Michigan EV Engineering

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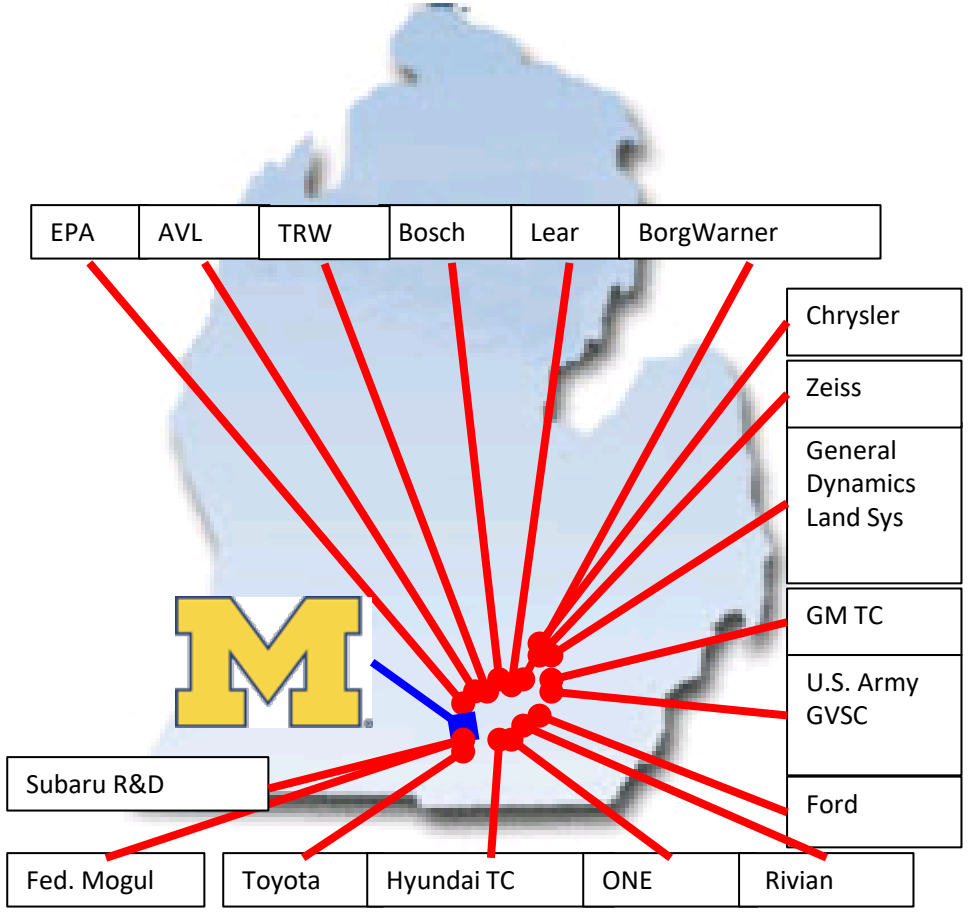
Battery Control Laboratory

