Transformation of the Automotive Industry:
Technological developments and their impact on employment and value creation

Visit of the IHEDATE Institute | Stuttgart | June 28, 2023

Dr.-Ing. Florian Herrmann
Profile of the Fraunhofer-Gesellschaft
Application-oriented research for the direct benefit of business and for the benefit of society

30,000 Employees
76 Institutes and research facilities

Financial volume

- €2.9 billion Expansion investments and defense research
- €2.5 billion Around 30 percent basic funding from the federal and state governments
- €2.5 billion Around 70 percent industry orders and publicly funded research projects

2021

30,000 Employees
76 Institutes and research facilities
Joseph von Fraunhofer (1787 to 1826)

- **Researcher**
- **Inventor**
- **Entrepreneur**

Fraunhofer-Gesellschaft (since 1949)

- **Research and development** on behalf of industry and government
- **Inventor**
- **Entrepreneur**

- **Music format mp3, white LED, high resolution thermal camera**

Discovery of the "Fraunhofer lines" in the solar spectrum

New processing methods for lenses

Manager and partner of a glassworks

Research volume: approx. €2.9 billion per year
Application-oriented research for business and society
Fraunhofer IAO and IAT of the University of Stuttgart

- 630+ Employees
- 43.2 Mill. EUR turnover
- 7 Locations and research facilities
- Center for Responsible Research and Innovation CeRRI, Berlin
- Fraunhofer application center KEIM, Esslingen
- Research and Innovation Center for Cognitive Service Systems KODIS, Heilbronn
- Werksviertel-Mitte Munich, living lab
- Fraunhofer Innovation Engineering Center IEC, Bozen (Italy)
Fraunhofer IZS
Institute Center Stuttgart

- Fraunhofer Institute for Industrial Engineering IAO
- University of Stuttgart Institute of Human Factors and Technology Management IAT
- Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
- Fraunhofer Institute for Building Physics IBP
- Fraunhofer Institute for Manufacturing Engineering and Automation IPA
- Fraunhofer Information Center for Planning and Building IRB
Joining forces for sustainable success

Locations

Center for Responsible Research and Innovation CeRRI, Berlin
www.cerri.iao.fraunhofer.de (German only)

Forschungs- und Innovationszentrum für Kognitive Dienstleistungssysteme (KODIS), Heilbronn
www.kodis.iao.fraunhofer.de/en

Werksviertel-Mitte Munich
https://s.fhg.de/pionierHUB (German only)

Application Center KEIM at Esslingen University
www.keim.iao.fraunhofer.de (German only)

Fraunhofer Innovation Engineering Center IEC, Bozen (Italy)
www.fraunhofer.it/en
Research and development fields of the Fraunhofer IAO
Work and innovation in the digital transformation for a sustainable world

Research on employment & corporate development
- Knowledge and innovation work
- Production work
- Service work
- Workforce transformation
- Change management

Transformation management

Technology & innovation management
- Technology radar
- Foresight and scenario management
- Smarter cities
- Mobility innovations
- Smart energy solutions

Digital transformation
- Product development
- Smart services
- Digital business models
- AI and learning systems
- Quantum computing
Fraunhofer IAO - we research and advise

01 Research
- Publicly funded
  - Funded research projects
  - Operational development projects
  - Studies
  - User testing

Dare to innovate

02 Networks
- Directly commissioned by industry
  - Innovation networks
  - Industrial working groups
  - Expert seminars
  - Business Breakfast

Share experience/gain knowledge

03 Consulting
- Awareness Workshop
- Quick Checks
- Analysis projects
- Design projects
- Evaluation projects

Increase competitiveness
Research in the field of automotive transformation at the Institute
Electromobility, digitalization and new business models as research priorities

Study »Electromobility and Employment« ELAB 2.0

»New Mobility Academy« qualification initiative

Study »Employment 2030« commissioned by Volkswagen (2020)

Transformation dialogs and platforms

Strategic workforce planning at suppliers

Study »Impact on jobs in the vehicle trade and repair business 2030 / 2040«
Transformation of the automotive industry
A multitude of changes are shaping entirely new mobility and value creation systems

