly %40 of respondent does not have qualified technical person.

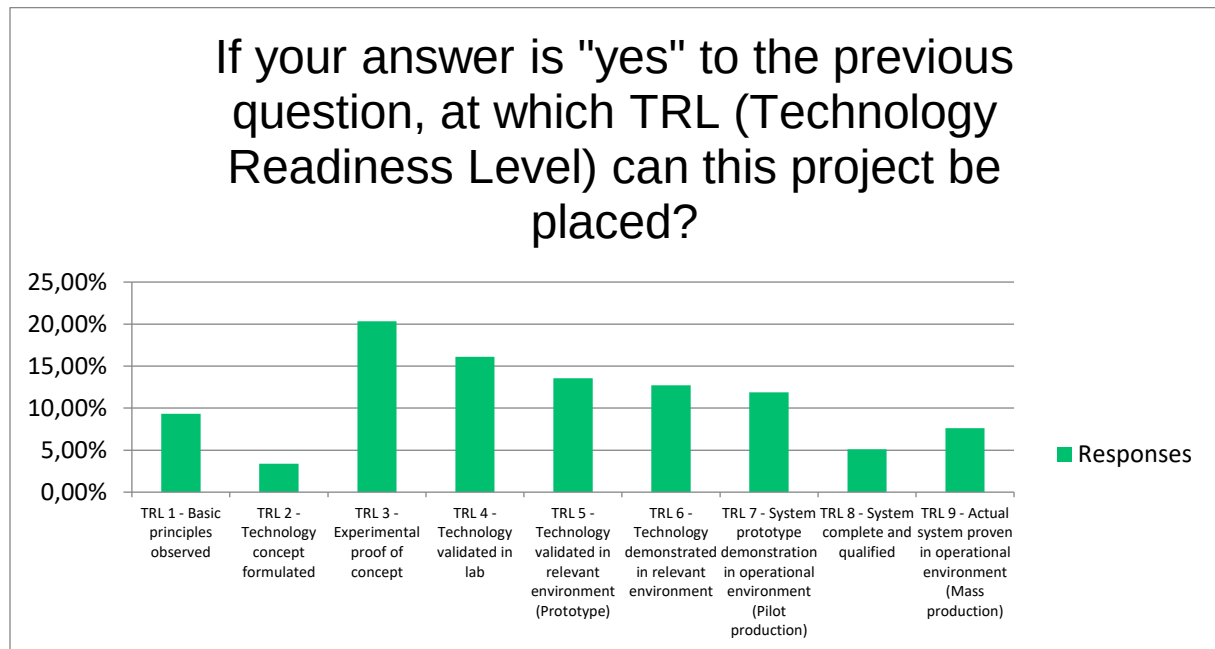
Q: What type of technical persons do you have for AM?



Q: Has your organization been involved/is currently involved in a research project on AM?



Q: If your answer is "yes" to the previous question, at which TRL (Technology Readiness Level) can this project be placed?



6.3. Survey Results and Analyses

Based on the survey results, the following conclusions can be drawn:

Type of Organization: The survey indicates that large companies and education institutions are the primary adopters of additive manufacturing (AM) technology. This can be attributed to the high investment requirements of AM and the composition of project partners, where half of them are education and training institutions. However, there is also a significant presence of small and medium-sized enterprises (SMEs), highlighting the potential for AM adoption in this sector.

Main Activity/Sector: The survey reveals a diverse range of sectors involved in AM. While "other" emerges as the second most marked answer, indicating a wide variety of activities, notable sectors include Rolling Stock Manufacturing, Metal/Alloy Powder Production, Additive Manufacturing, Research, Nuclear, and AM Service Bureau.

Geographic Distribution: The survey results show the presence of various countries where organizations are based. However, "other" is also mentioned as the third most marked answer, suggesting additional countries not explicitly listed in the survey.

Current and Future AM Usage: The survey includes questions about current AM usage and future implementation plans. The responses to these questions provide insights into the willingness of organizations to adopt AM technologies.

Investment Types: The survey respondents indicate that training and personnel investment are critical alongside financial investment in AM. This highlights the importance of having qualified personnel and the need for continuous training and development to support successful AM implementation.

Duration of AM Usage: The majority of survey respondents have been using AM for more than five years, indicating a significant level of experience and maturity in the technology. However, these organizations still express a need for training and personnel investment, suggesting a continuous focus on improving their capabilities.

AM Technologies and Materials: The survey reveals that each respondent, on average, integrates two different AM technologies and two different AM materials into their organization's activities. This indicates a diverse range of technologies and materials being employed, showcasing the maturity of the technology among the respondents.

