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Different Perspectives in Enabling Materials Resource Sustainability

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The REWAS 2013 symposium at this year's TMS Annual Meeting in San Antonio, TX, follows in the footsteps of previous REWAS conferences organized by TMS. REWAS 2013 builds on the 2010 Sustainable Materials Processing and Production Symposium and the 2011 Materials and Society plenary session "Linking Science and Technology for Global Energy Solutions." In the 2010 symposium, for the first time, we connected the metallurgical and materials science community to the broader, interdisciplinary topic of sustainability by linking technology, metrics, modeling, education, and the role materials play in the transition to a sustainable society.[1,2]

REWAS 2013 again brought together the material science community and other stakeholders from across the material and product life cycle,[3] resulting in 75 presentations. Its topic and focus is well timed as it coincides with the recent UNEP Resource Panel report "Metal Recycling: Opportunities, Limits, Infrastructure."[4] The next REWAS will be held in conjunction with the TMS 2016 Annual Meeting in Nashville.

By pulling in practitioners and educators from outside the TMS community, interdisciplinary approaches and system thinking can be further fostered. This was one of the most important aspects of the symposium. Some examples from the proceedings are as follows:[5]

- "Stock Dynamics and Emission Pathways of the Global Aluminium Cycle," by Daniel Muller et al.
- "Recycling Oriented Product Characterization for Electric Equipment," by Vera Rotter et al.
- "Critical Analysis of Existing Recyclability Assessment Methods for New Products," by Elisabeth Maris.
- "Potential of Steelmaking Slag as New Phosphorus Resource in Terms of Total Materials Requirement," by Eiji Yamasue et al.
- "Resource Efficient Metal and Material Recycling," by Markus Reuter et al.
- "Assessing the Criticality of Metals," by Tom Graedel.
- "Towards Zero Waste Production in the Minerals and Metals Sector," by John Rankin.
- "Input–Output Mass Flow Analysis (IO-MFA) and Thermodynamic Approach for Metal Recycling," by Kenichi Nakajima et al.

These papers focused on nonmetallurgical considerations in the pursuit of sustainability, or the linkages between metallurgical considerations and sustainable systems. Such presentations show a larger view of the world, which ties into more specific issues.

Enabling sustainability requires fundamental knowledge as well as technical solutions that are based on and derived from fundamental knowledge. This is the natural habitat of the metallurgical engineer and material scientist. Process modeling and simulation, process design, and material and product design are just some of the tools that lead to novel materials and technologies. One could say the devil or God is in the detail, depending on the perspective.

This does not mean that *only* the details are important. Understanding sustainability requires also a bigger system or life cycle perspective. Insight in the interactions between different parts of whole systems enables deeper understanding of the levers toward sustainability. Combining details such as fundamental knowledge into a larger perspective points out where nonintuitive behavior may arise due to the vast complexity.

Sustainability goes beyond the engineering sciences to the social sciences to address the different aspects of

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sustainability. The REWAS session on Education and Communication pointed out that even communication skills are needed. Among others, Jason Jay, Director of the MIT Sloan Initiative for Sustainable Business and Society, and Gabriel Grant, of Yale University, talked about the pitfalls and pathways in communicating about sustainability.[6] The pitfalls are so common that everyone has probably fallen into them and gotten stuck. The pathways to get out provided the audience with a range of insights for direct use in any type of discussion.

As is always the case, the number of presentations at the Annual Meeting that participants were interested in seeing is greater than the available time with which to see them. As a result, this issue of *JOM* presents papers under the same topic—Enabling Materials Resource Sustainability. The goal is to present a bird's-eye view of resource sustainability, along with a demonstration of its importance in specific industries and technologies.

The first article is a summary of the REWAS plenary session, which presented overviews of sustainability as it applies to buildings, electronics, energy, water, and economy. Gabrielle Gaustad provides the highlights from the five plenary speakers. Despite the breadth of experience and current application areas, each shared the same outlook that material scientists are a key enabling force for achieving sustainability in our world.

The next paper by Laura Talens-Piero et al. tells the life cycle story of lithium. Lithium is increasingly important due to its use in batteries for electronic devices and electric vehicles. The paper gives a comprehensive overview of sources, extraction and production, uses, and recovery and recycling.

The following three articles are in-depth research summaries. Mari Naess et al. dive into silicon processing, with a detailed study of the element emissions in fumes from the tapping and refining processes. As a result, a new method for estimation of emissions from silicon refining operations, with associated error analysis, is suggested. The methodology is transferrable to other metallurgical refining/fuming processes.

The second research summary is by Julia Ayala and Begona Fernandez. They propose a hydrometallurgical process to recover manganese from zinc anode slimes. The paper describes the digestion-leaching experiments, precipitation, and electro-winning assays to recover manganese from this residue.

The third research summary by Lu Wang and Ming Chen gives an update about end-of-life vehicles (ELV) and their recycling in China, looking at the number of vehicles, recycling, and the legal situation with regard to the recovery and recycling rate. There are 492 verified dismantling enterprises. However, 80% of all ELV enter the black market. The authors recommend that vehicle manufacturers pay the ELV companies for waste disposal or that government subsidies be introduced.

In closing, the challenge is to not forget that the big picture exists while looking at matters close up. Trying to take the two perspectives is like taking a road less traveled—not easy, but worth it. A new perspective gives a new perception.

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