AMPOWER INSIGHTS

Additive Manufacturing **Make or Buy?**

An overview of today's supplier market and cost structure for metal AM parts.

INSIGHTS GAINED:

- Cost structure of metal Additive Manufacturing
- Key decision factors to make or buy
- Today's market pricing

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Insights gained

Cost structure of metal additive manufacturing
Key decision factors to make or buy
Today's market pricing

Management summary

Additive Manufacturing became a game changer in many industries. Especially for SMEs, however, high part cost are still the main restriction for further wide-spread adoption of this production technology. For Laser and Electron Beam Melting (LBM and EBM), a significant part of the (AM) manufacturing/ production costs results from high machine hourly rates of 40-50 €/h paired with relatively slow building speeds.

Ampower Insights gives a detailed calculation of production costs and introduces the ratio of cost per unit of volume for an easy comparison of technologies and materials. Today, the in-house production cost ranges between 0,86 €/cm³ for aluminum alloy AlSi10Mg to 3,20 €/cm³ for light-weight and medical grade titanium alloy Ti-6Al-4V.

The existing market of metal service bureaus is analyzed for a representative depiction of market prices. The AM capacity at suppliers currently consists of a total of approximately 120 machines installed in service bureaus in the selected study region Germany, Switzerland, and Austria.

The majority of service bureaus is concentrated in Southern Germany. Market prices range between 3-10 €/cm³ for finished aluminum parts, representing a spread of 35-240% around the mean value. The price spread for titanium parts is significantly lower with market prices around 5-7 €/cm³.

The surprisingly large spread in market prices persists even when larger lot sizes resembling a continuous serial production are requested. Comparing different materials, aluminum offers the largest margins on the supplier market while stainless steel yields much lower returns.

Ampower Insights closes with procurement guide lines and key factors for a Make or Buy decision. The decision to Make or Buy generally depends on the amount of parts printed per year. For aluminum a profitable in-house production starts at approximately 125 kg per year. For stainless steel, the break-even is reached at 420 kg per year. Therefore, even with in-house production it might be beneficial to secure supply for low volume parts and materials.

Download this paper and access the corresponding cost calculator at www.am-power.de/insights

Content

About Ampower

The consulting company Ampower specializes in industrial Additive Manufacturing. It offers identification of products suitable for AM and qualification of personnel and infrastructure. Ampower strives towards developing valuable business cases for its customers. The training program focuses on qualifying personnel along the whole value chain from R&D, design, production and quality assurance to procurement as well as management.

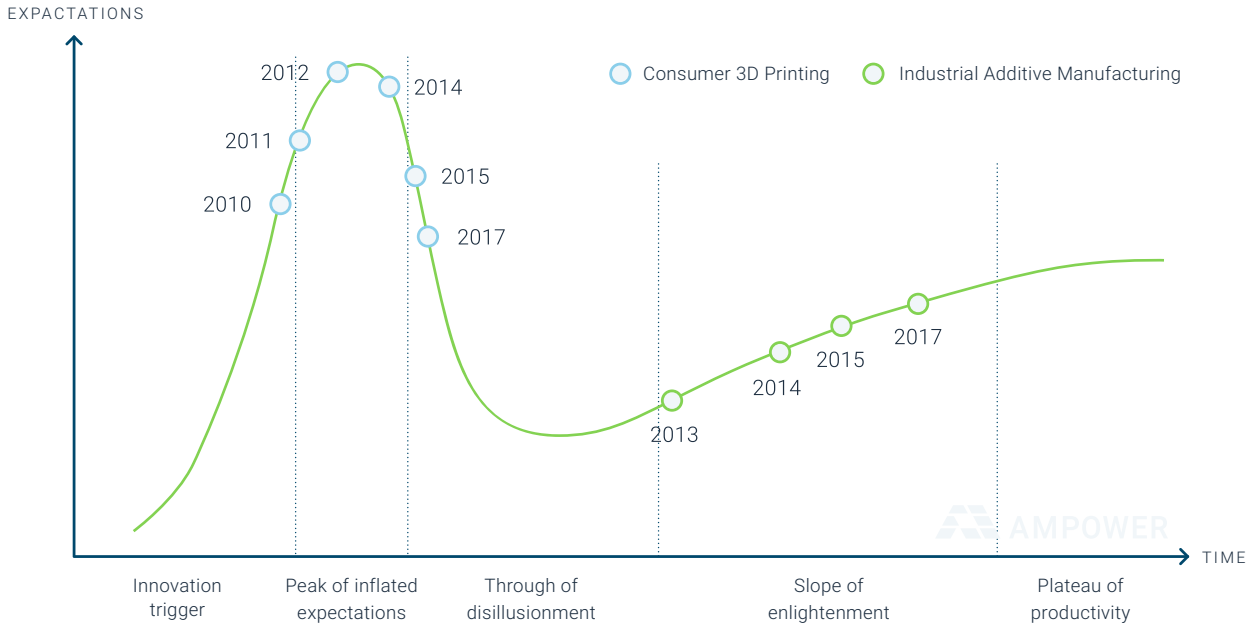
The Ampower qualification procedure for machine technology provides robust manufacturing processes and ensures that the production line excels at all certification requirements. The Ampower founders have a strong industrial background in Additive Manufacturing with a combined experience of over 20 years. Ampower enables their customers to successfully implement the challenging Additive Manufacturing technology.

Cost of metal Additive Manufacturing

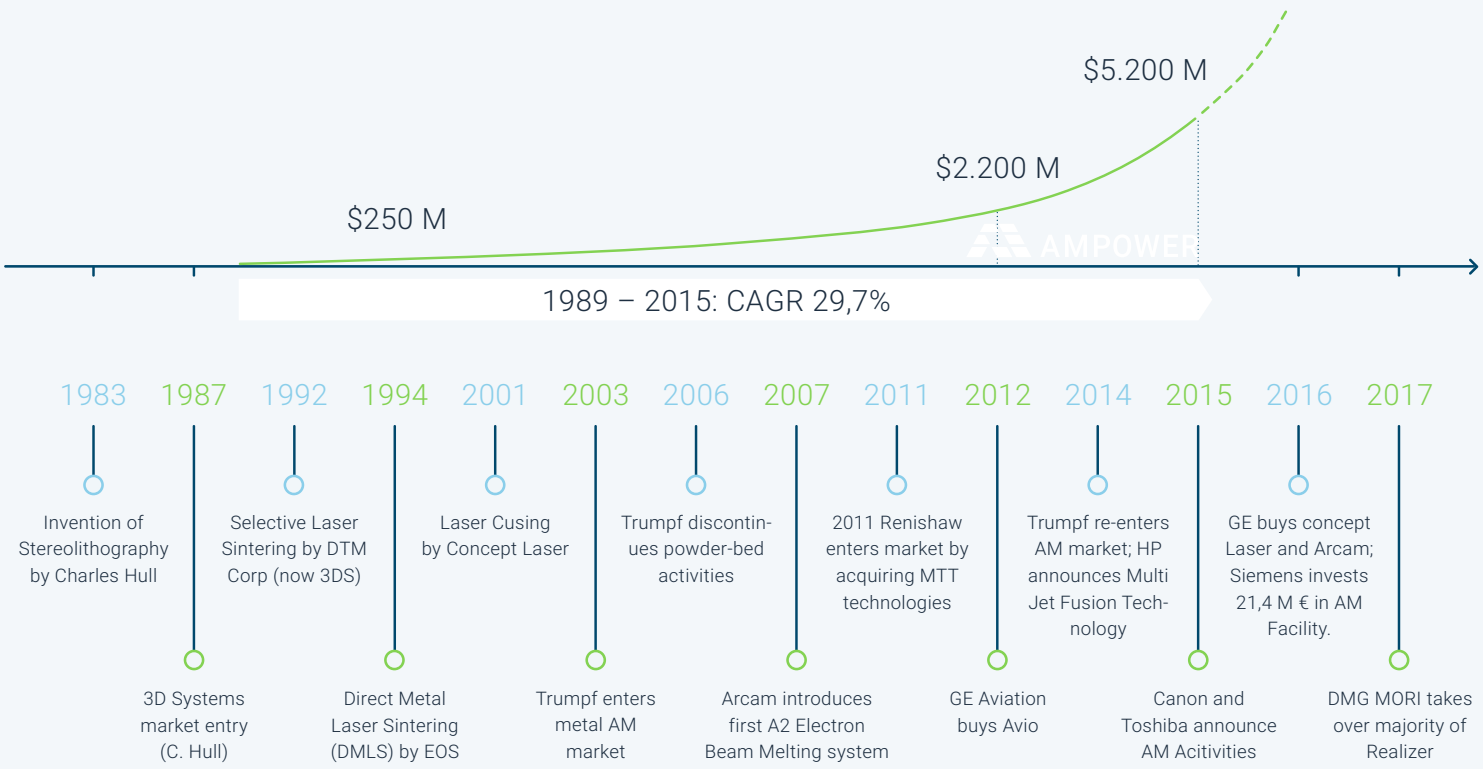
Hype versus business case – growth continues despite high cost

Major players enter the Additive Manufacturing market with high investments in infrastructure and human resources. SMEs are struggling with high inhibition threshold caused by large investments and lack of knowledge.

