Lithium-Ion Battery Issues

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LITHIUM SUPPLY AND DEMAND

Known Li reserves could meet world demand to 2050, even under high demand scenario

	Cumulative demand to 2050 (Contained lithium, 1000 Metric tons)
Large batteries, no recycling	6,474
Smaller batteries, no recycling	2,791
Smaller batteries, recycling	1,981
	Reserve Estimates
USGS Reserves*	13,000
USGS World Resource*	29,000
Other Reserve Estimates	30,000+

*Revised January 2011
http://minerals.usgs.gov/minerals/pubs/commodity/lithium/mcs-2011-lithi.pdf

U.S. cobalt use could make dent in reserve base by 2050

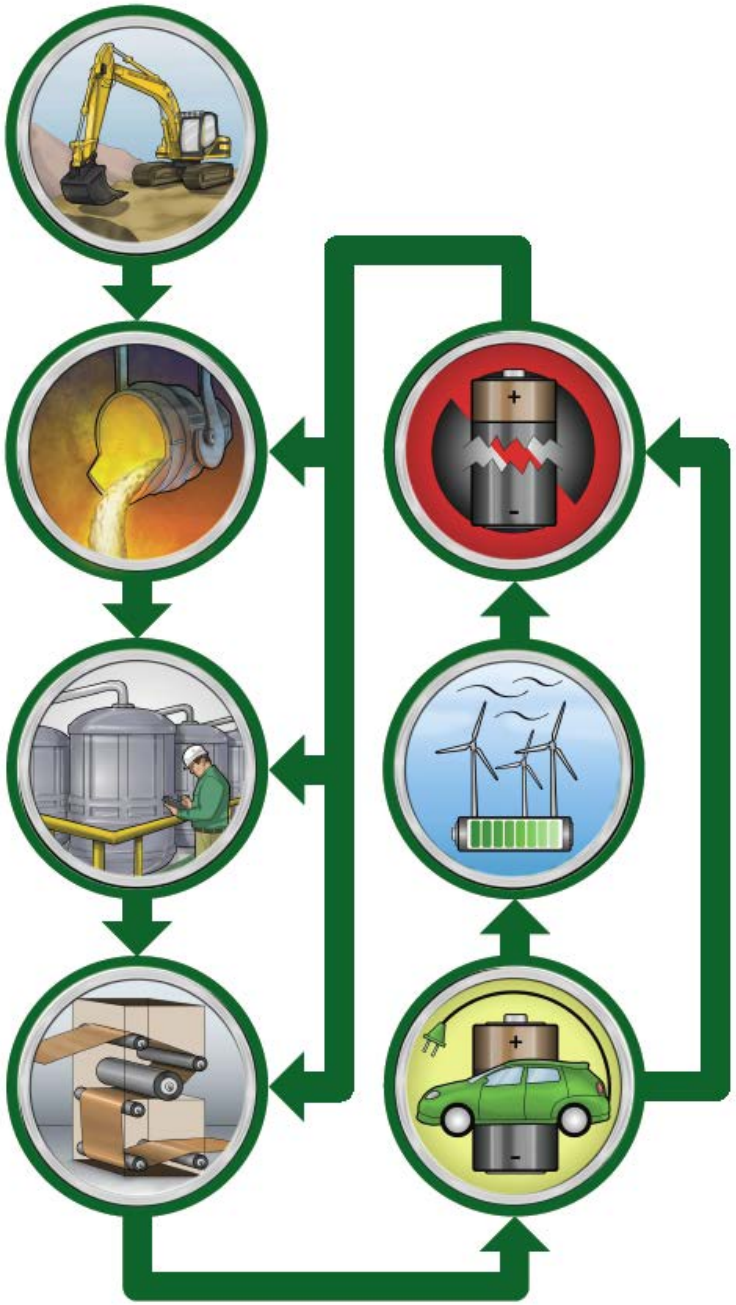
Material	Availability (million tons)	Cumulative demand	Percent demanded	Basis
Co	13	1.1	9	World reserve base
Ni	150	6	4	World reserve base
Al	42.7	0.2	0.5	US capacity
Iron/steel	1320	4	0.3	US production
P	50,000	2.3	~0	US phosphate rock production
Mn	5200	6.1	0.12	World reserve base
Ti	5000	7.4	0.15	World reserve base

RECYCLING PROCESS COMPARISON

Why think about recycling?