Interdependencies at different system levels

Component layer
- Software
- Material
- Semiconductors
- Sustainable drives
- HMI concepts
- Energy storage
- Software-Defined Car
- Modular design
- E/E architecture
- Geopolitics
- Mixed traffic
- Infrastructure integration

Vehicle layer
- (Open) vehicle platforms
- Modular design
- (Open) vehicle platforms
- E/E architecture

Ecosystem layer
- Legislation
- Multimodal mobility
- Social trends

Transformation of mobility solutions
- Electromobility
- Automated driving
- Connectivity

Transformation of mobility providers
- Standardization
- (Re-)qualification strategy
- AI
- Software development
- Data Science
- Circular economy
- Security
- Design for Sustainability
- Life Cycle Engineering
- Advanced Systems Engineering
- New business models
- Value networks

Competences
- Software
- Energy storage
- Semiconductors
- HMI concepts
- Energy storage
- Modular design
- E/E architecture

Processes
- New business models
- Value networks
- Design for Sustainability
- Advanced Systems Engineering
- Life Cycle Engineering

Value added
- Sector coupling
- Product Service Systems
- Supplier strategies

Interdependencies at different system levels

26/06/2023
Electromobility: Changes in the OEM production mix

Transformation speed increases rapidly

Clear trend through coalition agreement 2021, Fit for 55, etc.

Quelle: ELAB 2.0, Final report 2018, Work within WG 4 of the National Platform Future of Mobility 2019/2020/2021
Employment effects in vehicle and component production
Findings from the Employment 2030 research project commissioned by Volkswagen

The roll-out of electromobility in German plants might lead to a decrease of employment demand by 12% until 2029.¹

Decline in employment demand in vehicle production due to ratio and unit effects in particular.²

¹ Source: Beschäftigung 2030;¹ Data basis for 2019 planning round, 2029 target year;² Related to the reference vehicles Golf 8 and ID.3

Component Production

Powertrain components for BEVs is 40 – 60 % are less employment-intensive compared to an ICE.²

Aggregated, ICE powertrains are 70 % greater in labor volume compared to those of BEVs.²

ICE forms 100 % employment intensity, all other figures refer to time spent in 2023 and 300,000 units.
Employment effects through digitization
Findings from the Employment 2030 research project commissioned by Volkswagen

- **Employees** considered in 32 job clusters.\(^1\)
- By 2030: **Employment decline** primarily in direct areas of production & logistics.
- Noticeable employment effects in the **indirect sectors** not expected until after 2030 as a result of large-scale IT projects.
- Increasing **product complexity** and **new scopes of value creation** require new competencies in indirect areas as well.
- **Competence development in digital key topics** becomes a central challenge, as the required competence carriers are not sufficiently available on the market.
- **Tertiarization of work**: In production, increasing use of automation; in knowledge-intensive and creative areas, human skills remain indispensable.

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\(^1\) Coverage: 57% of VW AG VW Passenger Cars total

\(^2\) Strong growth expected due to increasing work volume through product and process digitization

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Employment effects 2030/2040 within the vehicle trade and repair business

Study in cooperation with Institute of Automotive Economics IfA commissioned by e-mobil BW

**Projection 1**
- Change in vehicle architecture
- New business models regarding the connected car
- Distribution models
- Process architecture
- Access to vehicle, customer and ecosystem data
- New services E-mobility

**Projection 2**
- Change in vehicle architecture
- Digitalization and automation of vehicles
- Digitalization of business processes
- Distribution models
- Process architecture
- New business models regarding the connected car
- Access to vehicle, customer and ecosystem data
- Electrification
- New services E-mobility

**Projection 3**
- Change in vehicle architecture
- Distribution models
- Process architecture
- New business models regarding the connected car
- Access to vehicle, customer and ecosystem data
- Electrification
- New services E-mobility

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Slide 14
**Employment effects 2030/2040 within the vehicle trade and repair business**

