

The Critical Materials Company

CRU Ryan's Notes – Vanadium Industry Outlook Mark Anderson AMG Vanadium, Inc.

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AMG is a critical materials company

Global Trends

Nb

Sb

CO₂ emission reduction, population growth, affluence, and energy efficiency

Ta

Demand

Innovative new products that are lighter, stronger, and resistant to higher temperatures

Supply: AMG

Sources, processes, and supplies the critical materials the market demands

Al

Si

Critical Raw Materials



Critical raw materials identified by the US and produced by AMG

- The EU identified 20 critical raw materials* to the European economy in 2014, focusing on two determinants: economic importance and supply risk
- The US identified 30 critical materials* which are vital to national defense, primarily through assessing supply risk
- AMG has a unique critical materials portfolio comprising:
- -5 EU critical raw materials
- -4 US critical raw materials
- Highly engineered Titanium Alloys for the aerospace industry
- High value added Aluminum Master Alloys
- Vanadium, Nickel and Molybdenum from recycled secondary raw materials

EU Critical Raw Materials



AMG Business Units



AMG Critical Materials

• Vanadium

- Superalloys
- Titanium Alloys & Coatings

• Aluminum Alloys

- Tantalum & Niobium
- Antimony
- Graphite
- Silicon

AMG Engineering

- Engineering
- Heat Treatment Services





AMG Global Footprint – Critical Materials







AMG Vanadium Overview

- US location (Cambridge, OH) is a key asset with stable customer base in **net import market**
- Provides environmental management services to the North American petroleum industry
- Preferred supplier status largest & most reliable producer in North America
- Produces ferrovanadium and ferronickel-molybdenum from spent catalyst to the North American steel markets
- Ferrovanadium is used in high strength low alloy steel production to increase strength, toughness and weld ability
- Ferronickel-molybdenum is used in stainless and specialty steels and aerospace applications

AMG Vanadium is the most advanced, lowest cost, environmentally friendly spent catalyst recycling facility in North America





Ferrovanadium Processing Routes

- Three FeV processing routes
 - Primary, Co Product, and Secondary
- AMG Vanadium produces FeV via secondary route
 - No intermediary production of V2O5
 - Eliminating environmental contaminations





Vanadium Production and Consumption



Sources: Roskill Vanadium Outlook 2014

- China is the dominant global producer of vanadium
- Global production in 2014 was estimated at 95,000 MTV and consumption was estimated at 92,700 MTV, thereof an excess supply of 2,300 MTV putting pressure on prices
- Steel market consumes 90% of global production and 5% each for chemicals and masteralloys
- Vanadium containing steel market share increasing as specific consumption (kgV/MT steel) continues to increase
- Rationalization of supply is underway with supply decreases in Australia, South Africa and China



Metal Index Price History



Source: Ryan's Notes Ferrovanadium NA Transaction Mid; LME Nickel Cash Daily Official \$ per tonne Monthly Average; Platt's Metals Week Monthly Report Moly Dealer Oxide Low



Market – Global Vanadium Production





Global Steel Production

- Vanadium consumption is closely tied to the steel industry
- Steel production drives up to 60% of the global vanadium supply through the production of V bearing slag
- The Chinese steel industry represents 55% of global V production through V bearing slag
- Steel production from V bearing ore has a direct impact on V production



Annual Global Steel Production

Chinese Vanadium Production

- China has 7 steel mills that collectively produce approximately 40 million MT steel and approximately 43,000 MT V
- Steel production from vanadium bearing ore is at the high end of the cost curve due to low iron content
- Longer term, a trend towards mini-mill steel production will gradually replace integrated steel production as scrap becomes more widely available in China
- China has approximately 100 million MT excess steelmaking capacity a rationalization process has begun

Chinese Iron Ore is the Lowest Grade Globally As China Imports more ore, its V content in steel slag declines

Vanadium production declines!

Country	Iron Content (%)
Brazil	68
Sweden	64
Australia	62
Canada	62
Russia	58
WORLD	44
China	33



South African Vanadium Production

- Evraz Highveld produces approximately 13,000 MT V per year:
- approximately 50% from slag processed primarily in Europe
- approximately 50% as ore in South Africa
- Evraz Highveld creditors have voted in favor of the business rescue plan submitted by International Resources Limited (IRL) - IRL investment required is \$376 Million
- IRL's plan provides for a wind-down should the offer not be consummated

Evraz Highveld issue is not clearly resolved and they remain a high cost producer of steel







Global Vanadium Demand





Global Demand for Vanadium

- Steel growth rate has been 4.9% CAGR 2003-2014
- Vanadium consumption grew 7.6% CAGR in same time period
- Specific consumption (i.e. concentration of V in Steel) represents 2.7% CAGR of the annual growth rate of Vanadium
- A global steel growth rate of 2.5% moving forward results in a forecast vanadium consumption growth rate of approximately 5.2%

• Vanadium demand will continue to grow at a higher rate than demand for steel



Annual Vanadium Consumption

*Assumes a 7.0% decrease in Vanadium consumption for 2015 and then flat for 2016 with a 5.2% CAGR thereafter



Market – Supply and Demand



- The current high cost of V production is driving rationalization in the market
- Supply increased in 2013 and 2014 primarily due to increases in Chinese steel production
- Forecast decrease in supply in 2015 and 2016 is driven primarily by South Africa and China; offset somewhat by increases in North America and Brazil

Market is currently over supplied however we expect a rebalancing to occur



Cost Curve Misconceptions

- Co-production
 - Russia, South Africa, New Zealand
 - Production cost depends on both Steel and Vanadium economics
 - High cost steel producers
 - Some slag processed on tolling basis or sold
- Primary production
- -South Africa, Brazil, China
- Production cost depends upon ore grade and logistics
- Secondary production (recycling)
 - -Asia Pacific, Europe, US
 - Metal price downside protected
 - Metal price upside shared with generators (suppliers of material)
 - Most environmentally friendly production method



- AMG Vanadium, as a secondary processor, is economically viable at all market price levels
- Metal bearing waste materials will continue to be recycled as other disposal options are limited and high cost



Future Trends & Outlook

- Vanadium Supply is expected to decrease due to market rationalization
- •The future of Evraz Highveld remains unclear
- Vanadium demand is projected to continue to grow

•AMG Vanadium, as a secondary processor, is economically viable at all market price levels



AMG Vanadium

- North American producer of ferrovanadium and ferronickelmoly
- Production capacity increased by approximately 100% between 2013 and 2015
- Current production capacity of approximately 7.0 M lbs. of Vanadium contained per year
- Continue to optimize production to provide specification ranges required by our customers
 - "World Grade" FeV with lower Si, S, and P
 - Higher V content Up to 70% V
 - Low AI content
 - Lower melting point = Better V recovery
- Centrally located in Cambridge, OH, U.S.A.
- Customized packaging and expediting of shipments on site.
- Cost model enables AMG Vanadium to be very competitive in down markets
- Environmentally friendly and low cost producer
 - Recycler of waste from refineries and power plants
 - Pyrometallurgical process minimizes effects on environment

AMG Vanadium is well positioned to be the long term supplier of choice to the North American steel industry



AMG Vanadium

Thank you!

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