Skills and Challenges: Respondents identify a wide range of skills that are still lacking in the field of AM. The main challenges mentioned include investment costs, lack of qualified workers, and a lack of market standardization. These challenges need to be addressed to facilitate wider adoption of AM.

Government/Public Funding: The survey highlights the availability of government/public funding opportunities in the field of AM. A significant portion of respondents has utilized such funding in the past, indicating its potential as a solution to address the challenges associated with AM implementation.

Collaboration with Universities/Research Institutions: Collaboration with universities, research institutions, and laboratories is deemed critical by the respondents. Project collaboration with universities emerges as the primary type of collaboration, followed by consultancy and training.

AM R&D Department: The presence of an AM research and development (R&D) department varies among the organizations surveyed. The financing of this activity is not explicitly mentioned in the provided information.

Training Programs: The survey respondents express a need for training programs in AM, with around 65% indicating the availability of such programs in their countries. However, the results suggest that the existing training programs may not fully meet the skill requirements, indicating a need for further improvement.

Level of Training Programs: The survey suggests that there is a lack of established basic standards for AM training programs. Different educational orientations for different specialties are observed, highlighting the need for standardized training programs.

Qualified AM Technical Persons: Around 40% of respondents state that their organizations do not have qualified technical persons for AM. This indicates a gap in the availability of skilled personnel to support AM activities.

Involvement in Research Projects: The survey asks whether organizations have been involved or are currently involved in research projects on AM. The extent of involvement in research projects is not explicitly mentioned in the provided information.

Technology Readiness Level (TRL): For organizations involved in research projects, the survey asks at which TRL the projects can be placed. The specific TRL levels and distribution among respondents are not provided in the given information.

Overall, the survey provides insights into the deployment of AM in organizations, highlighting the sectors involved, geographical distribution, current usage, future plans, investments made, challenges faced, and collaboration efforts. The results suggest both the progress and ongoing challenges in the adoption of AM technologies, emphasizing the need for qualified personnel, training programs, and government support to overcome barriers and further enhance AM implementation.

7. DISSEMINATION ACTIVITIES

ADDRESS project was announced by all partners on social media channels.

Logo work has been done for this project, and all work outputs and activities are published on the website.

<https://www.addressforfuture.com/>



Press reflection at the first introductory meeting Bursa kick off, is as follows;

Featured publications in the print media; Hürriyet Bursa, Yeni Şafak, Dünya, Analysis, Cumhuriyet Newspapers, Para Magazine, and local publications. The reach of the news in 23 publications was 1.388.917.

In digital, it was published on 242 news sites. Featured publications; Habertürk.com, yenisafak.com, dunya.com, iha.com.tr, inbusiness.com.tr, analizgazetesi.com.tr, mynet.com, Olay.com.tr and local publications. The reach of digital news was 330,775.

A total of 265 reflections, 23 written and 242 online, were obtained. Total reach was 1,719,692.

The survey created for the 1st work package AM Strategy Framework was distributed to the company lists created by all partners. 254 people participated in the survey.

The ADDRESS Project was presented at the very important 4 different AM Events held in different European countries since the beginning of the project, and communication and information exchange was ensured with institutions.

- Additive Manufacturing Conference, AMC Türkiye 2022 06-08 October
- EPMA World PM 2022 Congress & Exhibition, France 2022 09-13 October
- I-AM 2022 International Additive Manufacturing Conference, Portugal 19-20 October 2022
- SAHA Expo Defence and Aerospace Exhibition, Türkiye 25-28 October 2022



Additive Manufacturing Conference, AMC Türkiye

06-08 October 2022

AMCTURKEY 2022 brings local and international scientists, researchers, and representatives both from academia and industry, where they can present and share their recent scientific discoveries, research activities and emerging applications in Additive Manufacturing and related technologies.

This year more than 250 attendees joined the event and share ideas and technologies and research. So, as Coşkunöz Education Foundation we had a booth there and presented the ADDRESS project.

EPMA World PM 2022 Congress & Exhibition, France

09-13 October 2022

World PM2022 Congress & Exhibition, organized and sponsored by the European Powder Metallurgy Association.

This year more than 650 attendees joined the event and share ideas and technologies and research.

EPMA as a partner of the ADDRESS project presented the details of the ADDRESS for Future aim and outputs.

I-AM 2022 International Additive Manufacturing Conference, Portugal

19-20 October 2022

I-AM 2022 International Additive Manufacturing Conference co-sponsored by The American Society of Mechanical Engineers (ASME) and European Federation for Welding, Joining and Cutting (EFW).

This year more than 650 attendees joined the event and share ideas and technologies and research.

