

# WHAT IS A “GREEN” COMPANY?

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This paper, co-authored by Dr. Heinz C. Schimmelbusch AMG Advanced Metallurgical Group N.V.’s Chief Executive Officer and Chairman of the Management Board, Dr. David J White, AMG Vice President Health, Safety and Environmental Affairs, and Mr. Jonathan A. Costello, AMG Vice President Corporate Development & Communications, explains how AMG approaches sustainability.

We speak of green technologies, green strategies, green companies, green IPO’s, green political policies, and lately “green bonds”. There are innumerable perceptions and meanings of “green” and no workable definition. We will offer a framework not only how to define “green” but also how to measure “greenness” of a company, a necessary step on the road to green ratings which then would assist investors with an interest or commitment to this movement. The proposed framework is the result of our involvement in “green” technologies at AMG Advanced Metallurgical Group, N.V., Amsterdam. A cautionary remark: The calculations in this brief are subject to further work and refining. By the very nature of their broad scope they will inevitably require approximations and estimations. However, we believe they are sufficiently accurate for the conclusions we have arrived at.

When AMG Advanced Metallurgical Group N.V. (“AMG”, EURONEXT AMSTERDAM: “AMG”) was created, the guiding principles were (1) that material science in general, and advanced metallurgy in particular, holds the key for technological solutions which respond to the trends towards a sustainable society; (2) that AMG would assemble a portfolio of productive assets in “critical” materials which are “critical” because of the demand shifts resulting from those trends; and (3) that AMG would focus on technological

innovations that combine financial with environmental attractiveness. We have consistently reiterated these principles.

The methodology of measuring financial attractiveness is well established. But how do we measure environmental attractiveness? In other words, how do we actually define the loosely and often carelessly used term “green”? Early on we decided to measure our environmental impact using CO2 emissions, and more particularly how does AMG contribute to the reduction of CO2 emissions. The reasons for this focus were that (1) there is a mounting body of evidence pointing toward anthropogenic CO2 emissions as the root cause of global warming; (2) even if this is not the case, fossil fuels must be finite and we must preserve them in order to have a sustainable society; and (3) if there is lack of final scientific proof of the impact of anthropogenic CO2 on temperatures and sea levels it is probably prudent to pay for a large insurance coverage.

In this exercise we end up with two different categories of CO2 reduction. One category includes process technology innovations that make possible a more efficient and less carbon intensive production of metals and alloys in comparison to traditional processes. In this case we are talking about energy savings and resulting CO2 reduction DURING manufacturing and we refer to those innovations as “mitigating” technologies as they “mitigate” emission risks (environmental viewpoint) and risks of being a high cost producer (financial viewpoint). The second category consists of the development of new offerings of products enabling our customers to reduce CO2 when USING these products in their operations compared to the use of traditional products. This second category we internally refer to as “enabling” technology innovations as they enable CO2 savings by our customers. Again, there is an environmental dimension (to arrest and reverse the global trend of increasing CO2 emissions) and a financial dimension (as the products in question tend to be highly competitive, and at least at the beginning of the lifecycle to command premium pricing).

## A SHORT HISTORY OF ENVIRONMENTAL POLICIES

Governmental policies for the protection of the environment developed in several waves which sometimes overlapped. The first wave was the targeting of industrial emissions; waste gas and waste water, industrial residues and soil contamination. This can be summarized as “end-of-the-pipe” regulations. As regard to clean air, emissions of sulfur oxides, of nitrogen oxides and of dust particles were to be captured with sophisticated filter systems. Incidentally, by the time the Deutsche Bundestag, in 1971, for the first time debated clean air strategies, Lurgi, a German engineering firm, had already sold over 5000 filter systems around the world, starting before World War I. Air quality improvement was followed by wastewater purification processes and the avoidance of soil contamination.

The next wave was to complement “end-of-the-pipe” systems with better “pipes”; in other words better process technologies, recognizing that a more efficient process reduces what comes out at the end of the “pipe”. That is when CO<sub>2</sub> reduction entered the scene of environmental policy in the context of the rapidly emerging climate change debate and the Kyoto agreement. Energy saving in all its forms was taking center stage far beyond industrial processes and including residential and commercial buildings and transportation. In the beginning this wave of energy saving has been driven largely by economics quickly taken over by regulations and incentive programs.

