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)

ICEVs require more labor

“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)

BEVs require more labor

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

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

- Engine block
- Crankshaft
- Camshafts
- Cylinder head
- Transmission
- Drive unit
- Fuel injection
- Exhaust
- E-motor
- Inverter
- Battery pack

Image: ClearBridge (2016), "Disruption from EVs"
Collected comprehensive shop floor industry data

<table>
<thead>
<tr>
<th>Component</th>
<th>Supplier/Manufacturer</th>
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<tbody>
<tr>
<td>Engine block</td>
<td>Automaker A</td>
</tr>
<tr>
<td>Transmission</td>
<td>Auto supplier E</td>
</tr>
<tr>
<td>Driveunit</td>
<td>Auto supplier F</td>
</tr>
<tr>
<td>Fuel injection, pump</td>
<td>Auto supplier G</td>
</tr>
<tr>
<td>Braking</td>
<td>Auto supplier G</td>
</tr>
<tr>
<td>Electric motor/drive</td>
<td>Auto supplier E, Auto supplier F, Auto supplier G</td>
</tr>
<tr>
<td>Battery cells, pack</td>
<td>Battery manufacturer H, Battery manufacturer I, International Battery Seminar experts</td>
</tr>
</tbody>
</table>

- 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

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

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