**Projection 2 - Transformation of the vehicle trade and repair business „leadership of the OEM“**

<table>
<thead>
<tr>
<th></th>
<th>2022</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC-Sales</td>
<td>14,460 Franchise</td>
<td>11,510 Franchise</td>
<td>10,060 Franchise</td>
</tr>
<tr>
<td></td>
<td>7,520 Franchised dealerships**</td>
<td>5,265 Franchised dealerships**</td>
<td>4,510 Franchised dealerships**</td>
</tr>
<tr>
<td></td>
<td>6,940 Franchised workshops</td>
<td>6,245 Franchised workshops</td>
<td>5,550 Franchised workshops</td>
</tr>
<tr>
<td>UC-Sales</td>
<td>22,110 Independent</td>
<td>17,690 Independent</td>
<td>13,265 Independent</td>
</tr>
<tr>
<td></td>
<td>-18% Employees*</td>
<td>-28% Employees*</td>
<td></td>
</tr>
<tr>
<td>Vehicle stock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>49 mio. (new registrations: 2,9 mio.)</td>
<td></td>
<td>48.5 mio. (new registrations: 2,6 mio.)</td>
</tr>
<tr>
<td>BEV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 mio.</td>
<td></td>
<td>28 mio.</td>
</tr>
<tr>
<td>Automation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mainly level 2</td>
<td></td>
<td>mainly level 3</td>
</tr>
<tr>
<td>Share connected car</td>
<td>74</td>
<td></td>
<td>90%</td>
</tr>
<tr>
<td>Repair frequency</td>
<td>0.35</td>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td>Maintenance frequency</td>
<td>0.76</td>
<td></td>
<td>0.73</td>
</tr>
</tbody>
</table>

Vehicle population: 48.5 mio. (new registrations: 2.6 mio.)
BEV: 28 mio.
Automation: mainly level 3
Share connected car: 90%
Repair frequency: 0.28
Maintenance frequency: 0.73

Employees* compared to 2022 | **the business model of „franchised dealership“ includes a workshop.
Value creation through R&D
(indirekt in Produktions-wertschöpfung inbegriffen)

Value added by production (direct) = Sales \times \text{manufacturing prices}

Value creation through (new)mobility and mobility-related services

Value creation through distribution, after-sales and recycling, new approaches to the circular economy

Upstream processes:
- Engineering service providers
- Plant Engineers
- Suppliers T1, T2, Tn
- OEM

Downstream processes:
- Automotive service providers
- Courier, express and parcel services
- Driving service broker
- Insurance companies
- Energy purchase/billing
- Start-ups
- Data service provider
- IT and platform

And much more.
Shift in the scope of value creation and required competences
Securing own value creation scopes as challenges especially for SMEs

V-Model of Value Creation

- **Requirements**
  - Vehicle integration
  - Systems and modules
  - Components and parts

- **Realization**
  - OEM
  - Tier 1 Supplier
  - Tier n Supplier (SME)

**Ecosystem**
Increasing importance of digitization (platforms, etc.) and startups across the ecosystem.

**System**
Increasing understanding of how components work together required.

**Component**
Increasing skills required in handling electronics and high voltage.

Note: The SystEM and LieSE projects were funded by the Baden-Württemberg Ministry of Economic Affairs
Future skills (abilities and knowledge) with strongly increasing importance

Example: Future Skills Cluster for Baden-Württemberg

<table>
<thead>
<tr>
<th>Technological capabilities</th>
<th>Digital key qualifications</th>
<th>Industry capabilities</th>
<th>Interdisciplinary skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cybersecurity</td>
<td>Agile working methods</td>
<td>Alternative</td>
<td>Eigeninitiative</td>
</tr>
<tr>
<td>Data management</td>
<td>Digital &amp; data literacy</td>
<td>Antriebstechnologien</td>
<td>Flexibilität</td>
</tr>
<tr>
<td>Data science &amp; AI</td>
<td>Digital collaboration &amp; interaction</td>
<td>Analytische Chemie</td>
<td>Führungsfähigkeiten</td>
</tr>
<tr>
<td>Design</td>
<td>Basic IT skills</td>
<td>Assistiertes &amp; autonomes Fahren</td>
<td>Kommunikation / Überzeugungsvermögen</td>
</tr>
<tr>
<td>Intelligent Hardware &amp; robotic</td>
<td>Programming skills</td>
<td>Biotechnologie</td>
<td>Problemlosungs-fähigkeit</td>
</tr>
<tr>
<td>IT-Infrastruktur &amp; Cloud</td>
<td></td>
<td>Electrical Engineering</td>
<td>Resilienz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zielorientierung</td>
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</tbody>
</table>

