

ARE “WE” ASKING TOO MUCH OF ELECTRICITY MARKETS?

CEE 4th Mid-Year Meeting, June 28, 2016

Critical Minerals Supply Chains

Raw materials can become the bottleneck for new energy technology deployment

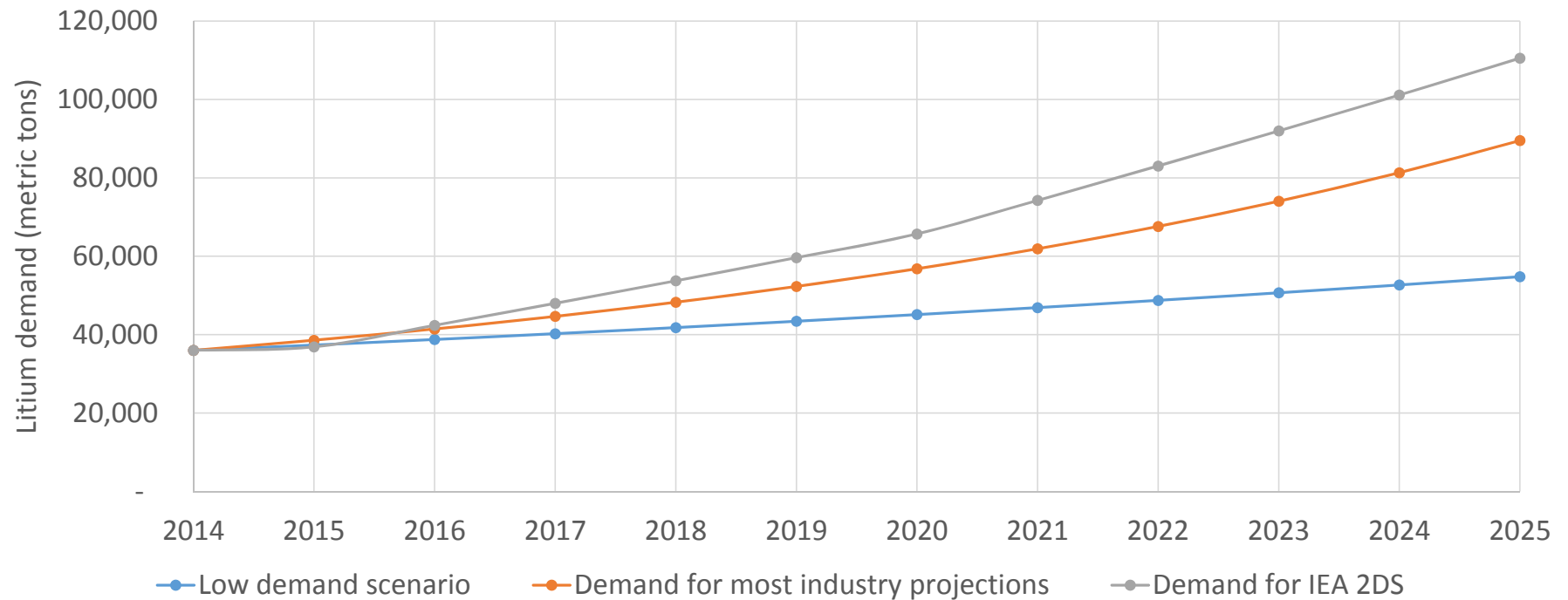
- Battery storage, wind turbines, and solar PV technologies are expected to grow phenomenally over the next decade
- There will be a massive demand for raw materials used in manufacturing
- The raw materials comprise some of the most critical materials
- Absence of substitutes and efficient recycling makes end-users even more vulnerable