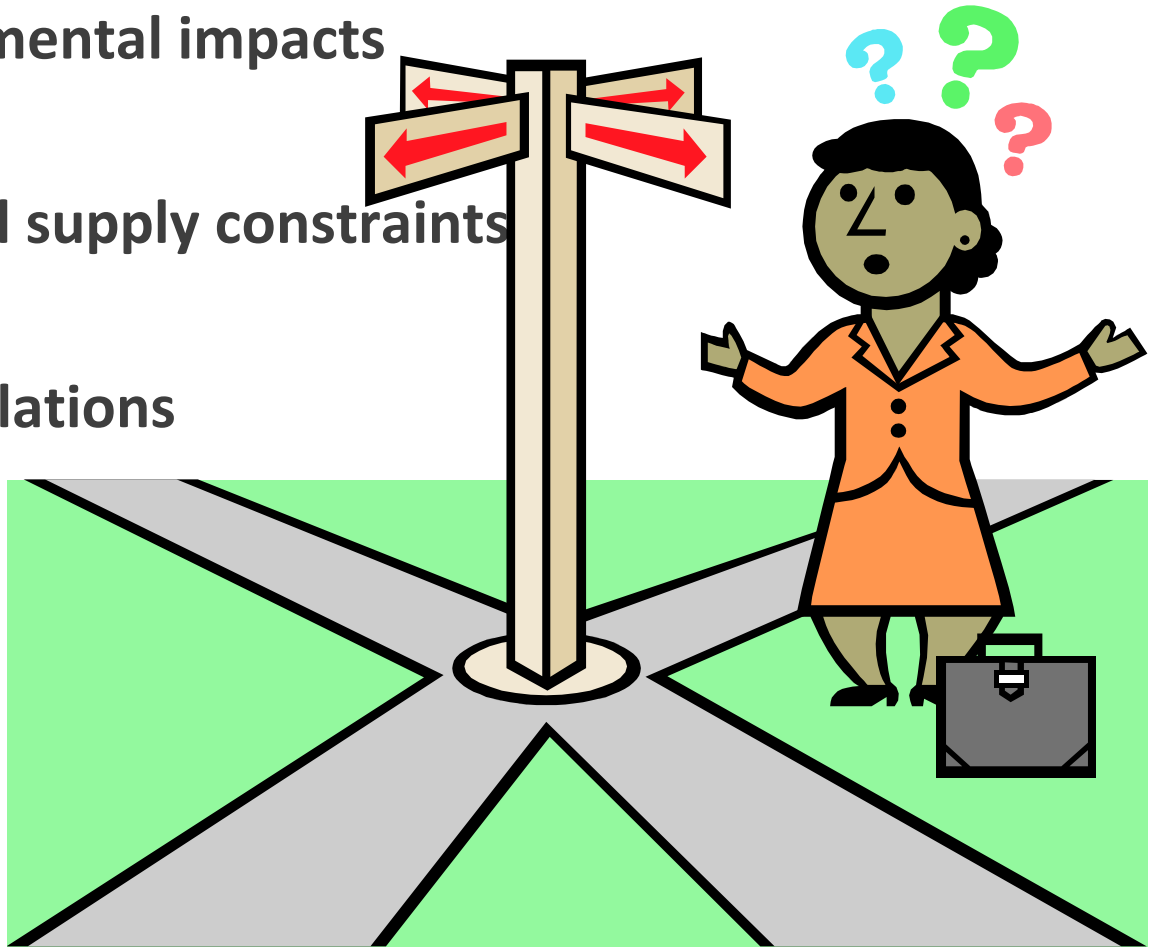
- **Material scarcity alleviated**
- **Recycled materials cheaper**
- **Production impacts avoided**
  - Energy use
  - Emissions
  - Mining impacts
- **Legally required**

- **But not all recycling processes are equal**
- **Which is best?**
  - LCA identifies “greenest” processes
  - May not be most economical
  - There may be other issues as well



