



Mohammed Benchekchou
Director New Business Development
Shell & AMG Recycling B.V.



Kevin Jones
Vice President
AMG



Jane Neal
Senior Vice President
AMG Vanadium

CREATING VALUE THROUGH A PROVEN CIRCULAR SOLUTION FOR REFINING SPENT RESIDUE-UPGRADING CATALYSTS

17 NOVEMBER 2020

14:00 BAHRAIN & KSA

MODERATOR



Raj Jhahharia, PMP, NEBOSH
Technical Manager
Acting Marketing & Communications Manager
Technical Manager



This document contains proprietary information and is being provided solely for information purposes by Shell & AMG Recycling B.V. (The “Company”) and may not be reproduced in any form or further distributed to any other person or published, in whole or in part, for any purpose, except with the prior written consent of the Company. Failure to comply with this restriction may constitute a violation of applicable securities laws.

Shell & AMG Recycling BV, also referred to as “SAR”, is a limited liability company organized under the laws of the Netherlands and owned jointly (50-50) by Shell Overseas Investment BV and AMG Advanced Metallurgical Group NV. The companies in which SAR directly and indirectly owns investments are separate entities. In this presentation “SAR” or “SAR group” may be used for convenience where references are made to SAR or SAR and any of its subsidiaries in general. Likewise, the words “we”, “us” and “our” are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. “subsidiaries”, “SAR subsidiaries” and “SAR companies” as used in this presentation refer to companies over which SAR either directly or indirectly has control. Companies over which SAR has joint control are generally referred to “joint ventures” and companies over which SAR has significant influence but neither control nor joint control are referred to as “associates”. In this presentation, joint ventures and associates may also be referred to as “equity-accounted investments”. The term “SAR interest” is used for convenience to indicate the direct and/or indirect (ownership interest held by SAR in a venture, partnership or company, after exclusion of all third-party interest.

This webinar could contain forward-looking statements about Shell & AMG Recycling. Forward-looking statements are not historical facts but may include statements concerning SARBV plans, expectations, competitive strengths and weaknesses, and future operations and development, our business strategy and the trends SARBV anticipates and other similar or different information that is not historical information. When used in this webinar call, the words “expects,” “believes,” “anticipates,” “plans,” “may,” “will,” “should,” and similar expressions, and the negatives thereof, are intended to identify forward-looking statements. By their very nature, forward-looking statements involve inherent risks and uncertainties, both general and specific, and risks exist that any predictions, forecasts, or similar projections contained by such forward-looking statements will not be achieved. These forward-looking statements speak only as of the date of this webinar. SARBV expressly disclaims any obligation or undertaking to release publicly any updates or revisions to any forward-looking statement contained herein to reflect any change in SARBV's expectations with regard thereto or any change in events, conditions or circumstances on which any forward-looking statement is based. There are a number of factors that could affect the future operations of SAR and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in feedstock materials that are used by SAR; (b) changes in demand for SAR's products and services; (c) currency fluctuations; (d) loss of market share and industry competition; (e) environmental and physical risks; (f) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (g) the risk of doing business in developing countries and countries subject to international sanctions; (h) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (i) economic and financial market conditions in various countries and regions; (j) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (k) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Each forward-looking statement speaks only as of the date of this presentation 01 September 2020. Neither SAR nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation.



AGENDA

SPENT CATALYST WEBINAR



- 1** Shell & AMG Recycling introduction
- 2** Market overview: Spent residue-upgrading catalyst situation
- 3** Market overview: Vanadium supply and demand
- 4** Spent catalyst management
- 5** Circular economy: Enabling CO₂ reduction
- 6** Spent catalyst economic drivers



SHELL CATALYST & TECHNOLOGIES

Shell Catalysts & Technologies, supports Shell and non-Shell refining and petrochemical businesses by working with them to co-create integrated, customised catalyst and licensing solutions.

- Five catalyst manufacturing plants in Belgium, China and the USA.
- Three research centres in India, the Netherlands and the USA.
- Sales and technical service offices in Canada, China, Dubai, India, the Netherlands Russia, Singapore, the UK and the USA.



