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# Future Trends in Production Engineering

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# Method to Determine and Quantify Changes in Value Chains Caused by E-Mobility

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W. Sihn, D. Palm, H. Gommel, W. Tober, and C. Bauer

## 9.1 Introduction

Increasing production and sales figures for electrically powered vehicles affect the medium term value chains of the automotive industry. Some components of vehicles with conventional internal combustion engines are experiencing declining demand and are being replaced by the electrification of the drivetrain, either partially or totally. This leads – in dependence of the unit numbers of individual drive concepts – to value added shifts for the companies involved or also for industries which are part of the development and production processes of drive components. Within the scope of this work, a methodology will be introduced that allows a forecast and quantification of the effects of electric mobility on vehicle-specific national value added chains.

Previous approaches to determine and quantify changes in automotive value-chains caused by e-mobility are either rudimental, describing value-added shifts from mechanical to electric/electro-mechanic value added in a qualitative manner (e.g. [1, 2]), or scientifically founded, using input–output-models to quantify the effects [3]. The initially mentioned, general descriptions of the value-added shifts, however, permit no derivation of quantitative magnitudes for the description of the effects on domestic value added chains. Input–output tables, the database for input–output (IO) models, illustrate the inter-industry relations within a national economy, and, hence, allow the description of the service relationships of the respective sectors of a national economy to each other. Meade [3] analyses the macroeconomic effects of electric mobility in the USA, using a model called INFORUM-LIFT, which is an input–output-model for the analysis of the developments of the American national economy. To this end, assumptions are made with regard to domestic market penetration and production of vehicles and charging stations in order to estimate the effects on the input-coefficients on the basis of the respective technical changes and to compute, finally, the macroeconomic effects. Meade arrives at the conclusion that electric mobility causes a low macroeconomic effect when using the assumed low market penetration as a basis but that, nevertheless, individual industry fields will be significantly influenced. A detailed analysis on industry sectors or components was not conducted.

The use of input–output models is principally suited for the analysis of the effects on the domestic value added chains. However, the determination of preferably exact and market based input-coefficients is crucial to the models result. Hence, a higher level of granularity in respect of the technical analysis is necessary and was considered within the presented method.

Furthermore, the following disadvantages are associated with IO models:

- Often, these tables are only created at intervals of several years and are partially not current, hence. This refers not only to the respective numerical values but also to the basic section breakdowns and their service description. Thus, for example, the currently available IO table for Austria dates back to 2006 and, hence, has not yet been adapted to the new industry classification. The currently available IO table for Germany dates back to 2007.
- When looking at several sectors at once, the number of the IO coefficients to be estimated increases exponentially and, hence, leads to great effort.

The fact that the available IO table is not current, as well as the need for the consideration of structural differences

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between national automotive industries in comparison to the USA is bypassed and/or considered in the approach which is described in this work. Using the example of Austria characterized by a high number of established automotive suppliers and no domestic OEM, the use of national total vehicle production numbers as model variable, as used in the model of Meade, would result in misleading effects. Therefore the presented model examines the national automotive production potential on the more detailed level of components and sub-components. Building on an analysis of the technological changes inside the vehicle, the vehicle components affected by this are evaluated according to production costs. Using an assignment of the components to the industry classification applied in the national accounts, the absolute value added potentials per vehicle can be determined from the production costs by using the assigned industry key performance indicators. Furthermore, a market analysis, which is created in each case for the value added-driving components, is used to determine and predict just how strongly the international value added integration is coined in these areas and in which fields the national economy is at its strongest. Using this is a basis, it is possible to derive – for the temporal development stages under consideration – which respective proportions of the worldwide expected unit numbers will have a nationwide impact and, therefore, which direct value added effect this is going to entail at national level. Indirect value added effects as a result of the national service integration can be determined by means of extrapolated industry-specific statistics derived from the current aggregated IO multipliers. The methodology thus developed, therefore, allows for making a sound statement about extent and direction of electro-mobility related value added shifts, on the basis of technological shifts that have been analysed as well as on the basis of market shares of the respective nation under investigation that, in turn, have been derived from market considerations.

