The Transition to Electrified Vehicles: Implications for the Future of Automotive Manufacturing Labor Demand and Worker Skills

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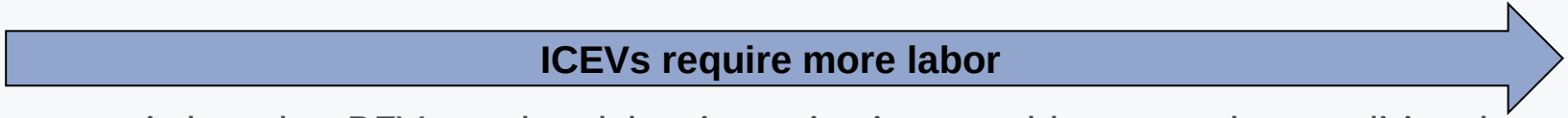
Industry claims about labor content are conflicting

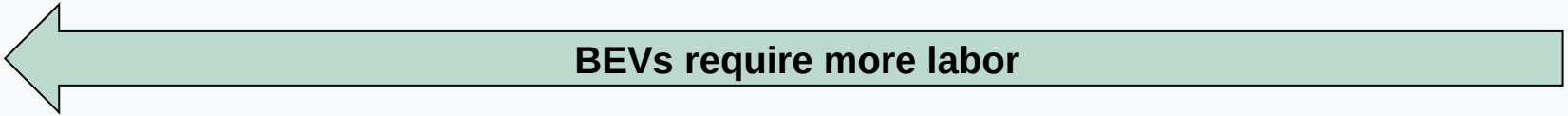
"A complex ICE with roughly 1,400 components involves **considerably more work** than an electric engine with a good 200 components in its drive train" (FES 2018)

Ford president: "Electric vehicles will mean auto factories can have . . . **30% fewer labor** hours per car" (Hart 2019)

"Autoworkers are worried; assembling a car powered by a battery requires about **a third fewer people** than one powered by an internal combustion engine" (NYT 2021)



"The common wisdom that BEVs are less labor intensive in assembly stages than traditional vehicles is inaccurate. In fact, the labor requirements for assembling BEVs and ICEVs are comparable" (BCG 2020)



EVs have 6-10 times more electronics content (UBS 2017)

"It's a myth that electric cars are easier to assemble than internal combustion engine cars. They're not. Nor is it true that EVs have fewer parts than ICEs. They don't." (McElroy 2019)

Our research proposes to empirically address these gaps

RQ: How does labor demand (hours) differ between ICEV and BEV manufacturing?

Unique contributions of our approach:

- Collection of detailed data through ICEV & BEV industry partnerships
- Application of engineering-based cost analyses
- Systems-level perspective of evolving industry and policy directions

Methods: Modeling labor & production requirements of emerging technologies

Image adapted from: Field et al. (2007)

Technical cost models are well-suited for accounting for the influence of technology choices on production step-level variables in manufacturing, including labor intensity.

Process-based cost modeling (PBCM) evaluates the economics of manufacturing operations and the implications of alternative manufacturing decisions by simulating each step of the production process and the interaction across these steps for a given product design (Busch 1983, Johnson and Kirchain 2009, Fuchs et al. 2008)

- **Forward-looking**: How will emerging technologies, concepts, and materials affect production costs prior to large-scale investment?
- Previous automotive application (Mangin et al. 1983, Urbance et al. 2002, Sakti et al. 2017)

Identified most important ICEV and BEV powertrain components from cost and labor perspectives