AMG ADVANCED METALLURGICAL GROUP



Cambridge Ohio, USA

- Originally built in 1953
- Processing Spent Resid Catalyst since 2002 using Cambridge Ferrovan® Process
- Best Practices industry standard for metals reclamation from spent resid catalyst

Zanesville, Ohio, USA

- Expanding to meet global demand from refineries for recycling spent catalyst
- Global shortage of sustainable recycling capacity
- Construction began 2019 and full production will begin in 2022

Nuremburg, Germany

- Established in the production of high purity vanadium since 1911
- Recovery of high-purity vanadium from gasification ash for specialty chemical and aerospace end uses like vanadium batteries



Shell & AMG Recycling Joint Venture's objective

To install state-of-the-art recycling capability for **Spent Residue Upgrading catalyst** and **Gasification ash** in the Middle East using AMG's technologies.

Problem

Environmentally sound management of Spent Resid Catalyst and Gasification Ash and associated environmental risks and the generators reputation



Recognized global leaders in production of fresh residue upgrading catalyst and management of the resulting spent catalyst ... providing end-to end value through sustainability

Opportunity

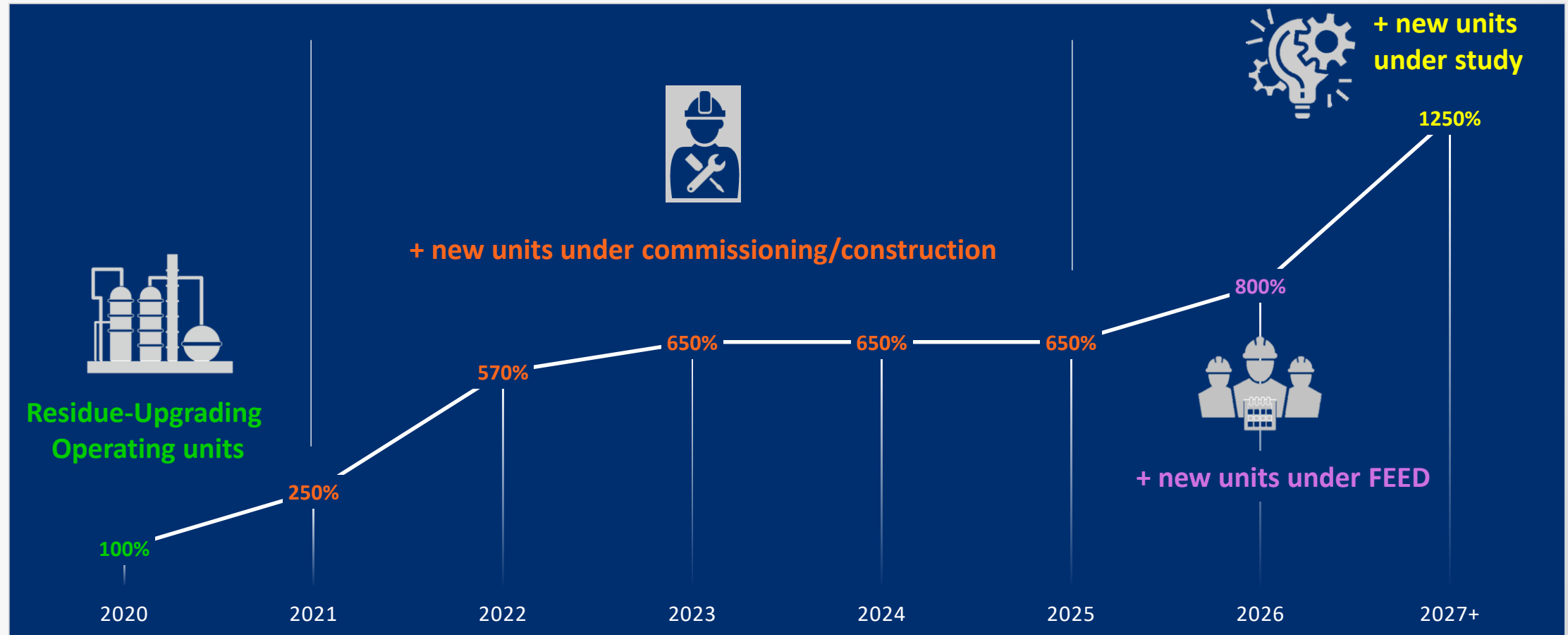
- Ferrovandium for regional steel industry and export
- High purity V_2O_5 for batteries
- Decrease of CO_2 footprint
- No need for landfill
- Support local economies



