



The 2020–2022 AIST John F. Elliott Lecture Tour

The John F. Elliott Lectureship Global Metallurgy — The Right Time for Metals

By Phillip Mackey

It was quite an honor when I learned in late February 2020 that I had won the 2020 AIST John Elliott Lectureship Award. Plans were soon made to map out a program of lectures. My topic was on the energy transition and new technology for critical metals, and I was ready for the challenge of the lecture tour. Yet, within a month of my learning of this prestigious award, the whole world effectively shut down as COVID-19 began spreading, and all plans had to be put on hold.

AISTech 2020 and the annual President's Award Breakfast, scheduled for May that year, were subsequently canceled due to the pandemic, and instead, given the COVID-19 uncertainties, early in 2021 AIST created a virtual award ceremony — which was new at the time — and which went online at the end of February 2021.¹ I wish to thank AIST for the award as well as a number of colleagues who helped along the way. The award citation reads:

“For innovation in the development of pyrometallurgical processes for the production of primary metal, and for promotion of the profession of metallurgical engineering.”

As the lockdown persisted during 2020, instead of visiting universities as would have been the case normally (that year, most universities were closed, and travel

was very restricted), not only was I able to spend time exploring new aspects of my topic, but the focus of the lecture changed to fully cover both the energy transition and the role of new technology for the decarbonization of iron and steel and critical metals. In other words, it was realized that moving forward, the world will be seeing a double transition — that of energy and one of mining/metallurgy. As a matter of interest, I have long followed the subject of energy consumption in metals production. My first paper on this subject was delivered at the Conference of Metallurgists held by the Metallurgical Society of The Canadian Institute of Mining and Metallurgy in August 1973 in Quebec City, Que., Canada.² Of interest, the conference was held in the aftermath of the Middle East crisis causing rapidly rising oil prices, and interestingly, our paper included a description of a metallurgical complex powered by electricity provided by a small nuclear reactor — a subject very much to the fore today.

I chose the topic for this lecture because it would give me both an opportunity to show how important metals, mining and metallurgy are to the energy transition and, importantly, to show students the exciting and valuable opportunities in chemical process metallurgy and materials chemistry at the present time and well into the

future. In effect, there can be no green energy projects without mining and metals — “a good time to be in metals” was one of my slogans.

Reflecting on the topic, Professor Hani Henein of the University of Alberta gave the following comments:

“Phillip Mackey chose a very timely topic for his Elliott Lecture. With the advent of net zero and the pursuit of sustainability with critical materials, it was apparent from his lecture that there are no inroads to lowering carbon dioxide without the use of more metals. All in the audience, students and faculty members, very much appreciated the presentation and the message. It was most timely to hear it and left a lasting impact on many in the audience.”

Because of uncertainty and limits on travel, many of the early lectures were given virtually, using the newly upgraded internet tools such as Zoom and Microsoft Teams. My first Elliott Lecture was given virtually on 11 November 2021 to the Department of Materials, Science and Technology at the Missouri University of Science and Technology (Missouri S&T) in Rolla, Mo., USA. From November 2021 to the end of 2022, a total of nine lectures were presented — both virtually and in person — in four countries, with one lecture still planned for late 2023 or early 2024 (see Table 1).

The lecture at Rolla was well received with good discussion, even if it was all carried out virtually. Professors Ron O'Malley and Mike Moats are to be thanked for all their help with arrangements, as well as support by Emeritus Professor David Robertson. I also acknowledge Professor Robertson's help in several aspects



of examining the hydrogen reduction of iron ore. The Kent Peaslee Steel Manufacturing Research Center at Missouri S&T supports a wide range of steel projects, including a major effort on hydrogen reduction of iron

Table 1
The 2021–2022 John F. Elliott Lecture Universities

No.	Institution	Location	In person or virtual	Date
1	Missouri University of Science and Technology	Rolla, Mo., USA	Virtual	11 November 2021
2	Aalto University	Espoo, Finland	Virtual	3 December 2021
3	University of Toronto	Toronto, Ont., Canada	In person	16 March 2022
4	McGill University	Montreal, Que., Canada	Virtual	25 March 2022
5	Colorado School of Mines	Golden, Colo., USA	In person	22 June 2022
6	Swinburne University of Technology	Melbourne, Vic., Australia	Virtual	8 September 2022
7	University of British Columbia	Vancouver, B.C., Canada	In person	15 September 2022
8	Case Western Reserve University	Cleveland, Ohio, USA	Virtual	20 September 2022
9	University of Alberta	Edmonton, Alta., Canada	In person	13 October 2022
10	Massachusetts Institute of Technology	Boston, Mass., USA	In person (planned)	To be determined (Q4 2023)

