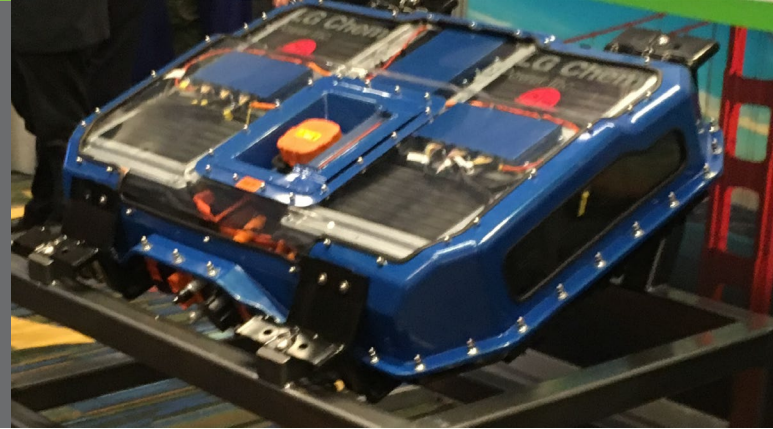


BATTERY RECYCLING R&D AND THE RECELL CENTER



LINDA GAINES

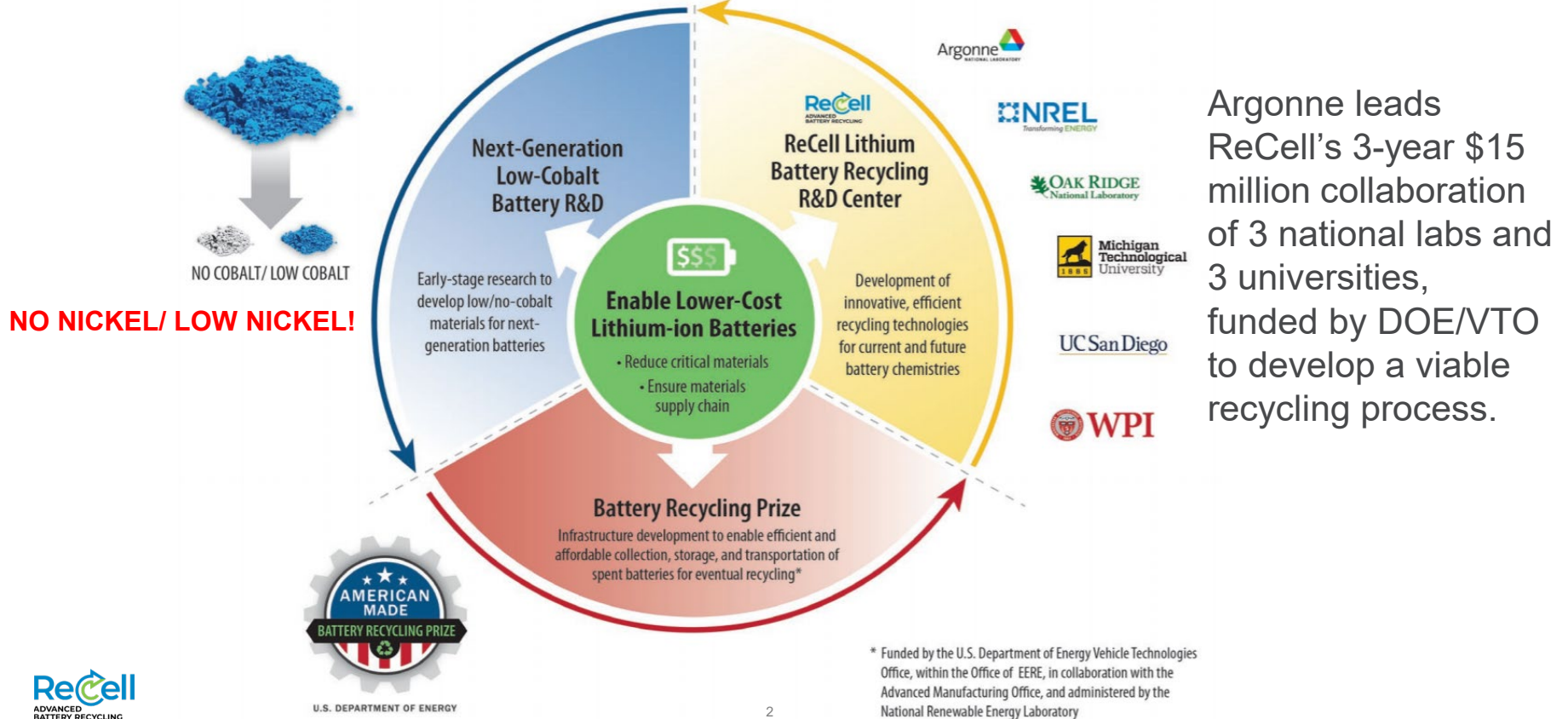
Chief Scientist ReCell Center
Argonne National Laboratory
lgaines@anl.gov