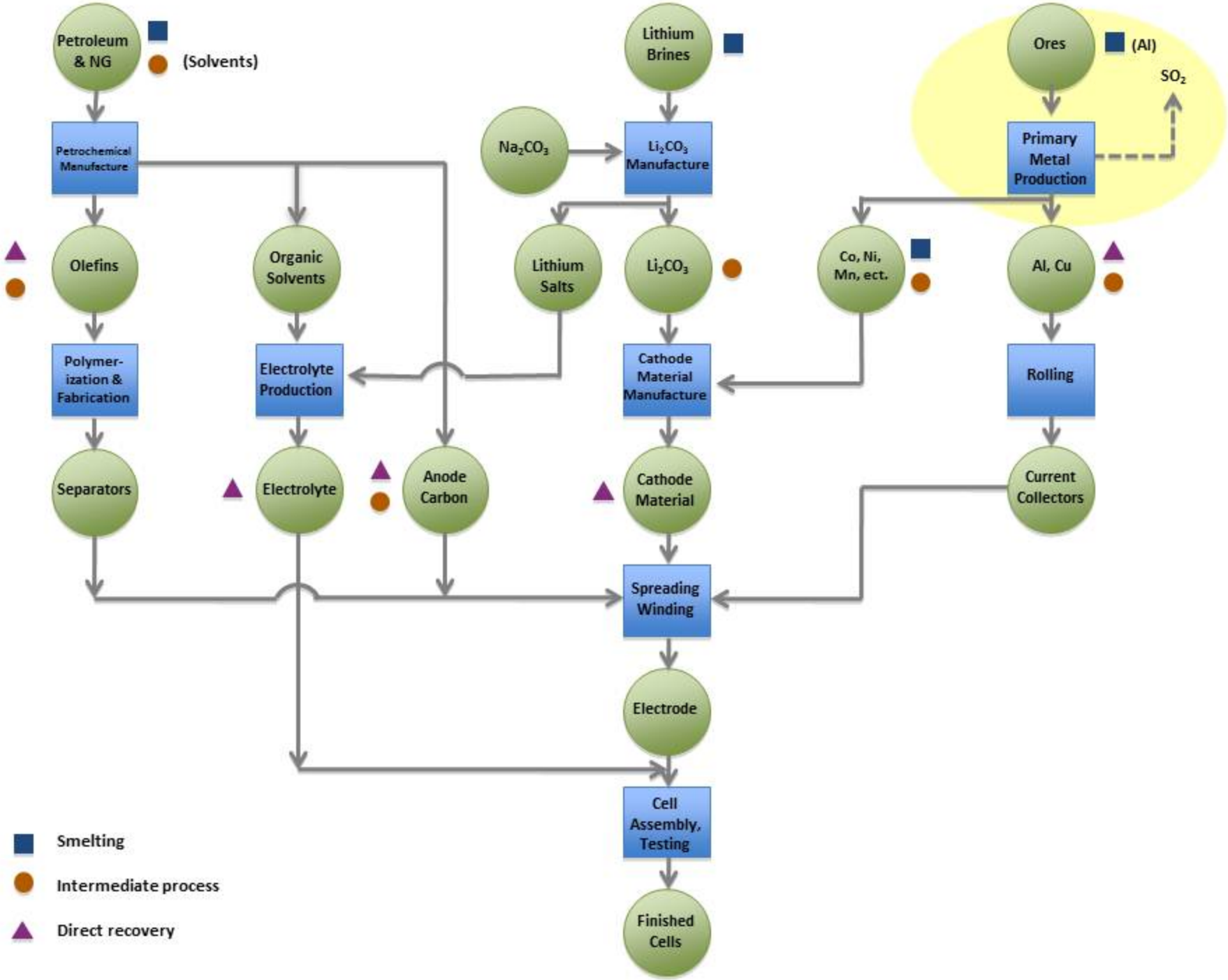
Recycling processes can be compared using several interconnected criteria

