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Reviewing the impact of the low-carbon mobility transition on jobs

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Table 0. List of acronyms used

Powertrain types	Abbreviation	Definition
Internal combustion engine	ICE	These are conventional petrol or diesel cars with an internal combustion engine.
Mild hybrid vehicles	MHEV	An ICE with a small electric motor which can be used to improve fuel efficiency but not to power motion independently
Hybrid electric vehicles	HEV	Full hybrid electric vehicles that can be run in pure EV mode for some time.
Plug-in hybrid electric vehicle	PHEV	Plug-in hybrid electric vehicles have a large battery and an internal combustion engine. They can be plugged in to recharge the vehicle battery.
Battery electric vehicle	BEV	This category refers to fully electric vehicles, with a battery but no engine.
Fuel cell electric vehicle	FCEV	FCEVs are hydrogen fuelled vehicles, which include a fuel cell and a battery-powered electric motor.

1 Introduction

This report provides detailed insight into the drivers of the impacts on jobs from the transition to low-carbon cars and vans in Europe.

Rationale for the study

Most studies which seek to measure the socioeconomic impacts of the decarbonisation of cars and vans show a decline in employment in the motor vehicles sector in the long term. This reflects the lower complexity involved in the manufacture of pure electric vehicles (substantially fewer moving parts means less labour input is required into the manufacturing process). However, there are a number of characteristics of the transition - for example, the speed of the transition, and the relative role for plug-in hybrids (PHEVs) versus battery electric vehicles (BEVs) – which impact upon the evolution of employment in the automotive sector during the transition.

The aim of this study is to better understand what drives changes in employment across the different studies that have been carried out in this area, to help inform the development of policy goals and objectives which take this into account.

A shift to low-carbon vehicles (including to advanced powertrains, such as BEVS and FCEVs), will lead to substantial change in the automotive industry, and therefore on national economies and across the globe. Production processes will change, impacting upon European economies which are currently engaged in the manufacture of traditional motor vehicles. This will create both opportunities and challenges, and there is a need for policy actions to effectively deal with the transformation. While these impacts are relatively easy to understand, they are more difficult to quantify and forecast. A clear example of this is the expected net employment impact of low-carbon vehicle transition across the economy as a whole, which should take into account the impacts on firms manufacturing vehicles, component suppliers, firms manufacturing, installing and operating supporting infrastructure, as well as the wider impacts on the rest of the economy from changes in oil demand and the costs of transportation.

There are two strands of literature that have been reviewed for this study:

- the ELAB series produced by the Fraunhofer Institute for Industrial Engineering IAO for the German market (two editions: ELAB 1.0 carried out in 2012 and ELAB 2.0, a summary report of which was published in 2018, referred to as “ELAB studies”). Both studies had a number of project partners, drawn from industry, including BMW, Daimler, IG Metall, MAHLE, Robert Bosch, Schaeffler, VDA, Volkswagen and ZF Friedrichshafen.
- the ‘Fuelling Europe’s Future’ series, published by Cambridge Econometrics, on the socioeconomic impacts of the low-carbon vehicle transition, carried out for the European Union as well as for specific member states (referred to here as ‘the FEF studies’). The workstream started in 2013, and in total ten separate studies have been carried out[1]. The key reference used in this analysis is the study carried out in Germany, *Low Carbon Cars in Germany*[2], in order to allow the most direct comparison with the ELAB studies. In all cases, assumptions and scenarios are developed with input from a wide range of stakeholders; in Germany this included 50Hertz Transmission, ABB, BMW, Continental, Daimler, EnBW, Eurobat, European Aluminium, IG Metall, LANXESS, Michelin, The Mobility House, Naturschuntzbund Deutschland, Nissan, Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie, Toyota, Valeo, Verkehrsclub Deutschland, Verband der Automobilindustrie, Volkswagen and Verbraucherzentrale Bundesverband.

In each chapter that follows, a different characteristic of the modelling work (and therefore the anticipated transition) is explored, setting out how this particular driver relates to observed employment outcomes in the studies and how the assumptions used in studies differ.

[1] Three EU-level studies have been carried out, two covering cars and one on freight vehicles. In addition, national-level studies have been carried out in the UK, France, Germany, Poland, Spain and Italy (forthcoming).
[2] See https://www.camecon.com/how/our-work/low-carbon-cars-in-germany/

2 Sectoral coverage of the reports

Both series of work assess the impact of the transition on employment. However, a key distinguishing feature between them is the breadth of sectors that are analysed. The FEF studies assess the whole-economy impacts of the transition, using the E3ME model, while the ELAB studies only assess the impacts on the automotive sector and its value chain.