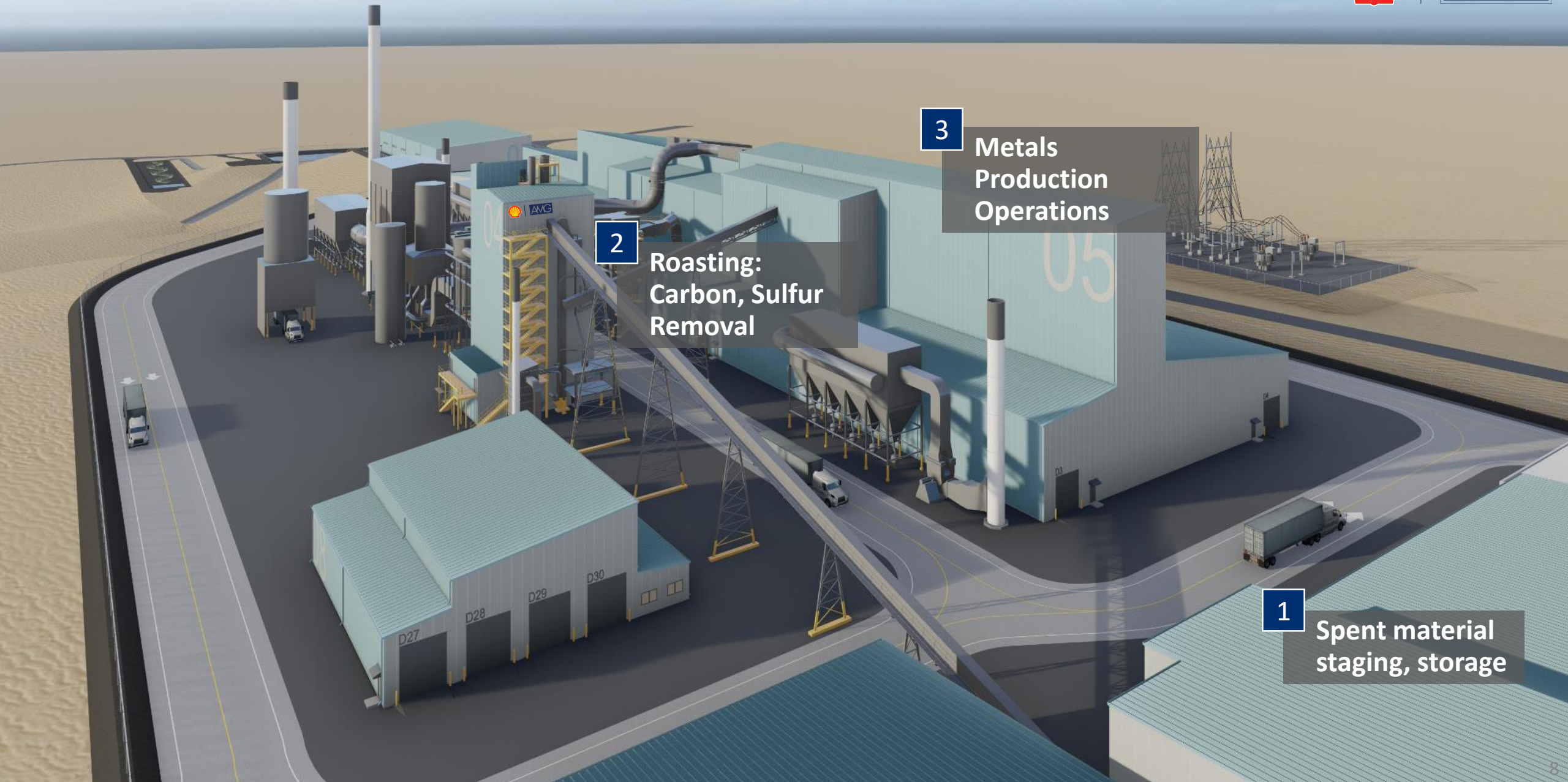
Spent Residue-Upgrading catalyst **growth** in the Middle East



Spent catalyst generation to increase 6x over the next 2 years, with potential 12x growth over the next 6–7 years