Automotive Laboratory: Heritage and Responsibility

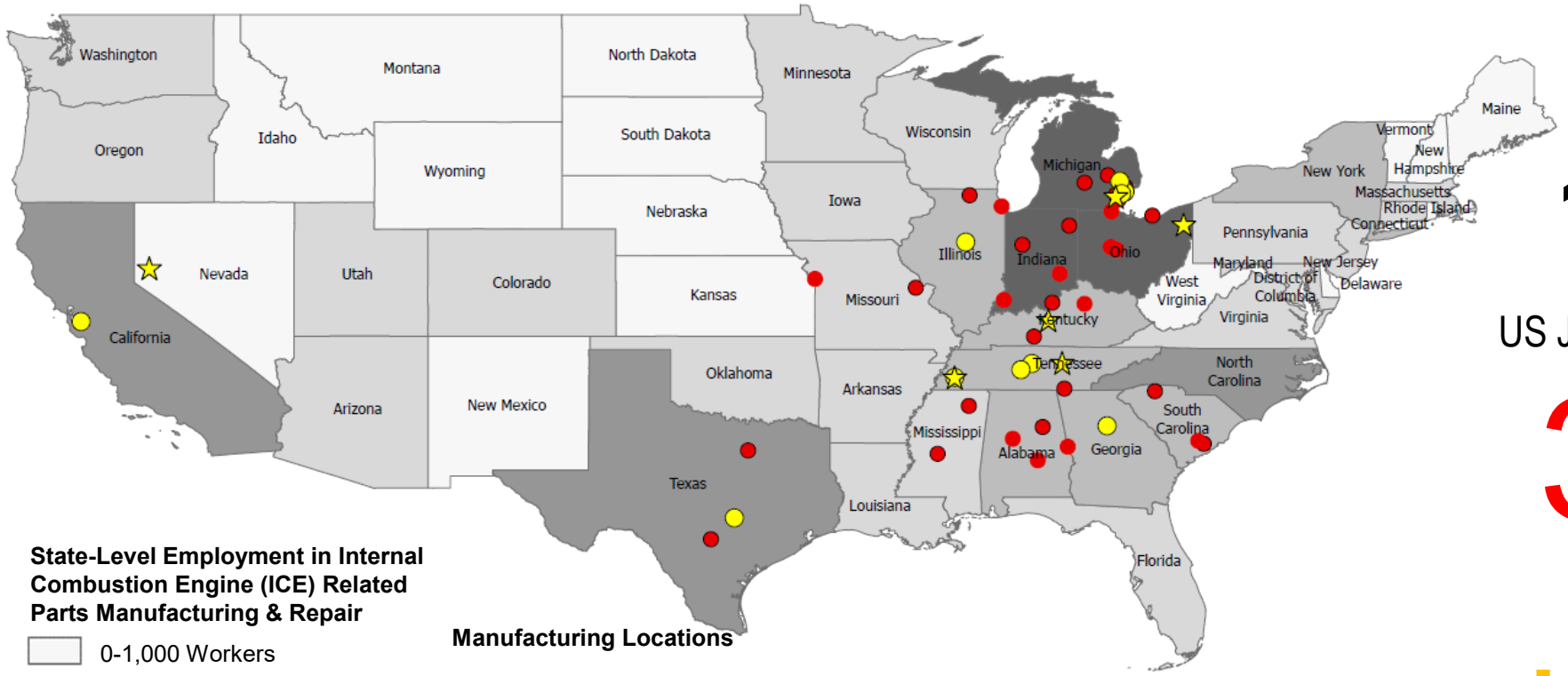


Surrounded by hundreds of vehicle-related R&D technical centers

US Goal:
50% of LDV sales by 2035
(10,000,000 EV/year)

Produce 2000 cells per min

Auto Manufacturing & Repair Employment



State-Level Employment in Internal Combustion Engine (ICE) Related Parts Manufacturing & Repair

- 0-1,000 Workers
- 1,001 – 5,000 Workers
- 5,001 – 10,000 Workers
- 10,001 – 20,000 Workers
- 20,001 – 40,000 Workers

Manufacturing Locations

- EV Battery Plants, Current & Announced
- EV Production, Current & Announced
- Hybrid / Hybrid & ICE Production
- ICE (Gas, Diesel) Production Only

1.8 million

US Jobs in Auto Manufacturing & Repair

303,000

of these Auto Jobs are in ICE-Related Transition.

How many

Jobs will be created in a Battery Economy?

"Early Evidence of the Employment Impact of the Transition to Battery Electric Vehicles"
by Rebecca Pickens and Anna Stefanopoulou
(https://drive.google.com/file/d/1s4mQZwn_tsltEI8HnIUIL-O0CoQmiC-k/view)