The E3ME model, which is used in the FEF studies, is an integrated macroeconomic simulation model, fully representing the linkages between the energy system, the economy and the environment at a national and global level. A key feature of the model is its ability to represent supply chain relationships and industry interdependencies: it incorporates automotive and petroleum refining industries explicitly and it can capture relevant spill-over impacts e.g. on jobs associated with increased demand for infrastructure deployment. E3ME also captures induced effects, due to changes in patterns of consumption. It can be broadly characterised as a ‘top down’ approach to understanding the impacts of the transition.

By comparison, the ELAB studies take a ‘bottom up’ approach to assessing employment impacts. They provide detailed insight into changes in employment in the motor vehicles manufacturing sector (ELAB 1.0, ELAB 2.0) and supply chains (ELAB 2.0), but do not consider the impacts of the transition across the rest of the economy.

This is a major difference between the studies; in the E3ME framework used in the FEF studies to assess the whole-economy impacts, while the impacts on the motor vehicles industry are mixed (for reasons explored in the subsequent chapters), the impacts on the rest of the economy are strongly positive; reductions in oil imports reduce leakage from the Germany economy, and create jobs and economic activity domestically.

The implication of this is that, by focussing solely on the motor vehicle industry and supply chains, i.e. those sectors which are expected to be most disrupted by the transition, the ELAB study will demonstrate the employment *cost* of the transition, without considering some of the wider economic benefits. Conversely, the FEF studies show employment impacts by sector, so demonstrate both the job losses (in fuel supply sectors, and potentially in motor vehicle manufacture) and the gains (in electricity & hydrogen supply, electrical equipment and services).

3 Differences in labour intensities used

In the ELAB series, a bottom-up approach is used to assess the personnel requirements of vehicle manufacture at the level of individual parts and components along the value chain. These are then aggregated based on the current requirements of different powertrains (ICE, PHEV, BEV) to capture total labour requirements[3].

In the ELAB 2.0 scenarios, there is a shift within ICEs, from pure ICEs to mild hybrid vehicles (MHEVs), which increases the labour content required by 5.1% (diesel) to 5.8% (gasoline). PHEVs require either 10.1% (diesel) or 25.4% (gasoline)[4] increase in labour input, while a BEV requires 62.1% or 66.8% less labour input (compared to a gasoline and diesel vehicle respectively). Table 1 presents the jobs created in the manufacture of 1m vehicles, per powertrain, across the portion of the value chain captured in the data collection work.

Table 1 Employment intensities used in ELAB 2.0

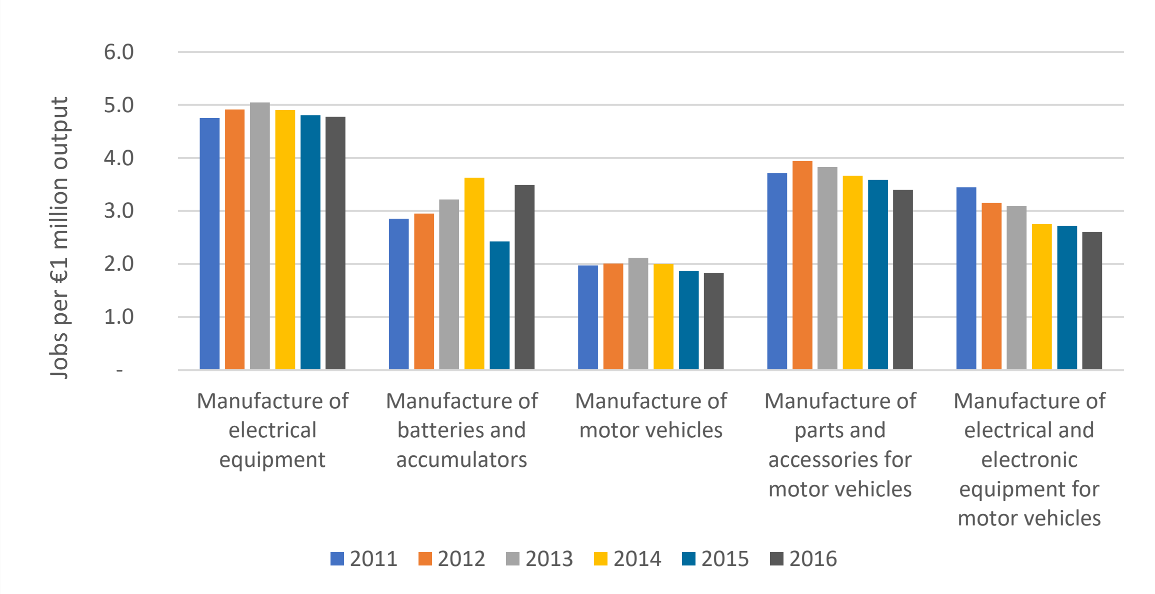
Powertrain	Employment per 1m units manufactured
Gasoline ICE	9450
Diesel ICE	10770
Gasoline MHEV	10002
Diesel MHEV	11322
PHEV	11854
BEV	3580