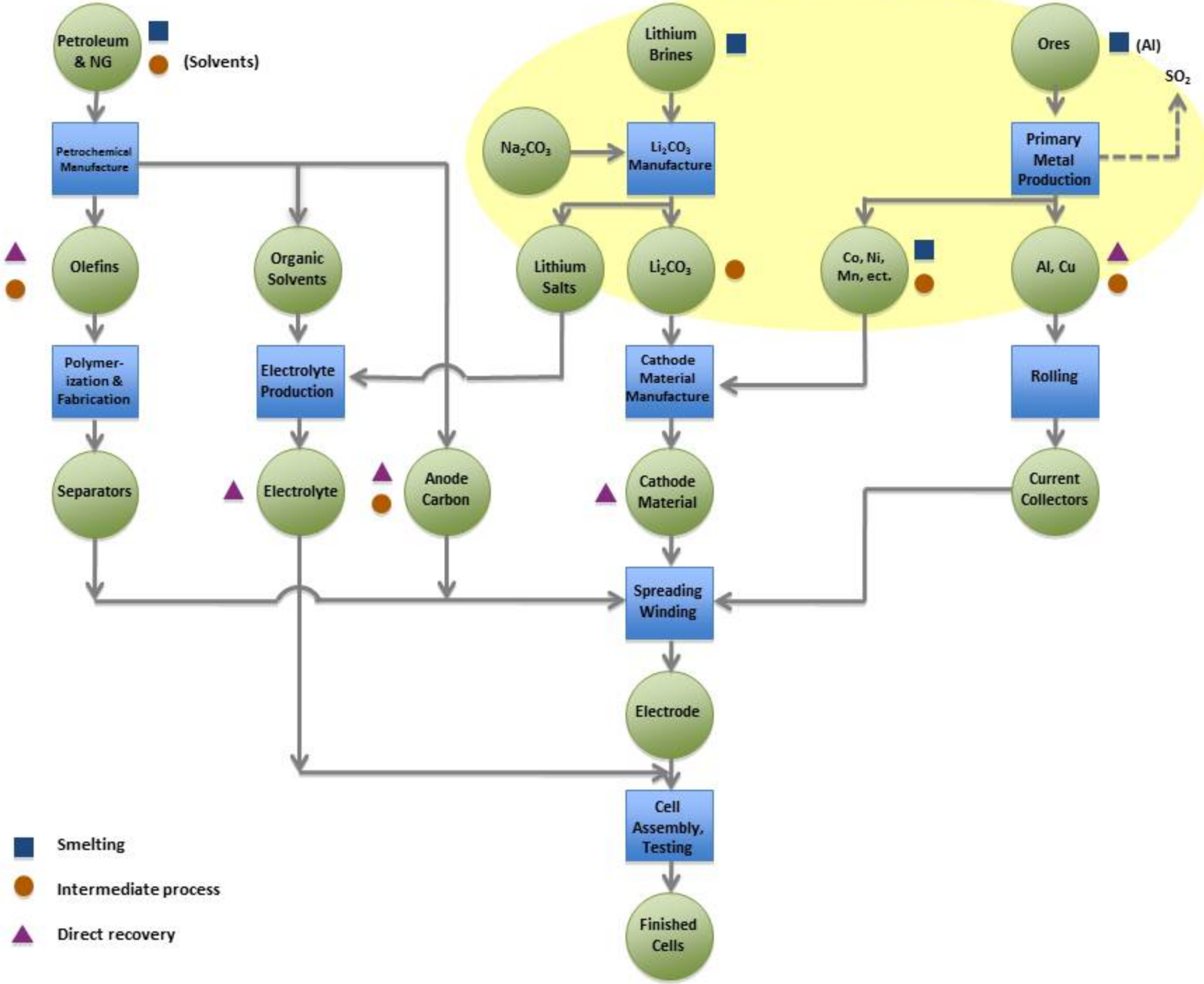
- Reduction of environmental impacts
- Energy savings
- Alleviation of material supply constraints
- Economics
- Compliance with regulations
- Feed requirements
- Utility of products
- Scale



Recycling processes differ in important ways

	Pyrometallurgical	Hydrometallurgical	Physical
Temperature	High	Low	Low
Materials recovered	Co, Ni	Metals, Li_2CO_3	Cathode, anode, electrolyte, metals
Feed requirements	None	Separation desirable	Single chemistry required
Comments	New chemistries yield reduced product value	New chemistries yield reduced product value	Recovers potentially high-value materials; Could implement on home scrap


