

# NAATBatt North American Lithium-ion Battery Supply Chain Database Documentation and User Guide

Ahmad A. Pesaran

Maggie Mann

Vicky Putsche

Previous Contributors: S. Santhanagopalan and Erik Witter

National Renewable Energy Laboratory

James Greenberger

NAATBatt International

Funded by NAATBAT under Technical Services Agreements(TSA-21-17854 and TSA-21-21593)

# Table of Contents

- Study Objectives
  - Phase I – September 2021
  - Phase II - Current
- Background and DB Summary
- User Guide
- DB Detailed Documentation

# Objectives/Tasks for Phase I – September 2021

- Task 1: Create a database of every company doing business within identified **Segments\*** that (a) has a manufacturing facility, or (b) employs at least 10 persons, (c) located in North America
- Task 2: Add list of companies engaged in (1) li-ion battery modeling tools and services (2) service and repair Li-ion systems in transportation and stationary applications, and (3) Lithium-ion battery R&D.
- Task 3: Collect the following information for each company as applicable (1) Installed battery capacity (in GW) or material production capability (in tons/year, (2) Other metrics based on the company's business, (3) Plans for future capacity, (4) Types of chemistries and processes, and (5) Future expansion for transportation and stationary sectors

\*Segments refer to Materials, Cell, Module/Packs, and End-of-Life (equipment, process)

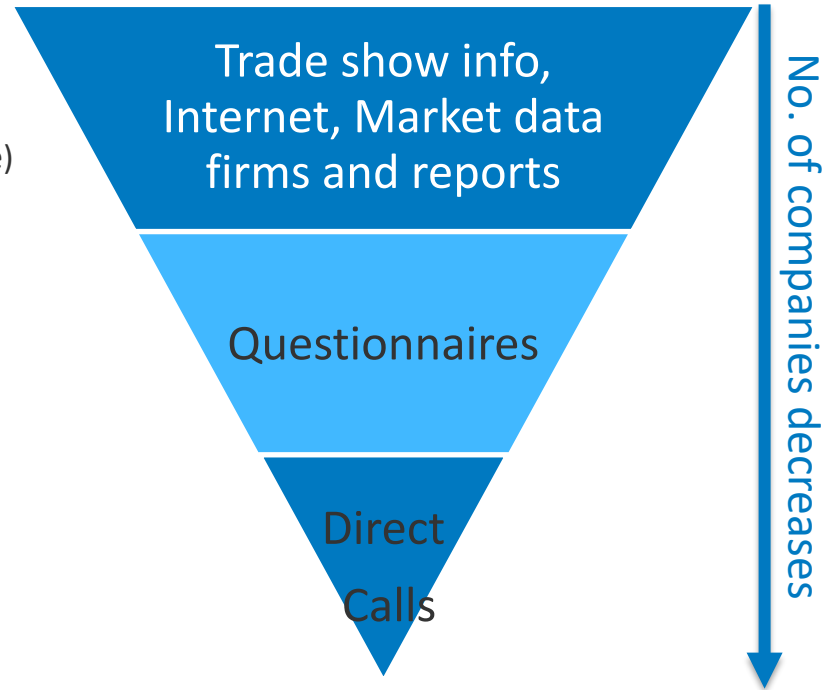
# Phase II - Improving and Expanding the Database

- Realizing this should be ongoing effort, NAATBatt funded NREL in May to initiate Phase II
  - LIB market is competitive and evolving fast
  - Some information (e.g., production capacity) is not always publicly available and companies may not want to share this
  - New companies and facilities will be constantly coming on-line
  - Impact of the Bipartisan Infrastructure Bill and DOE FOA for developing battery supply chain
- Phase II - August 29<sup>th</sup> 2022 Release:
  - Added workforce and production capacity, where publicly available
  - Added new (> 75) entries, including those that emailed to be added
  - Corrected information based on feedback on last version
  - Added Maps Instructions worksheet
  - Improved Search function to include searching on Product (Facility Type for EOL) and State, updated notes and included NAATBatt membership in records retrieved
- We ask you to send comments, corrections and additional information concerning the Database through [LIB.SupplyChain@nrel.gov](mailto:LIB.SupplyChain@nrel.gov)
- NREL/NAATBATT intend to update the information in the database every 6 months after.

# Database Background and Summary

# Data Sources

- **Public Search**
  - ✓ Internet search
  - ✓ Business directories in in all U.S. states and Canadian territories
  - ✓ Technical and marketing conferences in battery materials, cells, systems, manufacturing, end-of life.
  - ✓ Literature Search
  - ✓ Government-supported efforts (AMR Reviews, STTR/SBIR database)
- **Private Searches**
  - ✓ Bloomberg New Energy Finance (BNEF)
  - ✓ Thomas databases (<https://business.thomasnet.com/about>)
  - ✓ Zaubas (for trade data - <https://www.zaubas.com/>)
  - ✓ Market reports
  - ✓ Commercial databases
- **Questionnaire**
  - ✓ Emailed to all NAATBatt members and other identified companies
- **Interviews with Stakeholders**



# Questionnaires and Interviews

- **Questionnaire Status**
  - Sent to all current NAATBatt members
  - Sent to approximately 600 others
  - Received > 150 responses
  - Research on responses required
- **Interviews**
  - Contacted companies with missing or confusing data

## NREL Li-Ion Supply Chain Questionnaire for NAATBatt

NAATBatt has commissioned the National Renewable Energy Laboratory (NREL) to collect data on the lithium ion battery (LIB) supply chain in North America. The purpose is to identify gaps in the supply chain and provide data to decision makers to aid in strengthening it for both electric vehicles and stationary applications.

Please complete this very short questionnaire for each facility in North America that is a part of the LIB supply chain. Filling out this questionnaire will ensure that your company is represented accurately in the database. Your specific data will not be shared with others.

Please submit responses by July 28th, 2021

Thank you.

