

ENABLING CO₂ REDUCTION

CEO UPDATE
MAY 2019



AMG ADVANCED METALLURGICAL GROUP N.V.



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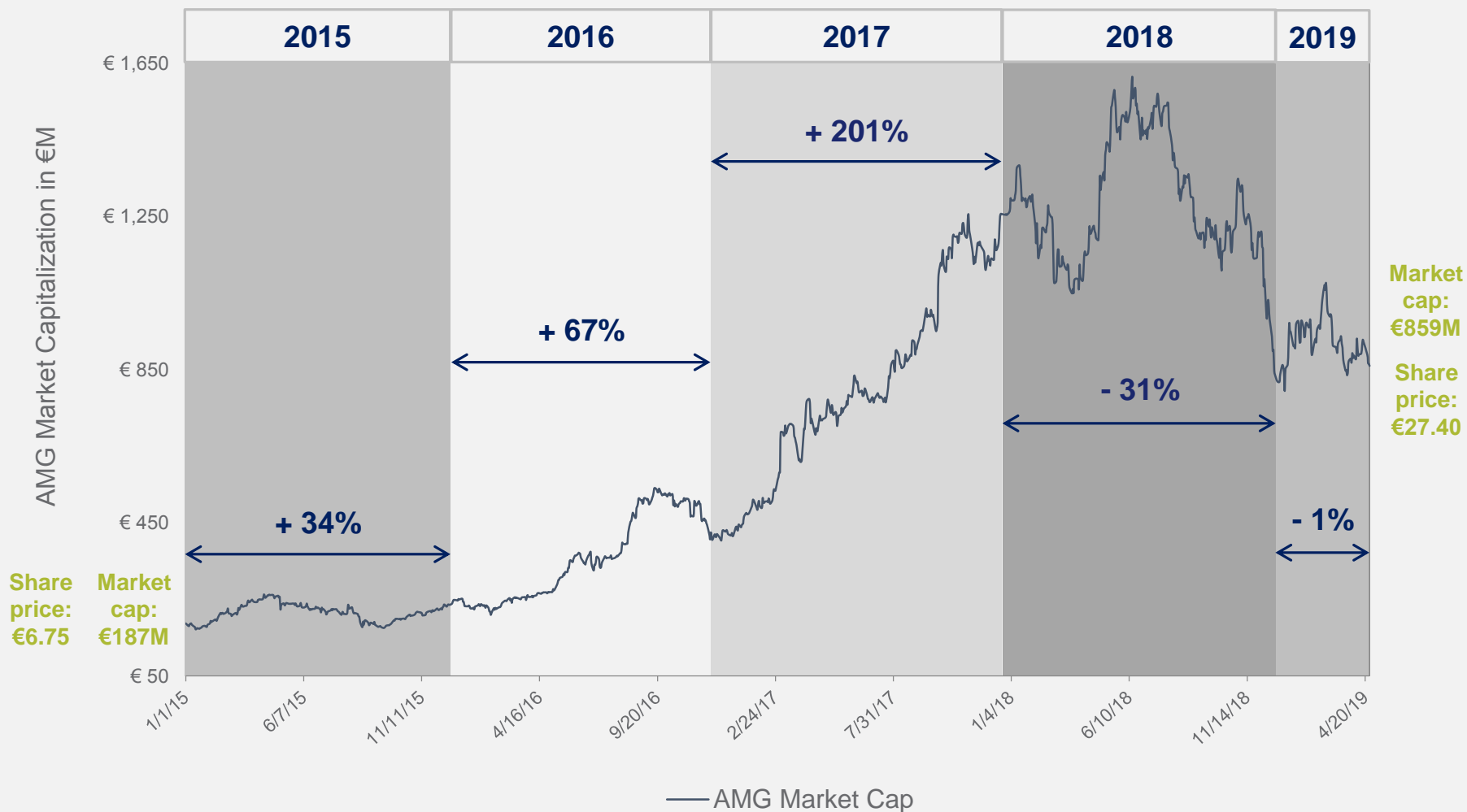
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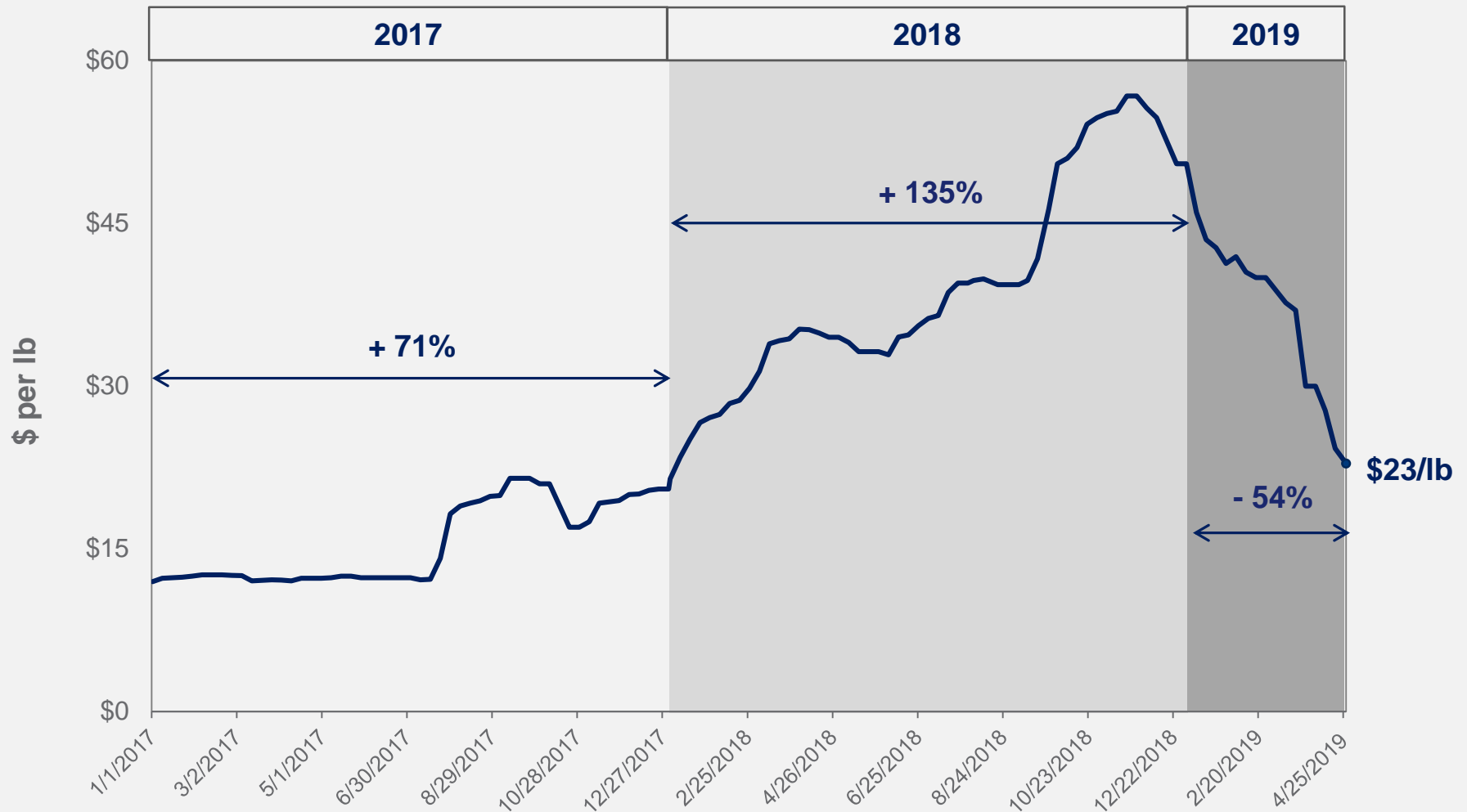