## 9.2 Problem Formulation

On account of the international integration of automotive value added chains and the focus of national value added chains on certain areas or sections of the value added, a uniform distribution of the national value added proportions in the global value added cannot be assumed across all the components of a given vehicle. Looking at the example of Austria, the nation holds 0.2% of the global market for total vehicles, but 2.5% of the world global for internal combustion engines or, more generally speaking, 0.25% of the global market for electronic components and 2% for mechanical components The neighbouring country of Germany, in comparison, already holds 9.5% of the global market share vehicles. Thus, a differentiated analysis of market shares at the component and part level is required.

In order to determine the value added shifts for existing parts, mean production costs, mean national value added and value added depth, as well as mean value added per employee can be used as reference. A similar approach of using these mean statistics was used in [4] to determine the value added an employee effects of charging infrastructures on Germany, or rather the region Baden-Württemberg.

However, what is more difficult here is the forecast for components for which no statistical data is available yet. This encompasses all electric-mobile induced components. For their calculation and potential determination, there is a need to disassemble them into part components until an unequivocal assignment is possible to electrical or mechanical components. Using the production costs resulting in this disassembled state as a basis, conclusions can be drawn in turn, with the help of the corresponding industry key performance indicators, regarding the value added potentials and employee figures.

With the help of the production figures of passenger cars and a predicted change across time, the national value added shift and number of employees can be determined, therefore. On this occasion, it is necessary – for certain, highly complicated parts – to consider existing production capacities and their capacity limits. Whether a new investment is to be expected, for new capacities in the case of growth, is something that can only be assumed with a certain probability which orientates itself on general location factors and a mastering of technology by individual resident companies. Thus, for example, a maximum production capacity is installed in Austria of 250,000 units for complete vehicles – a further increase would be possible only by means of a new construction of a passenger vehicle factory. The probability that this could be set up in Austria, however, seems to be very low. With general components in the area of electronics or mechanics, there is no need to assume a basic capacity bottleneck.

## 9.3 Approach

The method is based on five defined passenger car-vehicle concepts which differ concerning drive, the exhaust after treatment, power transmission and the energy storage; however, they are comparable in terms of road performance. Based on a classical internal combustion engine reference vehicle (RV), the following vehicle concepts for electric mobility have been defined: Plug-In-Hybrid electric vehicle (PHEV), Range-Extender vehicle (REV), battery electric vehicle (BEV) and fuel cell electric vehicle (FCEV). At component level, three different types can be identified in the five vehicle concepts: unchanged components, components affected by changes and new electric mobility components. New components and components affected by changes were evaluated for the individual vehicle concepts according to production costs and were forecast for 2020 as well as in 2030, taking into account