Over the past two years the industry became witness to a significant increase of interest in Additive Manufacturing spreading over all kinds of industries and sectors. For Consumer 3D Printing, the technology is widely known as 3D Printing while the industrial sector prefers the term Additive Manufacturing. For industrial applications gartner predicts a consolidated market around 2020, meaning the industry is right in the middle of defining their position within this promising market. In 2016 the Gartner hype cycle suggests that the Industrial Additive Manufacturing technology nearly reached the plateau of productivity. Market consolidation is the logical consequence, best-known from the take-over of Additive Manufacturing pioneers Concept Laser and Arcam by General Electric in 2016.



SOURCE: GARTNER 2010-2017



SOURCE: WOHLERS REPORT, AMPOWER

Most industrial users currently focus on part screening, identification of potential AM applications and new business models. However, the actual cost structure in Additive Manufacturing is treated with little attention.

Today, procurement and purchase departments have very limited knowledge about pricing. It may be available in R&D departments, but typically does not consider the whole production chain.

Yet, it is worth having a closer look at the cost structure of Additive Manufacturing since it will become the focus of attention of companies on their path to industrialization.

In AM industry, service bureaus have the most experience in cost calucation. However, today, they focus mostly on prototyping applications. This results in neglect of cost for post processing steps as well as quality assurance. The impact of post processing on total cost should not be underestimated. When it comes to a decision to make or buy, the pricing of both supplier and in-house production has to be considered by the decision maker.

Total Production Cost

Additional post-processing and finishing cost depending on application between 60-300 % of the AM manufacturing cost

+

AM manufacturing cost

SOURCE: ADDITIVE MANUFACTURING –
NEXT GENERATION (AMNX) STUDY BY ROLAND BERGER APRIL 2016

The technology has to match the application

Cost of production is always driven by the specific application. For serial production of medical acetabular cups, Electron Beam Melting (EBM) proves to be most cost-efficient. The disadvantage of relatively low surface quality in EBM, in this case, is compensated for by complete milling and or even a desired property in the net structure.

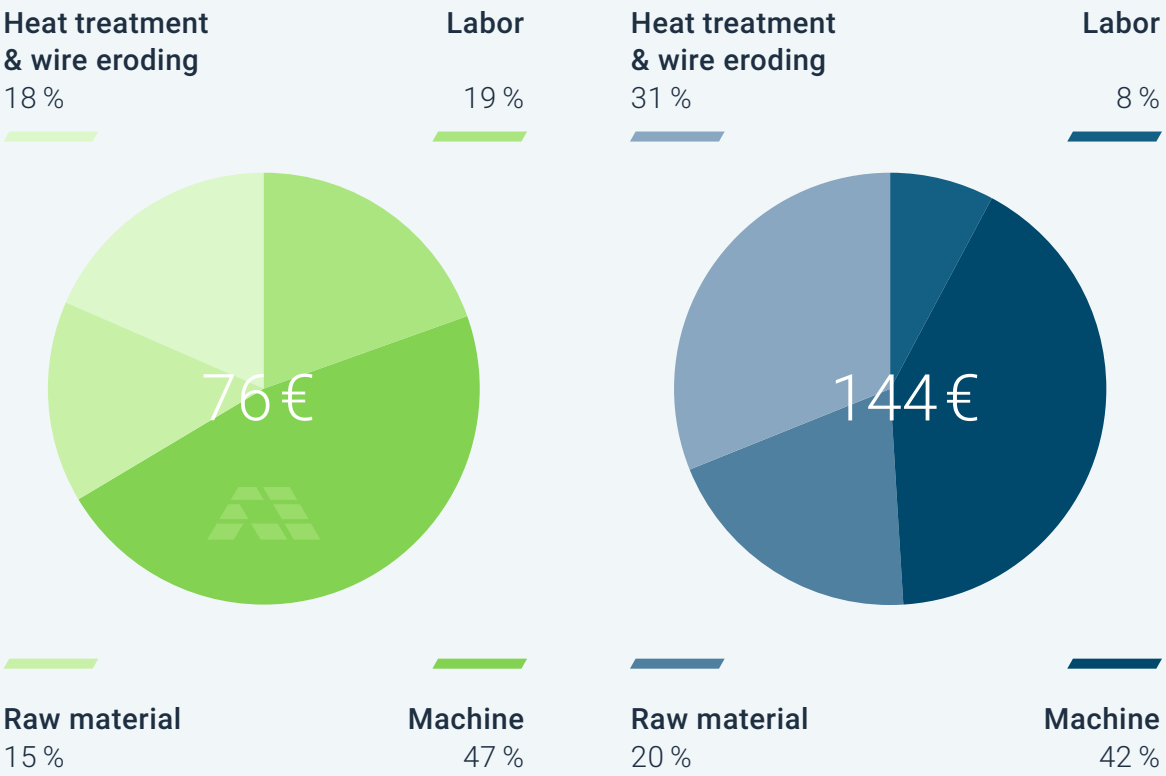
AM blank cost of a 54 mm medical acetabular cup

Laser Beam Melting: 144 €
Electron Beam Melting: 76 €
Milling (EBM and LBM): 41 €

Hip cups as a major business case for EBM

In 2007, the first acetabular cups were printed by Lima Corp. using Electron Beam Melting technology. Today, EBM is a reference technology due to its low costs by stacking parts and a state of low residual stresses after the printing process.

Cost breakdown of blank medical acetabular cups



EBM cost breakdown

Machine cost dominate the EBM cost breakdown for acetabular cup production. Since parts are not fixed by supports to a base plate and become thus stackable, the volume per build can be up to three times higher than compared to LBM. Cost for heat treatment is limited to the HIP (hot isostatic pressing) process.

LBM cost breakdown

The cost breakdown for acetabular cups in low volume Ti-6Al-4V LBM production shows high cost for wire eroding and qualified heat treatment. For high volume serial production, such post processing cost will be reduced by Economies of scale.

Ampower Insights Vol 2

Learn more about the differences of Electron and Laser Beam Melting technology in our next publication of Ampower Insights Vol 2.
Subscribe to our newsletter to be the first to receive the new issue under:

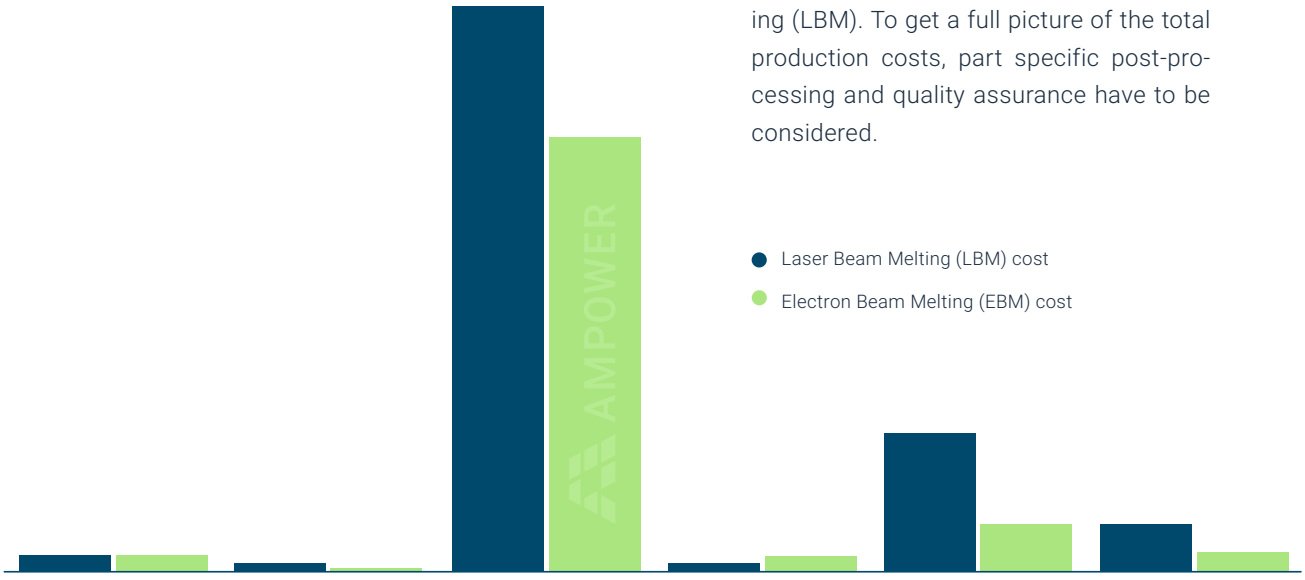
www.am-power.de/insights

The cost structure along the process chain

Sound knowledge of the actual manufacturing cost is the basis for every decision made on Additive Manufacturing business cases. The inability to exactly forecast the production time of future jobs typically represents the biggest obstacle in a precise cost prediction for Additive Manufacturing.