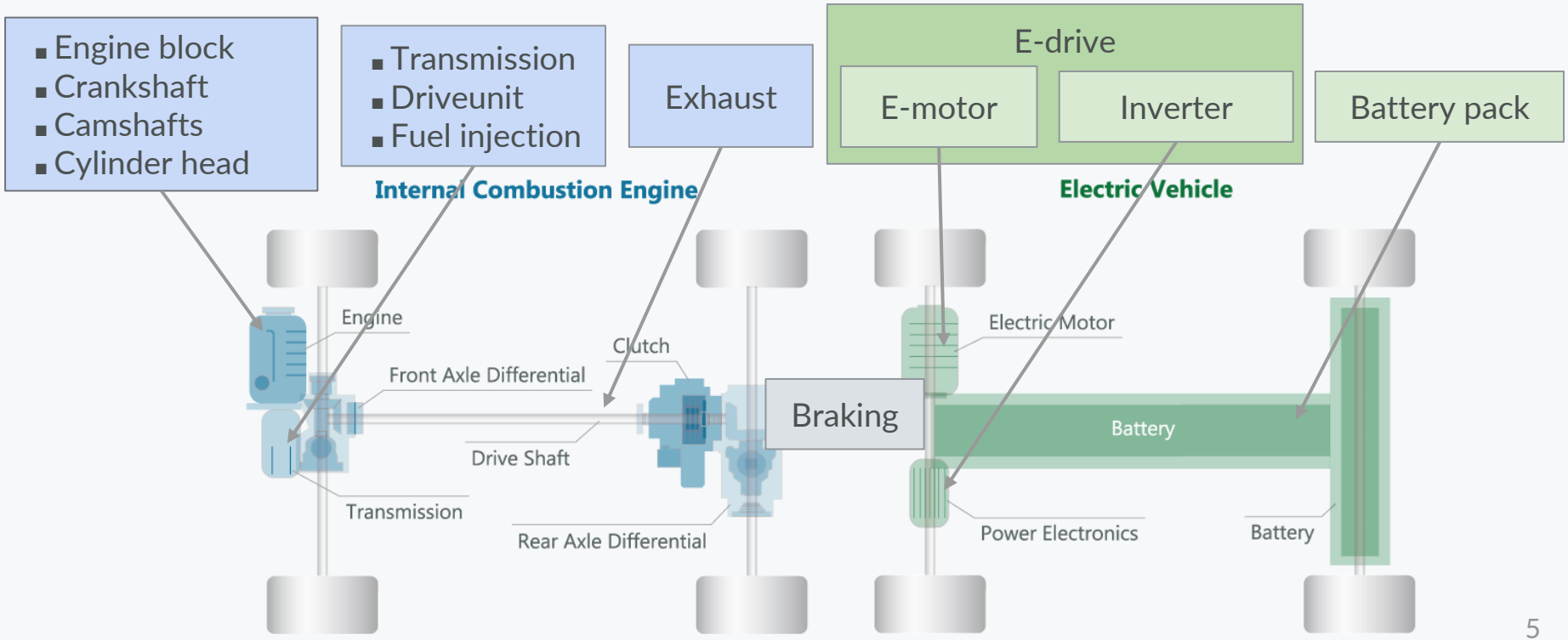


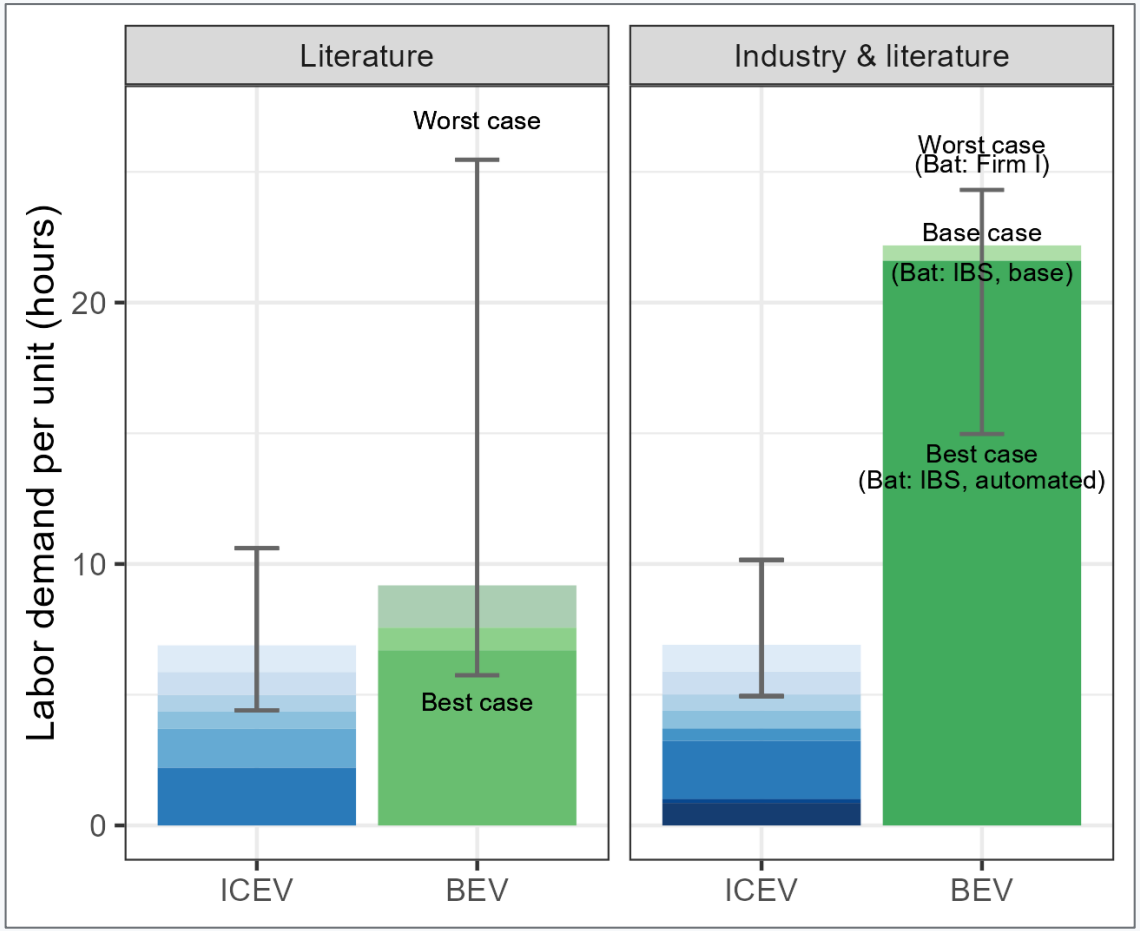
Image: ClearBridge (2016), “Disruption from EVs”