Source: own calculation, based on data from ELAB 2.0

By comparison, in the FEF studies, a top-down approach is used to estimate the impact of the transition to low-carbon cars and vans on the automotive sector and the electrical equipment sector. The approach involves the comparison of sectoral labour intensities (jobs per €1 million output), using data from Eurostat SBS (see Figure 1 below).

[3] To allow for a valid comparison when referring to the results of ELAB 1.0, the following aggregation of categories was used (original ELAB 1.0 categories in parentheses): ICE (ICE, Mild-HEV), HEV/PHEV (HEV, REX), Pure EV (BEV, FCEV).
[4] Note that in this study there is just a single archetype for PHEV, which uses a gasoline powertrain

Figure 1 Labour intensity of key manufacturing sectors in Germany



Source: Eurostat SBS (sbs_na_ind_r2), ratio of 'number of employees' to 'total production value'

In the FEF studies, the impact on employment is dependent on:

- the relative share of BEVs/PHEVs/FCEVs that are manufactured
- the labour intensity of manufacturing batteries versus ICEs
- the location of battery production and ICE production

In the FEF studies, personnel requirements for current vehicle production are calculated based on national accounts data. To model the effects of the transition to low-carbon mobility, supply chains for the traditional motor vehicle sector (captured through national-level input-output tables reflecting current value chains) are altered, with intermediate demand for motor vehicle components reducing (reflecting the removal of the internal combustion engine from the vehicle), and demand for electrical equipment increasing (to reflect the demand for electric motors and batteries). The employment intensity of the additional demand in the electrical equipment sector is calculated based upon detailed 4-digit NACE code data related to the current manufacture of electric motors and batteries (refer to Figure 1 above, which shows a comparison of sectoral labour intensities -jobs per €1 million output in Germany using data from Eurostat SBS).

Both the ELAB projects and CE FEF studies show that the production of a BEV requires less labour input than a current ICE vehicle, but also that the manufacture of HEVs and PHEVs is more labour-intensive than ICEs, reflecting the fact that these vehicles are more complex than ICEs.

The other key driver of the scale of automotive and supply chain jobs in the transition is the location of production, particularly of components required for advanced powertrains. In the FEF studies, sensitivities are carried out based on different future scenarios for battery cell manufacture; in the central scenario, in the specific case of Low carbon cars in Germany, it is assumed that battery cells are imported from Asia, and a sensitivity is tested where it is assumed that battery cells are manufactured in the EU. The FEF studies assume that battery cells account for half of the total value of a battery pack, with the assembly of battery packs and modules accounting for the remaining cost. Due to transportation costs and for logistical reasons, in the FEF studies, battery packs and modules are assumed to be assembled close to the intended market (i.e. in Europe).

In the ELAB 2.0 study, while an assessment is made of jobs created in the manufacture of battery packs (traction battery, 60 kWh), the value chain for these components does not include the manufacture of the cells.

The ELAB 2.0 study presents greater job losses in the automotive sector and supply chain than the FEF studies; based upon the bottom-up approach used in ELAB, these numbers are likely to be more accurate for Germany than the top-down approach taken in FEF based upon broader sectoral productivity levels, even though there is not complete coverage of the value chain. However, it should be noted that the archetypes presented in ELAB omit some components (such as batteries) that are not currently manufactured in the EU, without assessing whether the onshoring of such activity might affect overall job numbers.

4 The impact of different fleet mixes

Both the ELAB and FEF studies agree that the net employment impact of the transition upon the automotive sector will be a function of the specific vehicle production mix required in Germany (and Europe) over the period, and specifically the balance between BEV and HEV/PHEV demand in new sales. As noted above, conventional ICEs are relatively complex to manufacture, while more efficient and more advanced ICEs are associated with even higher labour inputs due to the higher component complexity. PHEVs, with two powertrains, are also more labour-intensive than conventional ICEs. BEVs, with fewer moving parts and reduced complexity, are more straightforward to build, and thus require less labour input.

As a result, the mix of powertrains in new sales over time is a major driver of differences in employment required in the automotive sector. Table 2 compares the powertrain deployments envisaged in the ELAB studies (1.0 and 2.0) and that from the Germany-specific FEF study, Low-carbon cars in Germany (comparing in all cases the central decarbonisation scenario).