Exemplary cost per cm³

It becomes evident, that machine run time is the main cost driver. An advantage in build rate for Electron Beam Melting (EBM) machines leads to lower machine time cost in comparison to Laser Beam Melting (LBM). To get a full picture of the total production costs, part specific post-processing and quality assurance have to be considered.



$$C_P = \frac{t_D \cdot C_L}{N_T} + \frac{t_M \cdot (C_L + C_{AM})}{N_B} + \frac{(M_M + M_M \cdot F_M) \cdot C_M + (t_V + (\frac{V_M}{P_M \cdot F_L}) + (\frac{t_R}{3600} \cdot \frac{h_B}{s_L \cdot 1000}) + t_C) \cdot C_{AM}}{N_B} + \frac{t_U \cdot C_{AM} + t_B \cdot C_L}{N_B} + C_H + \frac{t_P \cdot C_L}{N_B}$$

Abbreviations

C_P	Cost per part [€/part]
t_D	Time for data preparation [h]
t_M	Time for machine preparation [h]
t_V	Time for producing vacuum (only EBM) [h]
t_C	Time for cool down (only EBM) [h]
t_R	Recoating and QS system time (Only LBM) [s]
t_U	Time to unpack the machine [h]
t_B	Time to unpack the build job [h]
t_P	Time to remove the supports per build job [h]
h_B	Total build job height [mm]
S_L	Layer thickness [µm]
V_M	Volume of parts incl. Supports per job [cm³]
M_M	Mass of parts incl. Supports per job [kg]
P_M	Build rate (at EBM incl. recoating, heating, QS) [cm³/h]
F_L	Laser utilization factor
F_M	Material loss factor [%]
C_L	Labor cost [€/h]
C_M	Material cost [€/kg]
C_{AM}	Machine hour rate incl. energy consumption and consumables [€/h]
C_H	Cost for heat treatment per part [€]
C_C	Cost for machining per part [€]
N_B	Number of parts per build job
N_T	Total number of parts

Presets

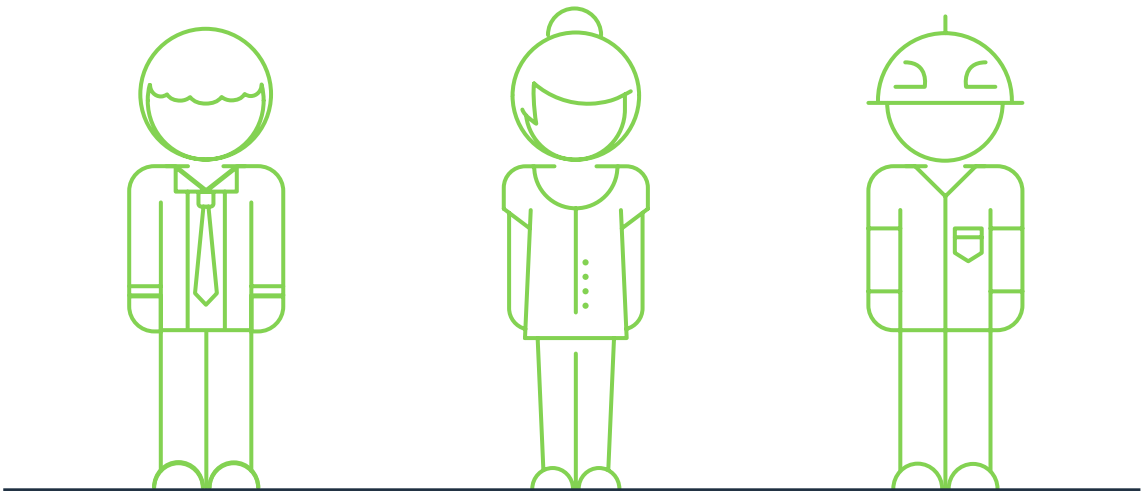
Material for comparison: Ti-6Al-4V
Build rate LBM: 14,4 cm³/h (excl. recoating)
Build rate EBM: 22 cm³/h (incl. recoating and heating)
Multi-laser: Dual laser with build rate x1,5
Layer thickness LBM: 60 µm
Layer thickness EBM: 50 µm
Time for data preparation: 2 h
Time for support removal: 0,1 h
Machine h rate LBM: 33 € (excl. maintenance)
Machine h rate EBM: 32 € (excl. maintenance)
Machine type LBM: midsize Dual laser system

Investment from human resource perspective

Creating a hands-on environment is the most successful way to generate awareness and knowledge within a company. Both aspects are very important when it comes to developing a positive business case. The setup of internal AM capacity is not only limited to AM machines but also requires extensive investments in peripheral devices and especially qualified personel.

AM personnel

Currently, the lack of qualified personnel is a major challenge especially for small or medium-sized enterprises. For a successful implementation, the personnel needs to be qualified along the whole process chain from R&D, design, production and quality assurance to procurment.



Business Development

Design & Application Engineer

AM Technician

SOURCE: ARCAM AB

Infrastructure investment

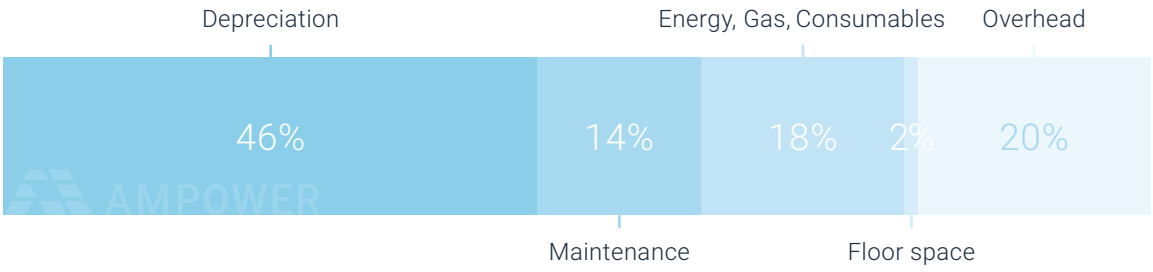
Major players continue to enter the Additive Manufacturing market with high investments in infrastructure and human resources. SMEs are struggling with high inhibition threshold caused by large investments and lack of knowledge.

Infrastructure

When planning the infrastructure there are several options to be considered. Investments in process monitoring highly depends on the actual part and process requirements. It should also be known that the installation and setup highly depends on the actual application, material and machine setup.