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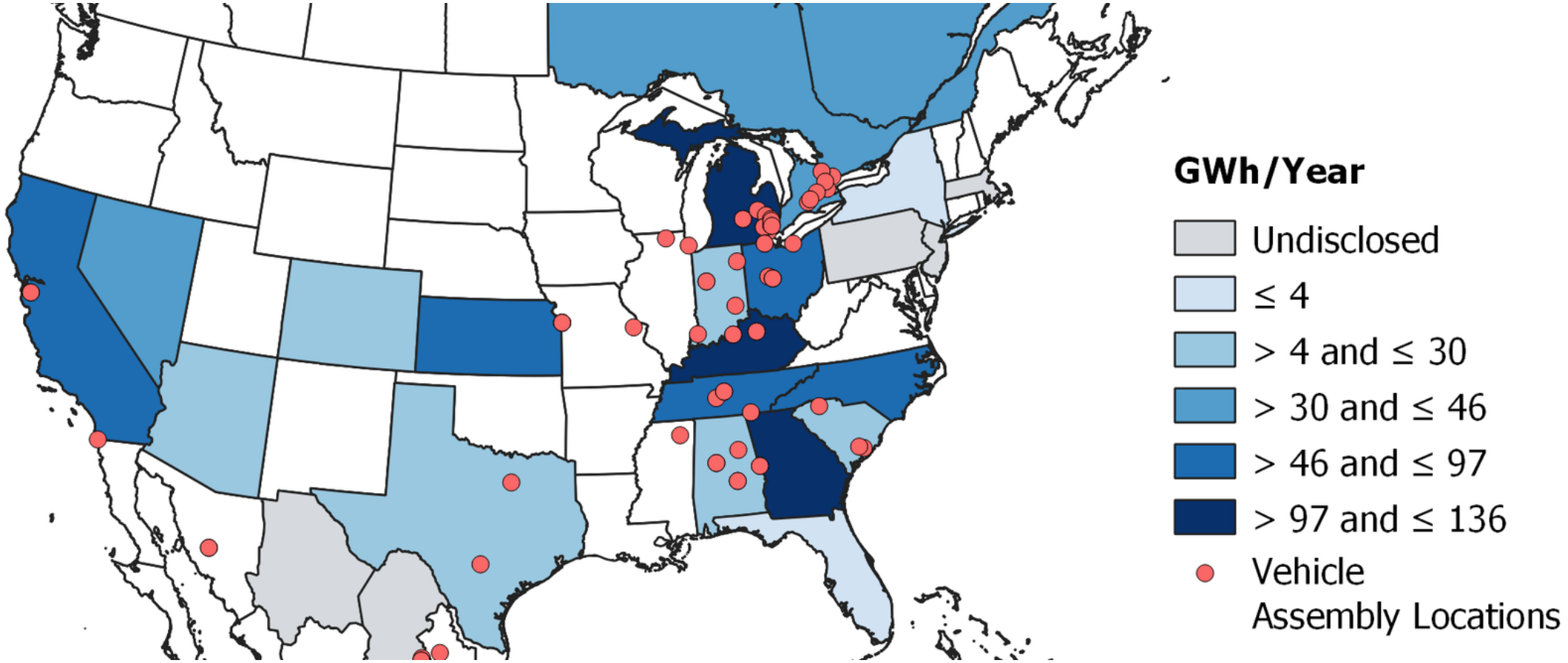
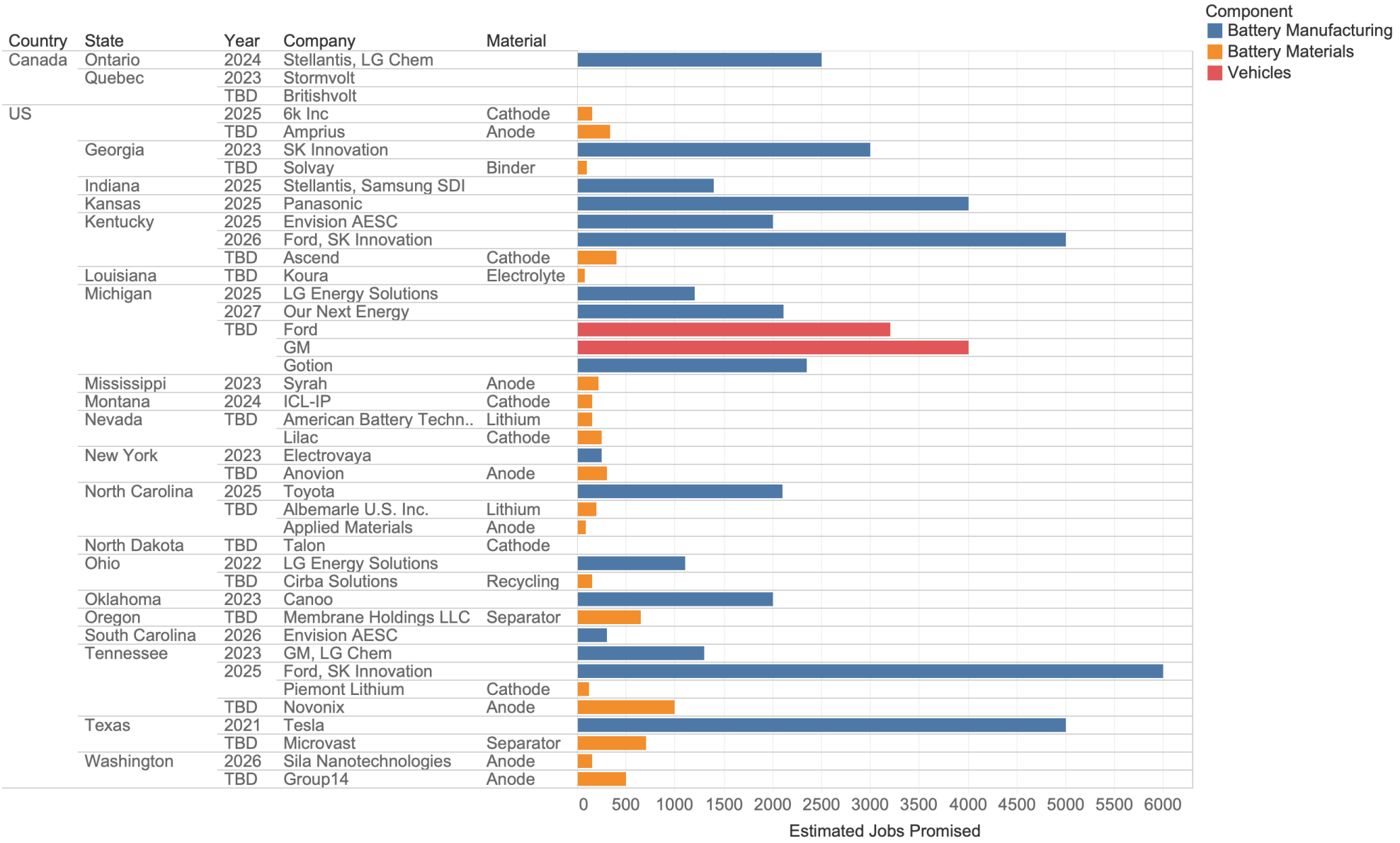
Planned Battery Capacity in North America by 2030



Argonne National Lab, Nov 22

Estimated Jobs Promised

Country	State	Year	Company	Material
Canada	Ontario	2024	Stellantis, LG Chem	
	Quebec	2023	Stormvolt	
		TBD	Britishvolt	
US		2025	6k Inc	Cathode
		TBD	Amprius	Anode
	Georgia	2023	SK Innovation	
		TBD	Solvay	Binder
	Indiana	2025	Stellantis, Samsung SDI	
	Kansas	2025	Panasonic	
	Kentucky	2025	Envision AESC	
		2026	Ford, SK Innovation	
		TBD	Ascend	Cathode
	Louisiana	TBD	Koura	Electrolyte
	Michigan	2025	LG Energy Solutions	
		2027	Our Next Energy	
		TBD	Ford	
			GM	
			Gotion	
	Mississippi	2023	Syrah	Anode
	Montana	2024	ICL-IP	Cathode
	Nevada	TBD	American Battery Techn..	Lithium
			Lilac	Cathode
	New York	2023	Electrovaya	
		TBD	Anovion	Anode
	North Carolina	2025	Toyota	
		TBD	Albemarle U.S. Inc.	Lithium
			Applied Materials	Anode
	North Dakota	TBD	Talon	Cathode
	Ohio	2022	LG Energy Solutions	
		TBD	Cirba Solutions	Recycling
	Oklahoma	2023	Canoo	
	Oregon	TBD	Membrane Holdings LLC	Separator
	South Carolina	2026	Envision AESC	
	Tennessee	2023	GM, LG Chem	
		2025	Ford, SK Innovation	
			Piemont Lithium	Cathode
		TBD	Novonix	Anode
	Texas	2021	Tesla	
		TBD	Microvast	Separator
	Washington	2026	Sila Nanotechnologies	Anode
		TBD	Group14	Anode



