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eceee Industrial Efficiency 2020 - Decarbonise Industry!

Value chain-wide energy efficiency potentials of additive manufacturing with metals – some preliminary hypotheses

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Significance of AM with metals

Research for a sustainable development

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- The current diffusion of AM with metals allows for a preliminary assessment of likely implications for energy efficiency.
- The main use still resides with light-weight aerospace applications.
- Unlike many cross-cutting energy efficiency technologies, energy use of AM may vary substantially depending on industry considered and material used.
- AM with metals may have much greater repercussions on other stages of value chains than conventional cross-cutting energy efficiency technologies.

Properties of AM technologies that can be used with metals

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Starting Material	Process	Material Preparation	Layer Creation	Phase Change	Materials	Applications
Powder	Selective Laser Sintering (SLS)	Powder in Bed	Laser Scanning	Partial Melting	Thermoplastics, Waxes, METAL, Ceramic	Prototypes, Casting Patterns, Metal and Ceramic Preforms
	Selective Laser Melting (SLM)	Powder in Bed	Laser Scanning	Full Melting	METAL	Tooling, Functional Parts
	Electron Beam Melting (EBM)	Powder in Bed	Electron Beam Scanning	Full Melting	METAL	Tooling, Functional Parts
	Laser Metal Deposition (LMD)	Powder Injection through Nozzle	Powder Injection/ Melting by Laser	Full Melting	METAL	Tooling, Functional Part Repair
	3D Printing (3DP)	Powder in Bed	Drop-on-Demand Binder Printing	-	Polymer, METAL, Ceramic, Other	Prototypes, Casting Shells, Tooling
Solid Sheet	Laminated Objective Manufacturing (LOM)	Laser Cutting	Feeding/ Binding of Sheets - with Adhesives	-	Paper, Plastic, METAL	Prototypes, Casting Models
Wire	Wire Arc Additive Manufacturing (WAAM)	Wire	Welding	Full Melting	METAL	Prototypes, Sculptures, Structures, Functional Parts, on-site Repair

Source: Partly adapted from US Department of Energy (2015)

The MX3D WAAM Pedestrian Bridge for Amsterdam

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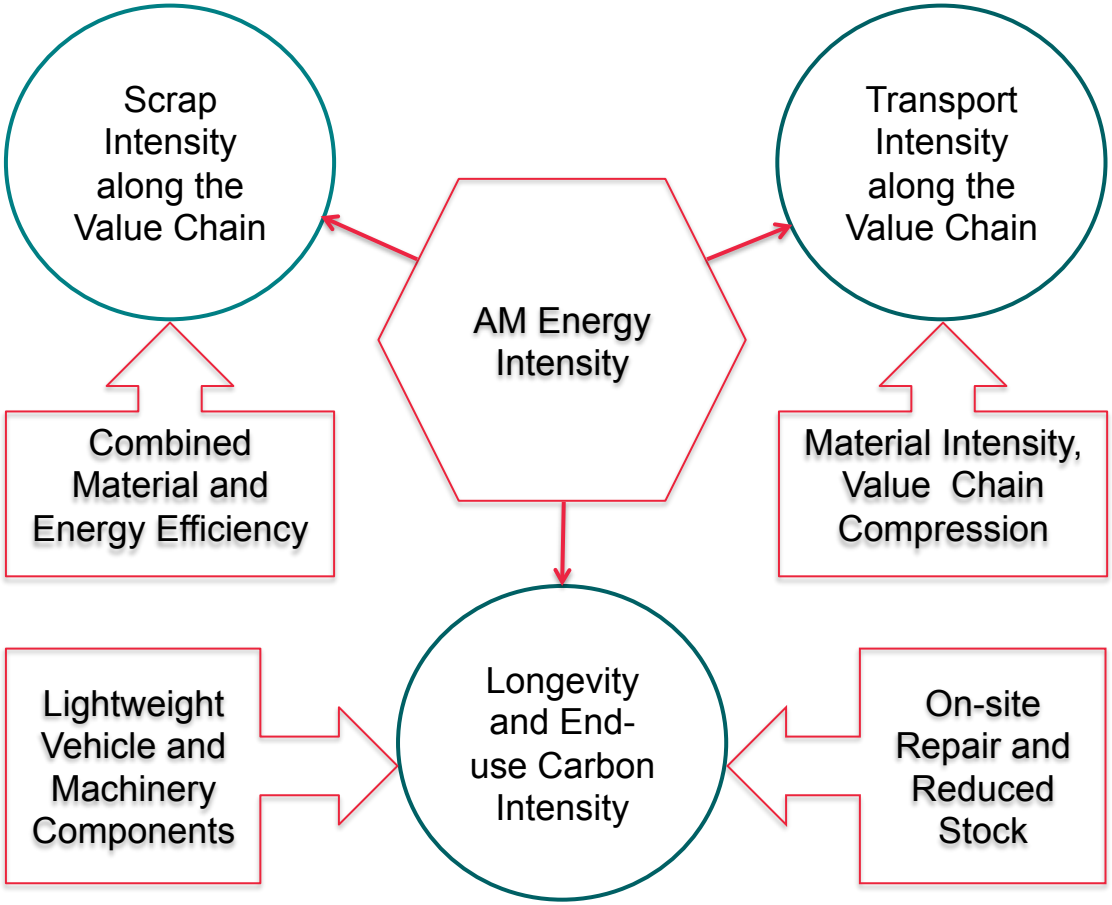
WAAM with metals may be used for specific objects, architecture and art. The latter not by Richard Serra but more so by Markus Lüpertz.

Picture courtesy of MX3D

Significance of AM with metals

Drivers of value chain-wide energy efficiency



Significance of AM with metals

Drivers of value chain-wide energy use

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- Energy efficiency as compared to the respective conventional processing technology – if available – that allows to manufacture similar products;
- Scrap intensity of processing and the amount of energy that has been lost up to the respective step in the value chain;
- Transport intensity and energy use and GHG emissions required for logistics related to production, maintenance, repair and (re-); and
- Longevity and end-use carbon intensity of the utilization of final products.

Preliminary assessment of AM with metals

Likely energy efficiency contributions by application and value chain component

	Aerospace Components	Ground Vehicle Components	Stationary Machinery Components	Construction Components	Onsite Production	Onsite Repair
Processing Energy Efficiency	++ Titanium, aluminum	++ Aluminum, steel	++ Steel	++ Steel	- Steel	+++ Steel
Supply Chain Material Efficiency	+++	+++	+++	+++	+++	+++
Supply Chain Transport Efficiency	+	+	+	+	++	+++
End Use Energy Efficiency	+++	++	+	-	-	-

Conclusions

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It can be expected, that the contribution of AM to decarbonisation of metal value chains can be very substantial in cases where it may allow to combine:

- Higher material efficiency during the processing stage over conventional subtractive manufacturing;
- A geographical compression of value chains by reshoring certain steps of them; and
- Increased energy efficiency during the end use phase of the respective products by reducing their weight.

Any robust assessment will require further research with a focus on energy use and decarbonisation potential of AM with metals.

Thank you
for your attention

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