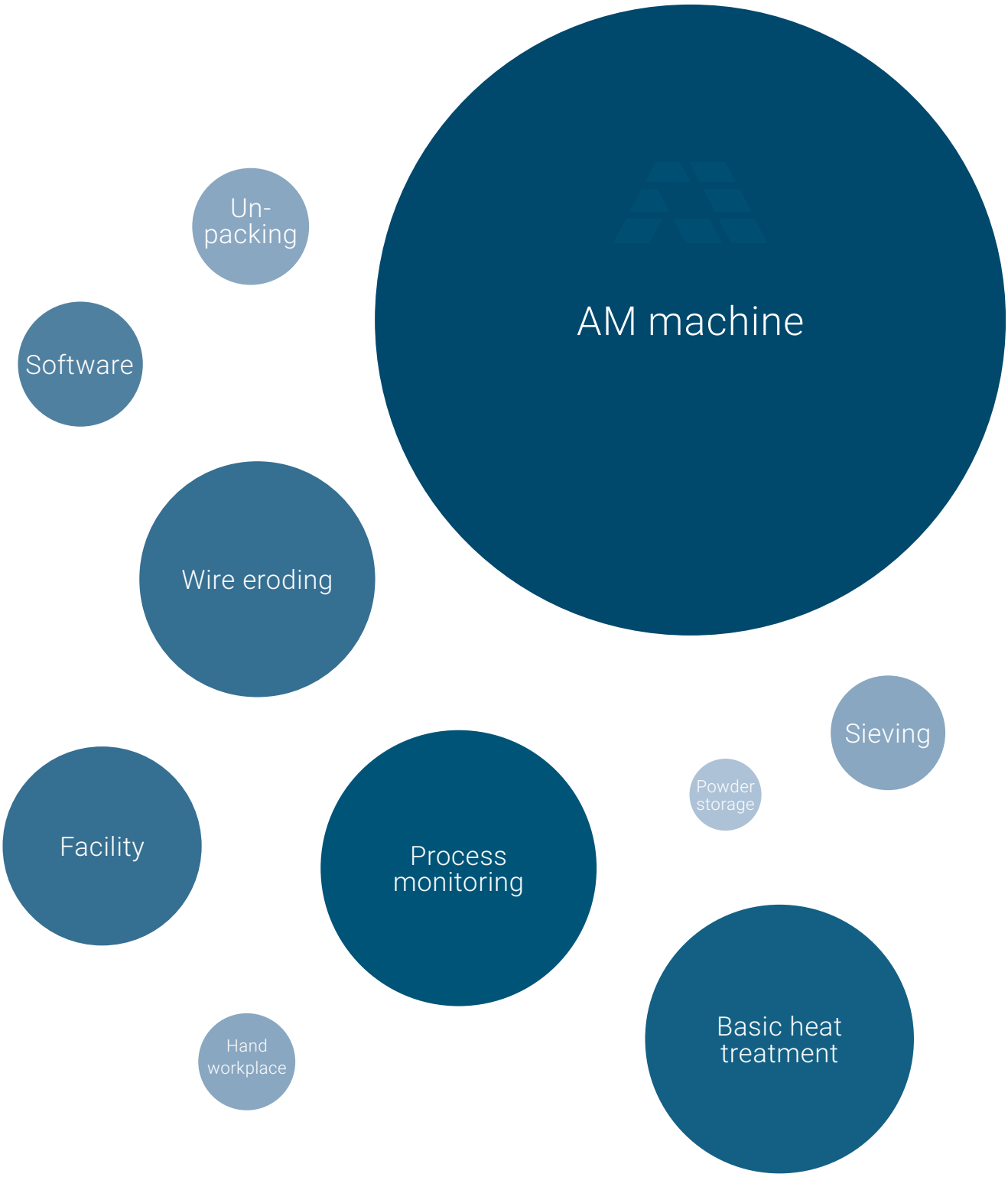
Qualification of the production to medical or aviation industry standards may require significant additional investments. The displayed percentage of investment in wire eroding and heat treatment capabilities can differ depending on the number of AM machines. If only one machine is running, qualified heat treatment should be done external. This is especially the case for HIP processes.

Average AM machine hourly rate: 30-50 €



Assumptions
Dual laser mid size AM System
5 year depreciation
6816 productive hours per year
240 hours downtime for maintenance.

The AM machine represents about 60% of the total infrastructure investment when considering internal AM capacity.

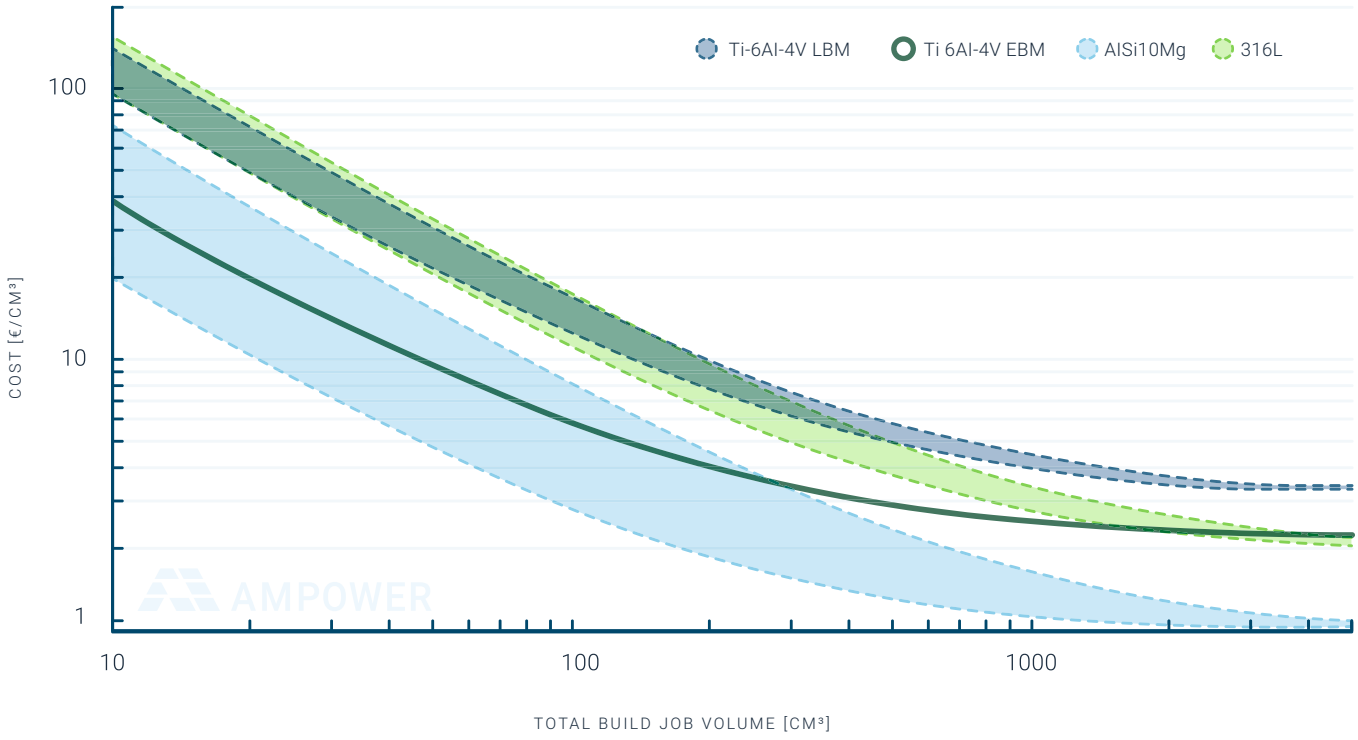


Cost in numbers

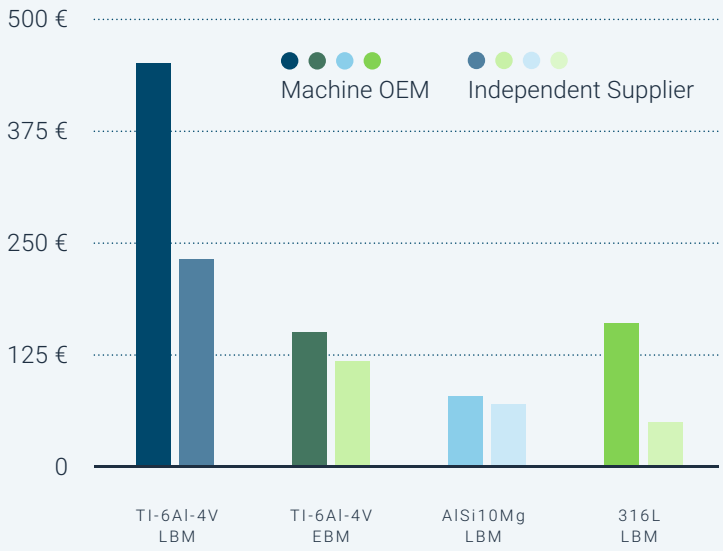
The cost of each part made by Additive Manufacturing is directly linked to its part volume. Increasing part volume drives the cost for machine time, but of course also increases use of atomized powder, the base material.

Cost per volume

During the phase of business case identification, it is often necessary to estimate the manufacturing cost without a final design. For this purpose it can be helpful to derive a rough estimate using the cost per volume. With increasing build job volume and thus higher utilization of the build chamber, the cost significantly decreases. From the graphic below, the manufacturing cost for each material can be estimated, if the total volume of parts in one build job is known. Since the Laser Beam Melting process speed depends on more than just the build volume, the cost is displayed within a range of a high and low boundary.