Skills Needed (Bright Red = High Need)

Skills	Trade School	In-House Training or Re-Training	2-Year Community College	4-Year College / University	Post-Graduate	Total Responses
Battery Materials	6	7	12	32	32	44
Mining	5	4	5	7	6	14
Electrical	4	4	14	15	7	23
Power Electronics	4	3	11	17	10	24
Software / Battery Management	2	3	12	22	12	31
System Design	2	4	8	21	14	30
Prototyping	5	11	11	18	9	25
Battery Testing	13	14	21	23	9	35
Design for Waste Management	6	6	9	16	8	20
Battery Recycling	9	8	13	18	15	27
Environmental Engineering	2	3	4	14	8	17
Project Management	3	7	12	16	6	21
Technical Lead / Management	3	9	7	19	11	25
Supply Chain Management	3	7	11	16	5	24
Manufacturing Including Plant Design	2	5	10	22	11	28
Applications (Installation, Operation)	6	6	12	13	6	21
Installation of Battery Systems	11	9	14	8	5	21
Operation and Maintenance of Systems	14	13	11	10	2	22
Electrical Skills for Techs (High Voltage)	16	13	20	13	4	29
Safety (Electrical, Hazmat, Fire)	11	11	15	14	8	23
First Response to Battery Fires	10	14	13	8	5	20
Total Responses from Training Institution	27	26	35	43	42	

What skills are needed and where should they be taught?

Greatest gaps for educational programs at the community college and 4-year-university level.

Looking for battery courses and programs? Start here.

Source: Table adapted from NAATBatt job skills survey, with 56 total participants. (Alyssa McQuilling - Project Lead, Energy Storage Southern Research, 2022)

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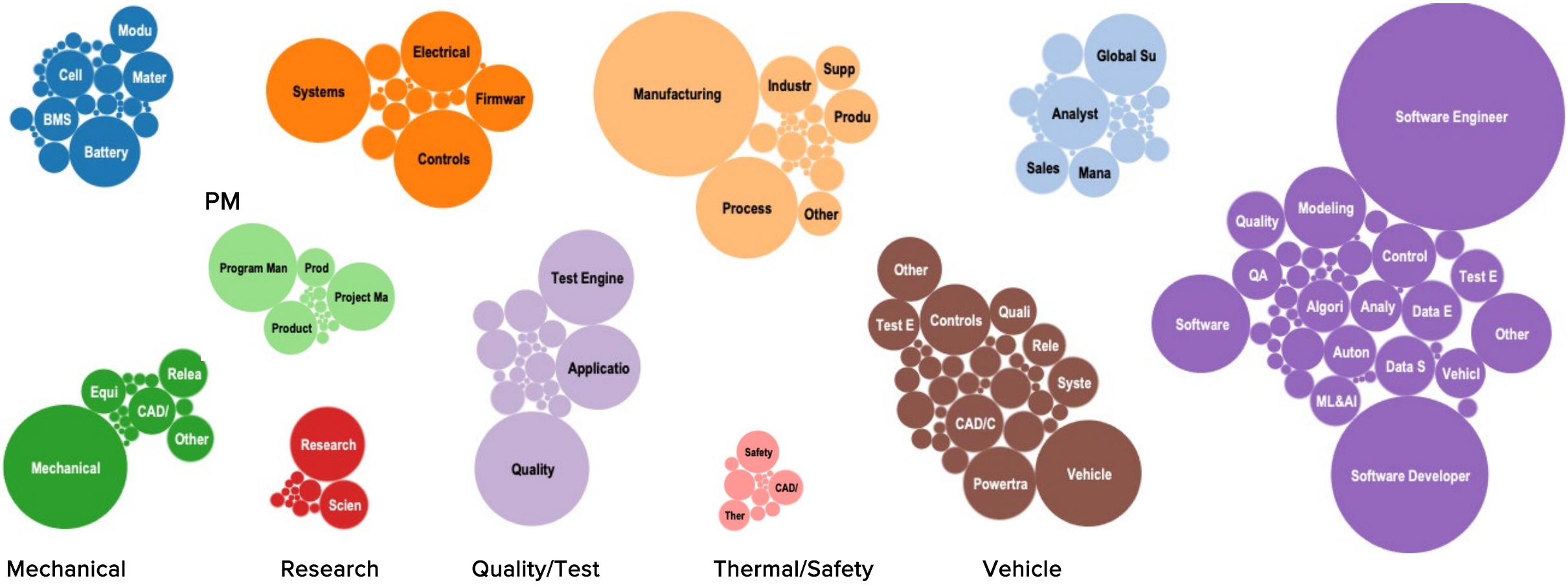
US H-1B Survey

Job titles containing “battery/cell/module” account for less than 5% of all battery-related jobs.



The size of each circle represents number of H-1B applications between Jan 1, 2011 and Apr 29, 2022, filtered for battery-related companies and jobs. Job categories are defined here. Job types are further grouped into sub-categories manually using Tableau. Source: h1bdata.info. Code: GitHub.

