Occupational Projections for Lithium-Ion Battery Production in Michigan

Presentation to the EV Jobs Academy

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Overview

- Supply chain concept for lithium-ion battery production
- Database of Companies in the lithium-ion battery supply chain
- Validation of data and imputation
- Establishing the relationship between supply chain employment and productive capacity
- Projecting occupational employment for lithium-ion battery production

In the ***National Blueprint for Lithium Batteries 2021-2030***, the Federal Consortium for Advanced Batteries differentiates the segments of the supply chain

- **Upstream**: raw materials production
- **Midstream**: materials processing and cell manufacturing
- **Downstream**: pack manufacturing and end-of-life recycling and reuse

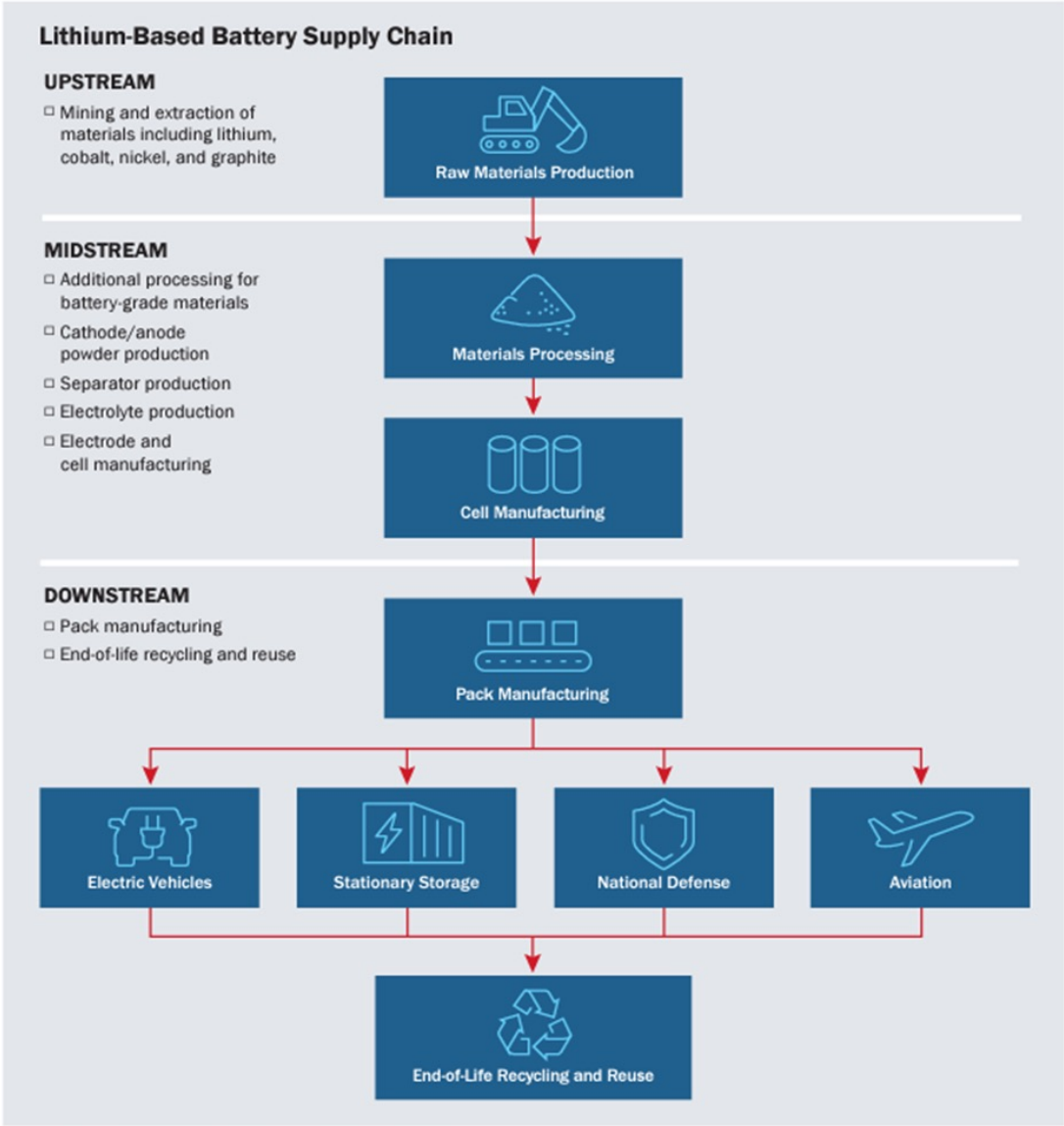


FIGURE 5. Steps in the lithium-battery material supply chain.