Petroleum & NG
(Solvents)
Lithium Brines
Ores
(Al)
SO_2
Petrochemical Manufacture
Na_2CO_3
Li_2CO_3 Manufacture
Primary Metal Production
Olefins
Organic Solvents
Lithium Salts
Li_2CO_3
Co, Ni, Mn, ect.
Al, Cu
Polymer-ization & Fabrication
Electrolyte Production
Cathode Material Manufacture
Rolling
Separators
Electrolyte
Anode Carbon
Cathode Material
Current Collectors
Spreading Winding
Electrode
Cell Assembly, Testing
Finished Cells
Smelting
Intermediate process
Direct recovery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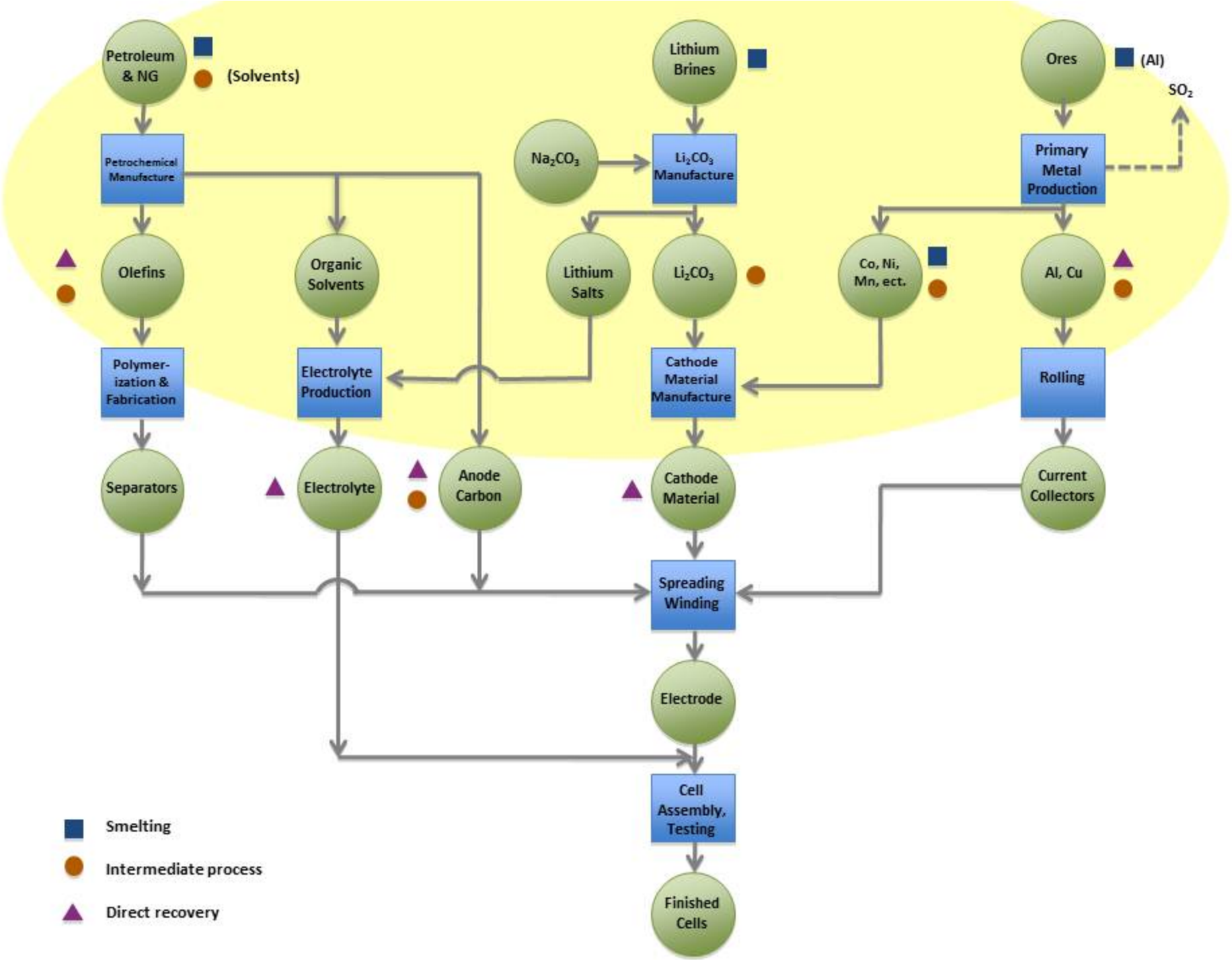
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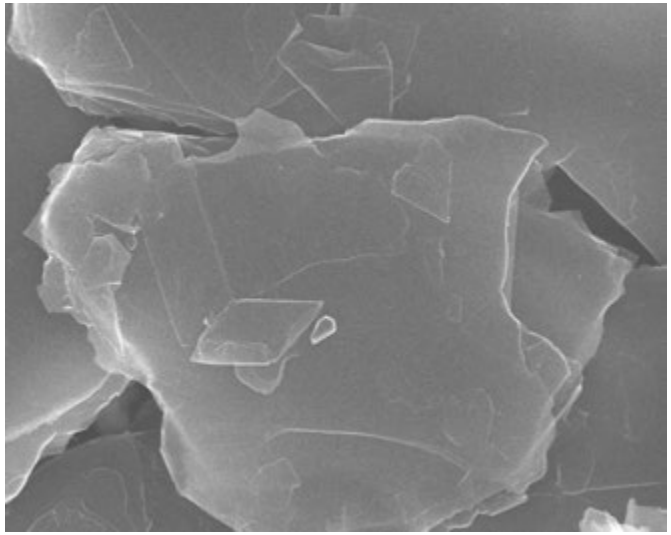
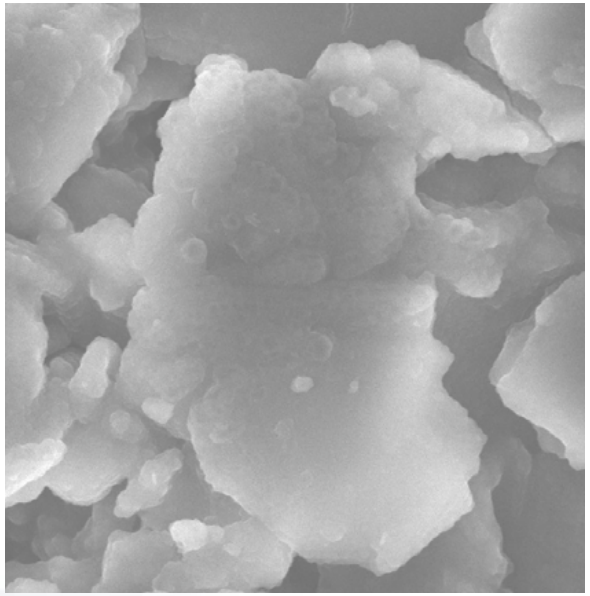
Active materials may be degraded after use