A third industrial movement, with large scale environmental benefits as a by-product, has been “recycling”, driven both by regulations (in the case for restrictions making land-fills more expensive) and by economics (raw material prices). “Cradle-to-Grave” was replaced by “Cradle-to-Cradle”, industrial residues turning into raw materials replacing primary sources. The term “urban mining” was coined. Over time this grew into a recycling boom, becoming very visible in the 70’s and 80’s. One very good example for this partial industrial revolution is the rapid growth of the so-called “mini-mills” revolutionizing the steel industry by replacing iron ore as a feed stock by steel scrap.

This movement then had a derivative, the recycling of zinc contained in the filter-dust of those mills into a material competing with primary zinc

concentrates. Recycling processes now cover a wide array of industries and are associated with massive CO<sub>2</sub> reductions compared with traditional processes based on primary resources only. Primary production continues, as inevitably it must to meet the demands of an increasing and more affluent population, but recycling is vital to a number of material supply chains including the large volume metals such as steel, aluminum and copper, and also niche metals including tantalum and tungsten, but also some non-metal commodities including paper, glass, and some plastics.

All these developments, partly environmentally motivated, but with concurrent financial benefits, cannot escape the fundamental law of diminishing returns. In addition, these measures have limited scale-ability. The same amount of money will buy fewer improvements than when it was spent last time. If you have installed a filter system, a water purification plant, an energy saving engine, a manufacturing scrap re-use circuit, you make a big step. From then on it is optimization, incremental improvements, “inch” by “inch”, so to speak. And the recycling movement ultimately is, in its growth potential, confined to the framework of general economic growth, it cannot – in the longer term – outgrow GDP.

Then, as the next wave, came the renewable energy movement, government subsidies for wind and solar, “bio” branded feedstock for energy production, motivated by CO<sub>2</sub> reduction strategies and commitments in the aftermath of the Kyoto Protocol. As mentioned, CO<sub>2</sub> reduction also stood behind the elaborate efforts to regulate the CO<sub>2</sub> emissions of the global transportation sector through elaborate miles-per-gallons targets and penalties, from California to the EU. We will come back to that later. And presently we are in the “distributed energy” wave. Fuel Cell technology makes it possible to convert natural gas into electricity at the point of use through a low emission chemical process. Battery technology is behind the emergence of electric cars which do reduce CO<sub>2</sub> emissions in densely populated areas, but only by shifting the emission point to the stack of the regional power plants that are necessary to generate the electricity required.

## WHAT THEN IS GREEN?

All definitions put forward on this question so far have been fluid, highly qualitative, subject to interpretation, and partly ideological. UNEP have stated: “There is no internationally agreed definition of green economy and at least eight separate definitions were identified in recent publications. For example, UNEP has defined the green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient, and socially inclusive, and has pointed to another definition, that of the Green Economy Coalition (a group of NGO’s, trade union groups and others doing grass roots work on a green economy), defining green economy as ‘a resilient economy that provides a better quality of life for all within the ecological limits of the planet’. The International Chamber of Commerce says “The business community believes that the term “green economy” is embedded in the broader sustainable development concept. The “green” economy is described as an economy in which economic growth and environmental responsibility work together in mutually reinforceable fashion while supporting progress on social development. Business and industry has a crucial role in delivering the economically viable products, processes, technologies, services, and solutions required for the transition to a Green Economy”. Bank of America says about its recently issued “green bond”:

*“The funds will be used specifically to finance renewable energy projects such as wind, solar and geothermal energy. Funds will also be used to finance energy efficiency projects that reduce energy consumption per unit of output and include projects such as lighting retrofits, district heating, co-generation, and building insulation in residential, commercial and public properties.”*

The Bond was issued within an initiative “to help address climate change, reduce demands on natural resources and advance lower carbon economic solutions.”

## ATMOSPHERIC CO2 CONCENTRATION

While all these environmental policy waves were going on the CO2 concentration in the atmosphere crept up year by year in a slightly accelerating mode and is presently crossing 400 ppm. The basic mechanics of that growth in CO2 levels can be expressed in terms of the KAYA equation, named after a Japanese scientist:

$$CO_2 = P * \frac{GWP}{P} * \frac{E}{GWP} * \frac{F}{E}$$

whereby P stands for Population, GWP for Gross World Product, E for Energy Consumption, F for CO2 emissions from Fuel combustion and industrial processes. Looking at this identity it is easy to see that if population and affluence, expressed by per capita output are rising, the CO2 level can only be kept constant if energy intensity (here as E/GWP) and Carbon intensity of energy production (here as F/E) are sufficiently falling. If, for example, the growth of renewable energy sources is not enough to compensate for falling nuclear energy production in the post Fukushima world, we are left with trying to lower energy intensity. Major advances in technology are necessary for that. In fact the World appears to becoming more, not less, dependent on carbon emitting energy generation. The resurgence of gas, particularly in the USA with the advent of hydraulic fracturing, has led a renaissance in gas powered energy generation. In terms of CO2 this is not a bad thing - every kilogram of methane gas burnt generates approximately 2.75 kilograms of CO2 and generates 14kWh. In contrast every kilogram of coal burnt generates 3.4 kilograms of CO2 and produces 11 kWh giving natural gas about 63% of the CO2 intensity of coal on a per kWh basis. Despite a fundamental change, World CO2 emissions continue to rise. The technological challenges in the energy generation space are self-evident – they require political will as well as available technologies. While there is a clear environmental motivation, the economic motivation is perhaps less clear. Oil and gas companies are in the business of selling oil and gas; power generators in the business of generating power and

more not less builds profits for these businesses, which are so vital to our economies.

If advances in energy generation are not available, not sufficient, without political will power, or without financial attractiveness, advances in energy utilization and efficiency can be made by organizations, independent of government regulations, have financial attractiveness in increasing efficiencies and may be sufficient to at least stem global CO2 emission trends. AMG, from its outset, was declaring it a priority to direct its technology resources based on material science to provide technology solutions in that space.

## MITIGATING TECHNOLOGIES

As mentioned in the introductory remarks, at AMG we refer to technologies which are designed to reduce energy consumption and CO2 emissions DURING the industrial manufacturing phase (remember the “better pipe”) as mitigating technologies. These technologies are supposed to mitigate emission risks associated with high energy use in industrial production. They also tend to be highly competitive as conventional technologies over time are almost surely subject to creative destruction. An example which demonstrates technological leaps in the AMG portfolio is the ferro-vanadium production of AMG Vanadium in Cambridge, Ohio, USA. The conventional technology to produce ferro-vanadium in Cambridge was based on converting raw materials from primary mining in South Africa. We have changed that through a transformational technology innovation and today we are producing ferro-vanadium by extracting vanadium from spent catalysts which are a byproduct of oil refineries and from other residues. In doing so we have reduced the CO2 emissions from 28 kg per pound of ferro-vanadium produced to 14 kg per pound or 58,000 tons of CO2 per annum. We believe, by the way, that we are now the lowest cost producer of ferro-vanadium in the world, which can be researched from public materials. We suggest that the environmental attractiveness and financial attractiveness of this mitigating technology are not unrelated.

Mitigating technologies are, by their nature, limited and bounded. The ultimate aim of any company in considering CO2 emissions is to have “zero carbon emissions”, (and zero waste and so on). This aim is pursued by introducing mitigating technologies to make processes as energy efficient as possible, but the fundamental laws of physics remind us that to do work requires energy – there are few, if any, industrial processes that can be conceived that do not consume energy. Thus to approach zero carbon emissions, a company must either install its own low carbon generating capacity (typically solar, wind or hydro) or rely on factors outside its control to get low carbon energy. Within AMG, we see both situations – in Brazil AMG has its own installed hydro generation capacity, satisfying the needs of our local operations, and exporting some power to the grid. In the United States, we operate two similar alloy production facilities, one in the Pacific Northwest, supplied with hydropower, and one in the Midwest supplied with coal-generated power. By historical accident of location (prior to climate warming concerns) these similar plants have very different emissions profiles. The ease of mitigating technology savings are, by their bounded nature, means that they are relatively easy to measure. Mitigating technologies often have a simple, if arbitrary, baseline position and the ‘ownership’ of the savings is clear. This is perhaps why they have long been the focus of governments and green investment opportunities.

## ENABLING TECHNOLOGIES

As the first case for an enabling technology innovation at AMG one could list AMG Engineering’s proprietary and highly innovative “Modultherm” heat treatment technology for the surface preparation of next generation engine parts. Comparing to conventional heat treatment processes our enhanced technology for heat treating 6 speed transmissions enables, by the way of higher torques and lower weight, CO2 savings of 14g/km per transmission adding up to about 400.000 tons per year when applied to our volume of 1.5 million transmissions per year (2011). Incidentally, the Modultherm technology also has a “mitigating” component as it uses gas for quenching instead of oil.



Even more dramatic is the case of AMG Engineering's application of this enhanced heat treatment process to the hardening of diesel fuel injector parts enabling them to operate under higher pressures (2250 bar vs. 150 bar) and they are utilized in new fuel efficient diesel engines. Applied to our volume (10 million units per year equivalent to 2.5 million four cylinder engines) this translates to CO2 savings of about 900.000 tons per year.