Coşkunöz Education foundation, EPMA, Cesol, UPM were there and present the ADDRESS project at the conference.

SAHA Expo Defence and Aerospace Exhibition, Türkiye

25-28 October 2022

SAHA Expo Defence and Aerospace is one of Turkey's largest defense aviation fairs.

In addition to Industry and Technology Ministry, it is also supported by the Ministry of Foreign Affairs, the Ministry of Interior, the Ministry of National Defense, the Ministry of Trade and the Presidency of Defense Industries. The number of professional visitors was recorded as 17,643 people, 17,046 domestic and 597 foreigners,

Coşkunöz Education Foundation had a booth at the exhibition and presented the ADDRESS project to participants.



Marie Curie High School Visit

Marie Curie High School is one of the biggest vocational high schools in France, was visited. During the visit, the subject of AM in vocational training was evaluated.

Attendees of the meeting,

Alain PROCAR - Lycée Marie Curie – School Principal

Guillaume COMTE – France National Education Ministry- L'Oise Territory Manager

Nelson ALVES DOS SANTOS - Lycée Marie Curie Science and Technology Department Manager

All partners of ADdress project



8. CONCLUSION

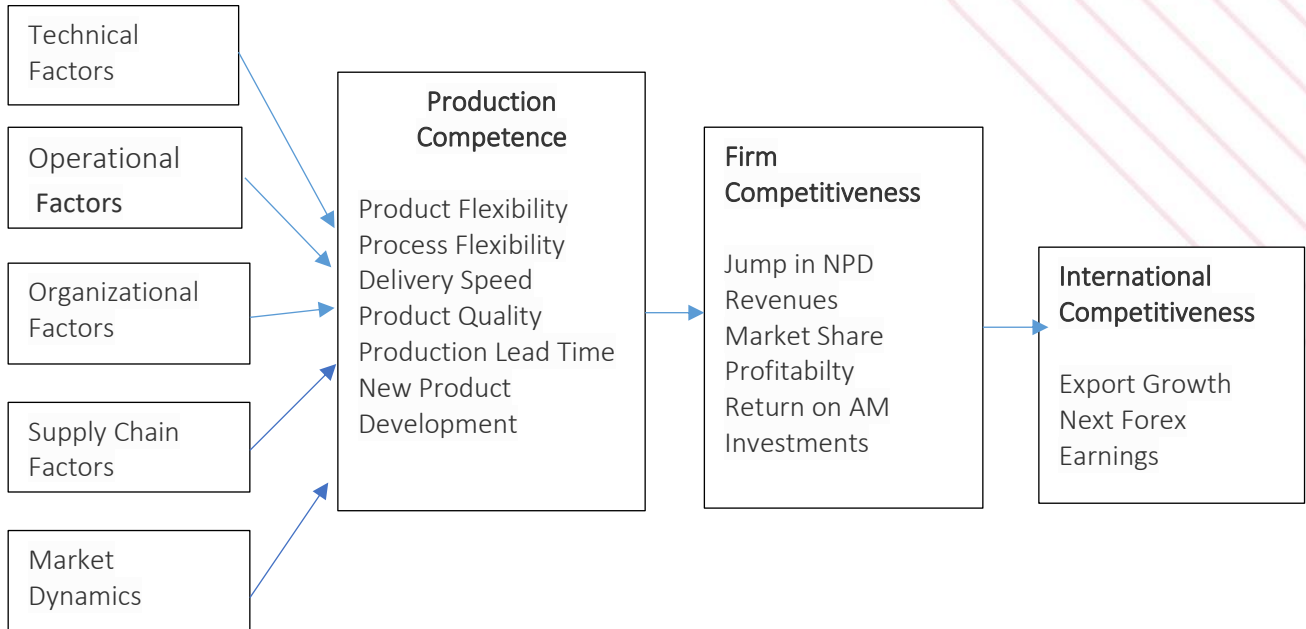
Many researchers have proposed AM implementation factors that consider organizational, technological, strategic, operational and supply chain considerations. Mellor et al. (2014) proposed AM implementation factors in engineering services. Recently, Deradjat and Minshall (2017) put forward key AM implementation factors in the dental industry. Similarly, Dwivedi et al. (2017) investigated AM technology implementation barriers in the Indian automotive industry.

- However, Sonar, Khanzode, and Akarte (2020) noted that these studies addressed either a single case or a single domain, making it impossible to generalize these factors. They also emphasized that in order to develop AM implementation strategies, the operations manager needs to gain significant expertise in AM implementation factors to develop competitive strategies. They identified eighteen AM implementation factors from past literature discussing AM implementation challenges.