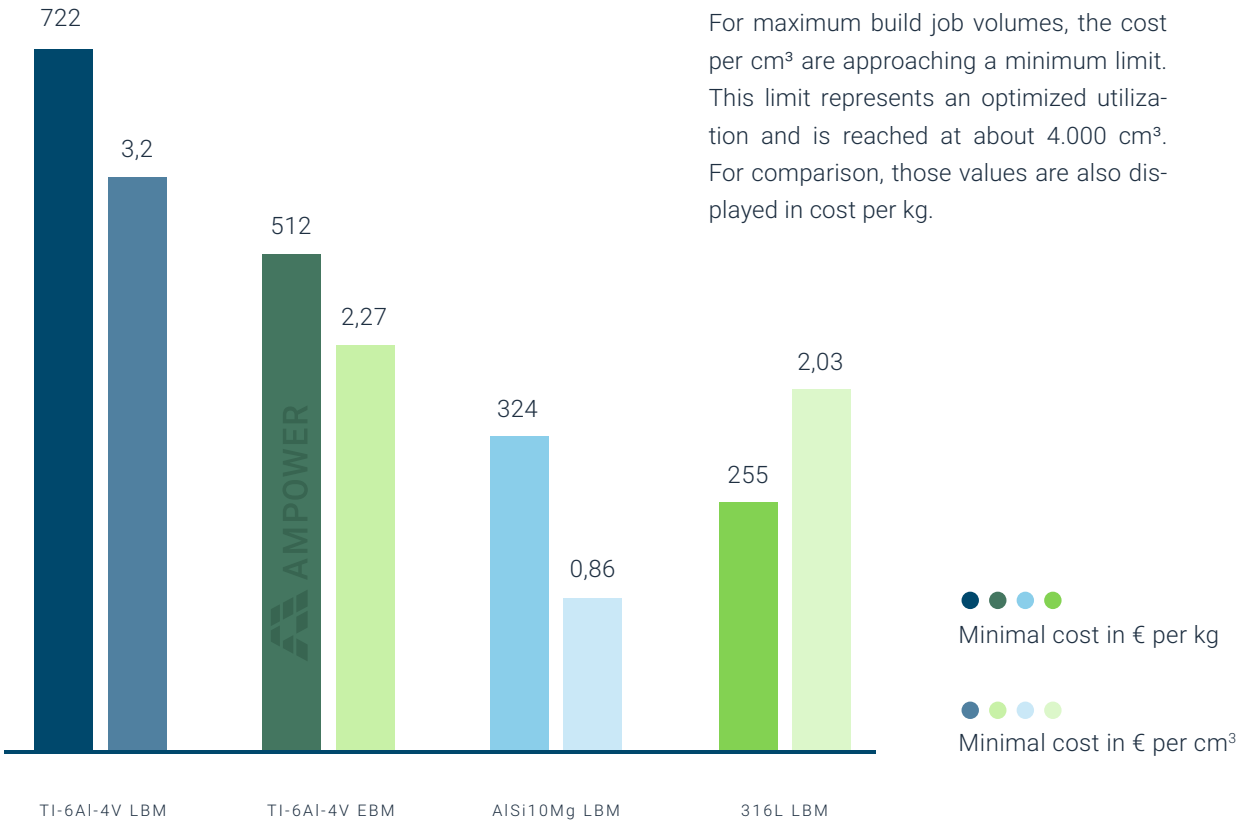


Powder cost



While machine costs are not likely to drop significantly in the near future, the productivity is expected to increase which will result in reduced production cost.

The material prices already dropped in the past few years. Further drop in material prices can be expected by the rise of more competition on the market. However, the current focus of powder distributers is the qualification of powders rather than pricing. This is also the main reason why customers still purchase the more expensive materials from the machine OEMs.



For maximum build job volumes, the cost per cm³ are approaching a minimum limit. This limit represents an optimized utilization and is reached at about 4.000 cm³. For comparison, those values are also displayed in cost per kg.

For evaluation of your part screening, calculate your cost based on our model at **www.am-power.de/calculator**

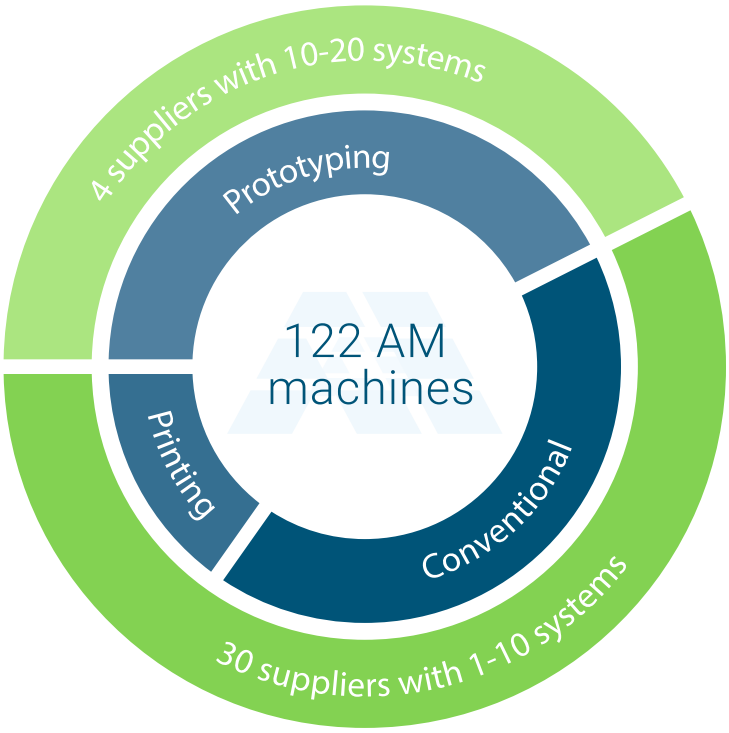
Today’s metal market pricing

Supplier market today

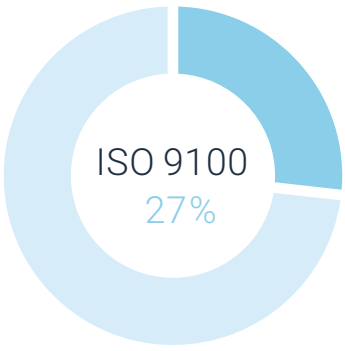
The metal service bureau market within the German speaking region is dominated by companies originating from the prototyping industry. However, companies with roots in conventional machining are picking up and are expected to set the standards for serial production in the future.

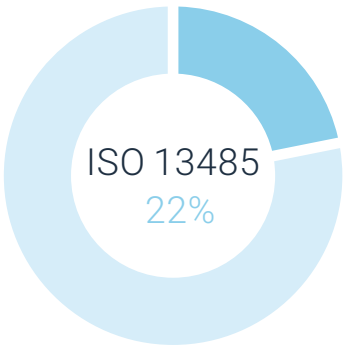
Supplier distribution

The four largest suppliers dominate the business by representing almost 50 % of total metal machine capacity. They all have a common history in the prototyping business. The market is already showing signs of separation between prototyping and serial production capacities. Most prominent example is the segmentation of the FIT AG into the subsidiaries FIT Prototyping and FIT Manufacturing.



ISO Certification



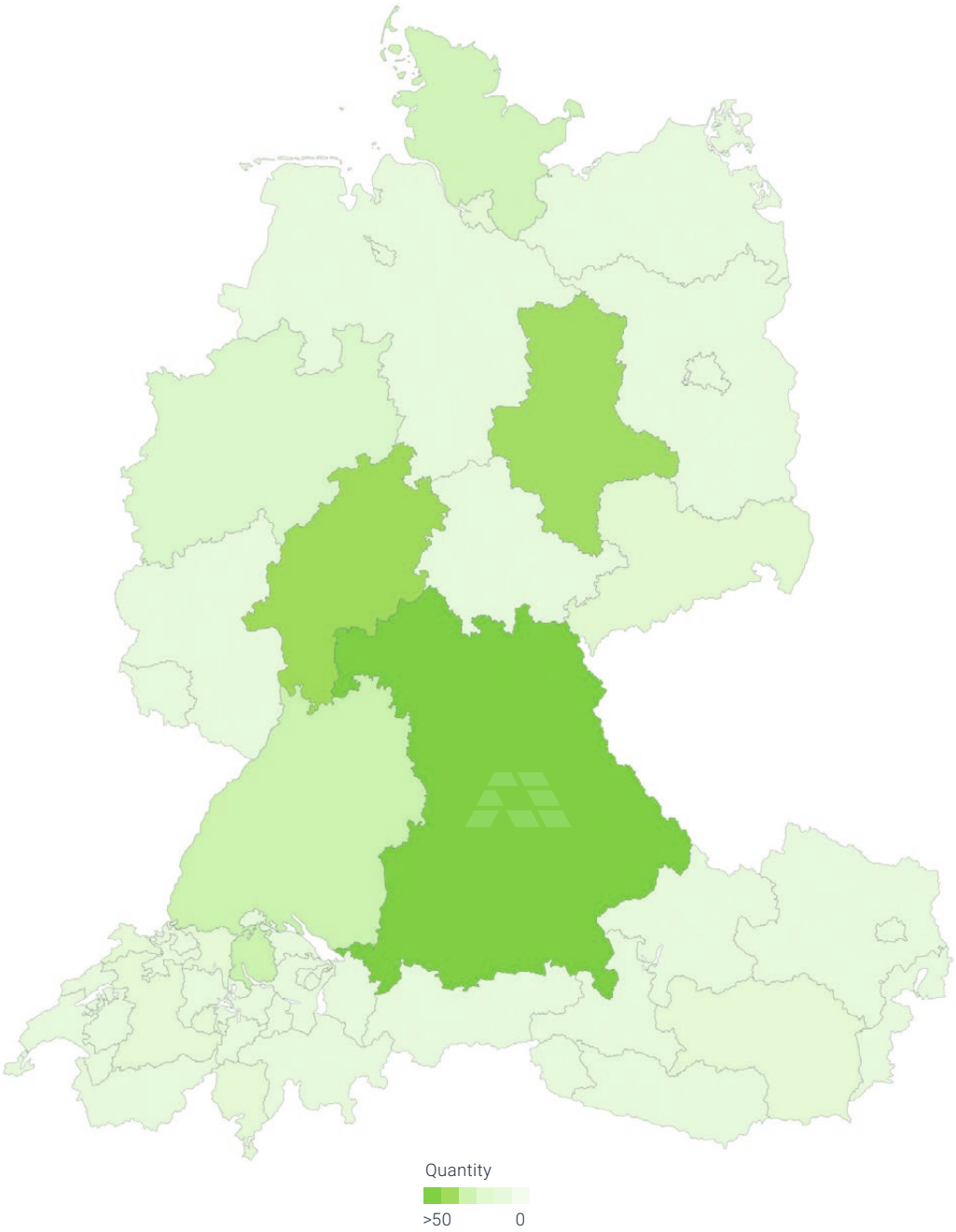


General management certifications are the base of a qualified supplier. Over 70 % of the suppliers are certified according to ISO 9001.