Another case for vehicle efficiency is the "light weighting" through the use of aluminum vehicle panels vs. steel panels. These military grade aluminum alloys utilize AMG Aluminum's enabling grain refining alloys. Applied to the new 2015 Ford-150, these weight reductions enable fuel efficiency to improve by an estimated 20% and correspondingly CO2 savings of about 685.000 tons per year across Ford's annual production volume for this model.

Let us switch to aerospace. AMG Processing's titanium alloys enables airframe weight reductions (compared to the conventional use of steel) leading to rather dramatic weight reductions: According to several public sources, the Airbus A320 aircraft generates CO2 per passenger per km of 97.5g against 75g from the more efficient Boeing 787-800. In 2011, 2.8 billion passengers travelled by air, with corresponding emissions of about 676 million tons of CO2. The use of titanium alloys in airframes (applying here a conservative estimate of our market share) is enabling a CO2 reduction of about 5.000.000 tons per year. AMG's titanium alloys typically contain high purity vanadium, a raw material that is sourced from vanadium containing residues.

In regard to aerospace, the final example is AMG Engineering's proprietary technology of thermal barrier coatings for turbine blades. This technology enables aerospace turbines to operate at higher temperatures and thus more efficiently. The thermal barrier coating facilitates operation of the turbine at temperatures above the melting point of the construction alloy. Applied to AMG's very high market share, this enables CO2 savings of about 800.000 tons per year.

These five examples all relate to transportation, which accounts for approximately 28% of all energy used by society. An even bigger area is in buildings where approximately 41% of energy is utilized for heating, cooling and lighting.

AMG also has a pivotal role in energy saving in buildings using state-of-the-art insulation materials. Graphite enhanced expanded polystyrene insulation increases the thermal coefficient of insulation materials resulting in estimated CO2 savings of about 6.000 kg per standard family home per year. In 2013, AMG Mining supplied enough graphite to produce insulation for approximately 160.000 homes, enabling about 930.000 metric tons of CO2 savings per year. This, by the way, is a perfect example of how materials, in this case natural graphite, turn into “critical materials” by the way of societal demand shifts.

Unlike mitigating technologies, enabling technologies are not bounded. The fact that they go into highly scalable (often consumer product) applications means that the CO2 savings they produce are quickly multiplied. In theory a company can not only become “zero carbon”, but go beyond into a carbon negative position. The challenge with enabling technologies comes in the measurement of the savings. Because the products are utilized by customers, producers cannot be sure of the savings. Further the model is different and more complex from that for mitigating technologies, under which it is clear who ‘owns’ the CO2 emission savings. In the case of enabling technologies there are often many organizations involved in providing consumers with a new lower carbon alternative, while it is the same consumer who will actually realize the saving (the airline passenger, the car driver or the home owner). We believe that, while both important, given the vast difference in scale of savings between mitigating and enabling technologies, that enabling technologies must now become the focus of green capital as the most effective return on investment in CO2 emission terms. Much greater strides may be made in global CO2 emission reductions from enabling thousands, millions or billions of others to make efficiencies in emissions, than even by making significant savings at one, two or a handful of locations.

## MITIGATING VERSUS ENABLING

As an order of magnitude, AMG adding up those processes and products saves or enables to save about 8.5 million tons of annual CO2 emissions, of which only 58.000 tons or 6 % come from mitigating technologies (“end-of-the-pipe” in a wider sense {is this not “in pipe” as it is a technology change}). The biggest market for enabling technologies here seems to be aerospace, followed by automotive and then buildings. Some enabling technologies are being driven by regulation or targets. Most notably in the automotive sector, in the USA the National Highway Traffic Safety Administration (NHTSA) and Environmental Protection Agency (EPA) have set ever tightening standards for vehicle emissions. In 2009 their ruling set the following targets:

<b>mpg</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>
<b>Passenger Cars</b>	31.2	32.8	34	34.8	35.7
<b>Light Trucks</b>	25	26.4	27.8	28.2	28.6

Longer term proposed standards, set out in a 2010 ruling, take these to 40.3 - 41.0 mpg in 2021 and 48.7-49.7 mpg in 2025. In the European Union (“EU”) the targets are more stringent and nearer term - 42 mpg in 2021 and 51 mpg 2021. Financially viable enabling technologies are clearly needed and needed quickly, to achieve the ambitious goals.