Ahmad Pesaran, NREL

**\* Required**

1. Company Name \*

Your answer \_\_\_\_\_

2. Is this company North American Owned, a Joint Venture between companies in North American and outside, or a Subsidiary of a non-North American entity?

- ☐ North American Owned
- ☐ Joint Venture between companies in North America and outside
- ☐ Subsidiary of a non-North American entity
- ☐ Other: \_\_\_\_\_

# Current Database Statistics

Supply Chain Segment	US		Canada		Other		Total	
	Companies	Facilities	Companies	Facilities	Companies	Facilities	Companies	Facilities
Raw Material Manufacturing	15	18	16	23	3	4	34	45
Battery Grade Component Manufacturing	44	58	10	11	5	5	59	74
Other Battery Components and Materials Manufacturing	33	41	1	1	1	1	35	43
Electrode and Cells Manufacturing	58	67	10	10	6	9	73	86
Modules and Packs Manufacturing	98	115	10	10	3	8	111	133
End of Life/Recycling	44	59	7	7	0	0	51	66
Equipment Manufacturing	44	46	2	2	3	3	49	51
R&D	68	76	7	7	6	6	81	89
Service and Repair	61	63	4	0	1	5	66	68
Modeling	19	19	2	2	0	1	21	22
Distributors	6	6	1	1	0	0	7	7
<b>Totals</b>	<b>490</b>	<b>568</b>	<b>70</b>	<b>74</b>	<b>28</b>	<b>42</b>	<b>587</b>	<b>684</b>

\*Companies are counted more than once if they are active in multiple sections of the supply chain and/or have multiple products



# User Guide

# List of Worksheets

Worksheet	Tab Color	Description
Summary Table	White	Dynamic table that summarizes the entries in the database by supply chain segment, country, company and facility
Search	White	Interface that allows the user to search all segments <u>except</u> EOL
EOL Search	White	Interface that allows the user to search the EOL segment
Map Instructions	White	Provides instructions for accessing maps of the data
RawMatl	Green	Data for facilities that extract raw materials
Battery Grade Materials	Brown	Data for facilities that produce battery grade materials
Other Battery Comps Matls	Brown	Data for facilities that produce battery components or other battery materials
Electrodes and Cells	Brown	Data for facilities that manufacture electrodes and cells
ModPack	Blue	Data for facilities that manufacture modules and packs
EOL	Blue	Data for facilities that process batteries at the end of life (EOL)
Equipment	Light Red	Data for companies that develop software or equips or offer equipment services
ServiceRepair	Light Red	Data for companies that offer services such as engineering or testing
RandD	Light Red	Data for Research and development facilities
Modeling	Light Red	Data for companies that develop software or models or offer modeling services
Distributors	Light Red	Data for companies that distribute products in the LIB supply chain
Terms	White	Glossary of important terms

The database also has 1 hidden sheet: Append2 which is a compilation of all segments. This standardizes data output.

# Database Summary Table

- First worksheet in the database
- Updates automatically as information is added or deleted
- No user input required or recommended

Supply Chain Segment	US		Canada		Other		Total	
	Companies	Facilities	Companies	Facilities	Companies	Facilities	Companies	Facilities
Raw Material Manufacturing	15	18	16	23	3	4	34	45
Battery Grade Component Manufacturing	44	58	10	11	5	5	59	74
Other Battery Components and Materials Manufacturing	33	41	1	1	1	1	35	43
Electrode and Cells Manufacturing	58	67	10	10	6	9	73	86
Modules and Packs Manufacturing	98	115	10	10	3	8	111	133
End of Life/Recycling	44	59	7	7	0	0	51	66
Equipment Manufacturing	44	46	2	2	3	3	49	51
R&D	68	76	7	7	6	6	81	89
Service and Repair	61	63	4	0	1	5	66	68
Modeling	19	19	2	2	0	1	21	22
Distributors	6	6	1	1	0	0	7	7
<b>Totals</b>	<b>490</b>	<b>568</b>	<b>70</b>	<b>74</b>	<b>28</b>	<b>42</b>	<b>587</b>	<b>684</b>

\*Companies are counted more than once if they are active in multiple sections of the supply chain and/or have multiple products

# Search Interfaces – Search and EOL Search Tabs

- Simple Search Interface developed for the Excel version of the DB
  - Search on Full or Partial Company, Product or State/Province Names
  - Search pulls results from all segments **except EOL**
  - EOL Search pulls results for **EOL** for Company, Facility Type or State/Province Names
  - Totals number of records retrieved

Directions:		1. Select the Search Type (Company, Product, State) in the yellow box next to Search Type. 2. Enter the full or partial name of a the selected Search Type in the 2nd yellow box and hit Enter											
		No. of Records: 10											
Search		Results											
Select Search Type (dropdown list):	Company	ID	Status*	NAATBatt Member?	Company	Facility Name	Facility City	Facility State or Province	Facility Country	Product or Service Type	Product or Service	Production Capacity	Units
Company	Vale	1048	C	No	Vale Canada Ltd.	Sudbury Basin - Copper Cliff Complex	Copper Cliff	ON	Canada	Cathode raw materials	Co concentrates	1,000	MT contained Co/yr
Note:	If a company is in the EOL sector (e.g. recycling), use the EOL Search sheet instead	1049	C	No	Vale Canada Ltd.	Thompson	Thompson	MB	Canada	Cathode raw materials	Co concentrates	800	MT contained Co/yr
		1050	C	No	Vale Canada Ltd.	Voisey Bay	Happy Valley - Goose Bay	NL	Canada	Cathode raw materials	Co concentrates	2,000	MT contained Co/yr
	*Status	1051	C	No	Vale Canada Ltd.	Sudbury Basin - Copper Cliff Complex	Copper Cliff	ON	Canada	Cathode raw materials	Ni concentrates	66,000	MT contained Ni/yr
	C - Commercial	1052	C	No	Vale Canada Ltd.	Thompson	Thompson	MB	Canada	Cathode raw materials	Ni concentrates	14,800	MT contained Ni/yr
	P - Planned	1053	C	No	Vale Canada Ltd.	Voisey Bay	Happy Valley - Goose Bay	NL	Canada	Cathode raw materials	Ni concentrates	80,000	MT contained Ni/yr
	PC-SU - Pre-commercial/startup	2083	C	No	Vale Canada Ltd.	Copper Cliff Nickel Refinery (Sudbury)	Sudbury	ON	Canada	Cathode Battery Grade (BG) Materials	Ni pellets, powder or rounds	66,000	MT contained Ni/yr
	UC - Under construction	2084	C	No	Vale Canada Ltd.	Copper Cliff Nickel Refinery (Sudbury)	Sudbury	ON	Canada	Cathode Battery Grade (BG) Materials	Co pellets, powder or rounds	1,400	MT contained Co/yr
		2085	C	No	Vale Canada Ltd.	Long Harbour Processing Plant	Long Harbour	NL	Canada	Cathode Battery Grade (BG) Materials	Ni pellets, powder or rounds	50,000	MT contained Ni/yr
		2086	C	No	Vale Canada Ltd.	Long Harbour Processing Plant	Long Harbour	NL	Canada	Cathode Battery Grade (BG) Materials	Co pellets, powder or rounds	1,700	MT contained Co/yr