However, there is no widely acknowledged certification with regards to the quality of Additive Manufacturing.

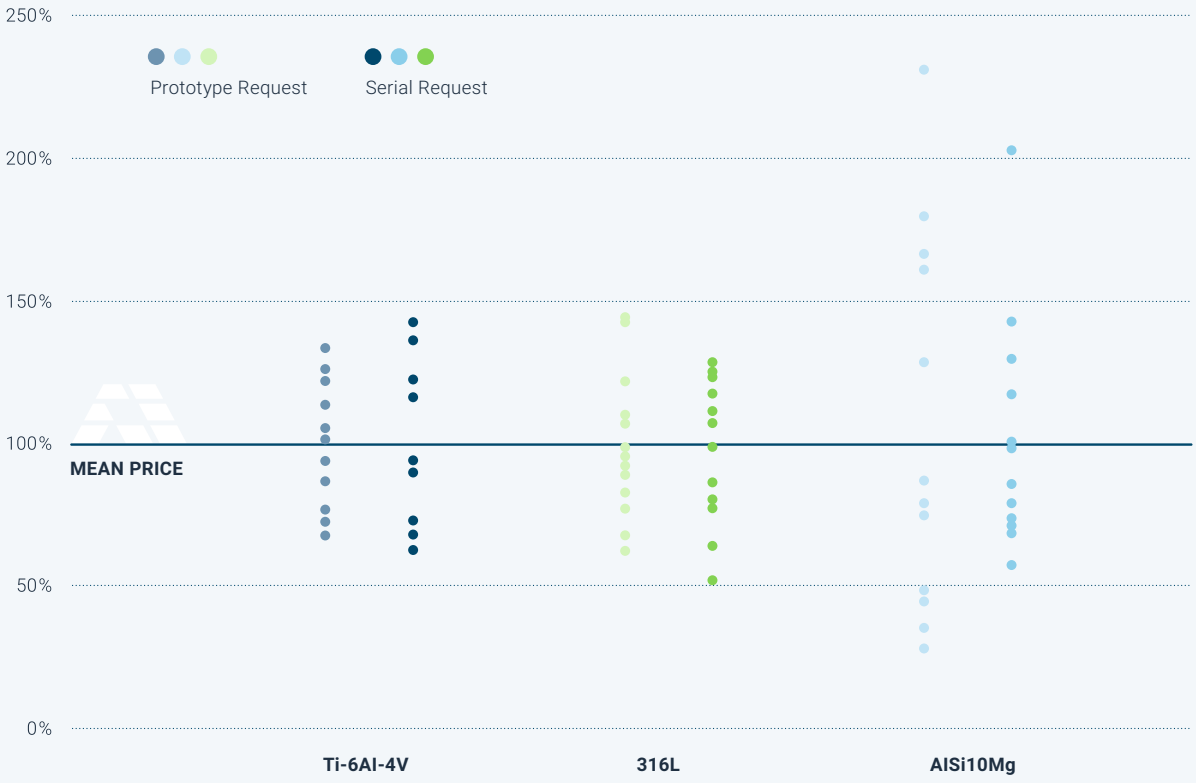
Geographical distribution

Additive Manufacturing metal service bureaus are concentrated in the area of Southern Germany, led by Bavaria with an installed machine capacity of more than 50 machines.



Market pricing

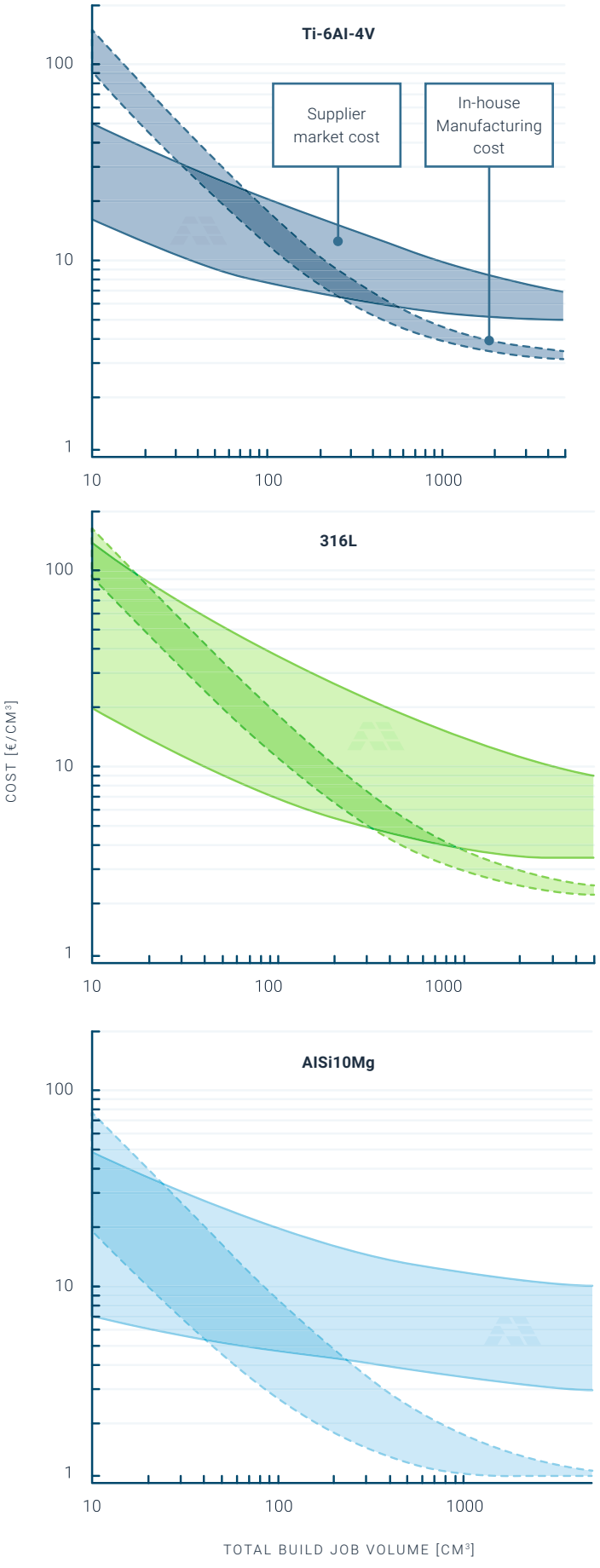
Besides the individual margin of each supplier, the utilization of the AM machine turns out to be the main parameter influencing the market price for AM parts. However, even at high volume build jobs, the price difference between suppliers is significant.



Pricing spread

The difference between the mean price offer and the highest offer can be up to 230 %. The lowest offer can be at 30 % of the mean value. This leads to the assumption that price comparison is more than advised in Additive Manufacturing.

It is also notable, that the offer spread does not reduce when requesting a large quantity of parts. Suppliers that offer the cheapest prototypes often also offer the cheapest serial parts. The offer spread is largest for AlSi10Mg material.



Utilization

For low build volumes, the market price is significantly lower than internal manufacturing. This is due to the utilization of the supplier's production. He is able to combine requests from multiple customers in the same build job and thus is able to offer a lower price for low volume part requests.

Margin

At high build volumes, the utilization does not affect the pricing anymore. At this point, margin and company overhead become the main price drivers.