- Quality and performance must be verified
- Treatment to upgrade could be developed
- Material may be suited for lower-performance uses
- Number of re-uses might be limited for some materials

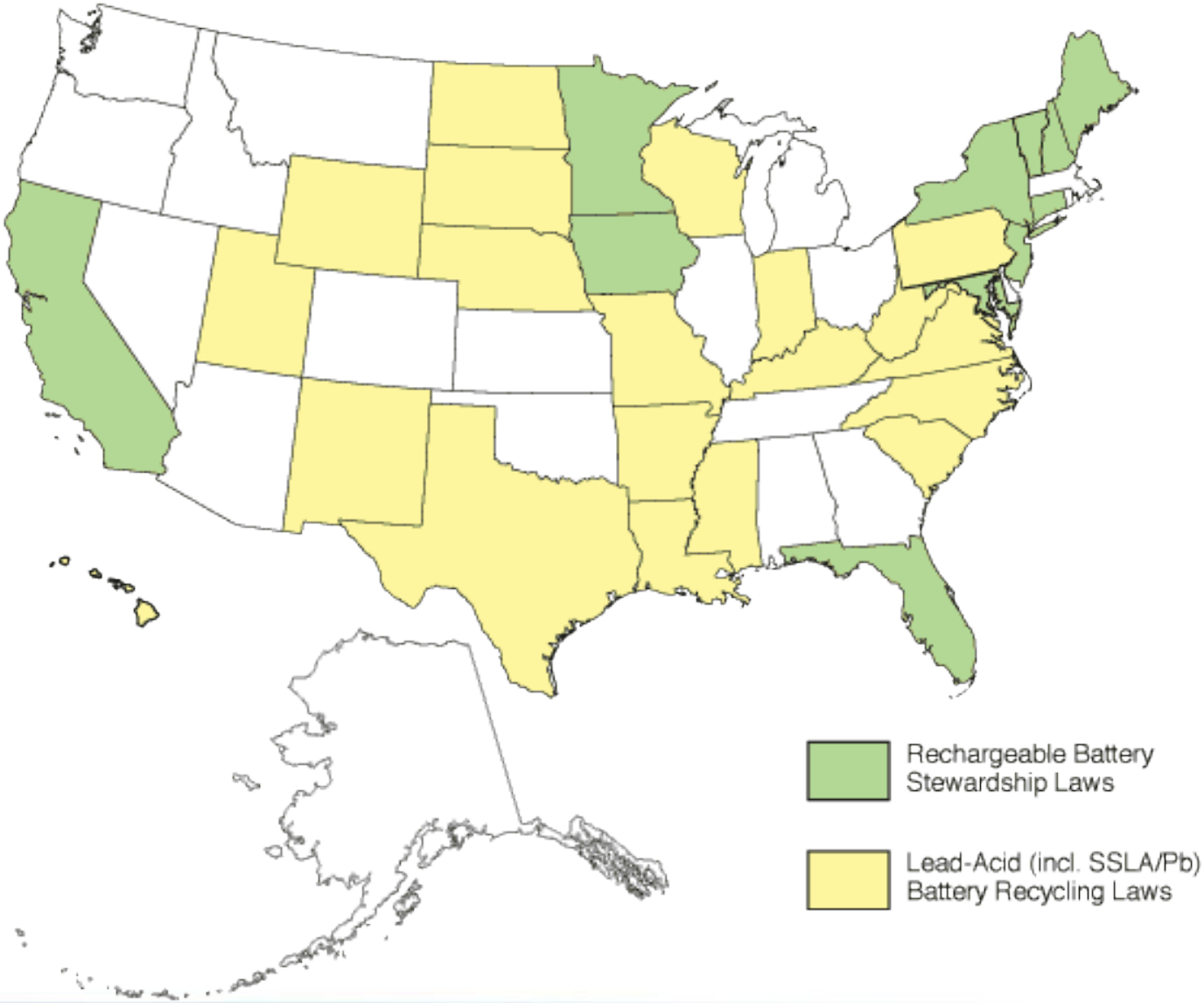


Graphite:
New and after 50% power fade

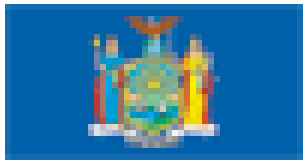


US REGULATIONS

There is no Federal battery recycling law; Only NY and CA stewardship laws cover Li-ion batteries



NY law is for non-automotive batteries



Local retailers and direct sellers that sell “rechargeable batteries” are required to collect used batteries of the same type from customers for recycling and post a sign on their premises indicating they do so. The law covers most dry cell, non-vehicular rechargeable batteries weighing less than twenty-five pounds, regardless of chemistry. Disposal of rechargeable batteries as solid waste also is prohibited after December 5, 2011. **Battery manufacturers are responsible for developing state approved plans for collecting and recycling batteries** at no expense to the consumer or retailer.

Non-compliance with these requirements is subject to potential civil penalties of up to five thousand dollars.

So is the California law

Retailers who sell small, non-vehicular rechargeable batteries **must provide consumers with a free system for returning these batteries for reuse, recycling or proper disposal.** It is unlawful for a retailer not in compliance with the law to sell rechargeable batteries in the State. A retailer is not subject to the requirements for the sale of rechargeable batteries that are contained in or packaged with a battery-operated device.

US regulates battery transport

- **Lithium metal and lithium ion cells and batteries are listed as Class 9 Miscellaneous hazardous materials in the U.S. and international hazardous materials regulations**
- There are specific packaging, marking, labeling, and shipping paper requirements, with exceptions if a limited amount of lithium metal or "equivalent lithium content" is contained.
- All shippers must still comply with requirements of 49 CFR 173.21(c). Cells and batteries must be securely packaged and offered for transportation in a manner that prevents the dangerous evolution of heat and short circuits.