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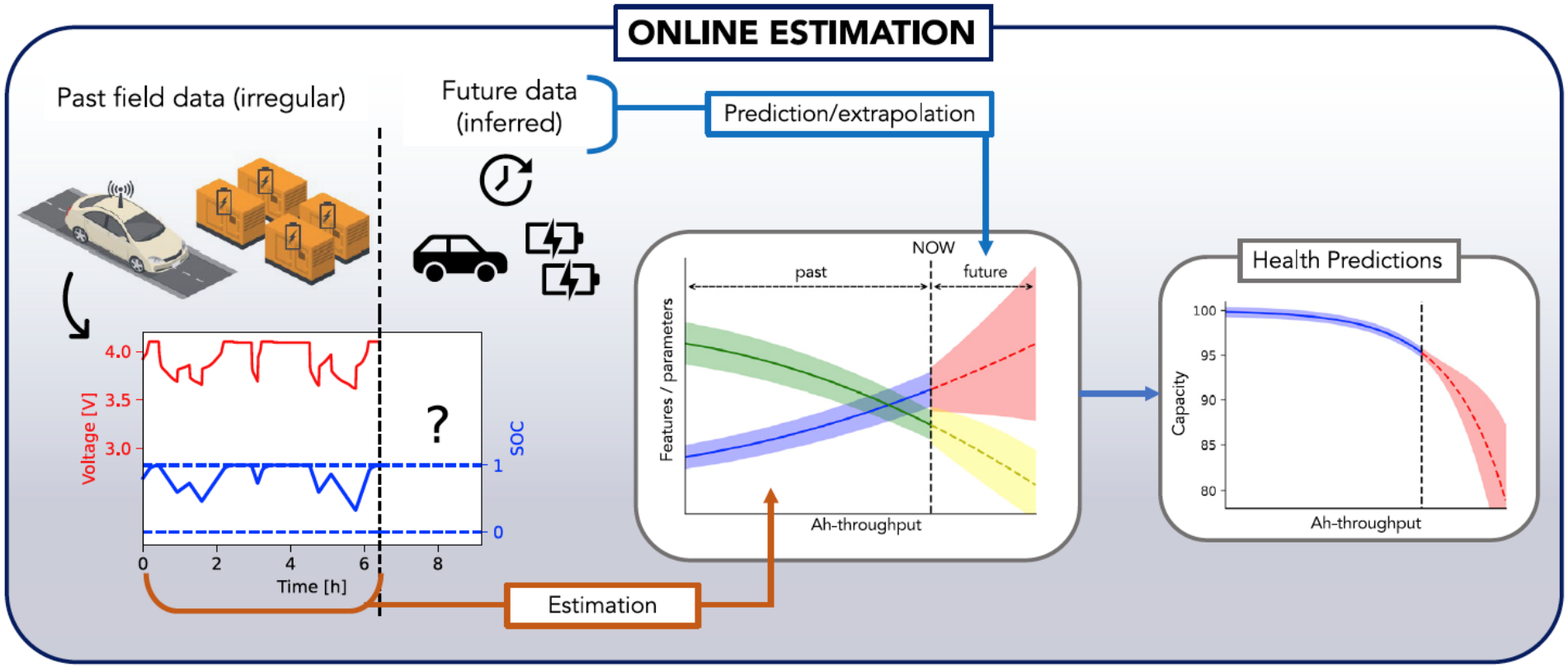
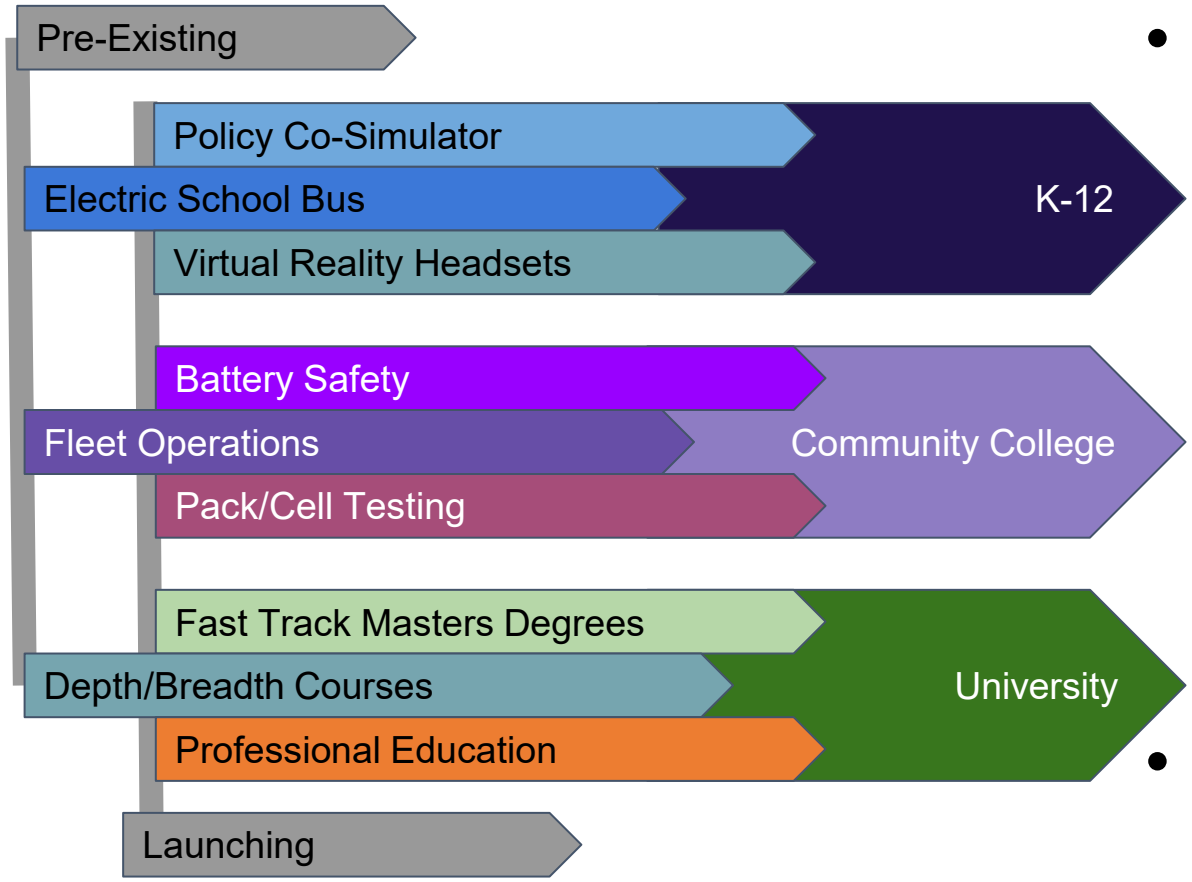
Control and Software in Battery Life