The regulatory approach in aviation is different. The EU introduced its contentious EU Emissions trading System at the beginning of 2012. This system gives tradable CO2 emissions credits to operators for their flights. While still operable for flights inside the EU, the Union was forced to suspend it for international flights pending a global agreement which the International Civil Aviation Organization (ICAO) has agreed to implement by 2020. This will again be a market based mechanism.

Early goals in the USA, set by the Federal Aviation Administration’s (FAA) focused on a 12 % reduction in fuel burn by 2011 versus a 2000 baseline. By 2010 the industry had achieved 15.25 % reductions. The current Administration

goal is to achieve carbon neutral aviation industry growth by 2020. To reach this the Environmentally Responsible Aviation (ERA) project is targeting a 50% reduction in fuel burn for every subsonic flight mission (passenger and cargo) by 2020 (from a 2005 baseline) through a mix of technological and operational advances. Fuel taxes have gone to fund research initiatives include 'NextGen' engine technology, which feature AMG enabling technologies such as turbine blade coating technologies.

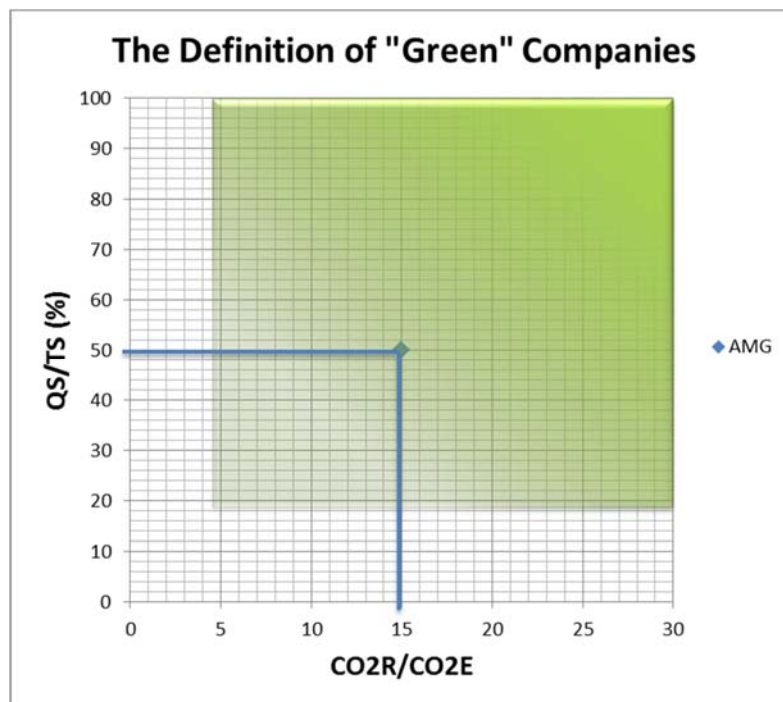
## CUMULATIVE EFFECTS

Mitigating technologies are not scalable, we have said that, and more important, do not produce cumulative effects. The CO<sub>2</sub> savings as a result of our ferro-vanadium innovation are about 58.000 tons per year each year during the lifetime of the recycling plant. That is different with enabling technologies for more efficient cars, planes or buildings. The units installed in year one create the calculated savings in year one and repeat that in year two, three and so on. These savings then are cumulative with the savings of the units installed in year two and so on continuing over the lifetime of the vehicle models, aircraft or buildings. The growth stops only when the models are taken out of production or when the buildings stop to use the insulation material referred to earlier. This cumulative feature is very powerful.

Consider the Ford F150 case. We have calculated the CO<sub>2</sub> savings of 685.000 tons per year estimating an annual sale of 520.000 vehicles per year. Whether these are new additions to the overall global vehicle fleet, or they replace older less efficient models which are removed from the fleet, the net savings are the same. Those savings continue to be realized year on year over the life of the vehicle, and further savings come for each new more fuel efficient vehicle sold. Because of the cumulative effect that totals up in ten years to a cumulative CO<sub>2</sub> saving of about 37.6 million tons, not of 5.2 million tons which would happen in the case of mitigating technology applications.

## HOW TO DEFINE A "GREEN" COMPANY

The AMG definition of “green” reduces activities to their net CO2 savings profile. The next step is to quantify the company’s green profile. AMG proposes this can be done by plotting qualifying sales (QS), sales which are associated with enabling technologies leading to global CO2 emissions reductions (i.e. sales associated with TCO2R below), as a percentage of total sales (TS) against the net CO2 reduction multiplier – defined as total CO2 reduction enabled (TCO2R)/ total CO2 emissions (TCO2E).