- U.S. DOT Interim Final Rule (December 2004) prohibits lithium primary battery shipments on passenger aircraft and requires markings on all packaging containing lithium primary batteries.
  - For batteries containing >25g Li, special fiberboard boxes must be marked "CAUTION! LITHIUM BATTERIES - FORBIDDEN FOR TRANSPORT ABOARD AIRCRAFT AND VESSEL".

Most US rules apply to collection and transport

- **There is no Federal recycling law or policy**
- **There are many collection programs**
- **Sorting and handling enabled by Universal Waste Rules**
  - Sorting batteries by type
  - Mixing types in containers
  - Discharging batteries to remove the electric charge
  - Regenerating batteries
  - Disassembling batteries or battery packs into individual batteries
  - Removing electrolyte
  - Removing batteries from discarded consumer products
- **Processing plants must get appropriate EPA permits**
- **Recycling processes and recovery targets not addressed**

Industry and government are working to enable battery recycling

- SAE has several battery working groups
  - Recycling
  - Labeling
  - Transportation
- EPA has life-cycle assessment in progress
- USABC and USCAR have a working group
- There are voluntary collection programs for consumers

When do Universal Waste Regulations apply to batteries?

40 CFR 273.2

(a) Batteries covered under 40 CFR part 273.

(1) The requirements of this part apply to persons managing batteries, as described in Sec. 273.9, except those listed in paragraph (b) of this section.

(2) Spent lead-acid batteries which are not managed under 40 CFR part 266, subpart G, are subject to management under this part.

(b) Batteries not covered under 40 CFR part 273. The requirements of this part do not apply to persons managing the following batteries:

(1) Spent lead-acid batteries that are managed under 40 CFR part 266, subpart G.

(2) Batteries, as described in Sec. 273.9, that are not yet wastes under part 261 of this chapter, including those that do not meet the criteria for waste generation in paragraph (c) of this section.