Impacts on Total Cost of Ownership

V. Sulzer, et al, "The challenge and opportunity of battery lifetime prediction from field data, Joule Oct 2021

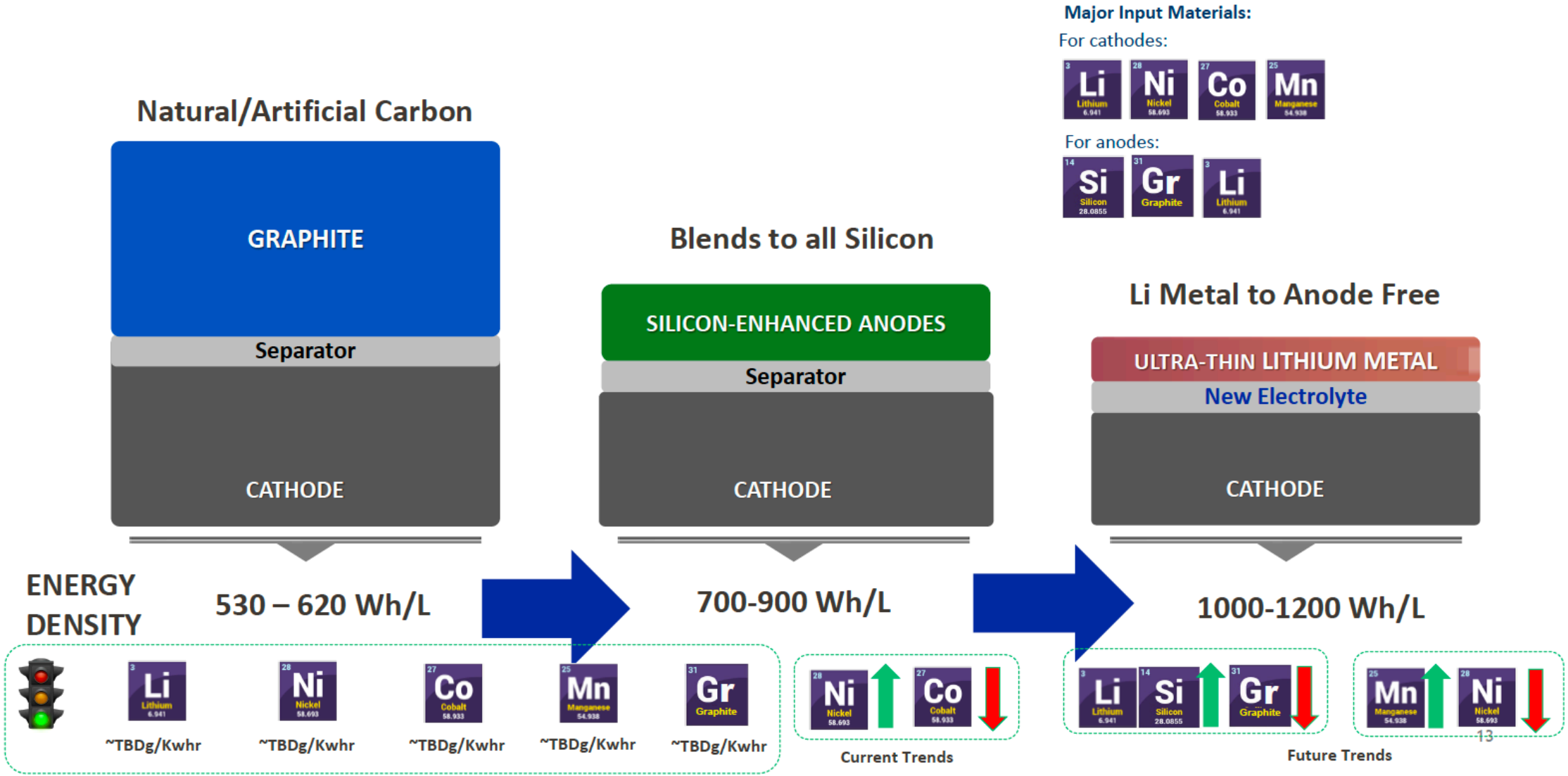
Engineering Workforce Development



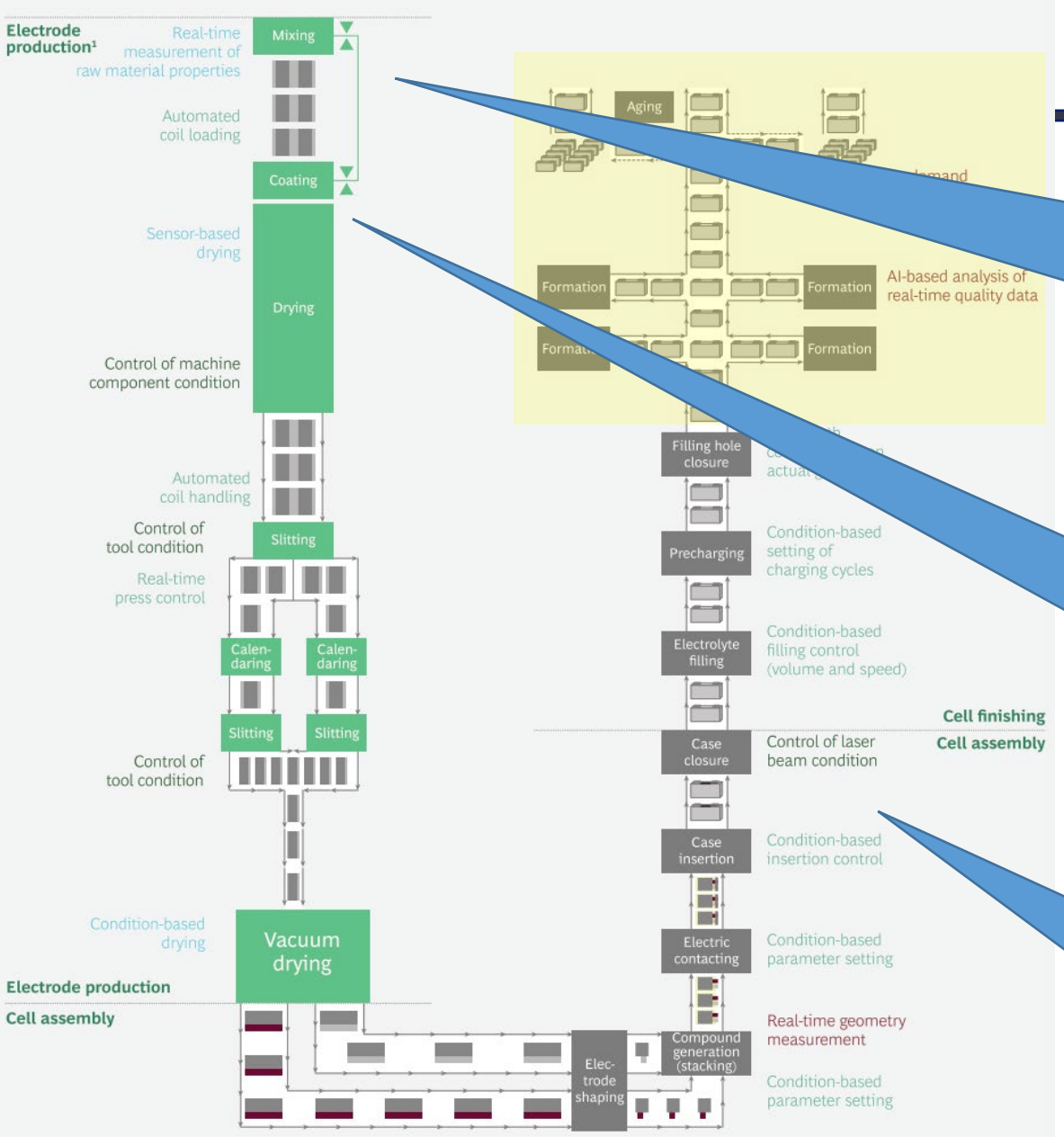
- Achieving the EV manufacturing targets will require a significant restructuring of the transportation workforce, e.g.:
  - Engineers/material scientists to develop/design electric vehicle technologies
  - Auto workers trained to work with high voltages and battery packs
  - Policymakers with a strong grasp of the capabilities/limitations of electric vehicles
- Obtaining the necessary workforce requires scalable efforts at all educational levels.

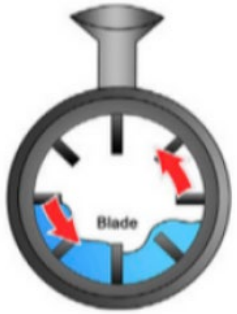
Thank you!

Next Gen ($/kWhr)



Cell manufacturing (baking)





Kuhlmann, K., Wolf, S., Pieper, C., Xu, G. & Ahmad, J. The Future of Battery Production for Electric Vehicles. *Boston Consulting Group* 1–22 (2018).