Layer thickness

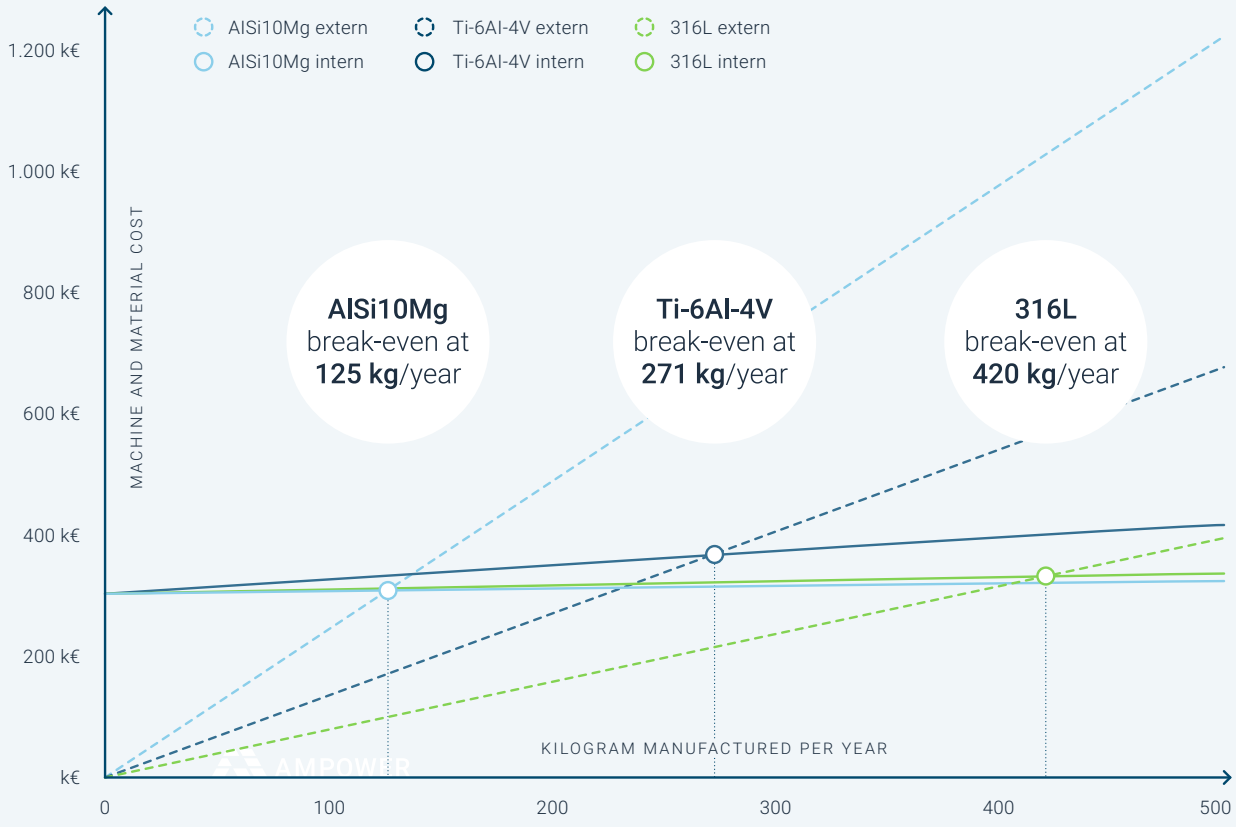
The layer thickness has a large impact on pricing and is not accounted for in this study. Prices may be reduced by nearly 50% when the layer thickness doubles from 30 µm to 60 µm for example.

- In-house Manufacturing cost
- Supplier market cost

Key decision factors to make or buy

Make or buy

The decision on whether or not to outsource your AM production is based on numerous factors. Most of them are related to corporate strategic decisions that cannot be generalized. However, the cost factor will always play a major role in this decision.



Break-even of in-house manufacturing

With increasing volume manufactured per year, the investment into internal AM capacity becomes more attractive. The break-even calculation assumes annual fixed cost of 300,000 € for a mid-sized dual laser machine including machine space, staff, and infrastructure.

Make vs. Buy

Large overheads increase production cost	Low investment in infrastructure
High initial investment and risk	Know-how transfer and synergies between partners

Development of protected material parameters	IP protection insufficient
IP on industrial production and quality assurance process	No developments in machine or material
High production integration increases quality	No increase of internal Know-how

Knowledge increase with in-house capacity

Lack of knowledge is one of the major barriers to overcome for a successful AM implementation. Only with in-house machine capacity this knowledge can be fully acquired. As soon as new AM designs are being tested, the direct feedback from the manufacturing process is required to fully optimize the part for Additive Manufacturing. During the initial phase of implementation while identifying promising business cases, the risk for investments can be reduced by using an external supply chain.

A quick guide on procurement of AM parts

If the decision for the AM production was made, the procurement should consider certain steps in order to receive valid quotations from service bureaus.

Data

Creating the right data for your production request is more crucial than for other technologies. Besides the right file formats, it might be necessary to define the orientation and support geometry of the part.

1.

2.

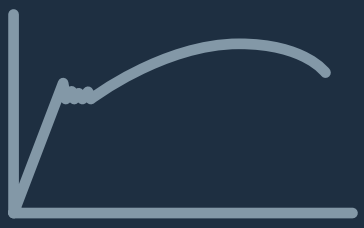
Specifications

A complete production request package contains not only the part geometry as a CAD file but all relevant specifications concerning material properties, heat treatment, material allowances and additional information if applicable.

3.

Focus

No supplier is interested in answering widely spread and impersonal cost offer requests. A well focused supplier screening leads to reliable offers. Suppliers also tend to adjust their price according to the application and the chance of an order. Describe the application, the background and your project timeline.



Material properties

A reliable supplier is tracking quality constantly. Do not accept default material data sheets from the machine manufacturer. Have a look at the material properties and its consistency over time. Density, tensile strength and analysis by micrographs are standard quality assurance results that a supplier should be able to provide.

4.

5.

Personal contact

AM suppliers have different backgrounds and work under different circumstances. Only by talking to future contractors in person and visiting their facilities, you will get a complete impression of the manufacturers capabilities.

Thinking ahead – metal pricing 2022

The development of AM production as a mainstream technology is just at its beginning. The prediction of the future is known to differ depending on who is being asked.

“Premium Aerotec is one of the early adopters of Additive Manufacturing in the aerospace industry. The sole manufacturing expenses only take a small share of the overall production cost since quality assurance efforts for aerospace applications are extremely high. Furthermore, initial process and part qualification drive the cost for this new technology. For the future however, I predict a significant drop in cost due to increased production volumes and productivity. Additionally, remaining hurdles in quality assurance will be overcome to further reduce costs and thus enabling even more business cases.”

GERD WEBER
Head of Plant Varel, Premium AEROTEC GmbH

"As a result of the future increase in the productivity and automation of AM factories and the intelligent AM design, comparable product costs will drop by a factor of 10 to 100 in the next 5-10 years and thus numerous applications will be profitable."

PROF. DR.-ING. CLAUS EMMELMANN
CEO of Laser Zentrum Nord GmbH

"We at Deutsche Bahn are absolutely convinced that 3d printing will play a main role in producing spare parts in future right on demand. Production costs for metal parts which are very relevant for the mobility sector due to flame retardancy and stability have to decrease rapidly in the next five years. Our aim is to save time and logistic costs by printing on demand. We share this aim with other big OEMs also in our Mobility goes Additive-network. They are all about to use AM much more and this will help to put emphasize on this subject."

STEFANIE BRICKWEDE
Head of AM, Deutsche Bahn
Managing Director Mobility goes Additive

"Today, our customers in orthopedics and aerospace produce parts with Electron Beam Melting technology that are cost competitive. Ongoing developments such as higher build speed, in-process verification and lower powder cost will drastically reduce cost and make the technology attractive for a wider range of applications and industries."

MAGNUS RENÉ
President and CEO of Arcam AB

"I expect the cost of parts produced by Additive Manufacturing to be reduced over the next 5 years. This assumption is based on the fact that the productivity of the machines will increase significantly during this period and the prices for materials will decrease."