Collected comprehensive shop floor industry data

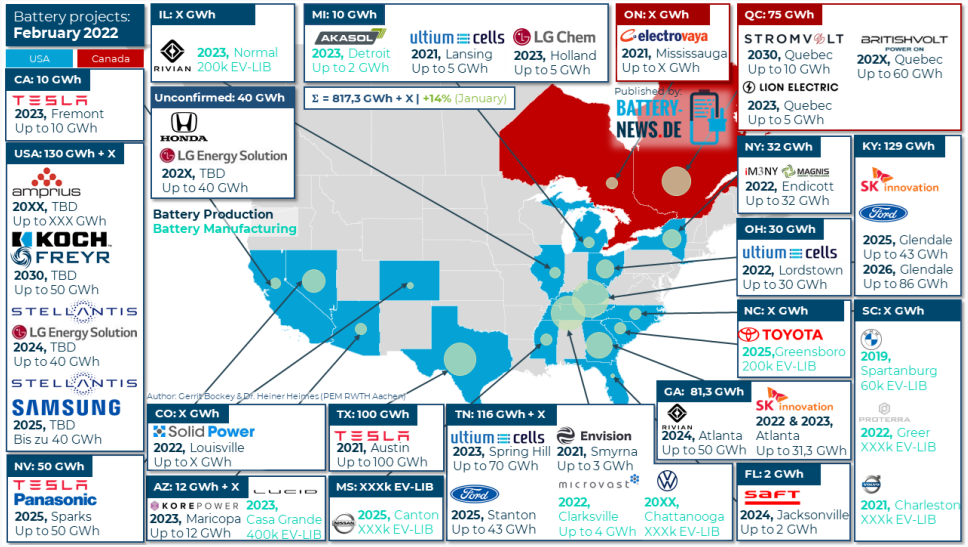
Engine block	Automaker A
Transmission	Auto supplier E
Driveunit	Auto supplier F
Fuel injection, pump	Auto supplier G
Braking	Auto supplier G
Electric motor/drive	Auto supplier E, Auto supplier F, Auto supplier G
Battery cells, pack	Battery manufacturer H, Battery manufacturer I, International Battery Seminar experts

- **Operations and production inputs for 300 process steps** collected from 4 OEMs, 3 suppliers, 2 battery manufacturers, plus direct observation in 5 production facilities
- Plus engagements with United Auto Workers Union, Motor & Equipment Manufacturers Association, National Alliance for Advanced Technology Batteries

Industry data, supplemented by literature: BEV powertrain requires more labor hours in all scenarios, driven by battery manufacturing



Open question: Will new North American battery plants capture most of the labor hours in production value chain?



Labor hours distributed over all battery manufacture steps, but larger portion in cell manufacture than module/pack assembly

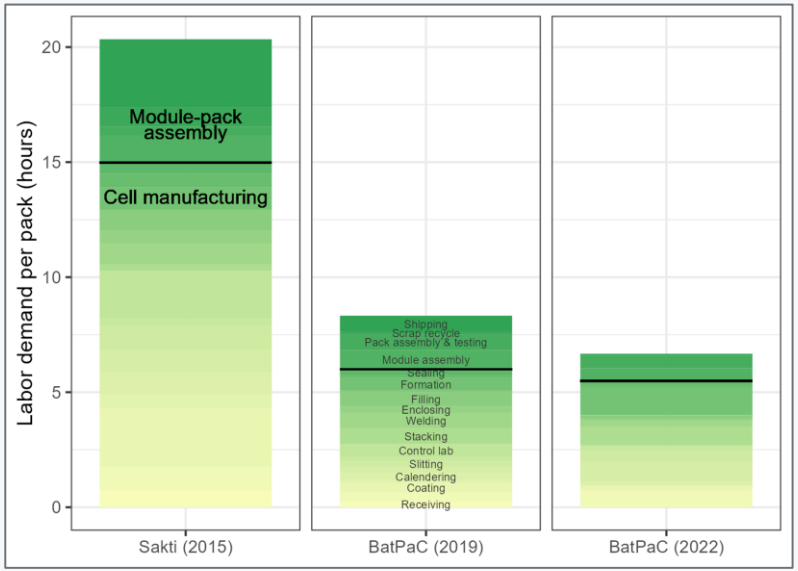


Image: Gerrit Bockey (Feb 2022), https://battery-news.de/index.php/2022/02/25/batterieprojekte-in-nordamerika-stand-februar-2022

Our research proposes to inform unresolved worker skill questions

RQ: How do worker skill requirements differ between ICEV and BEV manufacturing?