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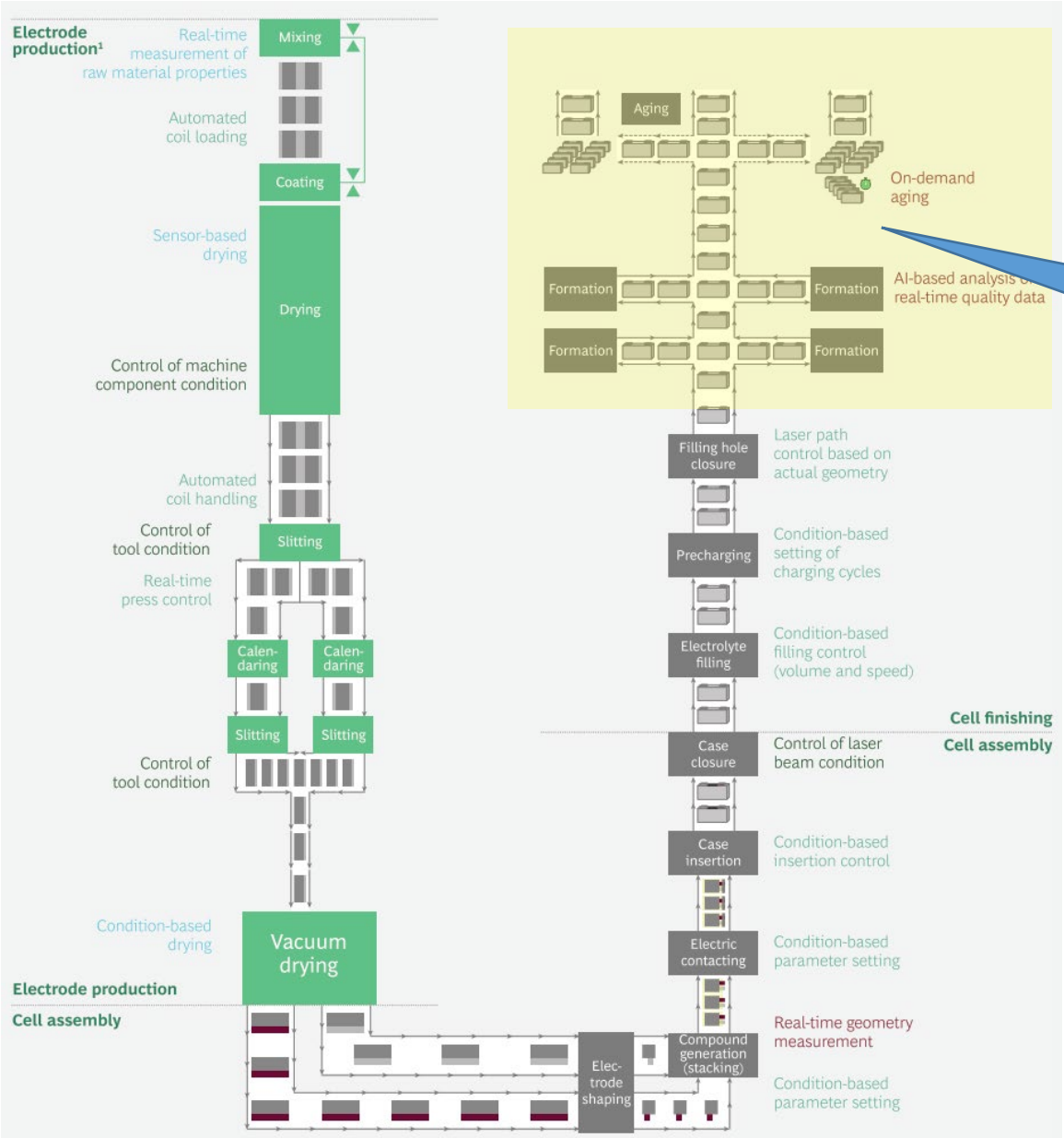
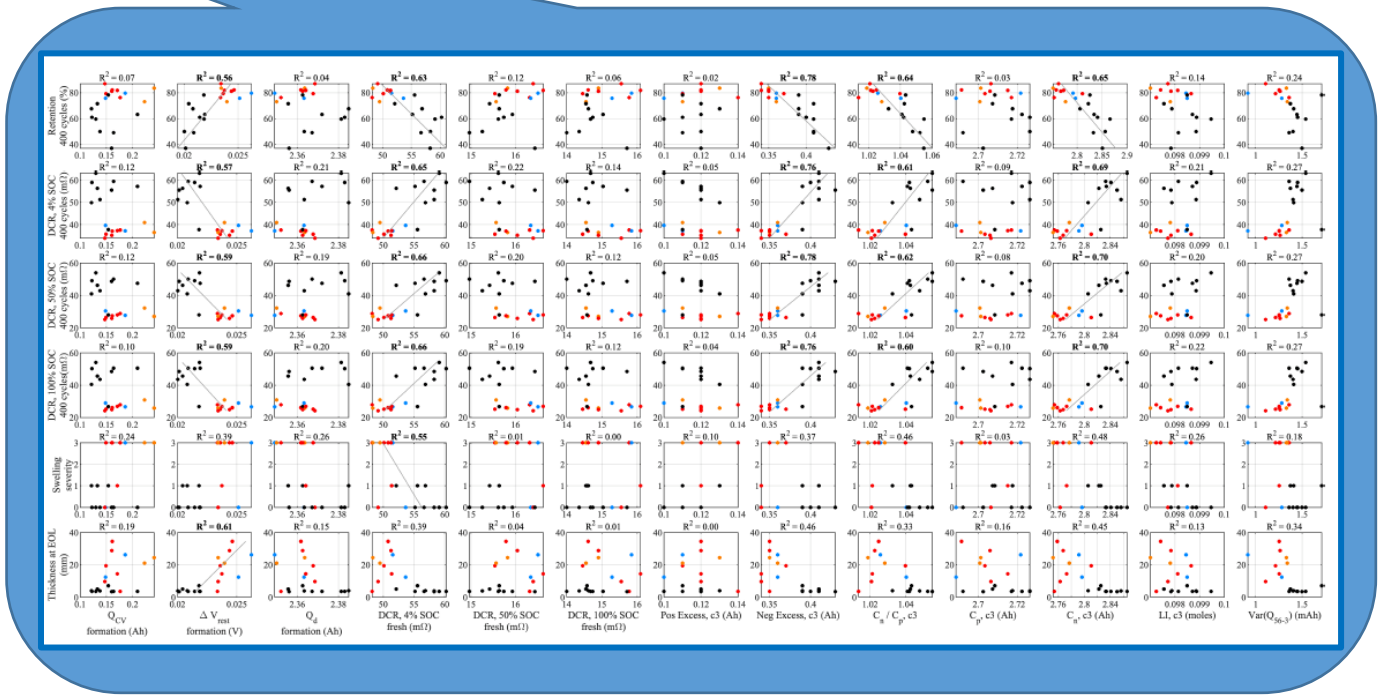
Cell manufacturing (data)





Managing End of Life