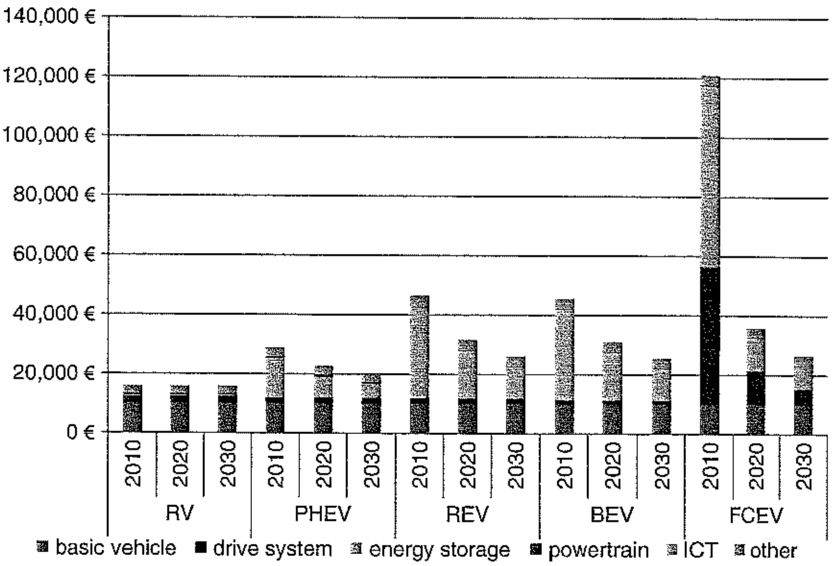


**Fig. 9.1** Production costs of vehicle concepts from 2010 to 2030

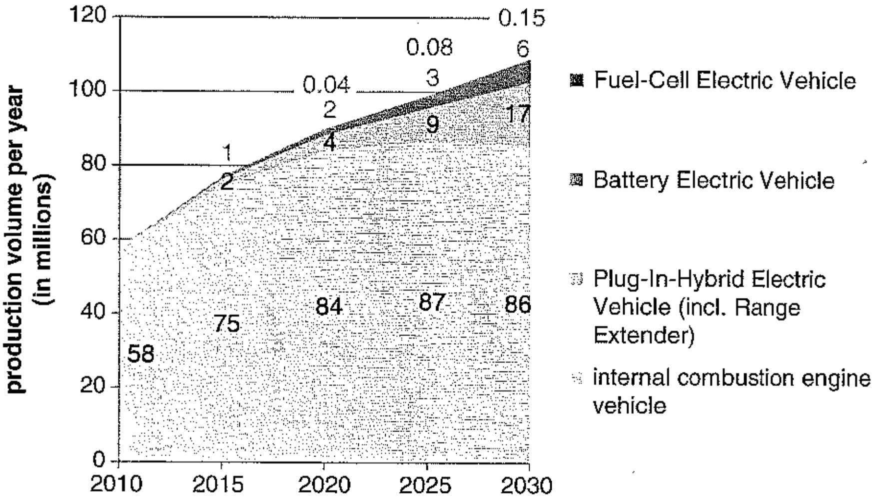


**Fig. 9.2** Annual production volumes of vehicle concepts from 2010 to 2030

learning effects and experience effects on account of rising unit numbers, new technologies and materials as well as increased efficiencies in the production processes (cf. Fig. 9.1).

### 9.3.1 Unit Number Scenario

On the basis of existing studies as well as with the help of OEM expert surveys and Technology Readiness Level estimates, a unit number scenario was developed for the five vehicle concepts for the years 2020–2030 (see Fig. 9.2).

With this, global value added shifts can be forecast at component level across the years under consideration (see Fig. 9.3).

If one compares global total value creation, taking into account electric mobility, it can be seen that this is higher in sum total than it would be when taken for conventional vehicles alone. The concepts of the electric mobility, therefore, lead to an overall higher value added in the automotive field. This is, above all, due to the high value added contribution in the area of traction batteries.

## 9.4 Effect on National Value Added Chains

On account of the international integration of automobile value added chains, the existing and theoretical potentials of the national companies must be put in context concerning