# Search Interface Results

- Enter full or partial name in Yellow Box
- Press Enter
- To search again, add another name or partial name
- To clear results, delete name in search box

ID Indicates Worksheet:

1000's – Raw Material

2000's – Battery Grade Materials

3000's – Other Materials

4000's – Electrodes and Cells

5000's – ModPack

6000's – EOL

7000's – Equipment

8000's – Service and Repair

9000's - R&D

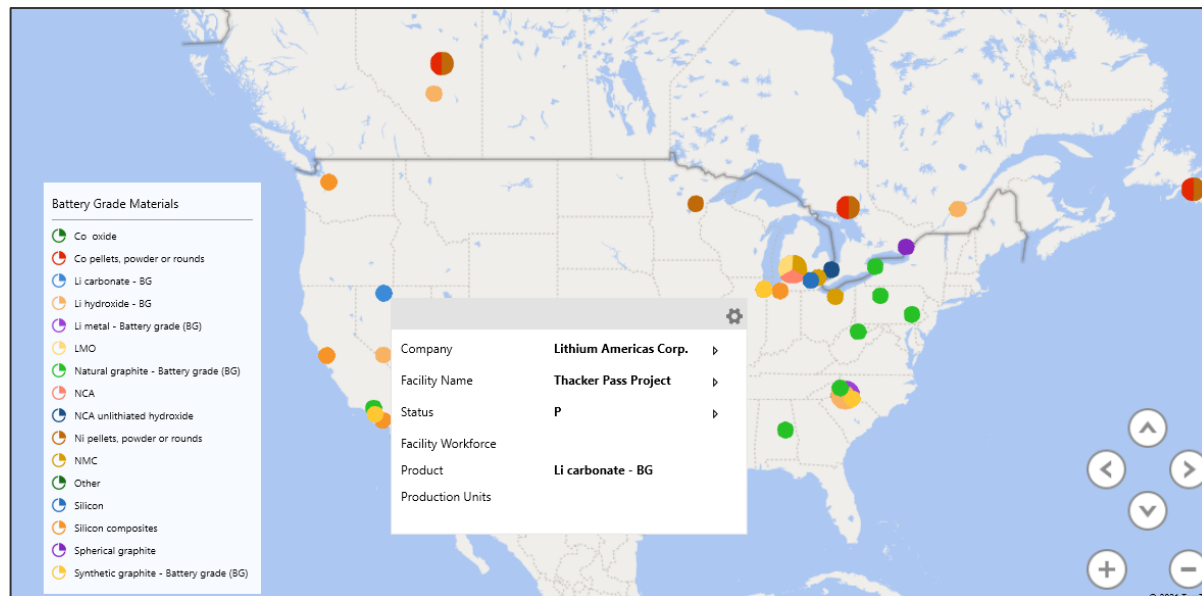
10000's- Modeling

11000's - Distributors

<b>Directions:</b>		1. Select the <b>Search Type</b> (Company, Product, State) in the yellow box next to <b>Search Type</b> . 2. Enter the full or partial name of a the selected <b>Search Type</b> in the 2nd yellow box and hit Enter											
		No. of Records: 10											
<b>Search</b>		<b>Results</b>											
<b>Select Search Type</b> (dropdown list):	Company	ID	Status*	NAATBatt Member?	Company	Facility Name	Facility City	Facility State or Province	Facility Country	Product or Service Type	Product or Service	Production Capacity	Units
	Company												
<b>Note:</b>	If a company is in the EOL sector (e.g. recycling), use the EOL Search sheet instead	1048	C	No	Vale Canada Ltd.	Sudbury Basin - Copper Cliff Complex	Copper Cliff	ON	Canada	Cathode raw materials	Co concentrates	1,000	MT contained Co/yr
		1049	C	No	Vale Canada Ltd.	Thompson	Thompson	MB	Canada	Cathode raw materials	Co concentrates	800	MT contained Co/yr
		1050	C	No	Vale Canada Ltd.	Voisey Bay	Happy Valley - Goose Bay	NL	Canada	Cathode raw materials	Co concentrates	2,000	MT contained Co/yr
		1051	C	No	Vale Canada Ltd.	Sudbury Basin - Copper Cliff Complex	Copper Cliff	ON	Canada	Cathode raw materials	Ni concentrates	66,000	MT contained Ni/yr
	C - Commercial	1052	C	No	Vale Canada Ltd.	Thompson	Thompson	MB	Canada	Cathode raw materials	Ni concentrates	14,800	MT contained Ni/yr
	P - Planned	1053	C	No	Vale Canada Ltd.	Voisey Bay	Happy Valley - Goose Bay	NL	Canada	Cathode raw materials	Ni concentrates	80,000	MT contained Ni/yr
	PC-SU - Pre-commercial/startup	2083	C	No	Vale Canada Ltd.	Copper Cliff Nickel Refinery (Sudbury)	Sudbury	ON	Canada	Cathode Battery Grade (BG) Materials	Ni pellets, powder or rounds	66,000	MT contained Ni/yr
	UC - Under construction	2084	C	No	Vale Canada Ltd.	Copper Cliff Nickel Refinery (Sudbury)	Sudbury	ON	Canada	Cathode Battery Grade (BG) Materials	Co pellets, powder or rounds	1,400	MT contained Co/yr
		2085	C	No	Vale Canada Ltd.	Long Harbour Processing Plant	Long Harbour	NL	Canada	Cathode Battery Grade (BG) Materials	Ni pellets, powder or rounds	50,000	MT contained Ni/yr
		2086	C	No	Vale Canada Ltd.	Long Harbour Processing Plant	Long Harbour	NL	Canada	Cathode Battery Grade (BG) Materials	Co pellets, powder or rounds	1,700	MT contained Co/yr