Source: National Blueprint for Lithium Batteries 2021-2030

National Alliance for Advanced Transportation Batteries

- R&D consortium of companies working to promote the manufacturing of lithium-ion and other advanced batteries
  - Incorporated as a Section 501(c)(6) trade association in 2009
  - 220+ corporate members in the energy storage industry

Source: NAATBatt International

North American Lithium-Ion Battery Supply Chain Database

In response to the national blueprint, **NAATBatt International** and the **National Renewable Energy Laboratory (NREL)** created a publicly available directory of North American companies in the lithium-ion supply chain.

- First released September 2021, with continued updates planned through 2025
- Recent release (June 2023) documents 791 firms engaged in the North American supply-chain for lithium-ion batteries

Source: NAATBatt International

North American Lithium-Ion Battery Supply Chain Database

For each facility, the database lists:

- Company name
- Website URL
- Facility in North America for the segment identified
- Facility address
- Products or services offered at the facility
- Approximate size of the company's overall workforce in North America, when available
- Headquarter company, location, and website
- Installed battery manufacturing capacity (in gigawatt-hours) and material production capability (in tons per year), plans for future capacity, types of chemistries and processes, and expansion plans by sector (e.g., transportation, stationary), when available

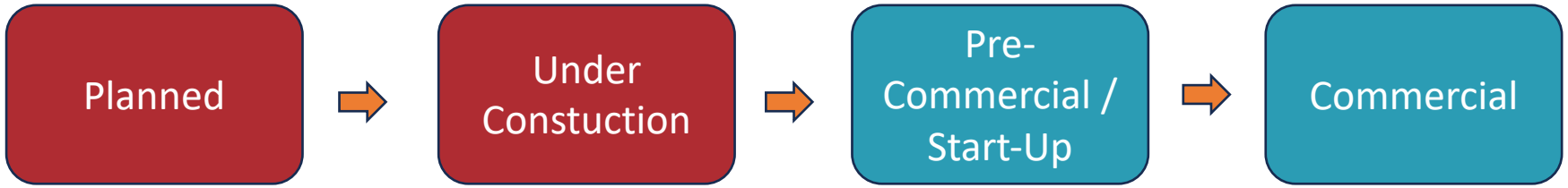
Source: NAATBatt International

NaatBatt and NREL Database

Data Validation

Methodology: Identification of Active Firms

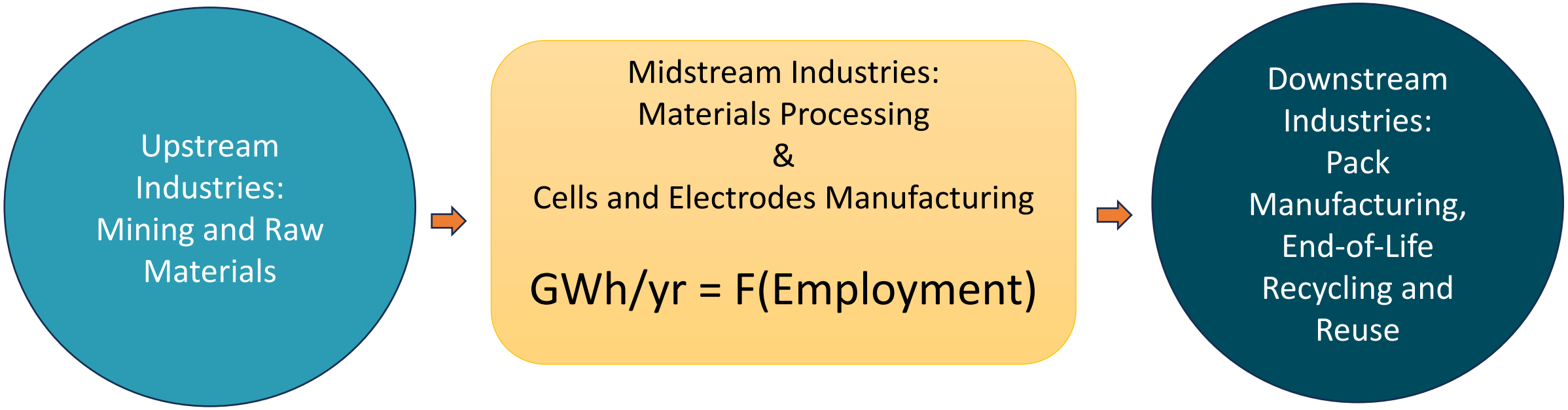
- The NaatBatt Database collects information on facilities in various stages of development. Facilities are placed into one of the following four stages:



- Our analysis is based on the 63 "Commercial" and "Pre-Commercial facilities" active in Michigan in year 2022

- Workforce estimates at facilities "Planned" and "Under Construction" are excluded from calculations of employment in the base period

Methodology: Establishing the relationship between supply chain employment and productive capacity



Employment forecasting assumes a stable relationship between supply chain employment and productive capacity in cells and electrodes manufacturing

Methodology: Imputation of Missing Values

- NaatBatt documents facility workforce and production capacity (where applicable) for firms in its database, but the data base does have some missing information:
  - In Michigan, 22 of 63 active firms contained missing information in one or both fields

- Imputation procedure for missing employment size:
  1. Direct outreach to establishment
  2. Web research
  3. Use of establishment databases (NETS, Claritas)
  4. Use median employment for all establishments in a particular supply-chain segment

Methodology: Imputation of Missing Values

- There was only one firm with missing productive capacity in the supply chain segment "4-Cells and Electrodes“
    - A linear regression model was used to model the relationship between workforce and productive capacity for all the firms with data and then to impute the missing observation
- In cases where a single workforce size is available for a firm with establishments in multiple supply-chain segments, we used national estimates of the proportions of workers in each supply chain segment

Establishing the relationship between supply-chain employment and productive capacity

Measuring the Output of Lithium-Ion Battery Manufacturers

- A Gigawatt-hour (GWh) is a unit of measurement for electric energy
  - Annualized as GWh/year

1 GWh/yr = 1,000 MWh/yr = 1 million kWh/yr

- Automakers quote a vehicle's battery capacity in terms of kilowatt-hours
  - Battery sizes range widely from 20 – 200 kWh
  - Trending larger with consumer demand for increased vehicle range

32.2 GWh/yr → Approximates the supply of 470,000 electric vehicle-grade batteries, where 68.4 kWh is regarded as an EV-average

Michigan Cells & Electrodes manufacturers total productive capacity in 2022 (NaatBatt)

Source: US Energy Information Administration, Electric Vehicle Database

Michigan Employment Across the Supply Chain

The following levels of employment in eleven supply chain segments are associated with 32.2 GWh/yr annual production capacity in the year 2022:

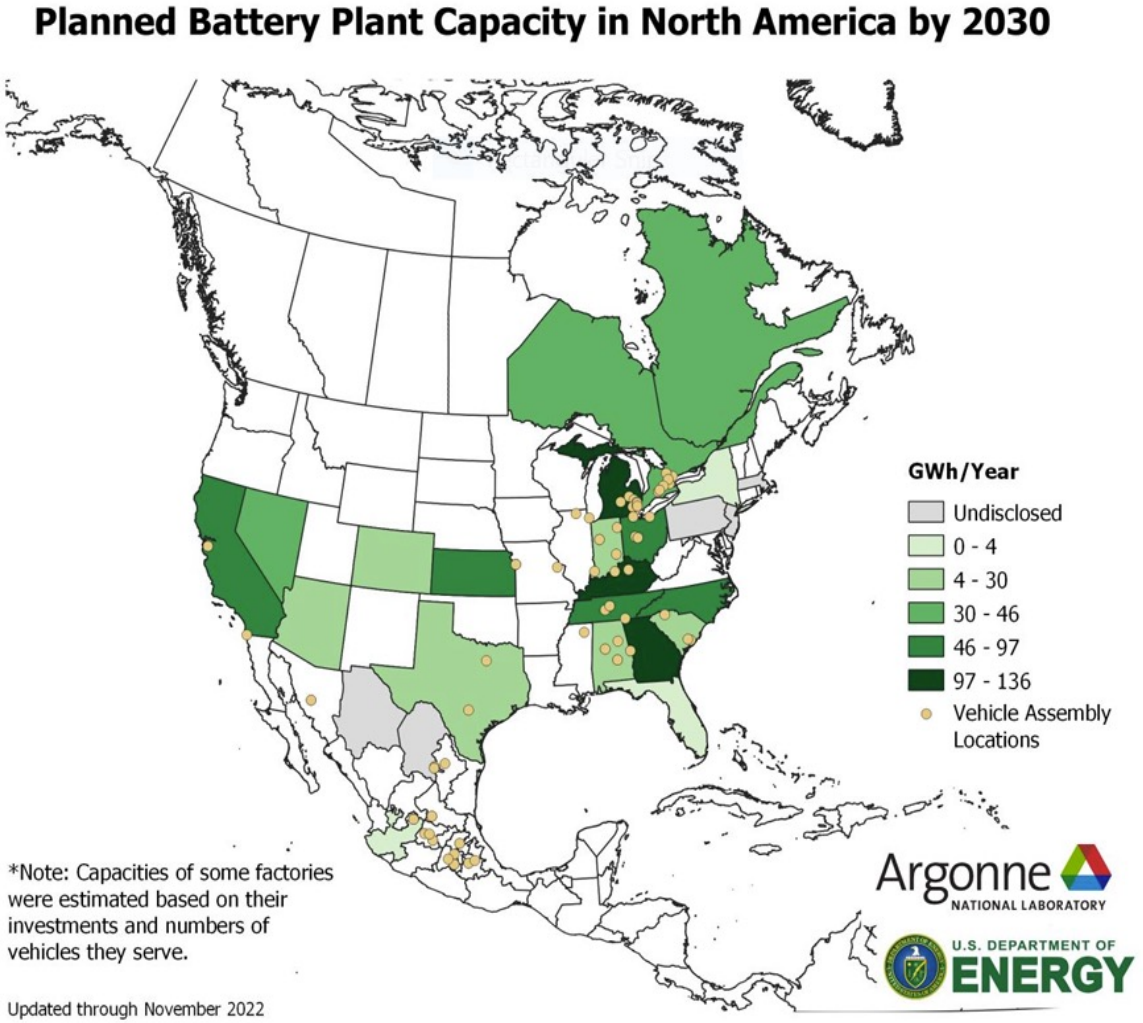
Supply Chain Segment	NAATBatt Employment In Michigan	Relative Share of Total Employment
1-Raw Materials	400	5.1%
2-Battery Grade Materials	121	1.5%
3-Other Battery Components Materials	63	0.8%
4-Electrodes and Cells	1,834	23.4%
5-Modpacks	3,641	46.4%
6-End of Life (EOL)	124	1.6%
7-Equipment	41	0.5%
8-Service and Repair	446	5.7%
9-Research and Development	1,021	13.0%
10-Modeling	160	2.0%
11-Distributors	0	0.0%
Total	**7,851**	**100%**

Michigan Employment by Industry NAICS (2022, 32.2 GWh/yr)

NAICS 3-Digit	Description	NAATBatt Employment in Michigan	Relative Share of Total Employment
212	Mining (except Oil and Gas)	400	5.1%
325	Chemical Manufacturing	107	1.4%
326	Plastics and Rubber Products Manufacturing	995	12.7%
333	Machinery Manufacturing	10	0.1%
334	Computer and Electronic Product Manufacturing	318	4.1%
335	Electrical Equipment, Appliance, and Component Manufacturing	3,879	49.4%
336	Transportation Equipment Manufacturing	795	10.1%
423	Merchant Wholesalers, Durable Goods	77	1.0%
441	Motor Vehicle and Parts Dealers	125	1.6%
541	Professional, Scientific, and Technical Services	964	12.3%
561	Administrative and Support Services	105	1.3%
562	Waste Management and Remediation Services	40	0.5%
811	Repair and Maintenance	36	0.5%
	Total	**7,851**	**100%**

Battery Production Capacity for Michigan

- NAATBatt/ NREL data currently active:
  32 GWh/yr
- Argonne National Labatory projection:
  97-136 GWh/yr
- NAATBatt/ NREL data current & planned:
  156 GWh/yr