Table 2 Powertrain deployment in new sales from key studies (% share, 2030)

% share of new sales	ELAB 1.0 Reference scenario	ELAB 2.0 Scenario 1 "EU-benchmark targets"	Low-carbon cars in Germany: TECH scenario
ICE	55	60	53
HEV/PHEV	30	15	31
Pure EVs	15	25	17

Notes: To allow for a valid comparison, powertrains used in ELAB 1.0 and Low carbon cars in Germany were aggregated to the categories presented in ELAB 2.0 in the following way - ICE (ICE, Mild-HEV), HEV/PHEV (HEV, REX), Pure EV (BEV, FCEV).
Source: Fraunhofer IAO (2018), Cambridge Econometrics (2017)

The ELAB 2.0 study sees a substantial shift towards pure BEVs, with only a small role for PHEVs. This contrasts markedly with both the assumptions of the original ELAB study and of the FEF Low-carbon cars in Germany study, both of which assumed in 2030 that hybrids (which are more labour intensive) would represent around 30% of new sales. In the FEF study, all scenarios were designed in consultation with the stakeholders, including vehicle manufacturers such as BMW, Daimler, Volkswagen and the VDA, in order to follow what the group believed was the most likely transition pathway.

Given that the ZLEV mandate suggested by the European Commission in November 2017 has an upper emissions limit of 50g CO_2/km, covering both PHEVs and BEVs, there is currently little in the way of policy to prompt a rapid shift to BEVs; it is thus largely a question of incentives provided by governments (where direct subsidies which favour one technology or the other could influence consumer take-up) or shifts in producer/consumer behaviour that will dictate the relative rates of take-up of PHEVs and BEVs. However, it is clear that the balance between these two substantially impacts upon the employment impacts of the transition within the automotive industry and supply chains.

Under the central scenario in ELAB 2.0, once expanding coverage to the whole value chain (rather than just those parts of the value chain that were directly contacted in the study), Scenario 1 leads to around 4,000 fewer jobs per 1m vehicles produced in 2030. If all German production of motor vehicles is considered (5.65m vehicles were produced in Germany in 2017[5]), this equates to around 22,600 fewer jobs than there are in the industry

[5] ibid

today. Note that all figures here exclude the impacts of productivity increases, which are discussed further below.

In the FEF central TECH scenario, the employment impacts over the same period (to 2030), are in fact positive, due to the shift to more HEVs and PHEVs, plus a more substantial increase in the labour content of ICEs (i.e. a greater deployment of new technology into these vehicles, as discussed later in this document). This leads to a net increase in jobs in the motor vehicle sector (including some, but not all, of the supply chains to the sector) of around 5,000 in 2030. Note that this is relative to the baseline scenario, rather than the current day, another point of distinction that is discussed later on.

The future take-up of PHEVs and BEVs is inherently uncertain; however, a more rapid switch to BEVs, as seen in ELAB 2.0, will lead to more automotive job losses in the period to 2030 than a slower shift supported by a shift towards PHEVs, as envisaged in the original ELAB study and (FEF) Low carbon cars in Germany study.

5 Technology improvements in ICEs

At the same time as motor vehicle purchases are shifting away from ICEs and towards advanced powertrains, in both the ELAB and the FEF studies new ICE vehicles are changing compared to the current generation of vehicles, and this has impacts upon the labour input required in their manufacture and therefore their net impact upon employment in the economy.

In ELAB 2.0, although not explicitly acknowledged, there appears to be a switch from traditional ICEs to mild hybrids. This is evidenced through i) the fact that archetypes exist for both gasoline and diesel mild hybrids and ii) that a decrease in market share of 37% for ICEs in Scenario 1 (from 97% to 60% of new sales) reduces personnel requirements attributable to ICEs by only 26%, implying a shift to more labour-intensive vehicles such as mild hybrids.

In the FEF studies, there is an explicit deployment of fuel-efficient technologies. In Low-carbon cars in Germany, this includes an explicit shift to more complex mild hybrids, but also the deployment of other efficiency measures such as engine downsizing, combustion improvements, thermodynamic cycle improvements and dual clutch transmission. These add to the complexity of the vehicle (and therefore the required labour input).

In both studies, the deployment of such technology leads to an increase in the labour input required for an ICE vehicle over time.

6 Improvements in the efficiency of production processes

There is plentiful evidence from the automotive industry and manufacturing more widely that production processes increase in efficiency over time and require less labour input for a given output. This is captured in both sets of studies.