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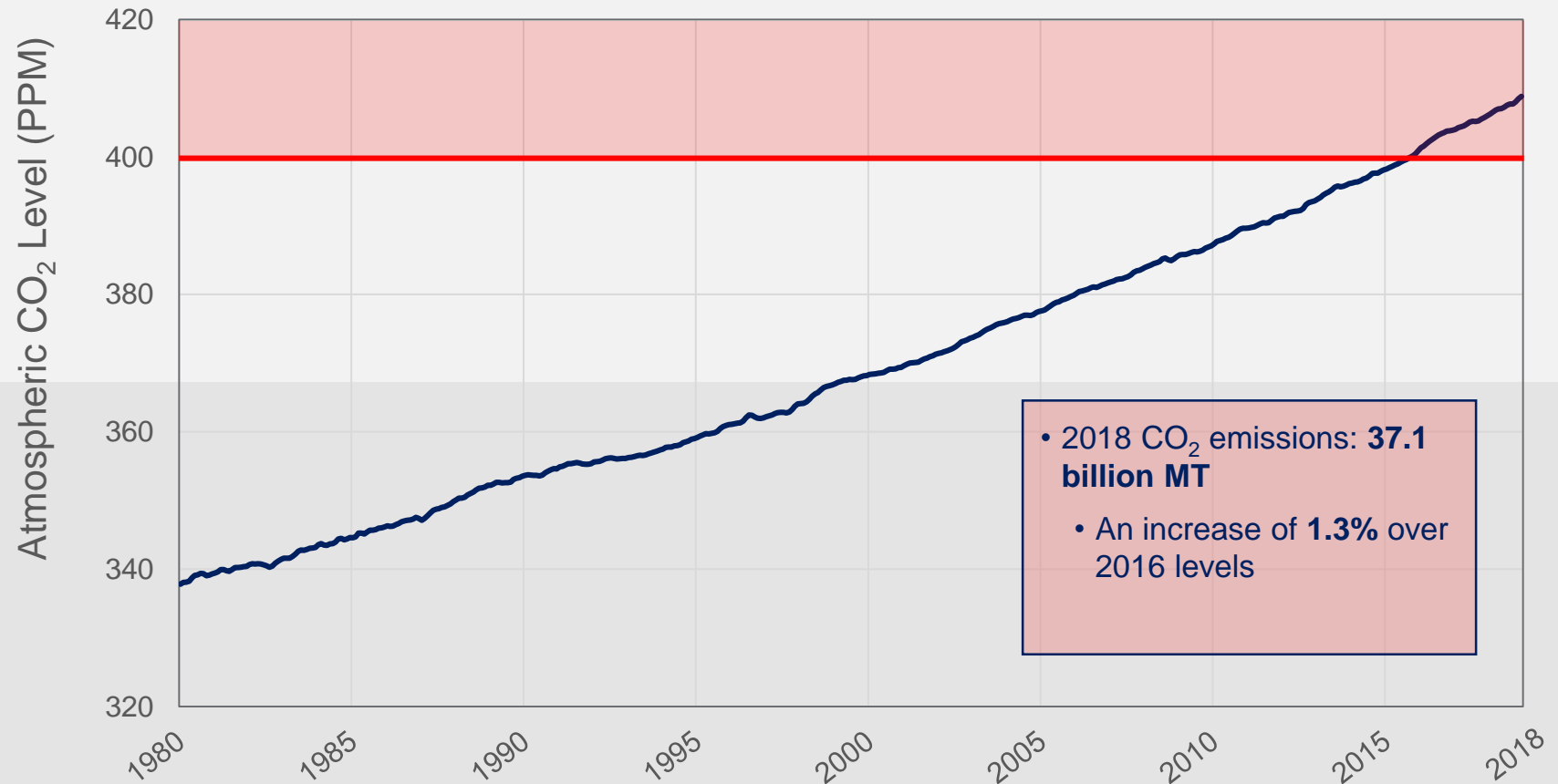
2015 – 2019 AMG MARKET CAPITALIZATION