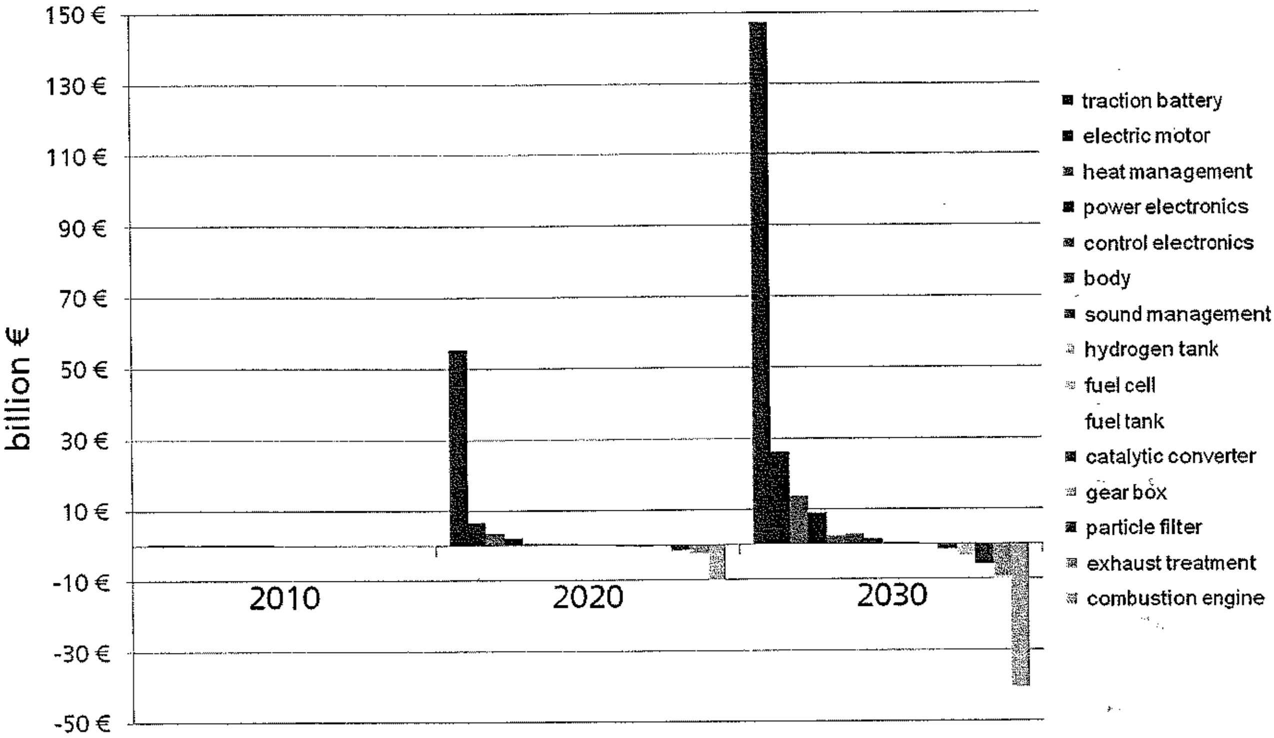


**Fig. 9.3** Changes in value adding for new and e-mobility-affected components (global)

international competition. Using research for the identification of the "global players" in the technology fields and product fields concerned, the competitive environment is evaluated for the different subassemblies and components. In subassembly-related market potential portfolios, the national position can be qualitatively evaluated, hence, in an international context: as a function of competitive environments and/or market entry barriers and competence of national companies, the potentials to position themselves in the markets for new technologies and products can be evaluated (ranging from very low to very high). This classification, in connection with determined average existing market shares of the national automotive industry relative to the global automotive value added, allows a forecast of potential market shares for the consideration period until the year 2030. The market shares calculated that way are validated with the help of an expert and company survey and were standardised. Using the global market shares determined at component level in connection with the component-related industry key performance indicators, finally, the value added impact and the impact on employment on the respective country can be calculated with the help of the unit number scenarios.

Another aspect with regard to the shift of national value added is the traction batteries' charging infrastructure necessary for electric mobility as well as hydrogen filling stations. Here, a clearly lower correlation is to be expected between worldwide production unit numbers and national values added. For instance, the sales of charging stations are primarily dependent on the number of electric vehicles in use. Hence, regional electric mobility proportions relative to the overall vehicle stock must be taken into account for infrastructure facilities. Using the average unit number growth factor of electric vehicles and the cost-based assessment of the charging stations, the national value added and the national impact on employment can be determined here in like manner to the approach with passenger vehicle components.

Figure 9.4 uses Austria as an example for the direct employment trend in automotive production. This consists of the additional employment potential for new components of electric mobility and the infrastructure, the positive as well as negative impacts on employment on the components affected by changes, as well as the components not affected by changes.