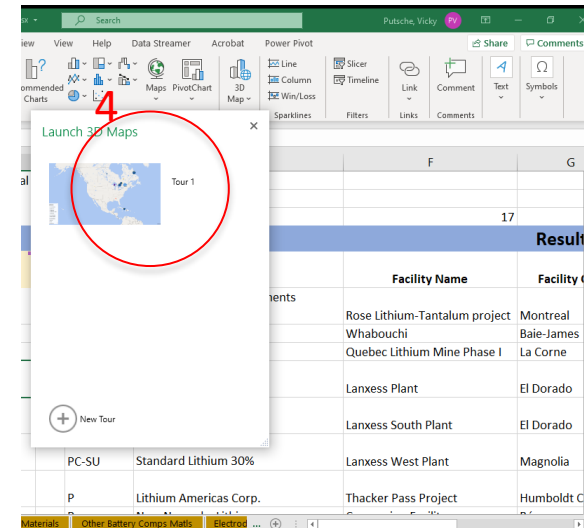
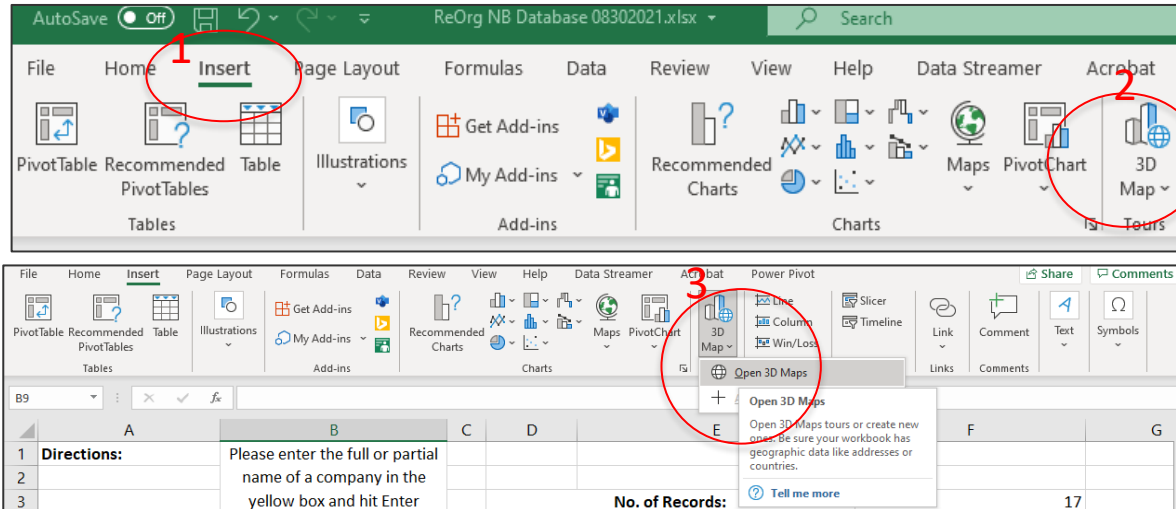
# Maps Overview

- 11 maps developed
  - 1 for each supply chain segment
- Built-in capability of Excel
- Each map shows all facilities for that segment
  - Markers are colored by product or product type
  - Details for each site available with roll-over option



# Maps Instructions

- Maps can be viewed from any worksheet
  - 1. Go to Insert menu
  - 2. Click on 3D Map
  - 3. Click on Open 3D Maps
  - 4. Launch 3D Maps and a list of available Tours will be shown
    - Select Tour 1



# Maps Instructions cont.

## 5. X out of Field List and layer

List of Fields  
for this map  
(x out of it)

Design  
parameter  
(x out of it)

Send Feedback

Thumbnails  
of  
all  
Maps  
Shown  
On  
left  
Side

FILE HOME

Play Tour Create Video Capture Screen New Scene Themes Scene Options Refresh Data Shapes Map Labels Flat Map Find Location Custom Regions 2D Chart Text Box Legend Time Line Date & Time Tour Editor Layer Pane Field List

Tour 1

1 Raw Materials (10 sec)

2 Battery Grade Materials (10 sec)

3 Other Battery Compon... (10 sec)

4 Cells and Electrodes (10 sec)

5 Modules and Packs (10 sec)

6 End of Life (EOL) (10 sec)

7

Raw Materials

- Co concentrates
- Graphite ore
- Li carbonate
- Li carbonate - crud
- Li hydroxide
- Mn concentrates
- Natural graphite
- Ni concentrates
- Ni matte
- Ni ore
- Spodumene

Field List

Drag fields to the Layer Pane.