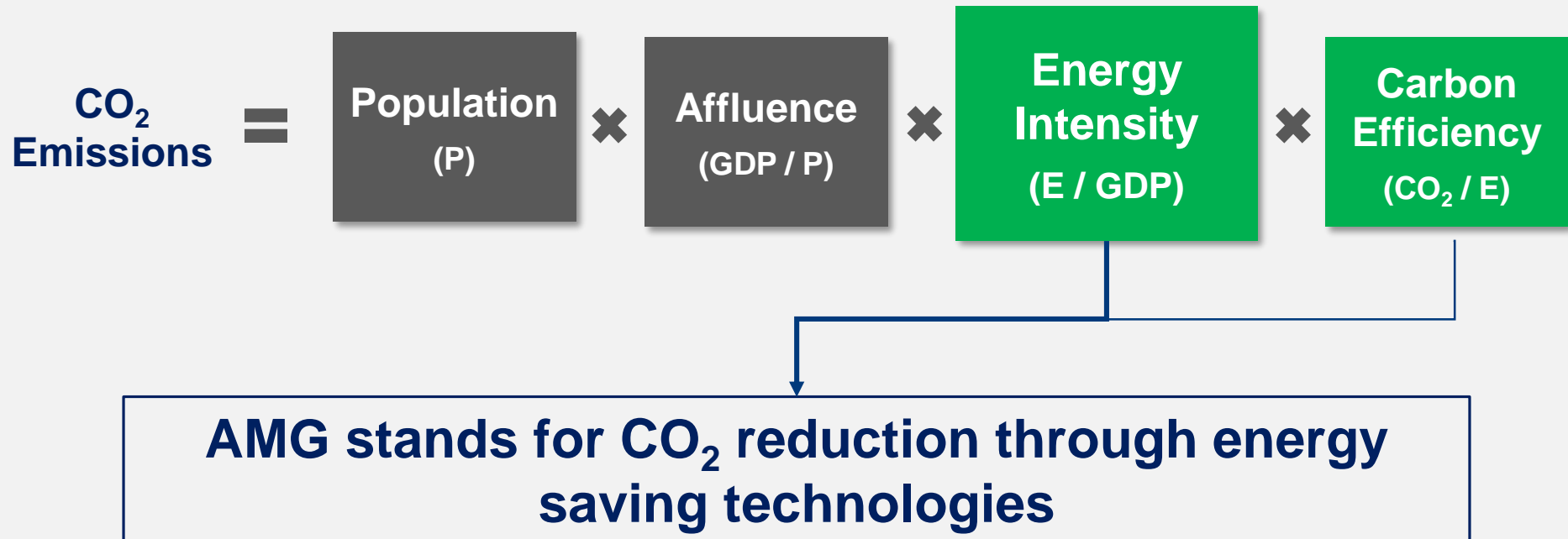
RECENT VANADIUM PRICES



ATMOSPHERIC CO₂ ACCUMULATION



MATERIAL SCIENCE BASED SOLUTIONS



THE AMG PORTFOLIO

AMG Critical Materials	CO ₂ Relevance	
	Energy Savings	Energy Storage
Aluminum	Transportation	-
Graphite	Buildings	Anodes
Silicon	-	Anodes
Vanadium	Steel	Stationary Batteries
Antimony	-	Batteries
Mineração	-	Lithium
Superalloys	-	Fuel Cells
AMG Technologies		
Titanium Alloys	Aero Engines	V ₂ O ₅
Engineering	Aero Engines	-

AMG'S ROLE IN CO₂ REDUCTION

Enabled CO ₂ Reduction - 2018		
Business Unit	Net CO ₂ Reduction (tons) *	Technology / Product
Engineering	43.5 million	Thermal Barrier Coatings & Turbocharger Wheel Castings
Titanium Alloys & Coatings	5.0 million	Titanium Aluminides
Vanadium	1.2 million	Steel Alloying / Light weighting
Graphite	1.0 million	Graphite Insulation