Lithium in lithium-ion batteries

Electric vehicles, consumer products, grid energy storage

Lithium demand will double by 2025 even in base assumptions

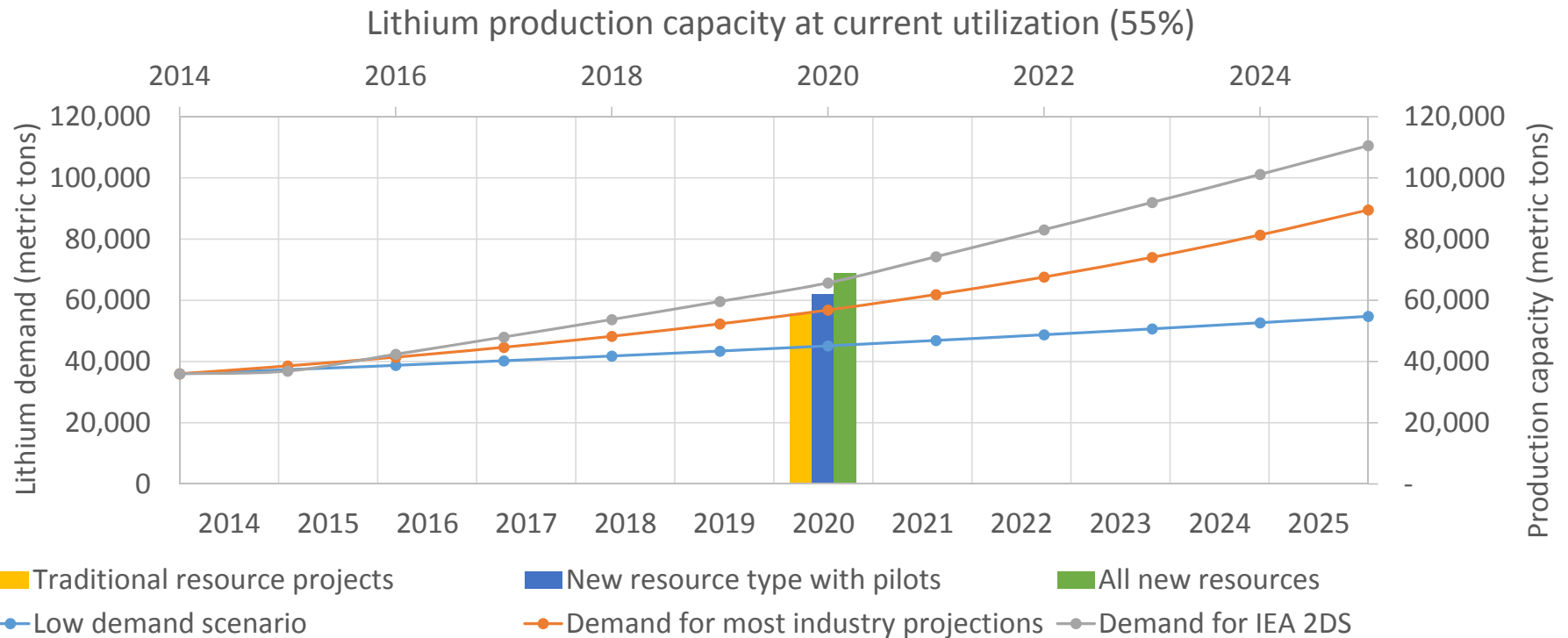
Lithium demand outlook



Data source: USGS, IEA, Roskill Information Services

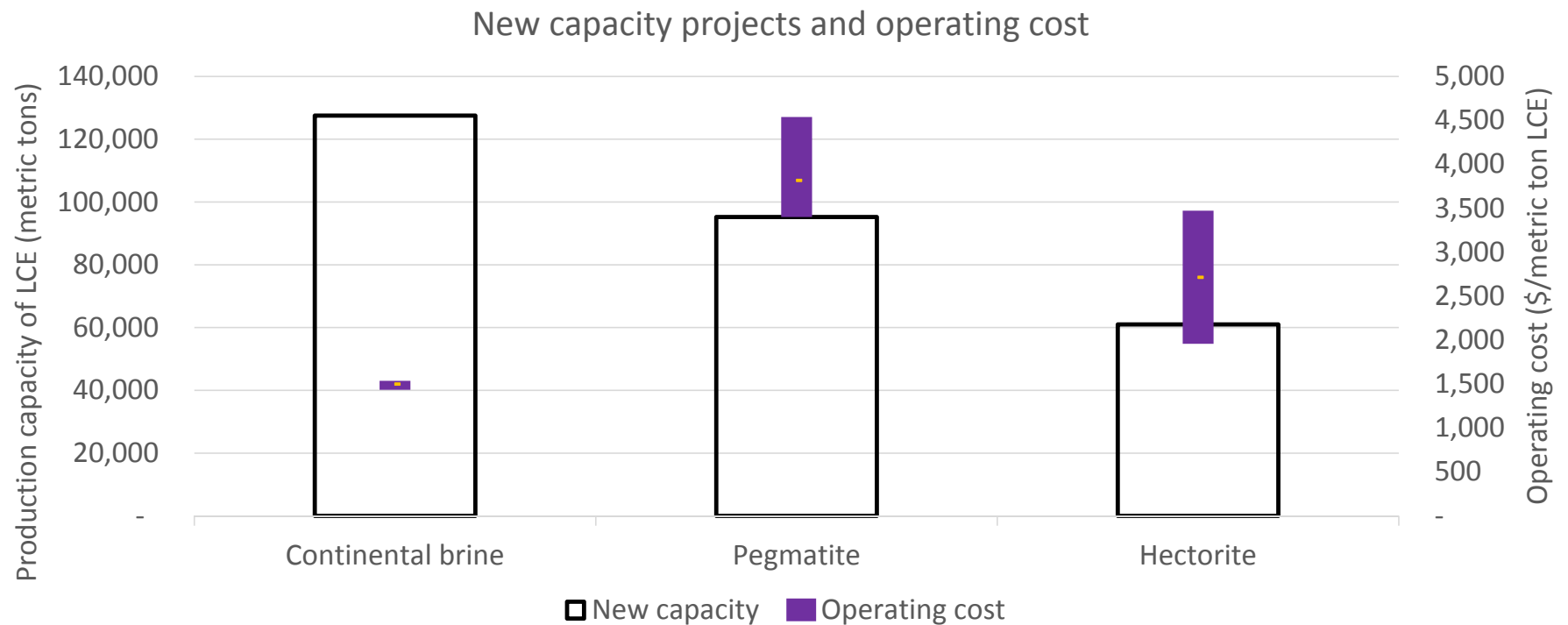
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Market response to increased demand is good