On account of the granularity, the model allows for different statements with regard to the employment trend. Thus, it is possible, for example, to determine industry-specific effects in such areas as mechanical or electric component manufacture, or even component-related or product-specific effects. Taking into account the multi-round effects on account of the national service integration, direct employment potentials can be used as a basis for drawing conclusions about indirect employment.

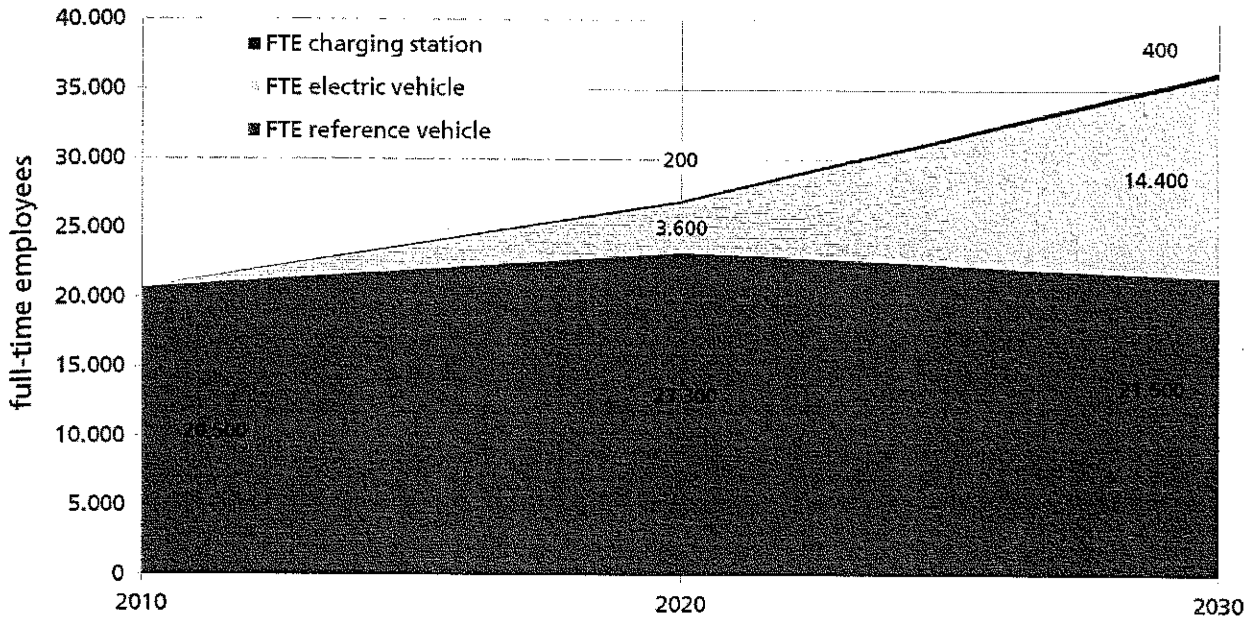


**Fig. 9.4** Development of direct employees in car production in Austria

## 9.5 Summary

The benefit of the method presented here, on the one hand, is in the findings from the competition analysis and competitor analysis and, on the other hand, the concrete determination of the value added potential. The advantages are briefly outlined below.

Competition analysis and competitor analysis:

- Pointing out national strengths for electric mobility
- Targeted use of national strengths by international comparison
- Identification of market opportunities which are internationally not exploited to capacity and of already exceptionally competitive fields

Value added potential determination:

- Improved risk evaluation for the existing national automotive industry
- Early reaction to qualification requirements in the industry
- Specific promotion of nationally especially relevant technologies and competencies
- Selection and promotion of technologies with high international unique selling proposition with, at the same time, high employment effect
- Targeted use of political grants and financial support measures in view of national value added effect

One aspect to be criticised here is that the methodology assumes a linear, continuous development in the subject area of electric mobility. Technology leaps, radical social or political change and corporate policy decisions of major impact cannot be registered and/or predicted by this method. Methods from the field of scenario engineering could be used here as well.

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