Source: NAATBatt Data and Upjohn Calculations, Argonne National Laboratory

Projecting Occupational Employment for Lithium-Ion Battery Production

Projecting Occupational Employment for Lithium-ion Battery Production

- For each 3-digit NAICS industry involved in lithium-ion battery production, identify its occupational staffing pattern in Michigan in 2021 using the Occupational Employment and Wage Survey Data (latest data available)
- Use Michigan projections data on occupational shares by 3-digit NAICS industry in 2030 for each occupation in that industry
- Apply these projected occupation/industry shares to the projected 3-digit NAICS employment associated with the 156 GWh production capability to generate projected occupational employment in 2030 by these NAICS industries
- For each occupation, add up the projected occupational needs across all the relevant NAICS codes to generate an estimate of overall occupational requirements

Projected employment of **assemblers and fabricators** in industries related to lithium-ion battery production based on an assumption of producing 156 Gigawatt hours battery output

3-digit NAICS	NAICS Title	NAATBatt Employment in Michigan in 2022 (32.2 Gigawatt hours)	NAATBatt Employment in Michigan in 2030 (156 Gigawatt hours)	Share of assemblers and fabricators out of total industry employment		Employment of assemblers and fabricators in the industry	
				2021	2030	2022	2030
325	Chemical Manufacturing	107	518	0.49%	0.42%	1	2
326	Plastics and Rubber Products Manufacturing	995	4,820	12.70%	11.29%	126	544
333	Machinery Manufacturing	10	48	8.04%	7.41%	1	4
334	Computer and Electronic Product Manufacturing	318	1,541	3.73%	3.23%	12	50
335	Electrical Equipment, Appliance, and Component Manufactu	3,879	18,793	10.12%	8.96%	393	1685
336	Transportation Equipment Manufacturing	795	3,852	32.52%	31.85%	259	1227
423	Merchant Wholesalers, Durable Goods	77	373	2.51%	2.19%	2	8
541	Professional, Scientific, and Technical Services	964	4,670	0.51%	0.43%	5	20
561	Administrative and Support Services	105	509	4.85%	4.79%	5	24
562	Waste Management and Remediation Services	40	194	0.00%	0.00%	0	0
	Total Employment	7,290	35,318			803	3564

Projected employment of **machinists** in industries related to lithium-ion battery production based on an assumption of producing 156 Gigawatt hours battery output

3-digit NAICS	NAICS Title	NAATBatt Employment in Michigan in 2022 (32.2 Gigawatt hours)	NAATBatt Employment in Michigan in 2030 (156 Gigawatt hours)	Share of machinists out of total industry employment		Employment of machinists in the industry	
				2021	2030	2022	2030
325	Chemical Manufacturing	107	518	0.00%	0.00%	0	0
326	Plastics and Rubber Products Manufacturing	995	4,820	0.49%	0.50%	5	24
333	Machinery Manufacturing	10	48	9.55%	9.69%	1	5
334	Computer and Electronic Product Manufacturing	318	1,541	2.47%	2.48%	8	38
335	Electrical Equipment, Appliance, and Component Manufactu	3,879	18,793	2.63%	2.75%	102	516
336	Transportation Equipment Manufacturing	795	3,852	1.67%	1.68%	13	65
423	Merchant Wholesalers, Durable Goods	77	373	0.40%	0.40%	0	1
541	Professional, Scientific, and Technical Services	964	4,670	0.08%	0.08%	1	4
561	Administrative and Support Services	105	509	0.46%	0.46%	0	2
562	Waste Management and Remediation Services	40	194	0.00%	0.00%	0	0
	Total Employment	7,290	35,318			131	655

Projected employment of **architecture and engineering occupations** in industries related to lithium-ion battery production based on an assumption of producing 156 Gigawatt hours battery output