Unique contributions of our approach:

- Collection of O*NET skills data through ICEV & BEV industry partnerships
- Application of qualitative and comparative descriptive statistics

Selected a subset of manufacturing-relevant O*NET skills to survey workers

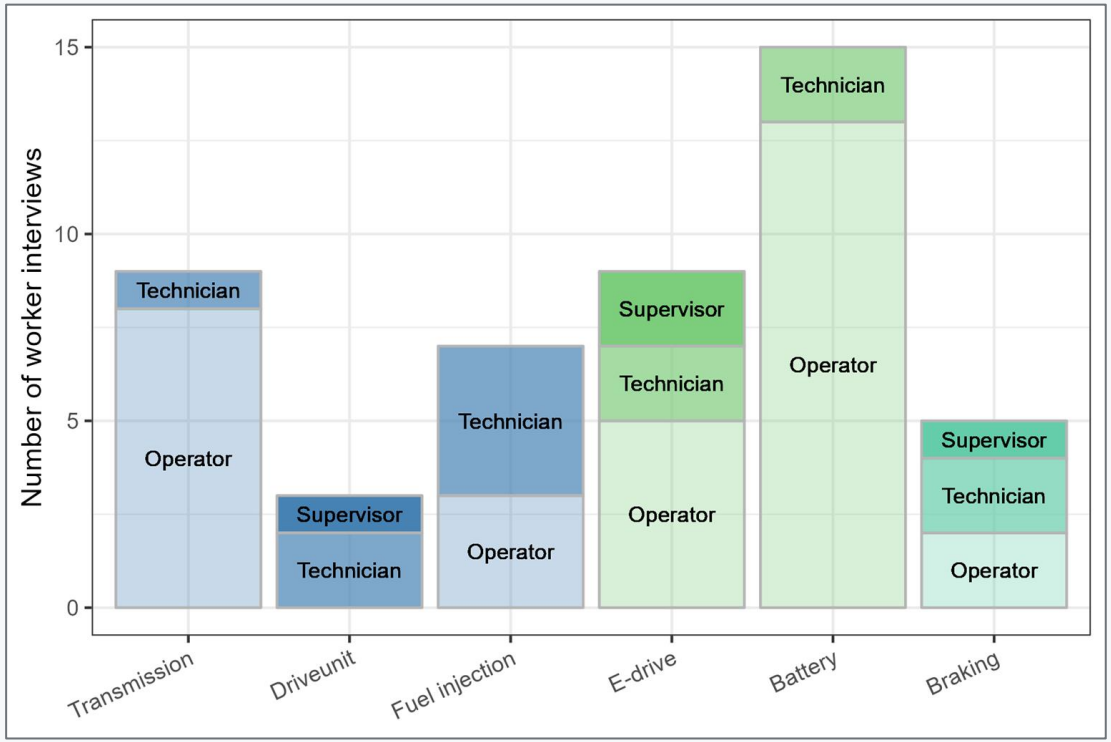
Physical	Finger dexterity	Make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects
	Near vision	See details at close range (within a few feet)
	Static strength	Exert maximum muscle force to lift, push, pull, or carry objects
Cognitive	Operation and control	Controlling operations of equipment or systems
	Complex problem solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions
Social	Instructing	Teaching others how to do something
	Social perceptiveness	Being aware of others' reactions and understanding why they react as they do

Worker-elicited skill levels measured through interviews

48 interviews with operators, technicians, supervisors (U.S., Germany, Poland, China)

Data from **industry firms**, representing key components in ICEV and BEV powertrains

Other details collected: Work experience, educational background, on-the-job training, job responsibilities



Takeaways

We find convincing evidence that **vehicle electrification leads to more labor hours in powertrain manufacturing**, at least in the short- to medium-term.

Shifts in the location of jobs (and thus losses) still likely as jobs shift away from OEMs towards 3rd party suppliers (e.g., battery and electronics manufacturers)

Industry's transition to large-scale production of BEVs accompanied by a transition of worker skills. Results indicate that BEV production **may increase demand for select mid- to upper-level, interdependent skills** in powertrain manufacturing:

- BEV operators: More homogeneous skill levels, on average
- Skill requirements for BEV powertrain components lie within ICEV range
- More skill interdependencies for BEV operators than ICEV operators; important to prepare BEV operators for full suite of skills