Preliminary Rendering of Spent Catalyst Recycling Facility in Middle East Region



3
Metals
Production
Operations

2
Roasting:
Carbon, Sulfur
Removal

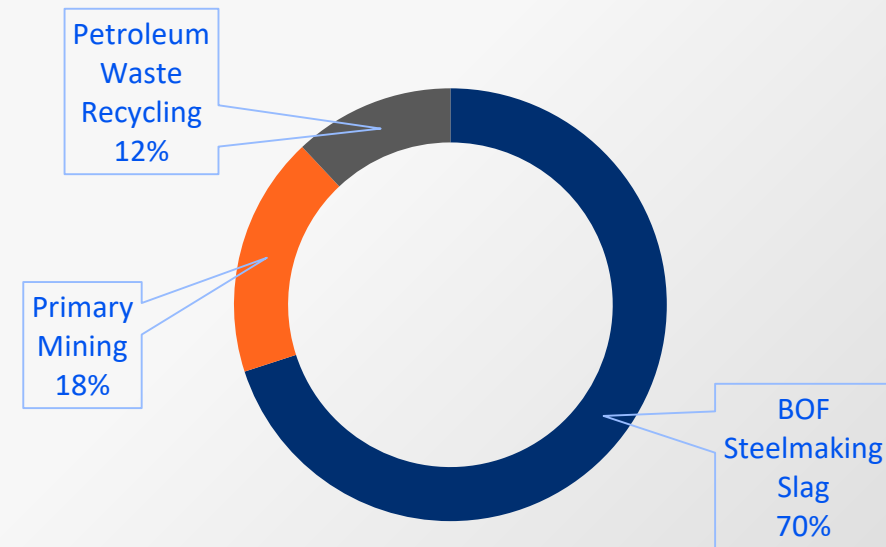
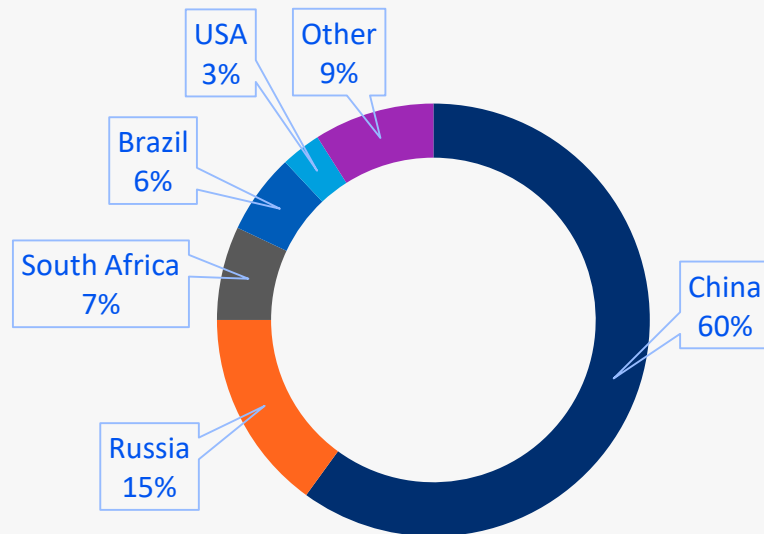
1
Spent material
staging, storage



Global Vanadium Supply (2019)

Current...

- **Main Vanadium Producers:** *China and Russia*
- **Vanadium Sources:** Largest is Basic Oxygen Furnace (BOF) Steelmaking



