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IMPACT OF ELECTRICALLY CHARGEABLE VEHICLES ON JOBS AND GROWTH IN THE EU

Particular focus on the EU automotive manufacturing and value chain

5 May 2018

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1. Summary of conclusions

The European Commission estimates the impact of electrification to be negative on jobs

1.1 The European Commission ("EC") published its Impact Assessment accompanying the proposal on CO2 targets for the EU automotive sector beyond the 2020/21 timeframe. The EC finds that:

(1) Battery Electric Vehicles ("BEVs") are less labour-intensive (i.e. reduce employment) and Plug-in-hybrids ("PHEVs"") are more labour-intensive (i.e. increase employment) than ICE vehicles;

(2) increasing the share of low emission vehicles[1] ("LEVs") has a small negative impact on employment (including a small negative impact on automotive employment) and a small positive impact on GDP by 2030.

Large differences between ICE and BEV technologies indicate the EC may have underestimated the scale of the negative impact on automotive jobs

1.2 Although the EC notes that BEVs are less labour intensive than ICEs, it does not explain its assumption on how much lower employment would be required in case of a switch to BEVs.

1.3 BEVs consist of fewer and less complex components and require less maintenance and fewer spare parts. The key differences between ICEs and BEVs summarised by a UBS study are reproduced in Table 1-1. This and other sources indicate that the reduction in automotive employment from switching to BEVs would be large: around 60% in powertrain manufacturing, spare part manufacturing and maintenance.[2]

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1 LEV passenger cars and LEV vans emit less than 25 gCO2/km and 40 gCO2/km, respectively.

2 See Section 3.

Table 1-1: Key differences between ICEs and BEVs

Aspect	ICEs (VW Golf)	BEVs (Chevrolet Bolt)
Mechanical complexity	More complex due to ~6-times more moving parts in the powertrain	Fewer moving parts, especially in engine and transmission
Complexity of electronics	Less complex	More complex: 6-10-times more semiconductor content
Spare parts	More spare parts required	Around 60% fewer spare parts required
After treatment equipment	Catalysts, filters which wear	None
Maintenance[3]	More maintenance needed First service after 16,000 km	Around 60% less maintenance First service after 240,000 km

Source: Table 3-1.

1.4 The findings of UBS are corroborated by a recent study by the IFO Institute which shows that in Germany 58% of German automotive manufacturing employment is dependent on ICE production.

1.5 Even if batteries were produced in the EU, the impact on employment would be small and would not compensate for the employment losses described above. In addition, since the skills needed for battery production are different from those needed for ICE production even partially offsetting automotive employment loss will require significant re-skilling.

The negative impact on certain regions, SMEs and employees with less relevant skills will be larger

1.6 Automobile manufacturing forms a significant share of total employment in some Member States and is further concentrated in certain regions. The transition to ECVs will disproportionately affect these regions which we list in Table 1-2 below.

3 This excludes tyre rotation and cabin filter change.

Table 1-2: EU regions with more than 20% share of automotive in manufacturing

Name of the region	Country	Automotive employment	Share of manufacturing employment	Share of total employment
Strední Cechy	Czech Republic	43,888	29%	7%
Stuttgart	Germany	160,445	28%	8%
Oberbayern	Germany	110,595	28%	5%
Niederbayern	Germany	38,869	27%	6%
Saarland	Germany	20,281	20%	5%
Leipzig	Germany	11,803	22%	2%
Molise	Italy	2,799	24%	3%
Basilicata	Italy	7,993	36%	4%
Dunántúl	Hungary	60,781	21%	5%
Sud - Muntenia	Romania	35,684	21%	3%
Macroregion 4	Romania	66,486	26%	4%
Bratislavský kraj	Slovakia	18,650	36%	6%
Västsverige	Sweden	35,822	25%	4%
West Midlands	UK	27,476	20%	2%

Source: Table 4-1.

1.7 Traditional part suppliers are expected to lose even more of the vehicle content that they currently capture (a loss of around 38%) than OEMs (a loss of around 17%).

1.8 Many of the part suppliers in the EU are small and medium enterprises, who may find it more difficult to manage the transition than OEMs. In Germany, around 21% of people employed directly or indirectly in the manufacturing of ICEs work for SMEs.

1.9 ECV production requires different and additional skills compared to ICE production. Large scale reskilling will therefore be necessary during the transition to ECVs. The new jobs which will be created in ECV production are largely skilled and semi-skilled which will place unskilled workers at a disadvantage.

2. The EC estimates the impact of increasing electrification to be negative on jobs

The impact of the transition to BEVs on the EU economy is complex

2.1 The mechanisms through which ECVs impact the EU economy are complex. The three main channels are:

(1) the switch to new technologies;

(2) the higher prices and lower mileage costs of ECVs; and

(3) the lower fuel consumption of ECVs.

2.2 The **switch to new technologies** has an impact on employment in manufacturing and in the supply chain depending on how labour intensive these technologies are and whether components are manufactured in the EU or outside. The maintenance requirements of ECVs are also different from those of conventional technologies. As the EC noted, BEVs are less labour-intensive whereas PHEVs are more labour-intensive than ICEs. Therefore a switch towards BEVs would be expected to decrease while a shift towards PHEVs would be expected to increase employment in the automotive value-chain.

2.3 On the other hand, ECVs require new infrastructure to be built and installed, which will have a positive impact on employment.

2.4 The **higher prices** of new technologies are expected to lead to a fall in car purchase and a decline in the competitiveness of EU manufacturers. The impact of these factors is negative on direct employment. Higher prices also reduce real consumer disposable income available for other products which reinforces the negative impact on EU wide-employment.