- Equip
- Company
- Facility Address
- Facility City
- Facility Country
- Facility Name
- Facility or Company Website
- Facility Phone
- Facility State or Province
- Facility Workforce
- Facility Zip
- GPS
- HQ City
- HQ Company

Add Layer

Raw Materials

Data

Location

- Facility Country Country/Region
- Facility State State/Province
- HQ City City
- Facility Workforce Latitude
- Facility Zip Longitude
- GPS
- HQ City
- HQ Company

Size

Production Capacity (Sum)

Add Field

Category

Product

Time

Add Field

Filters

Layer Options

Send Feedback



# Maps Instructions cont.

7. Click on other maps to see each segment

Maps are labelled by segment

6. Roll over sites to get details

Company	Vale Canada Ltd.
Facility Name	Voisey Bay
Status	C
Facility Workforce	900
Product	Ni concentrates
Production Capacity	80,000
Annual Production Units	MT contained metal

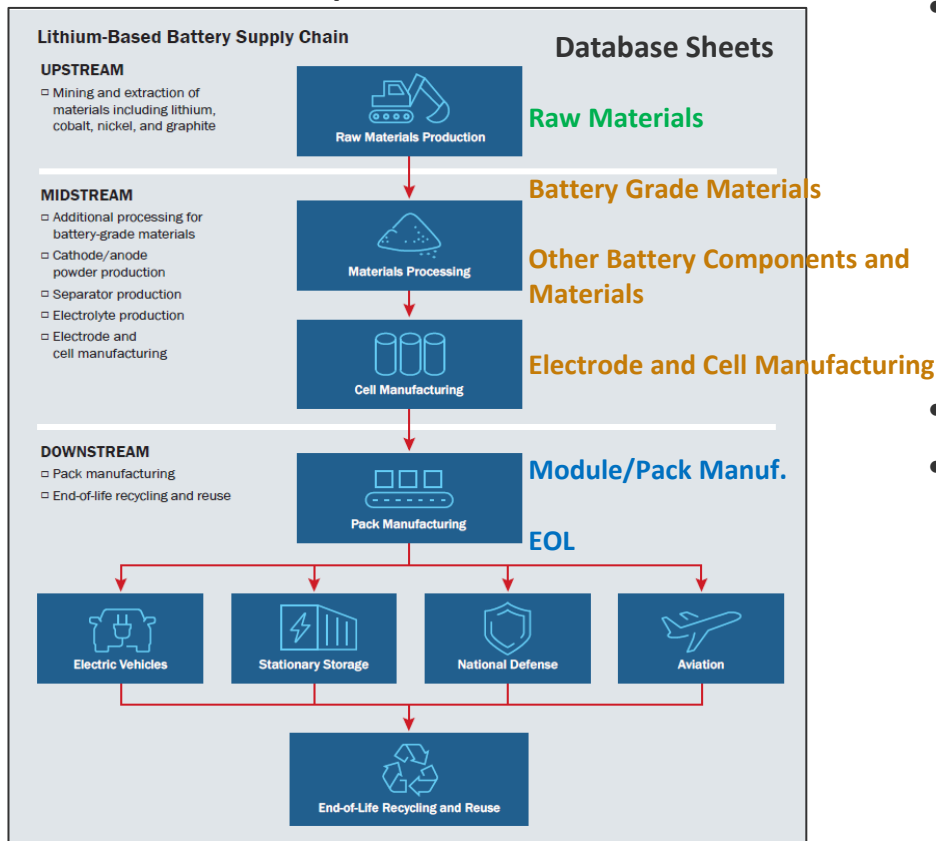
Raw Materials

- Co concentrates
- Graphite ore
- Li carbonate
- Li carbonate - crud
- Li hydroxide
- Mn concentrates
- Natural graphite
- Ni concentrates
- Ni matte
- Ni ore
- Spodumene

# Database Documentation

# Supply Chain Segments in the Database

## FCAB National Blueprint for Batteries 2021-2030



### • Manufacturing Supply Chain

- Raw Materials
- Battery Grade Materials
- Other Battery Components and Materials
- Electrode and Cell Manufacturing
- Module/Pack Manufacturing

### • EOL Supply Chain

### • Other Segment Supply Chains

- Equipment
- Service
- R&D
- Modeling and Software
- Distributors

# Manufacturing Supply Chain Representation in the Database

- Worksheet tabs and sheets colored by Supply Chain Segment
  - Upstream, Midstream, Downstream
- Raw Matl – Raw Material Extraction and Initial Processing
- Battery Grade Materials – Refining into Battery Grade Materials
- Other Battery Comps Matls – Other Cell Components and Materials
- Electrodes and Cells - Electrode and Cell Production
- ModPack – Module, Pack and their Components Manufacturing
- EOL – End of life processing (e.g., recycling)
  - More complex and covered in its own detailed supply chain

The screenshot shows a database interface with multiple worksheet tabs at the top, each color-coded by supply chain segment: Upstream (green), Midstream (yellow), and Downstream (blue). The active sheet displays a detailed table of manufacturing data with columns for company, location, and various product specifications.

RawMatl | Battery Grade Materials | Other Battery Comps Matls | Electrodes and Cells | ModPack | EOL

# Database Metadata\*

Database Column	Data Description	Database Column	Data Description
Status	Commercial, Planned, Under construction, Pre-commercial/Startup	Latitude	
Supply Chain Segment	Upstream, Midstream, Downstream, Other	Longitude	
Company		Facility Workforce	Number of employees
NAATBatt Member	Yes/No	Production Capacity	Annual capacity or production
Facility Name		Annual Production Units	Standardized for each segment
Product Type	Drop-down menu depending on segment	HQ Company	
Product	Drop down menu depending on product	HQ Website	
Facility Website		HQ City	
Facility Address		HQ State or Province	
Facility City		HQ Country	
Facility State		QC	Initials of individual who checked data
Facility Country		QC Date	Date of QC
Facility Zip		Sources	Free form - Sources used for entry
Facility Phone		Notes	Free form - Supplementary info

\*EOL has slightly different metadata

Status Abbreviations:

C – Commercial

P – Planned

UC – Under Construction

PC-SU – Pre-commercial/start-up

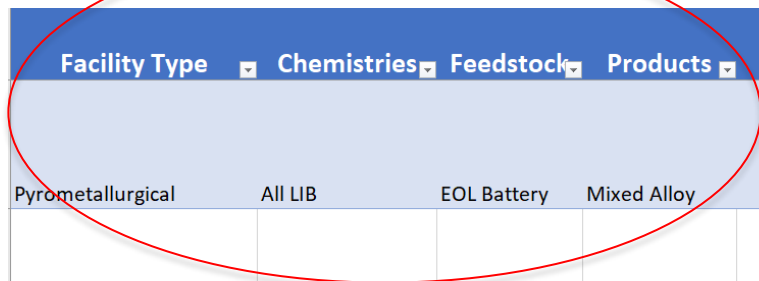
# Manufacturing Supply Chain (not EOL) Classification

- Facility meta-data tag
  - Modeled on Segment Spreadsheet Groups
- **Product Type** Drop Down
  - Class of products from each step in supply chain
- **Product** Drop Down
  - Depends upon selection in Product Type

NAATBatt				
Company	Member	Facility Name	Product Type	Product
Vale Canada Ltd.	No	Sudbury Basin	Cathode raw materials	Co concentrates
Vale Canada Ltd.	No	Thompson	Cathode raw materials	Co concentrates
Vale Canada Ltd.	No	Voisey Bay	Cathode raw materials	Co concentrates
Moa JV	No	Moa Bay mine	Cathode raw materials	Co concentrates
Moa JV	No	Moa Bay mine	Cathode raw materials	Ni concentrates
Glencore	Yes	Raglan Mine	Cathode raw materials	Ni concentrates

# EOL Supply Chain Classification

- Facility meta-data tag
  - Modeled on Segment Spreadsheet Groups
- **Facility Type** Drop Down
  - Boxes from supply chain diagram
- **Feedstock and Product** Drop Downs
  - Specific materials listed
- **Feedstock Chemistry**, if available



Facility Type ▾	Chemistries ▾	Feedstock ▾	Products ▾	Capacity ▾	Capacity Units ▾
Pyrometallurgical	All LIB	EOL Battery	Mixed Alloy	15	MT/yr
Pyrometallurgical	All LIB	EOL Battery	Mixed Alloy	15	MT/yr
Collection and Disassembling	All LIB	EOL Battery	Black Mass		
UW Handlers	⬇ All LIB	EOL Battery	Sorted Battery	2,086	MT/y

# Raw Materials

- RawMatl Spreadsheet
- Mining and extraction of cathode and anode materials and initial processing (e.g., concentrating) of those materials
- Other component raw materials are not included



RAW MATERIALS				
Company	Facility	Location	Product Type	Product
Vale Canada Ltd	Sudbury Basin	Copper Cliff, ON	Cathode raw materials	Co concentrates
Glencore	Raglan Mine	Rouyn-Noranda, QC	Cathode raw materials	Ni concentrates
Albemarle	Silver Peak Phase I	Silver Peak, NV	Cathode raw materials	Li concentrates/salts
Nouveau Monde Graphite	Advanced Materials Plant (Planned)	Becancour, QC	Anode raw materials	Graphite ore/concentrate

RAW MATERIALS SUPPLY CHAIN	
Product Type	Product
Anode raw materials (crude)	Brine
	Li carbonate - crude
	Graphite ore/ concentrates
	Spodumene
	Other
Cathode raw materials (crude)	Brine
	Co concentrates
	Co ore
	Li carbonate - crude
	Li clay
	Li concentrates/salts
	Mn concentrates
	Mn ore
	Ni concentrates
	Ni ore
	Spodumene
	Other



# Battery Grade Materials

- Processing to:
  - Anode Active Materials
  - Anode Battery Grade (BG) materials,
  - Cathode Active Materials (CAM)
  - Cathode Battery Grade (BG) Materials
  - precursor Cathode Active Materials (pCAM)
- Everything from concentrated raw materials to finished electrodes or cells



## Materials Processing

### MIDSTREAM

- Additional processing for battery-grade materials
- Cathode/anode powder production

**MIDSTREAM**

- Additional processing for battery-grade materials
- Cathode/anode powder production

# Battery Grade Materials - Groupings

## BATTERY GRADE MATERIALS

Product Type	Product
Cathode Battery Grade (BG) Materials	Co oxide
	Co pellets, powder or rounds
	Co sulfate
	Li carbonate - BG
	Li hydroxide - BG
	Mn sulfate
	Ni pellets, powder or rounds
	Ni sulfate
	Other
precursor Cathode Active Material (pCAM)	LCO unlithiated hydroxide
	LFP unlithiated hydroxide
	LMO unlithiated hydroxide
	NCA unlithiated hydroxide
	NMC unlithiated hydroxide
	NMCA unlithiated hydroxide
	Other/ Unknown pCAM

## BATTERY GRADE MATERIALS

Product Type	Product
Anode Active Material	Li metal
	Natural graphite
	Silicon composites
	Synthetic graphite
	Other
Anode Battery Grade (BG) Materials	Li metal - Battery grade (BG)
	Natural graphite - Battery grade (BG)
	Silicon
	Spherical graphite
	Synthetic graphite - Battery grade (BG)
Cathode Active Material (CAM)	Other
	LCO
	LFP
	LMO
	NCA
	NMC
	NMCA
	Other/ Unknown



Materials Processing

#### MIDSTREAM

- Additional processing for battery-grade materials
- Cathode/anode powder production

# Battery Grade Materials - Examples

BATTERY GRADE MATERIALS				
Company	Facility	Location	Product Type	Product
Toda Advanced Materials	Toda America Battle Sarnia Plant	Sarnia, ON	Cathode Active Material (CAM)	NMC
Pyrotek	Pyrotek Sanborn Battery Component Plant	Sanborn, NY	Anode Battery Grade (BG) Materials	Synthetic graphite
Boleo Copper Project	Boleo Copper/Cobalt Mine	Santa Rosalia, Baja California Sur	Cathode Battery Grade (BG) Materials	Co oxide
Sherritt Int'l	Fort Saskatchewan	FS, AB	Cathode Battery Grade (BG) Materials	Ni pellets, powder or rounds