Source: Study "Future Skills - Which skills are critical for success in Baden-Württemberg today and in the future", AgenturQ 2021
New value creation paths for companies

Opportunities for tapping value creation potentials

Transfer of **product and process know-how** to future requirements of modern e-vehicles (e.g. contacting, filter systems, thermal management, E/E architectures)

**Development of new competencies** and **market fields** in automotive **growth drivers** (e.g. drive and charging technology, energy storage, fuel cell technology)

Transfer of product and process know-how to new application fields outside the vehicle (e.g. e-bikes and micromobiles, automated transportation, drones and air cabs, stationary applications, vehicle and infrastructure networking)

**Establishment of new value creation systems and business models** (e.g. hydrogen economy, new services and data-driven business models)

Challenge: "Utilization" of competencies from conventional fields and development of competencies for future fields
New value creation paths for companies
New value creation systems and business models - example hydrogen economy

<table>
<thead>
<tr>
<th>Mobility and transport</th>
<th>Building heat and power</th>
<th>Electricity sector</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Public transport (bus, train, plane...)</td>
<td>• Building heating systems</td>
<td>• Intermediate storage of green power (e.g. at generation plants)</td>
<td>• Burners for process heat</td>
</tr>
<tr>
<td>• Freight transport (truck, ship...)</td>
<td>• (Emergency) power units</td>
<td>• Power generation (gas turbines, peak load coverage)</td>
<td>• Mobile micro fuel cells (laptop, cell phones, lighting)</td>
</tr>
<tr>
<td>• Intra/extralogistics (forklift, apron vehicle)</td>
<td>• Supply infrastructure</td>
<td></td>
<td>• Construction machinery and off-road applications</td>
</tr>
<tr>
<td>• Car, drone, micromobile...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Gas stations and infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Technologies (selection):
- Fuel cells (systems)
- Batteries (short-term storage)
- H2 combustion engines
- Storage & Compressors
- Safety technology
- Pipelines

Technologies (selection):
- Fuel cell heating systems
- Batteries (short-term storage)
- Pressure accumulators
- Water treatment
- Electrolysers
- PV systems

Technologies (selection):
- Fuel cells (systems)
- Electrolysers
- Gas turbines
- Storage technologies
- Smart grid systems
- Transmission lines

Technologies (selection):
- Fuel cells (systems)
- Storage technologies
- Burner technologies
- Electrolysers
- PV systems

Challenges:
Economical production of green H2 (+E-Fuels), distribution infrastructure, safe and compact storage, general production readiness

Source: H2-Innovationslabor Heilbronn-Franken
Project example CYCLOMETRIC

More sustainable development of vehicle components in terms of the circular economy

Research subject
Impact of design decisions (e.g. modularization, material selection) in early phases of development on sustainability and cycle aspects of a vehicle.

Goal of the project
- Tool-based decision support for developers

Projektinhalte
- Development of a meta-model for product architecture design considering cycle-oriented influencing factors
- Definition of an approach for cycle-oriented product development
- Research approaches are based on Advanced Systems Engineering, in particular Model-Based Systems Engineering in combination with approaches of Life Cycle Assessment as well as Business Model Analysis.
Workforce Transformation
Concrete approaches for securing employment and expanding competencies

Within the company and between companies
- Development of new education and training formats and offerings (e.g. Faculty 73 at VW, Continental Institute for Technology and Transformation (CITT))
- Exchange of experience on framework conditions and best practices
- Early and proactive involvement of employees, e.g. in the testing of automation approaches and digitization tools

New paths and formats
- New ways of training future professionals and specialists, e.g. programming schools 42, Educational Technologies
- Establishment of new innovation and qualification formats in the company (Makeathons / Hackathons, Students teach Professionals, etc.)
- Agility in learning and in activities as well as strengthening of employees’ personal responsibility to make the workplace more attractive
- Utilization of opportunities for hybrid working / new work

Together in the network
- Participation in clusters of excellence, innovation partnerships and collaborative projects, e.g. in the areas of digital vehicles, data-based ecosystems, new business models, climate neutrality
- Participation in regional competence hubs and their activities in the individual federal states
- Utilization of funding opportunities in the context of the transformation (e.g. funding package KoPa 35c)
Thank you for your attention

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