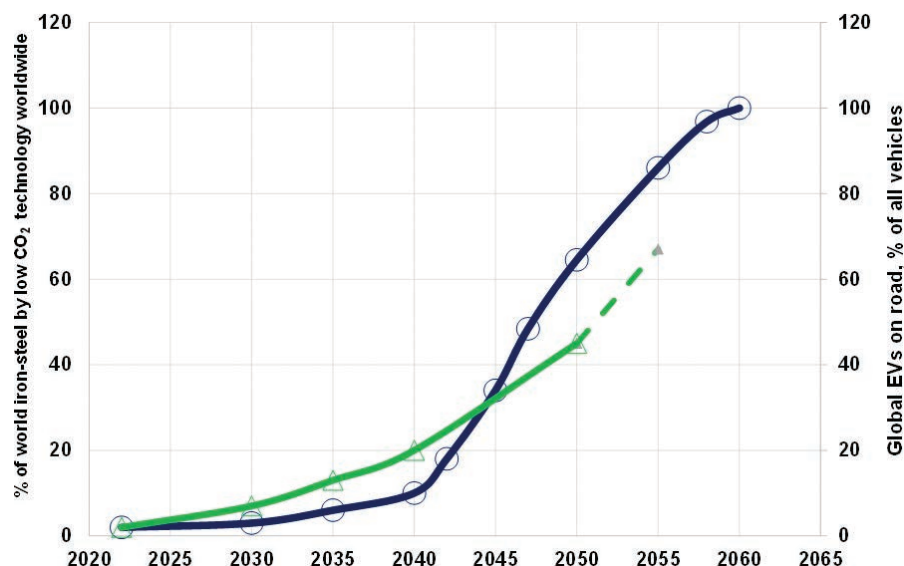


Figure 1

Projected trend worldwide in the percent of world iron and steel production by low-CO₂ technology, as developed by the author (heavy green line, LH scale). Global EVs on the road as a percent of all vehicles is also shown (curve with dotted line, RH scale). Note: Low-CO₂ steel is considered here as < 200 kg CO₂/t steel.

ore combined with electric furnace melting of direct reduced iron for steelmaking and managed by Professor Ron O'Malley.

Emeritus Professor Robertson said:

"Dr. Mackey's Elliott Lecture was given at Missouri S&T on 11 November 2021. The topic was how we can best make the transition to the adoption of metal production processes that have low carbon emissions. Dr. Mackey's choice of topic will inform those entering the profession about the important task of combating climate change.

"This challenge is going to be the work of people who are now students of extractive metallurgy in departments of materials science and engineering, and Dr. Mackey's lecture was aimed at this cohort. Dr. Mackey discussed the history of metal production processes for nickel, copper and steel.

"He also covered the current efforts to pilot processes using hydrogen as the alternative to natural gas in iron production. His historical and technical analysis showed that the task will not be an easy one and will likely take decades."

The next lecture was given on 3 December 2021 to a large, interested group at Aalto University, Espoo, Finland — also virtually even though the author was visiting Finland at the time. Aalto University, which was formed in 2010 by merging three leading Finnish universities, is very active in metallurgical research. Projects at the School of Chemical Engineering related to the metallurgy of critical metals and recycling as described by staff were of great interest. Thanks are given to Professors Mari Lundström and Sipi Seisko for their help in planning the lecture.

The first in-person lecture was given to a packed lecture room at the University of Toronto in Toronto, Ont.,

Canada, on 16 March 2022. At this time, masks were generally needed, and proof of vaccination was still required for travel. Professor Naomi Matsuura of the Department of Materials Science and Engineering and Professor Vladimiro Papangelakis of the Department of Chemical Engineering and Applied Chemistry coordinated the visit. With increasing interest in new ironmaking technologies and the importance of decarbonization of the iron and steel industry, the ensuring discussion was quite lively. Still, as the lecture discussed, the technology transition in the steel industry will require many decades to be fully implemented worldwide, in large part due to the significant level of new testing and piloting required and the huge funding needed (refer to Fig. 1).