CEC EPIC Forum

Creating California's Advanced Lithium Battery Ecosystem
August 4, 2021

RECELL IS PART OF DOE'S CRITICAL MATERIALS PLAN

to reduce the cost of EV batteries while significantly reducing or eliminating dependency on critical materials (such as Co and Ni) and using recycled material feedstocks.



Argonne leads ReCell's 3-year \$15 million collaboration of 3 national labs and 3 universities, funded by DOE/VTO to develop a viable recycling process.

* Funded by the U.S. Department of Energy Vehicle Technologies Office, within the Office of EERE, in collaboration with the Advanced Manufacturing Office, and administered by the National Renewable Energy Laboratory

HOW MUCH MATERIAL IS THERE?

How many NMC811 car batteries could you make using reserves?

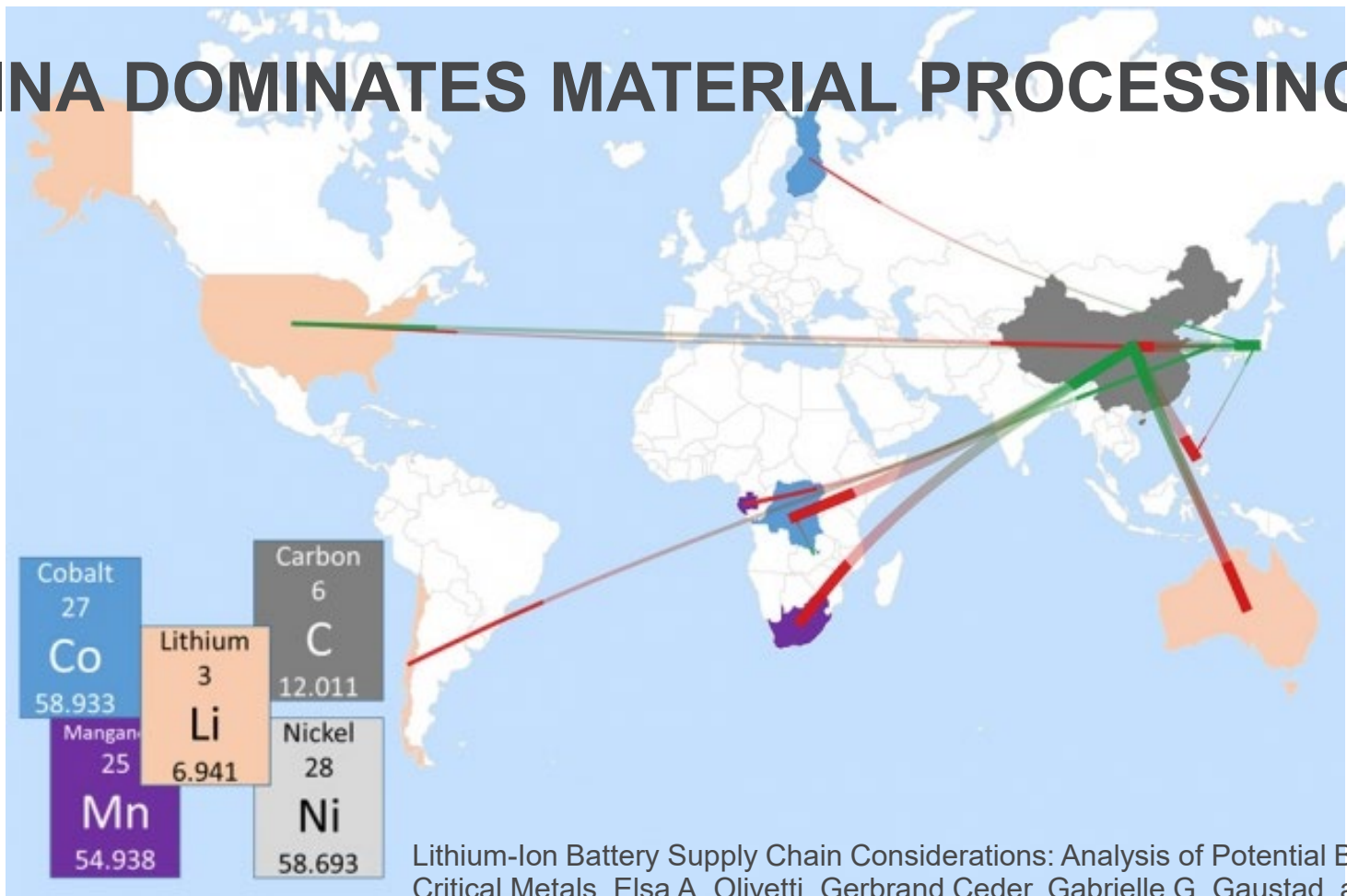
Element	kg/kWh* @85 kwh/car	kg per car @85 kwh/car	US reserves (kT)**	World reserves (KT)**	number for US (millions)	global number (billions)
Cobalt	0.08	6.8	53	7100	7.8	1.0
Nickel	0.6	51	100	94,000	2.0	1.8
Lithium	0.1	8.5	750	21,000	89	2.5
Manganese	0.07	5.95	230,000	1,300,000	38,656	219