Source: Vanitec

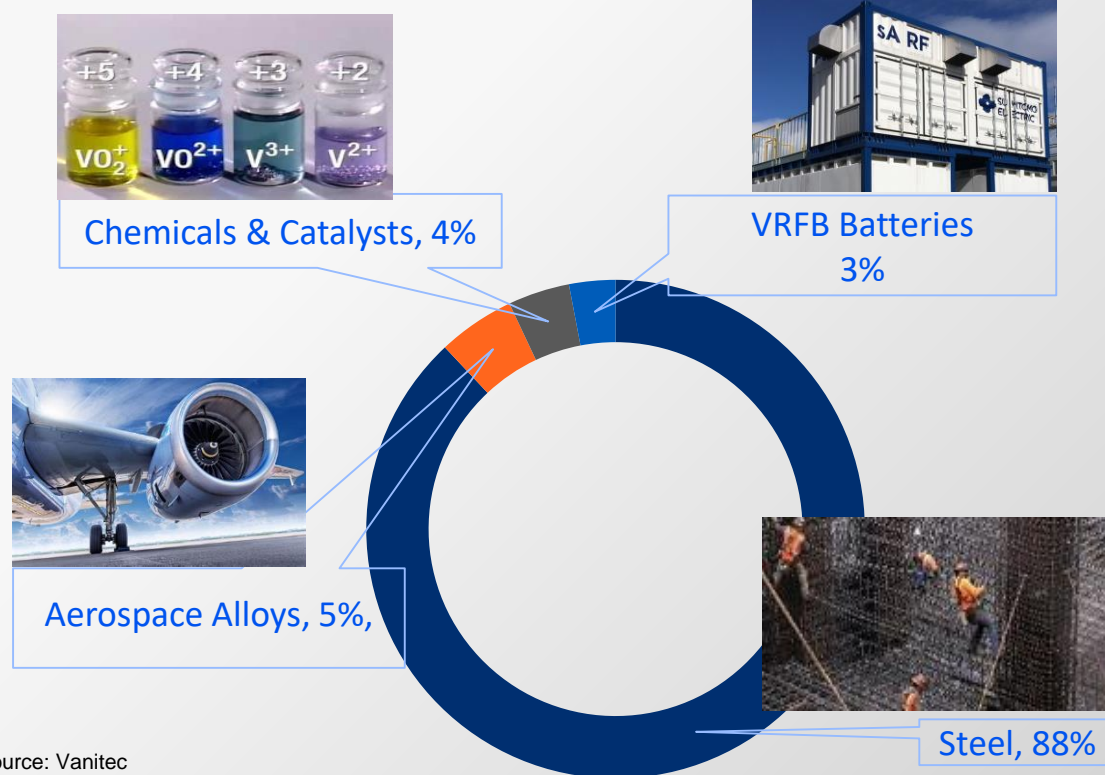
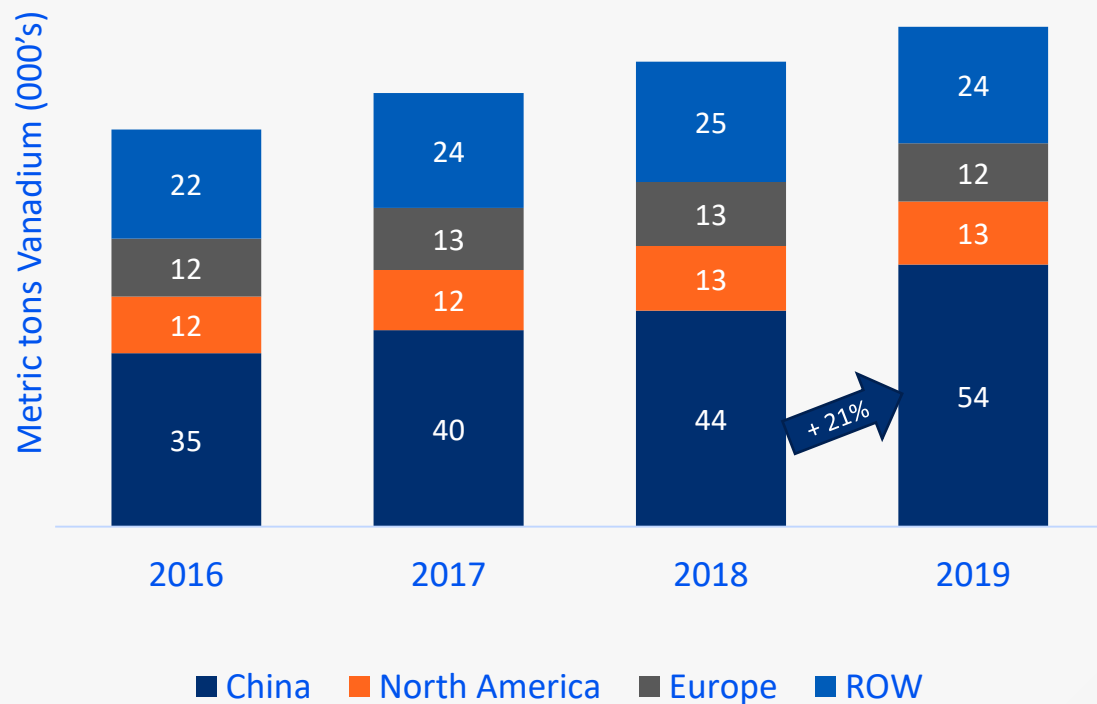
Future...