Also in March 2022, the Elliott Lecture was given virtually to a large group of students in the Department of Mining and Materials Engineering at McGill University in Montreal, Que., Canada. Professor Omelon was helpful in arranging the lecture.

An in-person lecture was well-received at the Colorado School of Mines as part of the workshop Recycling Metals From Industrial Waste on 22 June 2022. Founded in 1874, the Colorado School of Mines is a major undergraduate and graduate university in the U.S. supporting the growing mining and minerals industries in the country.

Swinburne University of Technology in Melbourne, Vic., Australia, hosted a virtual lecture on 8 September 2022. Coordinated by Professor Geoffrey Brooks of the School of Engineering, the lecture was well attended. Professor Brooks and his group are active in high-temperature processing covering ferrous and non-ferrous metals and green processing.

Professor Brooks commented on the lecture as follows:

“The John Elliott Lecture delivered by Phil Mackey was excellent. He really explained very clearly to the students the key issues and highlighted recent advances. I really liked the way he brought the challenges of decarbonization down to a very practical and understandable level. I know the students were inspired by his talk.”

Two in-person lectures were given at universities in Western Canada — in Vancouver, British Columbia, and Edmonton, Alberta. The lecture at the Department of Materials Engineering at the University of British Columbia in Vancouver was given on 15 September 2022 to a well-attended audience of student and staff. Professors Asselin, Lui and Dreisinger were helpful in all arrangements. The department has a long and successful history in all aspects of metallurgy and materials engineering, and currently has several active projects in both hydrometallurgy and pyrometallurgy. At the University of Alberta in Edmonton, a large group of students and staff attended the Elliott Lecture delivered on 13 October 2022. There was a lively discussion session following the lecture. Professors Henein, Bobicki and Sadri kindly assisted in publicizing the lecture and helping with arrangements.

On 20 September, a virtual presentation was given to the Case School of Engineering at the Case Western

Reserve University, in Cleveland, Ohio, USA. Hosted by Professor Carter, the lecture prompted active discussion on several aspects related to sustainable metal production. A final lecture is planned at Massachusetts Institute of Technology, Boston, Mass., USA, for the 2023–2024 winter term.

In my introductory remarks, I would comment on Professor Elliott’s life and his work. Of interest, I mentioned that with some prescience, his 1972 paper in the *Journal of Metals* entitled, “100 Years of Progress in Process Metallurgy” included the following prediction on energy use: “electricity will become more important as an energy source than it is now.” While Professor Elliott may have had environmental issues in mind, likely not carbon dioxide, he was certainly correct in his assessment. It has been my honor to be the 2020–2022 Elliott Lecturer.

Acknowledgments

The author acknowledges the kind assistance given by a large number of colleagues and organizations who helped by providing information for this lecture; too many to name individually, however the lecture itself provides details.³ Thanks are also given to staff at the various universities for their help.

References

1. 2020 AIST Board of Directors Awards, <https://www.youtube.com/watch?v=dXRn5hMtlyY>.
2. P.J. Mackey and D.V. Parsons, “Energy Consumption in Metals Production,” *12th Annual Conference of Metallurgists*, Canadian Institute of Mining and Metallurgy, Quebec City, Que., Canada, 26–29 August 1973.
3. P.J. Mackey, “The Importance of the Metals Industry in a Low-Carbon Economy: A Look at Future Technologies,” John F. Elliott Lecture, Missouri University of Science and Technology, 11 November 2021.



The AIST John F. Elliott Lectureship was established in 1990. This honorary lectureship is designed to acquaint students and engineers with the exciting opportunities in chemical process metallurgy; inspire them to pursue careers in this field; inform the public of the contributions of chemical process metallurgy and materials chemistry to the association; and honor the late Professor John Elliott of the Massachusetts Institute of Technology for his many accomplishments and the leadership that he provided during his career. The recipient presents a lecture at three or more universities throughout the year following selection.