3-digit NAICS	NAICS Title	NAATBatt Employment in Michigan in 2022 (32.2 Gigawatt hours)	NAATBatt Employment in Michigan in 2030 (156 Gigawatt hours)	Share of architects and engineers out of total industry employment		Employment of architects and engineers in the industry	
				2021	2030	2022	2030
325	Chemical Manufacturing	107	518	5.72%	6.08%	6	32
326	Plastics and Rubber Products Manufacturing	995	4,820	6.43%	6.59%	64	318
333	Machinery Manufacturing	10	48	10.15%	10.93%	1	5
334	Computer and Electronic Product Manufacturing	318	1,541	12.04%	12.21%	38	188
335	Electrical Equipment, Appliance, and Component Manufactu	3,879	18,793	12.35%	13.07%	479	2457
336	Transportation Equipment Manufacturing	795	3,852	7.33%	7.61%	58	293
423	Merchant Wholesalers, Durable Goods	77	373	4.62%	4.65%	4	17
541	Professional, Scientific, and Technical Services	964	4,670	18.81%	18.07%	181	844
561	Administrative and Support Services	105	509	3.65%	3.67%	4	19
562	Waste Management and Remediation Services	40	194	0.62%	0.63%	0	1
	Total Employment	7,290	35,318			836	4174

Projected employment of **software developers** in industries related to lithium-ion battery production based on an assumption of producing 156 Gigawatt hours battery output

3-digit NAICS	NAICS Title	NAATBatt Employment in Michigan in 2022 (32.2 Gigawatt hours)	NAATBatt Employment in Michigan in 2030 (156 Gigawatt hours)	Share of software developers out of total industry employment		Employment of software developers in the industry	
				2021	2030	2022	2030
325	Chemical Manufacturing	107	518	0.46%	0.54%	0	3
326	Plastics and Rubber Products Manufacturing	995	4,820	0.26%	0.30%	3	14
333	Machinery Manufacturing	10	48	0.68%	0.80%	0	0
334	Computer and Electronic Product Manufacturing	318	1,541	2.72%	3.09%	9	48
335	Electrical Equipment, Appliance, and Component Manufactu	3,879	18,793	1.27%	1.45%	49	273
336	Transportation Equipment Manufacturing	795	3,852	0.42%	0.47%	3	18
423	Merchant Wholesalers, Durable Goods	77	373	1.58%	1.81%	1	7
541	Professional, Scientific, and Technical Services	964	4,670	6.82%	7.92%	66	370
561	Administrative and Support Services	105	509	0.72%	0.85%	1	4
562	Waste Management and Remediation Services	40	194	0.23%	0.22%	0	0
	Total Employment	7,290	35,318			132	737

Projected employment of **management occupations** in industries related to lithium-ion battery production based on an assumption of producing 156 Gigawatt hours battery output

3-digit NAICS	NAICS Title	NAATBatt Employment in Michigan in 2022 (32.2 Gigawatt hours)	NAATBatt Employment in Michigan in 2030 (156 Gigawatt hours)	Share of managers out of total industry employment		Employment of managers in the industry	
				2021	2030	2022	2030
325	Chemical Manufacturing	107	518	9.01%	9.20%	10	48
326	Plastics and Rubber Products Manufacturing	995	4,820	5.86%	6.06%	58	292
333	Machinery Manufacturing	10	48	7.43%	7.66%	1	4
334	Computer and Electronic Product Manufacturing	318	1,541	9.22%	9.34%	29	144
335	Electrical Equipment, Appliance, and Component Manufactu	3,879	18,793	8.69%	8.94%	337	1681
336	Transportation Equipment Manufacturing	795	3,852	4.62%	4.71%	37	181
423	Merchant Wholesalers, Durable Goods	77	373	10.12%	10.30%	8	38
541	Professional, Scientific, and Technical Services	964	4,670	10.47%	10.62%	101	496
561	Administrative and Support Services	105	509	4.15%	4.44%	4	23
562	Waste Management and Remediation Services	40	194	5.71%	5.86%	2	11
	Total Employment	7,290	35,318			587	2918

Areas to Research

- Output / employment relationship in the base period
- Gigawatt projections
- Occupations most relevant
- Productivity impacts on occupational shares

Sources

Sources

National Blueprint for Lithium Batteries 2021-2030. Federal Consortium for Advanced Batteries. June 2021.

NAATBatt Lithium-Ion Battery Supply Chain Database. NAATBatt. Last updated June 2023.

Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010 – 2021. David Gohlke, Yan Zhou, Xinyi Wu, and Calista Courtney. Energy Systems and Infrastructure Analysis Division, Argonne National Laboratory. November 2022

Occupational Employment and Wage Survey, Bureau of Labor Statistics, May 2021, Michigan

Occupational Employment Projections by Industry, Michigan, 2020-2030, Department of Technology, Management, and Budget, Michigan Department of Labor and Economic Opportunity.

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