Total net CO₂ reduction (2018): 50.7 million tons

* Net of operating emissions

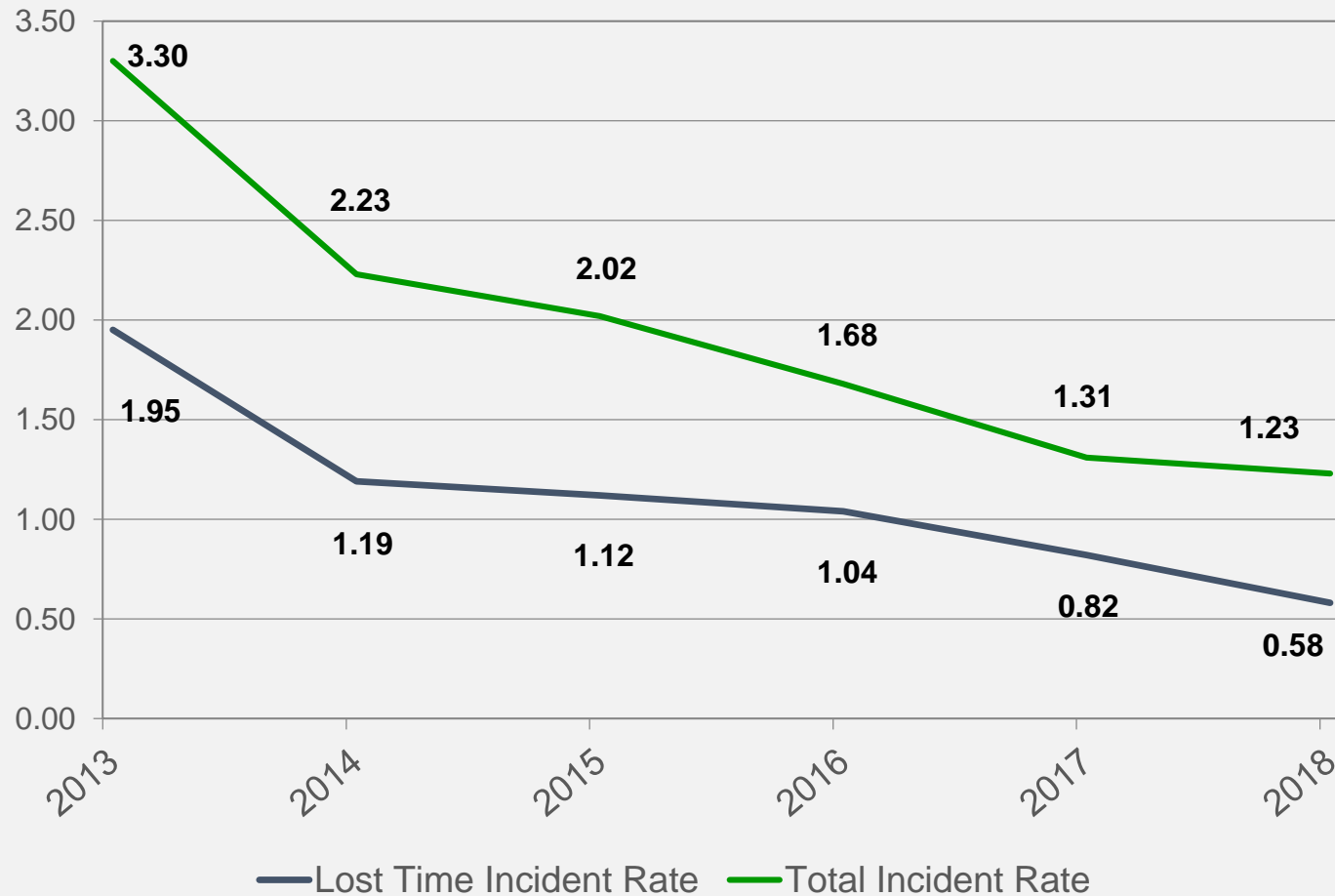
THE CO₂ REDUCTION RATIO

Business Unit	Net CO ₂ Reduction (tons)	Total Assets (\$M)	CO ₂ Reduction Return *
Engineering	43.5 million	\$158	275.3 x
Titanium Alloys & Coatings	5.0 million	\$120	41.6 x
Vanadium	1.2 million	\$177	67.8 x
Graphite	1.0 million	\$94	10.6 x

* Measured as ton of CO₂ reduction per \$1,000 invested

HEALTH AND SAFETY

AMG consolidated safety results: 2013 – 2018



SPODUMENE I STATUS

Operating Metric	Status
Feed Rate	90 tons per hour (95% of target)
Metallurgical Recovery	90% of target
Product Quality	'in spec'
Production Costs	Estimated to be on target

CAMBRIDGE, OHIO RECYCLING FACILITY



SPENT CATALYST SEEKING RECYCLING SOLUTIONS

GLOBAL REGULATION & GOVERNANCE

- IMO 2020 legislation – reduction in sulfur limits from 3.5% to 0.5%
- Increased industry focus on proper management of waste streams

MIDDLE EAST & CHINA

- Shift away from export of crude oil and towards in-region refining and upgrading
- Chinese government-imposed ban on import of vanadium-bearing waste

CAMBRIDGE II

THE PROJECT	Double AMG V's capacity to process spent vanadium-bearing catalyst, using the existing conversion process as implemented at the Cambridge site, optimized via technological improvements
PROJECT SCOPE	Construction of a roasting and smelting facility in close proximity to the Cambridge site, taking advantage of personnel efficiencies such as shared oversight and management/control
CAPEX COST	Estimated at approximately \$300 million, including contingencies. Funding via low-cost, tax-exempt bond facility
FINANCIAL METRICS	Opex costs estimated to be equivalent to current costs at the existing site. At full capacity, the second site will offer additional processing capacity of 30,000 MT per year