# Other Cell Components and Materials Manufacturing

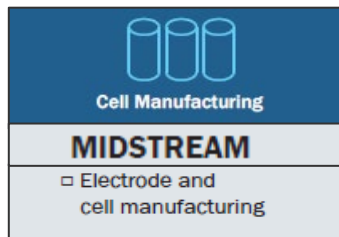
- Other Battery Comps Matls Spreadsheet
- Cell components and materials except anode active material, cathode active material (CAM)

OTHER BATTERY COMPONENTS AND MATERIALS				
Company	Facility	Location	Product Type	Product
Daikin America	Daikin Decatur Battery Material Plant	Decatur, AL	Electrode materials	Additives
Soulbrain MI	Northville Plant	Norville, MI	Electrolyte (liquid)	Liquid electrolyte
Huntsman Petrochemical LLC	Conroe Plant	Conroe, TX	Electrolyte (liquid)	Solvents
Entek	Entek Separator Plant	Entek, OR	Separators	Separators

OTHER BATTERY COMPONENTS AND MATERIALS	
Product Type	Product
Cell components	Tabs
	Tapes
	Other
Current collectors	Aluminum
	Copper
	Other
Electrode materials	Additives
	Adhesives
	Binders
	Other
Electrolyte (liquid)	Additives
	Li salts
	Liquid electrolyte
	Polymers
	Solvents
	Other
Electrolyte (solid)	Ceramic
	Oxides
	Polymers
	Sulfides
	Other
Separators	Separators

# Electrode and Cell Manufacturing

- Electrodes and Cells Spreadsheet
- Cell Production
  - Based on cathode chemistry
  - Anodes are generally not specified except LTO or silicon



ELECTRODE AND CELL SUPPLY CHAIN		
Product Type	Chemistry/Electrode	Notes
Coated electrode rolls	Anode	Can be paired with any of the anodes: Li metal LTO Natural graphite Silicon composite Synthetic graphite Other; LTO chemistries can be paired with any of the cathodes Anode type, if known, is specified in notes
	Cathode	
Cylindrical cells	LCO	
	LFP	
	LMO	
	LTO	
	NCA	
	NMC	
	NMCA	
	Other/ Unknown	
Prismatic (metal can) cells	Same chemistries as for cylindrical cells	
Prismatic (pouch) cells		
Other/ Unknown cells		
LTO is sometimes specified when the cathode is not		

ELECTRODE AND CELL MANUFACTURING				
Company	Facility	Location	Product Type	Product
Tesla	Tesla Gigafactory	Sparks, NV	Cylindrical cells	NCA
LG Chem	LG Chem Michigan Plant	Holland, MI	Prismatic (pouch) cells	NMC
EnerDel	Ener1 Battery Manufacturing Plant	Indianapolis, IN	Prismatic (metal can) cells	NMC

# Module/Pack Supply Chain

- Mod/Pack Spreadsheet
  - Manufacturing of Modules, Packs and their non-cell components
  - Product details in Notes



MODULE/PACK SUPPLY CHAIN	
Product Type	Product
Cell Assemblies/ Groupings	Modules/ Arrays
	Pack
	Rack/ Cabinets
Non-cell Components	BMS
	Control Systems
	Electrical Systems
	Packaging Systems
	Safety Systems
	Thermal Systems
	Other

MODULES, PACKS AND THEIR COMPONENTS				
Company	Facility	Location	Product Type	Product
Storage Battery Systems LLC	Fort Wayne	Fort Wayne, IN	Non-cell Components	Thermal systems
Saft America, Inc	Valdosta	Valdosta, GA	Non-cell Components	Electrical systems
Xalt Energy MI LLC	Xalt Energy Battery Park	Midland, MI	Cell Assemblies/ Groupings	Packs



End-of-Life Recycling and Reuse

#### DOWNSTREAM

- Pack manufacturing
- End-of-life recycling and reuse

# EOL Facility Types and Feedstocks/Products

- Facilities are represented by:
  - Facility Type
  - Chemistry
  - Feedstock
  - Product

EOL FACILITIES
4R's - Repair, Remanufacture, Refurbish and/or Repurpose
Battery material refining
Battery recycling - hydro/ pyro/ direct
Collection and Logistics
Collection, Disassembling and/or Storage
(Universal Waste Handlers)
Shredding and screening (Physical processing)
Other

EOL Feedstock/Product
Battery grade lithium carbonate
Battery grade lithium hydroxide
Battery grade lithium intermediates
Battery grade metal sulfates
Black Mass
Cathode Precursor
Rejected cells and/or components
Consumer Electronics
EOL Battery
EV/HEV/PHEV
Mixed metal intermediates - alloy/ salts/ sulfates/ mattes
Other Crude Products
Second Life Battery
Sorted EOL Battery
Other