- **Vanadium Sources:** increased recycling of petroleum wastes, decline from BOF steelmaking
- **High-purity vanadium, as produced by AMG, required for redox flow batteries, is in short supply**



Global Vanadium Consumption, End Markets (2019)

- China is largest & growing vanadium consumer, becoming a net importer
- Current low demand outside of China expected to return soon
- Vanadium Redox Flow Batteries (VRFB) demand will increase high-purity vanadium demand

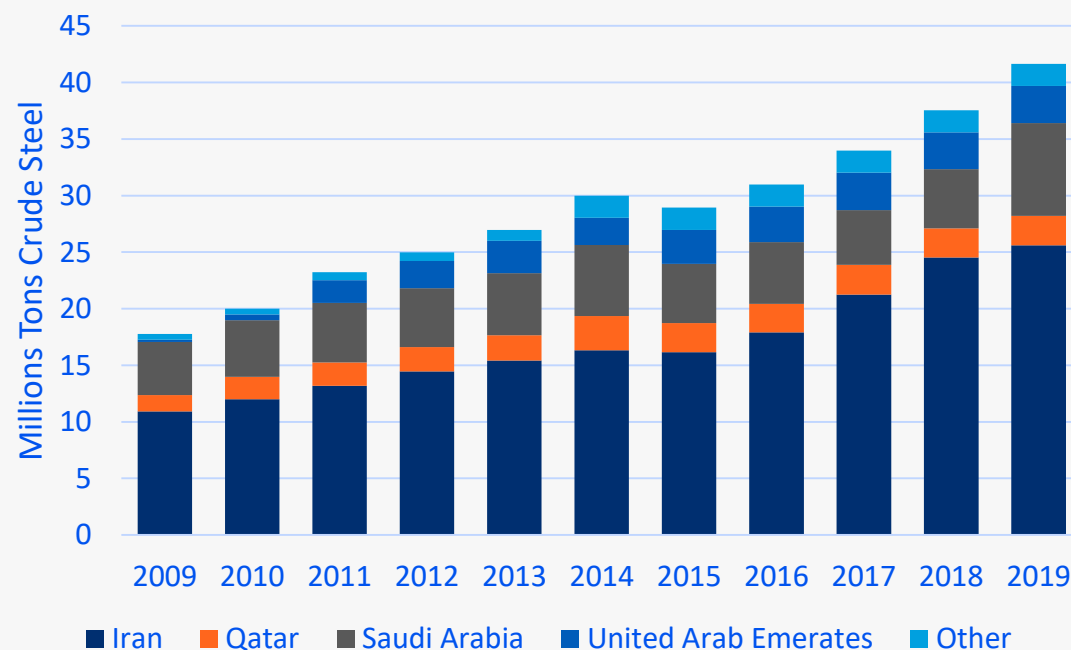




Middle East Crude Steel Production

- Middle East Crude Steel production has increased an average of >10% per year over the last decade and this trend is expected to continue over the next decade
- Vanadium consumption use per ton of steel is also expected to grow over the next decade