In ELAB 2.0, productivity improvements are explicitly stated; the efficiency of production (measured as output produced by a fixed volume of labour) increases by 2% per annum with respect to the production of conventional components, and by 3% per annum for new components (reflecting the less mature nature of production processes for these new components, and therefore the greater potential for improvements).

In the FEF reports, the productivity of labour (captured as the volume of labour required to meet a given level of output) also improves over time, in line with long-term trends of improving productivity in the automotive sector and the relevant supply chain sectors (i.e. productivity improvements are all estimates based upon historical trends). In addition, the cost evolution of particular technologies is explicitly assessed (for example, batteries follow an exogenous cost reduction curve drawn from other studies), leading to productivity increases in these sectors.

However, the way such trends are reported is substantially different between the two studies. In the FEF studies, employment outcomes in the scenarios are always compared to a reference scenario (where the mix of vehicles being sold does not alter over time); this means that any productivity increases that are in ***both*** the reference and the TECH scenario will not influence the reporting of the difference between the scenarios (apart from where such productivity trends affect one technology more than another, and this is reflected in the scenarios). By contrast, the ELAB studies report employment impacts relative to recent history (i.e. 2017). In doing this, some of the reporting of results conflates employment effects from the shift in powertrains with the reduction in employment that would happen *regardless of the transition* due to productivity improvements in the industry over time.

While both studies take account of potential future improvements in improved efficiency in the production of both ICEs and advanced powertrains, the way that results are presented in the ELAB studies can conflate these with the explicit impact of the transition. By comparison, in the FEF studies, productivity trends are considered in baseline and technology scenarios in order to isolate the jobs impact of different transition scenarios.

7 Natural turnover in the labour force

Neither the ELAB nor the FEF studies consider how changes in employment in the automotive sector and supply chains relates to natural turnover in the labour force; specifically, how job losses in the sector relate to the number of retiring workers that can be expected over the period to 2030.

The majority of the workforce that are currently 50 and older employed in these sectors could be expected to retire by 2030; if job losses from the transition (as captured by the ELAB and FEF studies) can be managed through this process, then job losses become an absence of replacement jobs, i.e. not hiring new workers, rather than making members of the current workforce unemployed. While mitigating policy (such as training schemes) are still required in order to make sure that new entrants to the labour market have skills relevant to the new jobs on offer, a transition managed in this way could avoid some of the negative outcomes associated with substantial increases in unemployment among the existing workforce.

While both the ELAB and FEF workstreams do not consider the extent to which job losses can be managed through retirements from the existing workforce, such an approach can help to reduce the socioeconomic impact of the shifts in sectoral employment that the transition is expected to bring about.

7 Conclusions

This report analysed two key evidence streams that set out to assess the employment impact of the transition to low-carbon mobility; the ELAB studies (1.0 and 2.0), carried out by Fraunhofer IAO, and the Fuelling Europe's Future series (and particularly Low-carbon cars in Germany, the national study for Germany), undertaken by Cambridge Econometrics.

The studies assume different developments in the sales of advanced powertrains over the period to 2030; however, both are clear that a transition that favours plug-in hybrids has the potential for employment gains, while a rapid shift to battery electric vehicles will lead to job losses within the sector.

There are important methodological differences between the studies. The ELAB work presents detailed bottom-up assessments of job implications for the traditional motor vehicles sector and key supply chains but stops there. The FEF reports also estimate impacts upon these sectors, using a top-down, macroeconomic modelling approach, but also considers the wider socioeconomic implications of the transition, including the reduction in demand for imported fuels, the lower cost of mobility and the economic impact of investment in supporting infrastructure such as charging points.

The point of reference for the two studies is also different; while FEF sets out to compare employment effects of the transition in 2030 compared to no transition, in ELAB there is some overlap between the effects of the transition and underlying improvements in the efficiency of production processes, which is exacerbated by the fact that comparisons are typically made to the current day (2017) rather than a counterfactual scenario in 2030.

Despite these conceptual differences, many of the over-arching conclusions that the two studies reach are shared; that there are some negative employment impacts from the transition, and that public policy has a role to play in ensuring that the benefits of the transition are maximised, and the costs (particularly the potential job losses in the traditional motor vehicles industry) are managed and minimised.

Furthermore, given that the current ZLEV mandates proposed by the European Commission include PHEVs alongside BEVs, if employment effects is the primary concern of policymakers during the transition, auto makers should consider how they might help to steer consumers towards PHEVs, and expand investment in new technologies (including battery cell production) in order to protect existing jobs and create new ones in the supply chains to advanced powertrain vehicles.

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