* from Shabbir Ahmed 2/8/21;
NMC811-Graphite System from BatPaC 4.0 1Oct2020.

** USGS Mineral Commodity Summaries 2021

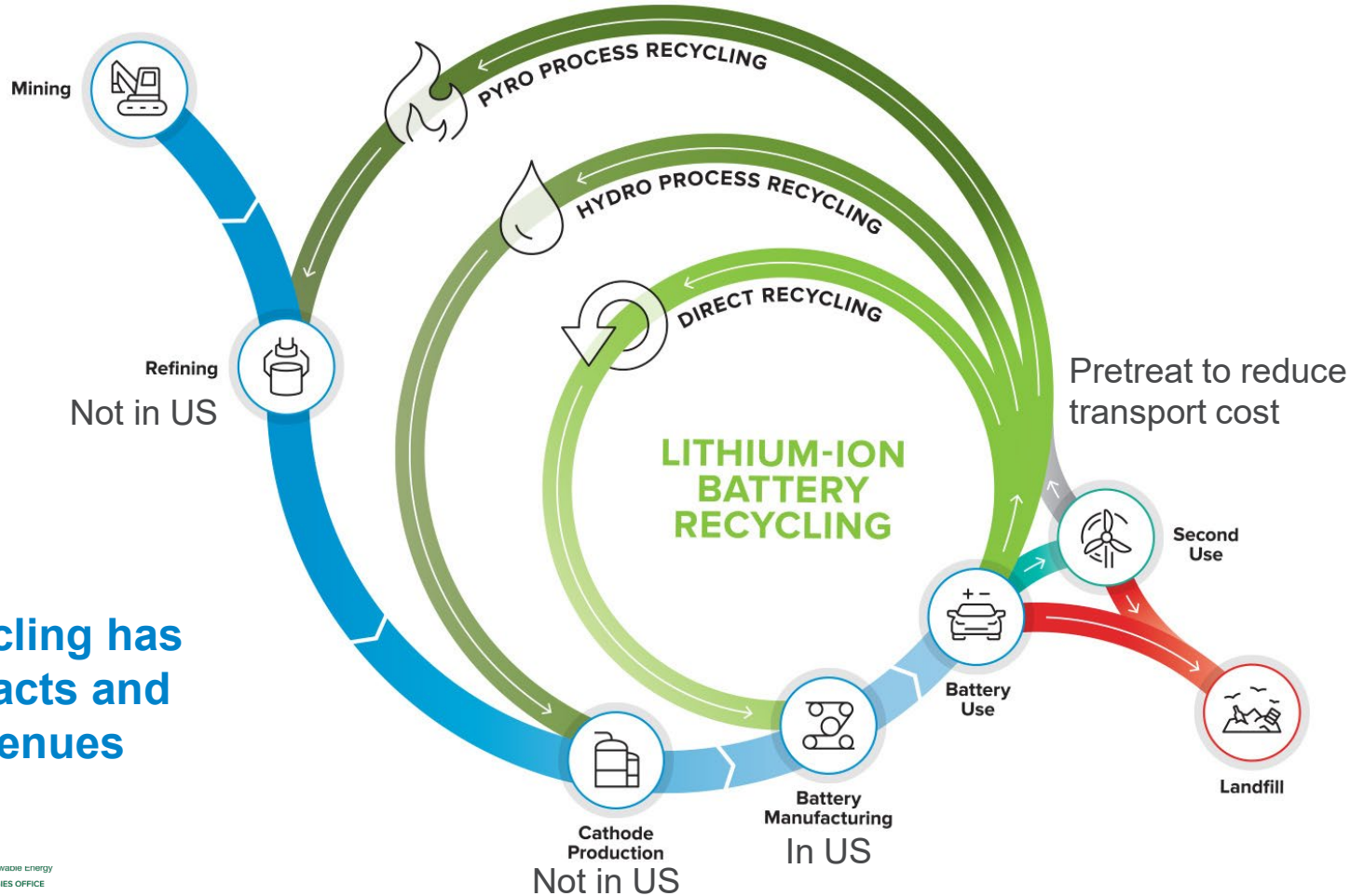
**Not enough, but recycling can help...
eventually.**