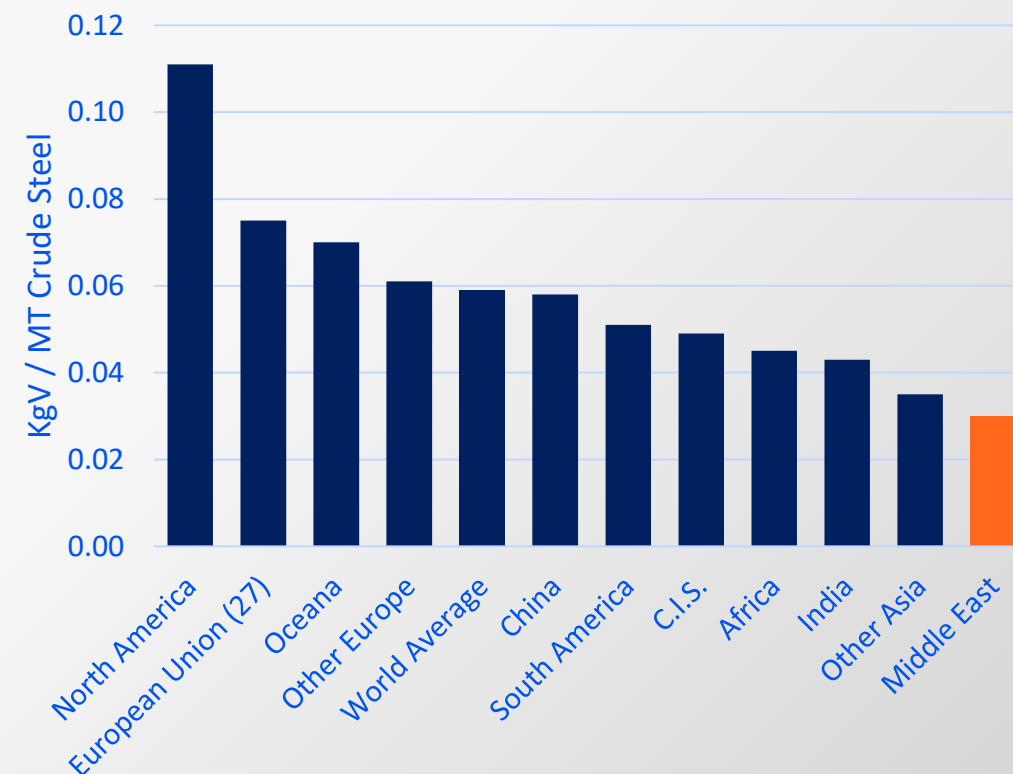
Production of Crude Steel



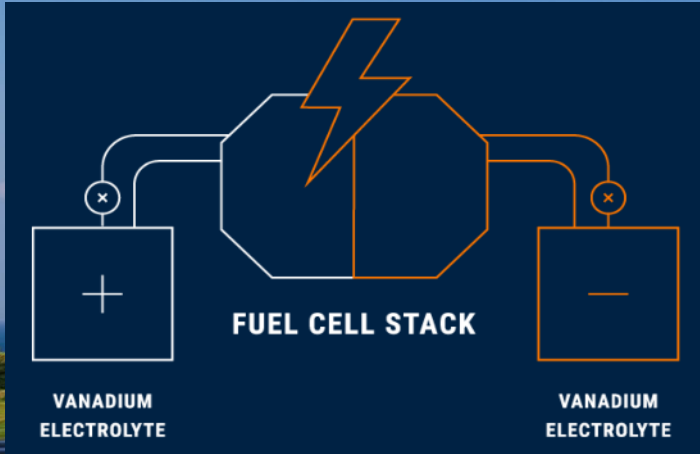
Source: World Steel Association, Vanitec

Note: Saudi Arabia crude steel production is HADEED only, Other category includes Israel, Jordan, Oman and Syria

Intensity of V Usage



Shell & AMG Recycling positioned to be a leader in VRFB supply chain



- **Long lifespan** ability to charge and discharge 10,000+ cycles for lifespan of 20+ years
- **100% depth of discharge** with no performance degradation
- **Environmentally friendly** with no emissions and recyclable
- **Scalable capacity** power and energy corresponding to requirement
- **Safe** with no risk of fire from thermal runaway

Shell & AMG Recycling

- Ambitious renewable energy targets of the region focused on solar and wind technologies, require effective energy storage solutions
- Vanadium redox flow battery (VRFB) technology is the key technology for enabling a regional value chain for energy storage
- Recycling of refinery wastes is enabling a circular economy where energy storage is supporting the growth in renewable energy



Best Practices for Managing Spent Residue Upgrading Catalyst



Spent catalyst must be properly managed

- **The Goal: safe, environmentally sound recycling of spent catalyst**
- **Reclamation must be performed in a way protective of the environment.**
- **Listed Hazardous Waste in the U.S. and in Europe**
 - High sulfide content (Self-heating, Pyrophoric, Reactive)
 - High polynuclear aromatic hydrocarbon (PAH)
 - Benzene and arsenic (As)
 - High oil content
 - High metals content
 - Leachability of TCLP metals



- The Basel Convention controls the transboundary movement of hazardous wastes and aims to restrict and regulate such movement if it can be done in an environmentally sound manner.
- Spent resid catalyst is classified as hazardous due to leachable metals, arsenic, benzene, PAH contents and self-heating tendencies
 - Self-heating tendencies originate from the sulfides in the spent catalyst, which will oxidize with exposure to air
 - The oil on the surface of the spent catalyst helps to prevent this reaction, so after the oil is removed, self-heating is more likely, not less
 - Complete Roasting, which removes the sulfur, eliminates the self-heating tendency
- Partial reclamation, such as thermal desorption, only removes the free oil and does not substantially change the catalyst and therefore does not eliminate need for the hazardous classification and may increase the flammability of the material



BASEL CONVENTION



Industry standards of risk mitigation for spent resid catalyst

- “Risk Mitigation Handbook for Reside Spent Catalyst” based on decades of AMG experience
- Key components of selecting and auditing a spent catalyst recycler partner:
 - General Facility Information
 - Waste Handling Operations
 - Facility Design
 - Regulatory Compliance
 - Environmental Evaluation
 - Community Relations
 - Facility Security
 - Financial Strength
 - Financial Assurance / Insurance