AMG / CRITERION JOINT VENTURE



Shell Global Solutions

Partnership between two market leaders to develop a sustainable 'cradle-to-grave' solution for catalyst supply and reclamation

AMG TECHNOLOGIES PRO FORMA, 2018

	Furnace Systems	Own & Operate
Heat Treatment	<div>✓</div> <div></div> <div>ModulTherm</div>	<div>✓</div> <div></div> <div>ALD Mexico</div>
Metallurgy	<div>✓</div> <div></div> <div>VIDP furnace</div>	<div>✓</div> <div></div> <div>AMG Titanium – Titanium Aluminides</div>

AMG TECHNOLOGIES: TECHNOLOGY HIGHLIGHTS



Select technology highlights:



- Vacuum melting technologies
- Thermal barrier coaters (world leader)
- Ceramic matrix composite (CMC) fiber coaters
- Powder atomization machines (Ti & Ni-based alloys)
- Heat treatment furnaces



- Titanium Aluminides (world leader)
- Master alloys for titanium alloys
- Master alloys for Ni-based superalloys
- Physical vapor deposition (PVD) coating materials
- Hydrogen storage alloys for fuel cells

SUSTAINED GROWTH IN LEAP ENGINE PLATFORM – FORECAST TO 2036



24,807 single-aisle aircraft

8,686 twin-aisle aircraft

1,406 very large aircraft

34,899 new aircraft

Boeing and Airbus
new aircraft forecast
as of October 2018
results in a total
demand for LEAP
1A/B engines for
single aisle aircraft of
approximately 88,000
units



29,530
NEW AIRPLANES



5,050
NEW AIRPLANES



3,160
NEW AIRPLANES

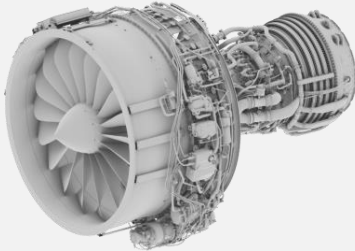
37,740 new airplanes

Source:
Airbus Global Market Forecast 2017 – 2036
Boeing Current Market Outlook 2017 - 2036



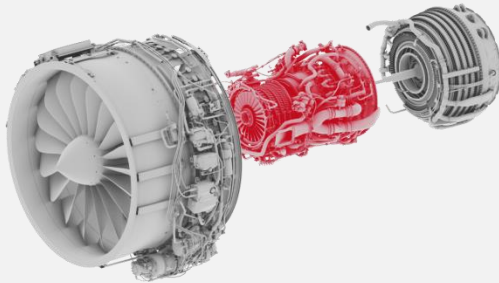
AMG TECHNOLOGIES IN THE LEAP ENGINE

Compressor Applications



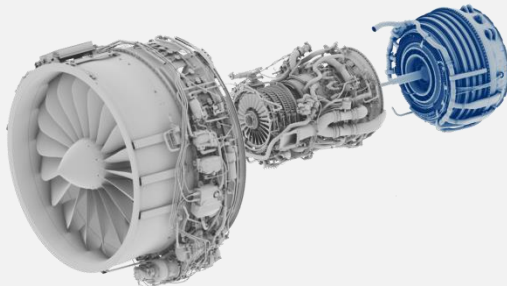
- Remelting Furnaces e.g. for Ti64
- Atomization Furnaces for Plasma Spray Powder, HIP'ed and Forged Parts
- Master Alloys for Ti Base Alloys
- Plasma Melting Systems for Ti Base Alloys