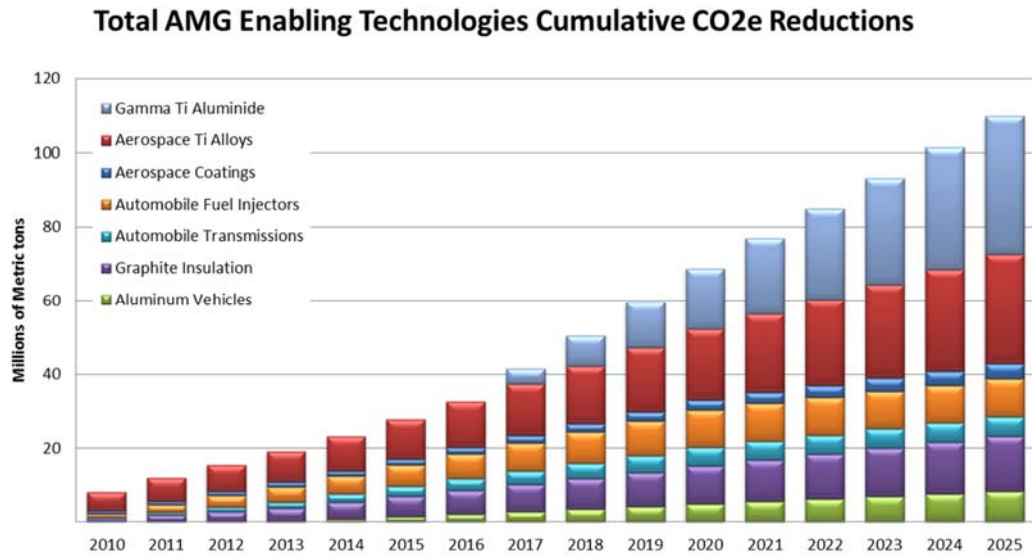


**Where:**

- QS – Qualifying Sales**
- TS – Total Sales**
- CO2R – CO2 Reduction Enabled**
- CO2E - CO2 Emissions**

The next challenge is how to set a minimum threshold on both scales where “green” companies come to reside. This has to be debated, an exercise which promises to be lively. Once defined, the green space would attract companies, especially if investors accept our framework for redefining “green” or a variation of it. In that case capital allocations would be incentivized to go “green” especially if the global investor community would declare a preference to finance “green” capital spending as defined.

For illustrative purposes we have attached AMG a selection of AMG’s enabling technology CO2 reduction profiles in both transportation and buildings, based on current estimated figures.



## About AMG

AMG creates and applies innovative metallurgical solutions to the global trend of sustainable development of natural resources and CO2 reduction. AMG produces highly engineered specialty metal products and advanced vacuum furnace systems for the Energy, Aerospace, Infrastructure, and Specialty Metals and Chemicals end markets.

AMG Processing develops and produces specialty metals, alloys, and high performance materials. AMG is a significant producer of specialty metals, such as ferrovanadium, ferronickel-molybdenum, aluminum master alloys and additives, chromium metal and ferrotitanium, for Energy, Aerospace, Infrastructure and Specialty Metal and Chemicals applications. Other key products include specialty alloys for titanium and superalloys, coating materials and vanadium chemicals.

AMG Engineering designs, engineers and produces advanced vacuum furnace systems and operates vacuum heat treatment facilities, primarily for the Aerospace and Energy (including solar and nuclear) industries. Furnace systems produced by AMG include vacuum remelting, solar silicon melting and crystallization, vacuum induction melting, vacuum heat treatment and high pressure gas quenching, turbine blade coating and sintering. AMG also provides vacuum case-hardening heat treatment services on a tolling basis.

AMG Mining produces critical materials utilizing its secure raw material sources in Africa, Asia, Europe, and South America. AMG Mining produces critical materials such as high purity natural graphite, tantalum, antimony and silicon metal. These materials are of significant importance to the global economy and are available in limited supply. End markets for these materials include electronics, energy efficiency, green energy, and infrastructure.

With over 3,000 employees, AMG operates globally with production facilities in Germany, the United Kingdom, France, Czech Republic, United States, China, Mexico, Brazil, Turkey, Poland, India, and Sri Lanka and has sales and customer service offices in Belgium, Russia, and Japan ([www.amg-nv.com](http://www.amg-nv.com)).

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