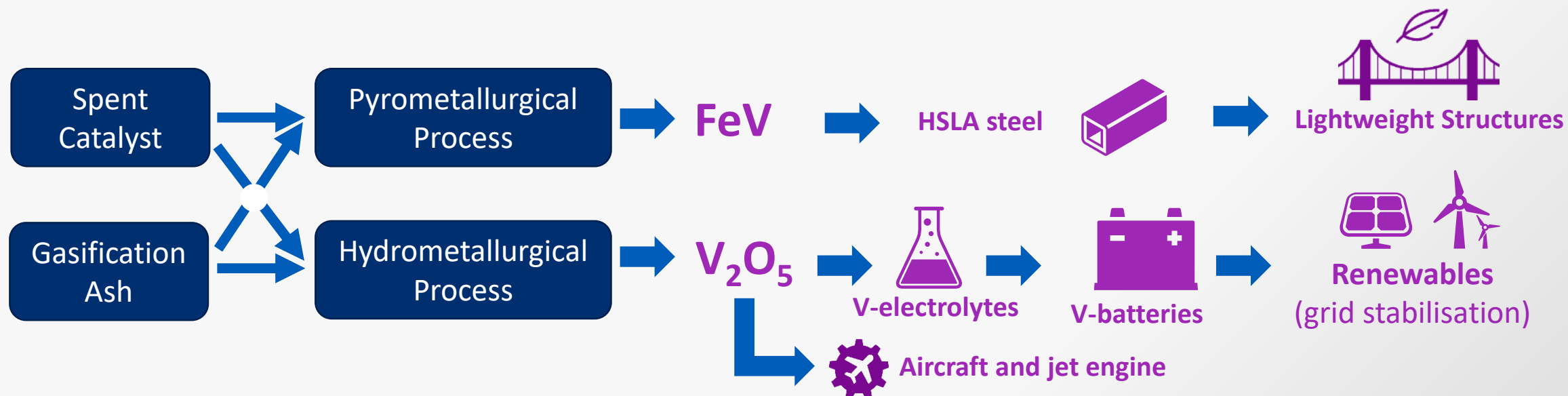
Risky practices observed in the industry

- Partial Processing to Avoid Shipping and Handling Requirements
- Improper Storage Practices by Processors
- Placement in Landfill
- Not Providing Evidence of the Fate for all Spent Catalyst Constituents including Byproducts and Waste Streams
- Improper Identification and Labeling
- Improper Packaging of Self Heating Material
- Occupational Health and Safety for Workers is Substandard or Not Fully Implemented
- Undercapitalization





Spent Catalyst Recycling and its contribution to CO₂ reduction



Contributing to GHG targets through ...

- Significant **CO₂ emission savings** via recycling, approx. 80% lower than primary extraction
- HSLA steel enables a **20-40% reduction in steel use**, significantly reducing resource use and transport-related CO₂ emissions
- High purity V₂O₅ for VRFB energy storage applications, enabling **renewable power growth** and advancement in energy storage capabilities

Proven experience in sustainable spent catalyst management: Recognition from Marathon Petroleum Corporation (MPC)



Catalyst metals reclamation: MPC and its strategic partner, AMG Vanadium (AMG), work together to improve the environment by minimizing waste and reducing greenhouse gas emissions.

In 2019, instead of landfill disposal, AMG received 5,300 tons of spent catalyst from MPC. AMG extracted the vanadium and other valuable metals to produce ferrovanadium and ferronickel–molybdenum alloys, which were sold to the steel industry. This produced 41,500 fewer metric tonnes of CO₂ emissions than the traditional steel manufacturing process.

5,300 tons of spent catalyst avoided landfill.

500 tons of vanadium were reclaimed for steel production.

41,500 metric tonnes of CO₂ emissions were avoided compared to mining for virgin ore.



MPC recognized AMG's contribution to its greenhouse gas and waste reduction efforts with its 2019 Environmental Stewardship Award and featured the process in the 2019 MPC Sustainability Report.



Key drivers for refinery spent catalyst economics



Metals markets

Metals content

Type of catalyst

Packaging

Logistics

Contract details



Live Q&A With Our Team

Please keep posting your questions

Thank you!



SHELL & AMG RECYCLING
VALUE THROUGH SUSTAINABILITY