High-Pressure Turbine & Combustion Section



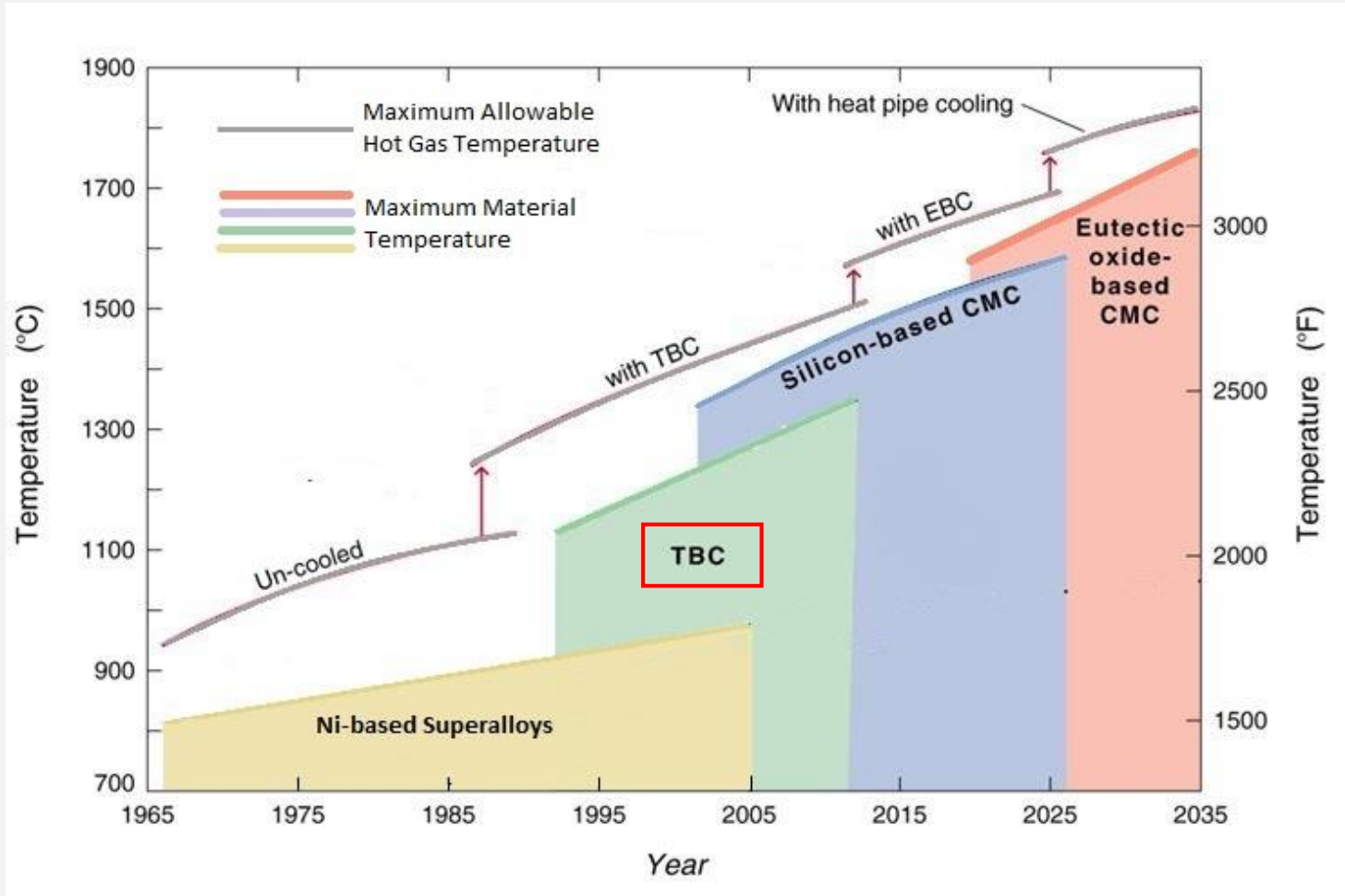
- Equipment for CMC Shrouds
- EB-PVD Coaters for Thermal Barrier Coatings
- Hot Isothermal Forging Systems for Superalloy Disks
- VIM Furnaces for Ni Base Superalloys
- Master Alloys for Ni Base Superalloys

Low-Pressure Turbine



- Hot Isothermal Forging Systems for Ni-based alloys
- Plasma Melting Systems for Titanium Aluminides
- VAR and VIM Furnaces for Titanium Aluminides
- Titanium Aluminide Feedstock for Blades