OLIVER EDELMANN
Global Sales Manager, GE Additive

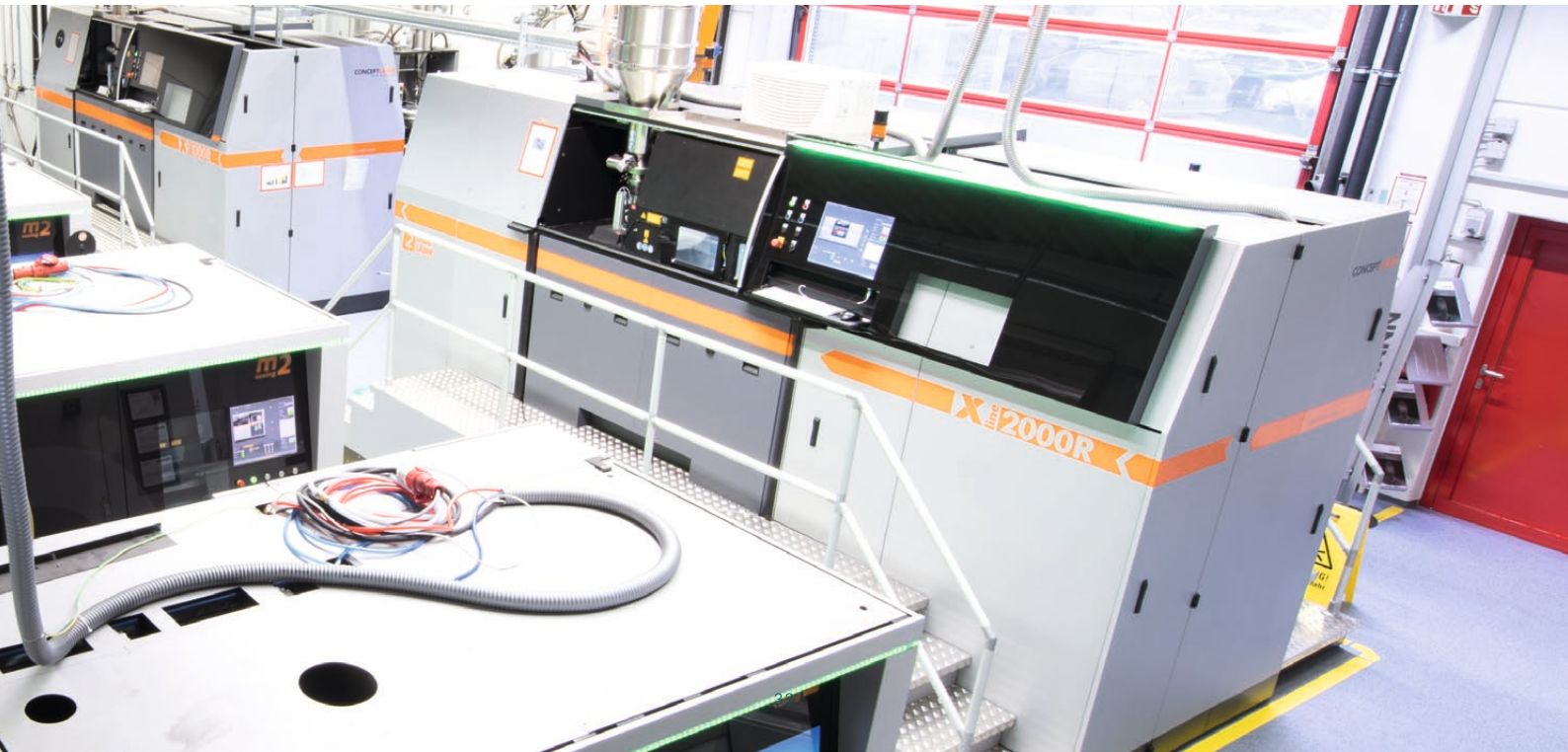
"The often anticipated question about the business case is completely overrated. It takes several years to develop and qualify a new AM product and to establish the engineering knowledge within the team. In the meantime, the powder market has responded to the growth, and the machine developments to the industrialization requirements appropriately."

PETER SANDER
Head of Emerging Technologies & Concepts at Airbus Operations

„Additive Manufacturing part costs for current technologies are driven by machine productivity and post processing efforts. Significant cost reductions will be achieved by new machine technologies and the industrialization of the entire production process chain. Furthermore, it will be important to determine the most cost effective AM technology according to the respective part requirements"

JENS HENZLER
CEO Robert Hofmann GmbH

ADDITIVE MANUFACTURING FACTORY AT ROBERT HOFMANN GMBH, ONE OF THE MAJOR METAL SUPPLIERS



About the authors

Dr.-Ing. Maximilian Munsch

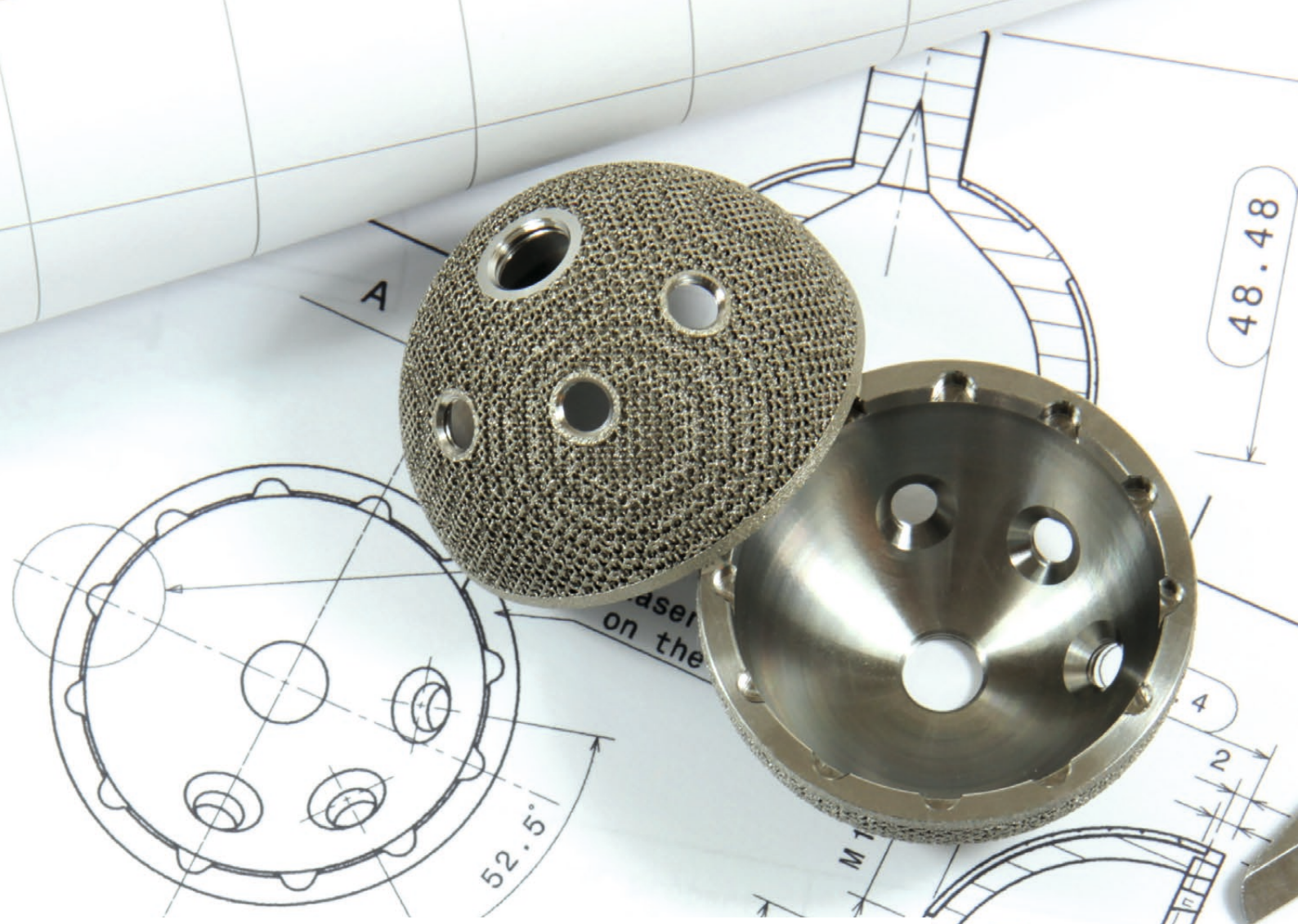
Since 2007, Maximilian Munsch is a professional user of Additive Manufacturing. After finishing his dissertation on reduction of residual stresses in metal Additive Manufacturing in 2012, he acquired extensive hands-on experience with metal powder bed based Laser and Electron Beam Melting processes in industry. His focus is on the full Additive Manufacturing process chain required for industrial production. Max has successfully planned, implemented and qualified multiple Additive Manufacturing productions for medical applications.

Eric Wycisk

Eric Wycisk can look back on 9 years in Additive Manufacturing with a focus on metal, especially titanium alloys. In his former affiliation, he was team leader and Key Account Manager for aviation applications and AM light weight design. He managed multiple projects concerning topology optimization and light weight design, process development and optimization as well as industrial implementation of Additive Manufacturing. The research in Erics dissertation focuses on fatigue properties of laser beam melted Ti-6Al-4V.

Matthias Schmidt-Lehr

Matthias Schmidt-Lehr successfully managed several projects in Additive Manufacturing with focus on part screening, business case development, AM design optimization and production in both metal and plastic materials. With a history in the consulting business, he is committed to customer satisfaction, project management and controlling. In his former positions Matthias gathered experience in business development, customer relationship management, as well as marketing and sales.



Special thanks

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