1. AMIF01 AM technology
2. AMIF02 Top management commitment
3. AMIF03 Information sharing
4. AMIF04 Supply chain coordination
5. AMIF05 Government support
6. AMIF06 Organization capability and human resource
7. AMIF07 Education and training
8. AMIF08 Resistance to change
9. AMIF09 Technological awareness
10. AMIF10 Market Support
11. AMIF11 Customer and service management
12. AMIF12 Organizational culture
13. AMIF13 Process improvement practices
14. AMIF14 Manufacturing flexibility
15. AMIF15 Environmental uncertainty
16. AMIF16 Financial capability
17. AMIF17 Operational Excellence
18. AMIF18 Firm competitiveness

In this framework, they proposed a conceptual model by showing the link between various AM implementation factors and firm competitiveness and suggested that this framework can be used in various industries.

AM Implementation



Conceptual model of linkages between AM implementation and competitiveness

The research and analysis in this report, prepared within the scope of the ADDRESS for Future project, is based on these factors.

New business models, value chain analysis, market volume development, strategies, policies, financial support, market trends and expectations have been analyzed to create a Strategic Framework for the Additive Manufacturing Sector at National and International Level.

The data obtained as a result of the analysis were organized according to the factors specified in the Conceptual model of linkages between AM implementation and Competitiveness model proposed by Sonar, Khanzode, and Akarte (2020).

1. Strategic Factors

Digital transformation is one of the main strategies of all EU. AM which is in a way digital manufacturing, has a critical path on this transformation. Creating awareness and fostering training and education in AM will support this transformation.

Additionally, AM has an important effect on green transformation. At the first look, AM is thought to have long production cycles with expensive raw material and infrastructure, nevertheless decreasing buy to fly ratio, combining several parts into a single product, and eliminating transport of goods with digital warehouses have a positive effect on sustainability.

When the vision about AM in all of Europe is analyzed, it is observed that this technology is thoroughly supported by the government authorities with different grants. Also, industry authorities are observing this as an opportunity and a challenge for the future of work.

Among European Countries, it is observed that certain countries have an advanced level of additive manufacturing applications, however some countries have very limited, nearly no applications on AM. The level of industrialization in the country determines the level of integration of AM applications.

By establishing studies, reports, the digital platform, and the contest in ADDRESS for Future project, these are going to have an impact on creating and fostering awareness through European countries on AM. The major effect of the digital platform will be the democratization of access to AM trainings and increasing the awareness on AM throughout Europe.

It is observed from the survey results, research projects with TRL 3 and 4 conditions are the most rated. Following these are projects with TRL 5 and 6 conditions. It is assumed that for TRL 1 and 2 conditions, academically competent and qualified human resources are required. The early awareness of AM, which can be fostered with ADDRESS for Future project, will support the talents to be attracted to studies on AM not only in institutions but also in industry's R&D studies.

2. Technical Factors

Several things that are obvious about the AM technology; continuous technical improvements on AM, the various design freedom that AM is capable of, the immense innovation potential on new raw material directly creates entrepreneurship and invention potential support productivity and competitiveness for new opportunities.

An important point to be highlighted is that fast improvements on AM technologies, it makes this report obsolete at the time of publication. This fact creates a challenge; updates of the studies or structures should also be analyzed and evaluated continuously.

The focus technologies have come out to be powder bed fusion, material extrusion and directed energy deposition. From the material point of view, the majority is on metals and plastics, where metals are said to be the most used among two.

3. Organizational Factors

The investment perspective of the companies comes out to be the machinery for AM with a 5-year plan. Although there is public grants and support in several countries, investment costs are still a challenge. This shows that the grants and support are not in parallel with the requirements or strategies of the companies/institutions. Thus, the companies fund their investments mostly with their own resources.

A critical point that should be highlighted is the question about the lacking skills on AM. It was asked to the respondents to mark the lacking skills on AM among 7 skills stated. As can be seen from the survey results chapter of this report, all 7 AM skills are marked as lacking by over %40 of the respondents.

Besides asking for skill requirements, availability of trainings and education on several subjects on AM is also asked in the survey. It is observed by the responses that companies access mainly to design and process trainings on AM. Although the answers states that there are trainings for engineers, designers and operators on AM Industry, responses from nearly half show that all skills are lacking which are critical for AM.

The reasons for this should be either the content of training and education does not fit with the requirements of the industry, or the required content is not accessible.

Besides, there are different training and education requirements regarding material, testing, quality control & assurance, post processing etc. where available training and education does not fulfil this requirement. The response to the questions about the research projects and their TRL conditions shows that different levels of technology readiness are required for calls among EU.