CHINA DOMINATES MATERIAL PROCESSING



Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals, Elsa A. Olivetti, Gerbrand Ceder, Gabrielle G. Gaustad, and Xinkai Fu, Joule 1, 229–243, October 11, 2017

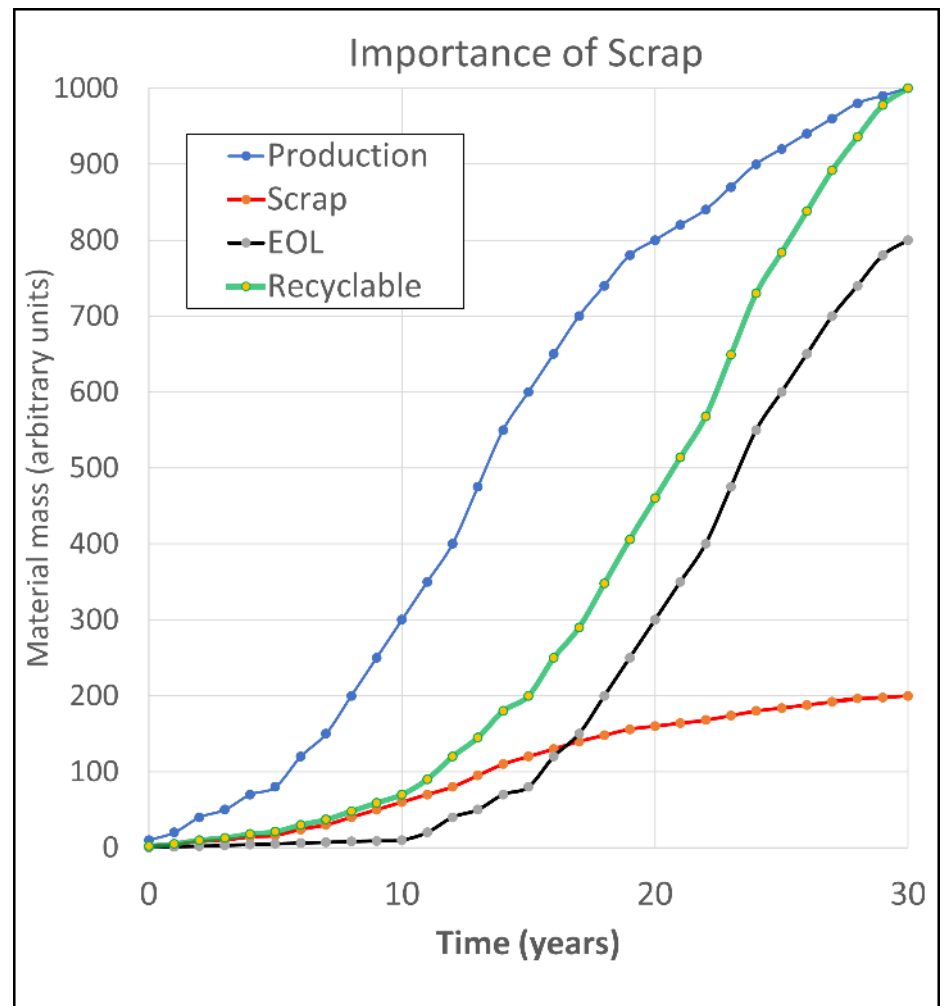
LI-ION BATTERY LIFECYCLE



Direct recycling has lowest impacts and highest revenues

NEW RECYCLING PLANTS' MAIN FEED IS PRODUCTION SCRAP

Artifact of rapid growth



REMAINING CHALLENGES AND BARRIERS

- Recovering materials that perform as well as new ones
- Obtaining value from a 10-year-old battery chemistry
- Developing sufficient technical and cost data to enable process selection
- Getting industry buy-in for commercialization
- Developing new recycling processes for future batteries
 - Sodium or magnesium-based cathodes
 - Lithium metal anodes and solid-state electrolytes

ReCell

ADVANCED
BATTERY RECYCLING

Thanks to:
Samm Gillard and Dave Howell

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

VEHICLE TECHNOLOGIES OFFICE
California Energy Commission