End-of-Life Recycling and Reuse

#### DOWNSTREAM

- Pack manufacturing
- End-of-life recycling and reuse

# Example EOL Supply Chain Classifications

Facility	Location	Facility Type	Feedstock	Product
Battery Resources	Worcester, MA	Battery recycling - hydro/ pyro/ direct	Rejected cells and/or components	Battery grade metal sulfates
Battery Solutions	Mesa, AZ	Collection, Sorting, Storage and/or Discharging (Universal Waste Handlers)	EOL Battery	Sorted Battery
Clean Earth Inc.	Melbourne, FL	Battery recycling - hydro/ pyro/ direct	EOL Battery	Mixed metal intermediates - alloy/ salts/ sulfates/ mattes
INMETCO	Elwood City, PA	Battery recycling - hydro/ pyro/ direct	EOL Battery	Mixed metal intermediates - alloy/ salts/ sulfates/ mattes
Li-Cycle Commercial Spoke 1	Kingston, ON	Shredding and screening (Physical processing)	EOL Battery	Black mass
Li-Cycle Commercial Hub 1 (under construction)	Rochester, NY	Battery recycling - hydro/ pyro/ direct	Black mass	Battery grade metal sulfates
Retriev Technologies, Inc.	Lancaster, OH	Shredding and screening (Physical processing)	EOL Battery	Black mass
Retriev Technologies, Inc.	Trail, BC	Battery recycling - hydro/ pyro/ direct	EOL Battery	Cathode Precursor
Retriev Technologies, Inc.	Trail, BC	Battery recycling - hydro/ pyro/ direct	Rejected cells and/or components	Cathode Precursor
Retriev Technologies, Inc.	Baltimore, OH	Collection, Sorting, Storage and/or Rendering Safe (Universal Waste Handlers)	EOL Battery	Sorted Battery
Spiers New Technologies	Oklahoma City, OK	4R's - Repair, Remanufacture, Refurbish and/or Repurpose	EOL Battery	Second Life Battery
Spiers New Technologies	Oklahoma City, OK	Shredding and screening (Physical processing)	EOL Battery	Black mass

\*UW Handling - Universal Waste Handling, which is a common facility type encompassing Collection, Logistics, Storage, Sorting and/or Discharging

Retriev has several types of facilities

Spiers offers both 4R's and Pre-processing



# Equipment Supply Chain

- Equipment Spreadsheet
- Companies that manufacture equipment for the LIB supply chain
- Manufacturing, Testing and Service Equipment

EQUIPMENT			
Company	Location	Product Type	Product
Arbin Instruments	College Station, TX	Testing Equipment	Cell tester
Midtronics	Willowbrook, IL	Service Equipment	Module Balancing
Digatron Power Electronics	Shelton, CT	Manufacturing Equipment	Vacuum Pumps and Systems
Digatron Power Electronics	Shelton, CT	Manufacturing Equipment	Winder

EQUIPMENT SUPPLY CHAIN	
Product Type	Product
Manufacturing Equipment	Calendering
	Coaters
	Electrolyte Fill
	Formation / Aging
	Laser cutters
	Mixers
	Ovens / vacuum drying
	Pneumatic / punch press
	Process Controls
	Slitters
	Stacking / Folding
	Vacuum pumps and systems
	Welders
	Winders
	Other
Testing Equipment	Cell testing
	EV/HEV/PHEV Battery Testers
	Mod/Pack Tester
	Other
Service Equipment	EV/HEV/PHEV battery Service
	Module Balancing
	Rescue Charging
	Other

# Services Supply Chain

- Services Worksheet
- Companies that provide services to other companies in the supply chain – e.g.,
  - Testing and Certification
  - Utilities
- Classified into broad service types with free form entries for specific services

SERVICES SUPPLY CHAIN	
Product Type	Product
Battery Maintenance	Free form entries
Consulting	
Engineering	
Equipment Service and Repair	
Logistics	
Packaging	
Process Development	
Testing and/or Certification	
Toll Manufacturing	
Utilities	
Other	

Services listed as “Product” and “Product Type” for consistency in database

SERVICES			
Company	Location	Product Type	Product
NSL Analytical Services	Cleveland, OH	Testing and/or Certification	Battery Materials Testing
Polaris Battery Labs	Beaverton, OH	Toll manufacturing	Toll manufacturing of electrodes and cells
Wood Mackenzie Power and Renewables	Calgary, AB	Consulting	Market analysis, strategic consulting
CSA Group	Toronto, ON	Testing and/or Certification	Cell, pack, module, ESS, e-mobility and other battery-powered products testing and certification for North America standards

# Research and Development Supply Chain

- R&D Spreadsheet
- Classified by broad R&D Area
- Free form details for each entry

RESEARCH & DEVELOPMENT	
Product Type	Product
Battery Development	Free form entries
Manufacturing/ Process Development	
Materials	
Recycling	
Safety	
Other	

R&D listed as “Product” and “Product Type” for consistency in database

R&D			
Company	Location	R&D Area	R&D Description
A123 Systems	Waltham, MA	Manufacturing/ Process Development	Cell chemistry and manufacturing
EaglePicher Technologies	East Greenwich, RI	Battery Development	Medical devices
Jet Propulsion Lab (JPL)	Pasadena, CA	Battery Development	Space-rated Li-ion batteries
NEI Corporation	Somerset, NJ	Materials	Electrode and electrolyte materials

# Modeling and Software Supply Chain

- Modeling Spreadsheet
- Modeling (Simulation) or Other Software (Design) Tools
- Free form details on the tools

MODELING AND SOFTWARE SUPPLY CHAIN	
Product Type	Product
Hardware	Free form entries
Hardware and Software System	
Modeling Services	
Software	
Software and Service	

MODELING AND SOFTWARE			
Company	Location	Product Type	Product
Battery Design LLC	Pleasanton, CA	Software	Battery Design Studio
Bloomy	Windsor, CT	Modeling	Battery Simulator 12000
NREL	Golden, CO	Software	CAEBAT
Fraunhofer	Plymouth, MI	Modeling	Battery and Electrochemistry Simulation Tool (BEST)

# Distributors Supply Chain

- Distributor Spreadsheet
- Classified by Supply Chain Area

DISTRIBUTORS SUPPLY CHAIN	
Product Type	Product
Raw Materials	Free form entries
Electrodes and Precursors	
Cells	
Modules and Packs	
Equipment	
Other	

DISTRIBUTORS			
Company	Location	Product Type	Product
Targray Technology International	Kirkland, QC	Battery Components	Liquid electrolyte
Targray Technology International	Kirkland, QC	Battery Components	Tabs
Targray Technology International	Kirkland, QC	Electrode and Precursors	Cathode Powder
Targray Technology International	Kirkland, QC	Cells	NMC