During the analysis with the network, it is seen that industry is really ready to collaborate with universities on AM.

These collaborations should not only support the academic research projects but also find appropriate solutions to the requirements of the industry on AM. With the digital platform, there is the opportunity for early adoption of AM applications training and students at every level can benefit from these earnings during their design and production applications at every stage of their studies and work life.

4. Supply Chain Factors

Additive Manufacturing implementation lies at the intersection of two supply chains; firstly, it involves a supply chain from the machine vendors to the purchaser of the technology.

Secondly, the purchaser will then embed the technology in their respective supply chain and hence influence their customers and suppliers. Regarding new process technologies implementation, Bessant has argued that for the technology to deliver its full potential significant organizational changes are required such as the restructuring of relationships with suppliers towards more collaborative forms. It is proposed that the implementation of AM technologies manufacture will require increased collaboration with suppliers and customers.

Vendor support during the implementation process has long been recognized as a critical factor of implementation success. It has been shown that the level of complexity of the technology innovation is directly related to the level of intensity of the user-supplier interaction processes. Therefore, vendor support is proposed to be a key factor in AM implementation.

A characteristic of current AM industry worthy of note is the tendency for machine suppliers to be material suppliers (such as the powders used) following implementation. This characteristic is partly due to the immaturity of the technology (with a shortage of material suppliers) and also likely a strategy on the machine supplier's part to protect future business.

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By establishing studies, reports, the digital platform, and the contest in ADDRESS for Future project, these are going to have an impact on creating and fostering awareness through European countries on AM. The major effect of the digital platform will be the democratization of access to AM trainings and increasing the awareness on AM throughout Europe.

But besides all of these, the lacking point on AM comes out to be;

- Lack of standardization of processes, raw material and products,
- Lack of expertise, knowledge and specialists,
- Lack of training of professionals,
- Lack of adequate levels of specific training about AM technologies, materials and processes,
- Lack of awareness on SMEs.

With the digital platform, there is the opportunity for early adoption of AM applications training and students at every level can benefit from these earnings during their design and production applications at every stage of their studies and work life.

Several things that are obvious about the AM technology; continuous technical improvements on AM, the various design freedom that AM is capable of, the immense innovation potential on new raw material directly creates entrepreneurship and invention potential support productivity and competitiveness for new opportunities. An important point to be highlighted

is that fast improvements on AM technologies, it makes this report obsolete at the time of publication. This fact creates a challenge; updates of the studies or structures should also be analysed and evaluated continuously.

Survey results indicates not only the issues above but also points out some critical points;

- Training for AM is the second item for future investment of the respondents,
- Design, simulation and QC subjects are the primer requirement of the respondents ,
- PBF, FDM and DED seems to be the first three of technology,
- Metal and plastic material usage has a same ratio.

The survey in this work package of the project is accomplished to identify the current situation on; AM strategies throughout Europe, variety of AM applications, human resources level and composition in AM industry, training and education requirements, investment position on machinery and material, grants and supports by the public organizations for AM, research studies and their level of technological readiness.

This survey has been sent to 700 correspondents all over Europe including industrial enterprises, universities, academicians, education and training providers, engineers, and students.

254 responses to these are received. Among survey respondents, the majority is from large companies and the education ecosystem.

When this is analysed on sectorial basis; automotive and education are the first two sectors. The investment perspective of the companies comes out to be the machinery for AM with a 5-year plan. Although there is public grants and support in several countries, investment costs are still a challenge. This shows that the grants and support are not in parallel with the requirements or strategies of the companies/institutions. Thus, the companies fund their investments mostly with their own resources.

The focus technologies have come out to be powder bed fusion, material extrusion and directed energy deposition. From the material point of view, the majority is on metals and plastics, where metals are said to be the most used among two.

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The reasons for this should be either the content of training and education does not fit with the requirements of the industry, or the required content is not accessible.

Besides, there are different training and education requirements on material, testing, quality control & assurance, post processing etc. where available training and education does not fulfil this requirement. The response to the questions about the research projects and their TRL conditions shows that different levels of technology readiness are required for calls among EU.

Companies should work on research projects with different TRL conditions to get the grant of the call. The effect of this condition can be observed in the responses of the survey.

It is observed from the survey results, research projects with TRL 3 and 4 conditions are the most rated. Following these are projects with TRL 5 and 6 conditions. It is assumed that for TRL 1 and 2 conditions, academically competent and qualified human resources are required. The early awareness of AM, which can be fostered with ADDRESS for Future project, will support the talents to be attracted to studies on AM not only in institutions but also in industry's R&D studies.

Appendix 1: Reports and Articles About Additive Manufacturing

Appendix 2: Survey Results



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