(3) Batteries, as described in Sec. 273.9, that are not hazardous waste. A battery is a hazardous waste if it exhibits one or more of the characteristics identified in 40 CFR part 261, subpart C.

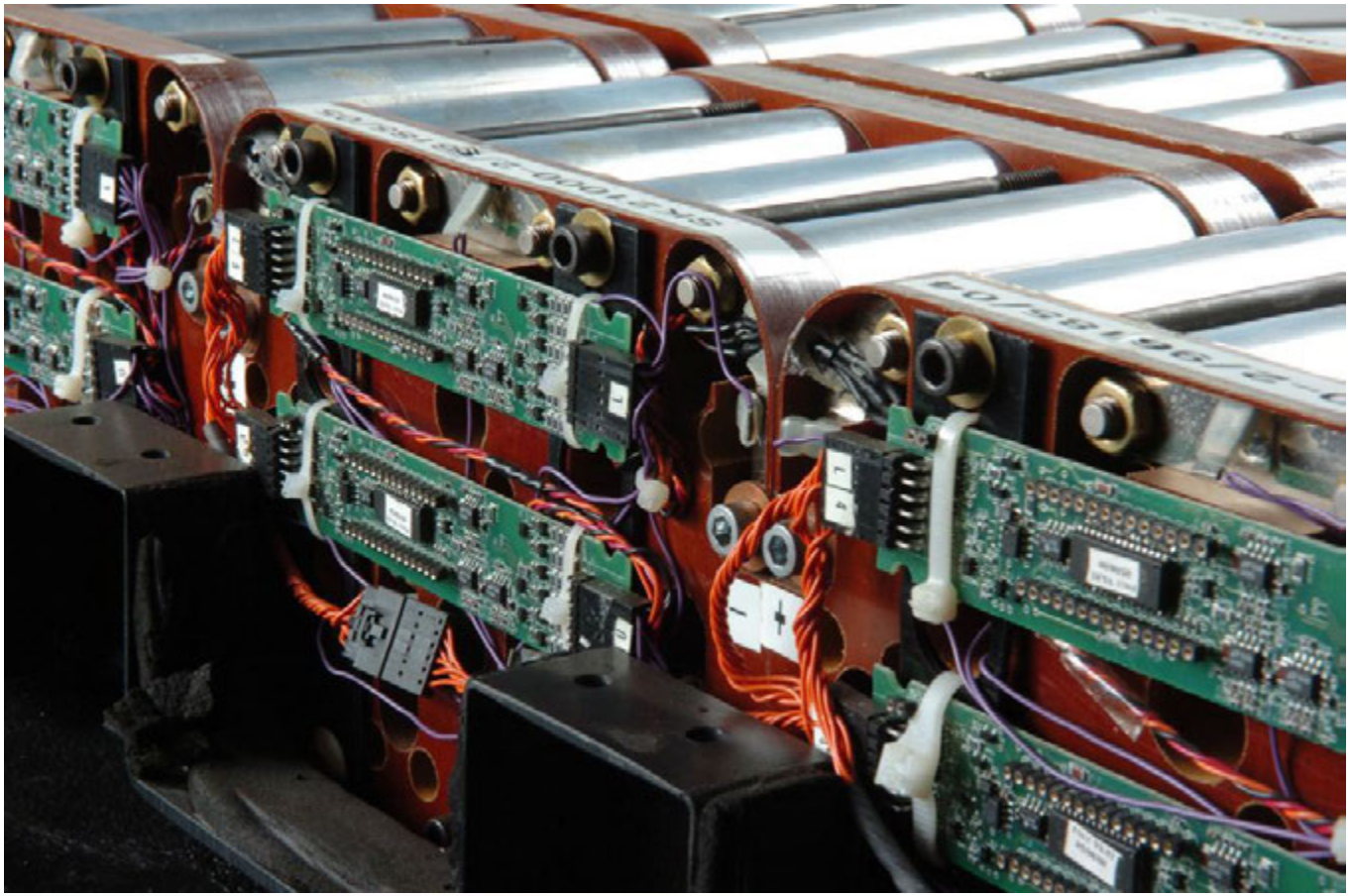
(c) Generation of waste batteries.

(1) A used battery becomes a waste on the date it is discarded (e.g., when sent for reclamation).

(2) An unused battery becomes a waste on the date the handler decides to discard it.

More could be done to facilitate recycling

- Chemistry standardization would reduce need for sorting
- Cell labeling would enable sorting by consumers and recyclers
- Standard configuration would enable design of recycling equipment
- Design for disassembly would enable material separation

Thank you!

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