THERMAL BARRIER COATING REVOLUTION



AMG IS THE GLOBAL LEADER IN TBC TECHNOLOGY

23 of the 24 advanced TBC systems in operation globally developed by AMG



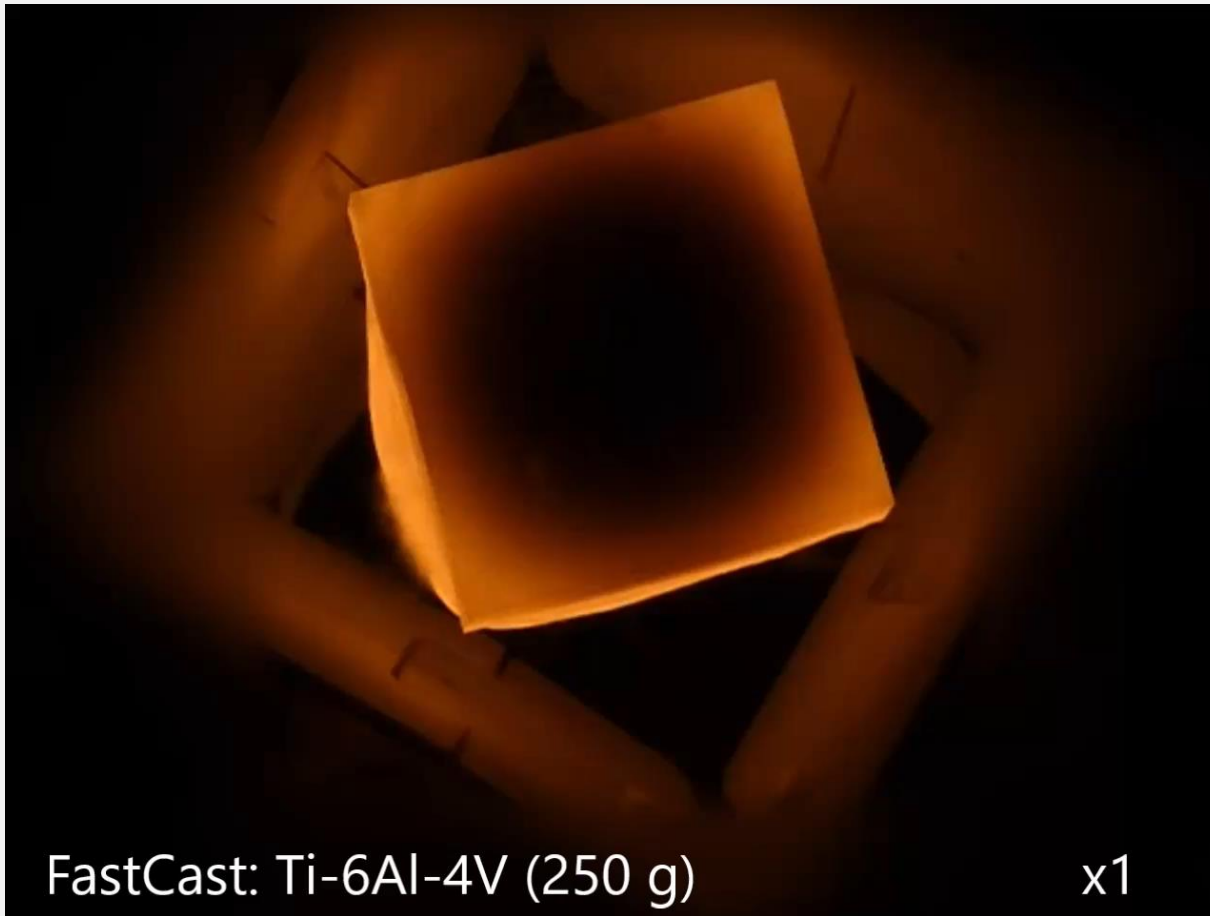
AMG IS THE GLOBAL LEADER IN TITANIUM ALUMINIDES



AMG TECHNOLOGIES INNOVATIONS

- **Ceramic Matrix Composite (CMC) fiber coater** – development of next-generation aerospace coating technology, permitting higher turbine temperatures while achieving significant weight reductions
- **FastCast** – new, proprietary casting technology which significantly improves yield in the casting process (e.g. low pressure turbine blades for aero engines)
- **Additive manufacturing** – Innovative 3D printing technology equipment, capable of producing larger components

FASTCAST IN OPERATION





Long-term Guidance:

“Given the strong underlying growth dynamics of the AMG portfolio, the management board is committed to deliver an EBITDA of \$350M, or more, in five years or less.”