Data source: USGS, IEA, Corporate reporting

...But new projects are costlier and some are based on unproven processes



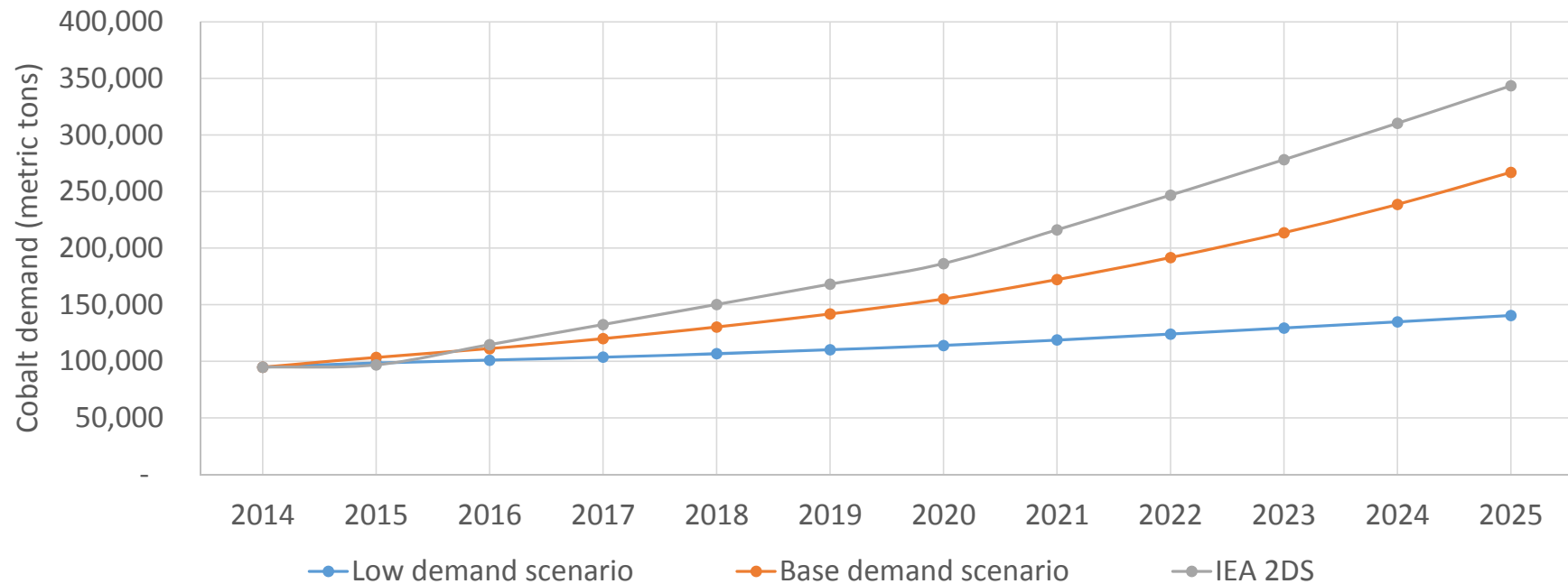
Data source: Corporate reporting

Cobalt in lithium-ion batteries

Electric vehicles, consumer products, grid energy storage

Cobalt demand will more than double to match battery demand

Cobalt demand outlook

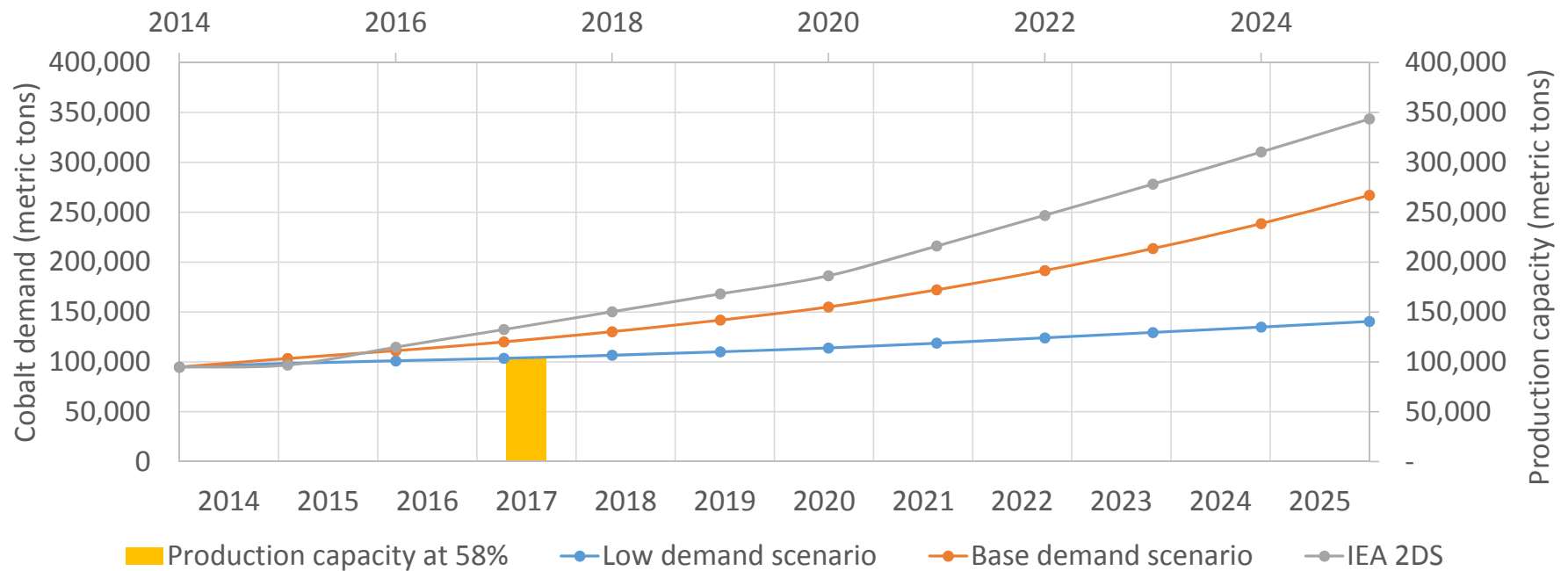


Data source: USGS, IEA

Cobalt supply will be constrained by 2018 at current production and new projects

Update: A new mine cleared environmental clearance in Minnesota for 320 metric tons cobalt

Cobalt production capacity at current utilization

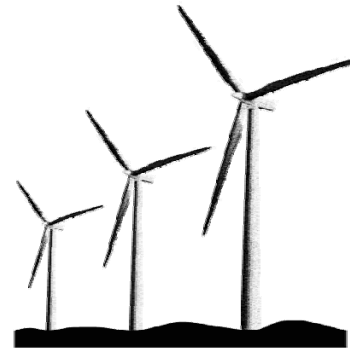


Data source: USGS, IEA, Corporate reporting

Other critical markets



Lithium
Cobalt
Graphite



Neodymium
Dysprosium



Tellurium



Europium
Terbium
Yttrium

Current criticality measurements do not account for commercial frameworks

- Current measures of criticality include
 - Price volatility
 - Governance indicators
 - Market concentration
 - Primary production growth
- Commercial framework analysis will include
 - Resource countries' laws and policies
 - Industry structure: national companies, private companies, artisanal mines
 - Analysis of risks and uncertainties in host countries

Scope for future research

- Commercial frameworks in resources countries
- Resource allocations, mine production capacity, refining capacity
- Supply-demand drivers
- Material demand breakdown by end user
- Geopolitical risk, bottlenecks, trade issues