2.5 **Low mileage costs** have a positive impact on consumer disposable income leading to increased EU wide employment. They also have a positive impact on the competitiveness of EU automotive manufacturers leading to increased direct employment.

2.6 **Lower fuel import** reduces employment in refining and gasoline stations but increases employment in EU electricity production (in case of a switch to ECVs).

2.7 We summarise these impacts in Table 2-1 below.

Table 2-1: Employment impact of moving towards BEVs

Driver	Impact	Mechanisms
Technological change	Decrease	BEVs are less labour-intensive and batteries and other components may be produced outside the EU
Maintenance/ recycling	Decrease	Maintenance costs of BEVs are expected to be lower than those of ICEs
Fuel import	Small increase	The switch to electricity decreases employment in refining and at gasoline stations which is expected to be more than offset by increased employment in the electricity sector
Infrastructure	Increase	There will be positive employment impact from the construction and installation/maintenance of charging infrastructure
Higher purchase costs	Decrease	Higher purchase costs are expected to lead to a fall in car purchase and to a negative impact on direct employment
Lower mileage costs	Increase	Lower mileage costs are expected to increase car usage and to a positive impact on indirect employment
Total cost of ownership	Increase	If the total cost of ownership of the car is reduced and there are savings from low fuel spend, consumers will be able to spend more on other goods which increases employment

Source: FTI based on CE Delft (2012)

Impact of low emission vehicle production on jobs and growth

2.8 The EC's Impact Assessment accompanying its proposal on CO2 targets for the EU automotive sector beyond the 2020/21 timeframe[4] assesses the impact of emission targets on employment and GDP.

2.9 As part of its analyses, the EC compares three different scenarios for the share of low emission vehicles in vehicle registrations (LEV passenger cars and LEV vans emit less than 25 gCO2/km and 40 gCO2/km respectively)[5]:

- the **base case** achieves the proposed emission target in 2030 with 13% LEVs in registrations;
- **two alternative scenarios** assume the use of LEV incentives which are expected to result in increased share of LEVs in registrations (25% and 30% respectively).

4 EC, Emission performance standards for new passenger cars and for new light commercial vehicles, 2017.

5 The EC examines a number of different scenarios. The ones presented here isolate the impact of increasing the share of low emission vehicles on jobs and growth.

2.10 The EC models the impact of these three scenarios on jobs and growth in the EU, and therefore differences in jobs and growth across the three scenarios show the impact of increasing the share of LEVs. The EC considers that battery cells will either be produced outside the EU or in the EU, however it provides more detailed results for the case in which battery cells are produced outside the EU.

2.11 Table 2-2 presents the EC's estimates of the impact on GDP and employment of increasing the share of low emission vehicles in new vehicle registrations (assuming battery cells are imported).[6] The results show that increasing the share of LEVs from 13% (assumed to be achieved in the base case) to 25% and to 30% has a small negative impact on employment while the impact on GDP is slightly positive. Overall, it the EC models the impact of electrification on both employment and GDP to be small.

Table 2-2: Impact of increasing share of low emission vehicles on GDP and employment (change compared to baseline)

Share of LEV (<25 g/km)	13% --> 25%	13 --> 30%
GDP, 2030	0.01%	0.00%
GDP, 2040	0.01%	0.01%
Employment, 2030	0	< 0
Employment, 2040	- 4.6 million	-11.1 million

Note: absolute figures are calculated from the EC's % figures which are rounded.
Source: EC Impact Assessment pages 138 and 140.

2.12 The small overall impact is not the result of large sectoral changes offsetting each other. Table 2-3 below sets out the EC's estimated impact of a higher share of low emission vehicles on employment by sector. The largest impact is on the automotive value chain which loses 16,600 jobs when the share of LEVs increases from 13% to 30%. In the same scenario the largest gain is by the electricity sector adding 9,400 jobs.

[6] Employment includes employment in the automotive value chain and other sectors such as refining and electricity production.

Table 2-3: Sectoral employment ('000s) by share of low emission vehicles, 2030

Share of LEV (<25 g/km)	Base case (13%) Total empl.	13%-->25% Δ empl.	13%-->30% Δ empl.
Petroleum refining	150	0.4	0.5
Automotive	2,451	-9.3	-16.6
Rubber and plastics	1,781	2.1	2.1
Metals	4,293	-0.7	-0.7
Electrical equipment	2,458	-2.1	0.4
Electricity, gas, water	2,854	6.6	9.4

Source: EC Impact Assessment page 95 and 141.

2.13 The EC does not provide much detail as to what assumptions underpin these results. It notes however that:[7]

(1) Manufacturing battery electric vehicles has a lower labour intensity than that of conventional vehicles (whereas plug-in hybrids have higher labour intensity).

(2) A higher share of electronic components will require different and additional skills compared to the skills needed for the development, manufacturing and maintaining of conventional powertrains ('reskilling').

(3) Unqualified or low qualified workers may have more difficulties in acquiring the new skills and qualifications needed.

(4) SMEs that are highly specialised in certain elements of conventional powertrains may need more time to identify and develop new business opportunities.

(5) Regions with industry clusters built around conventional powertrains or with a strong refining industry may be more negatively affected.

[7] EC, IA, pages 95, 97, 98.

Stricter targets are projected to increase employment due to the share of PHEVs increasing faster than the share of BEVs

2.14 The EC's Impact Assessment estimates that a 40% emission target has a larger positive impact on employment than a 20% or a 30% target.[8] However, the EC's estimates do not distinguish between the effect of the move to ECVs (and in particular, to LEVs), which has a negative impact on employment (see Table 2-2 and Table 2-3), and the other impacts of emission targets on the economy.

2.15 The EC has noted that the labour intensity of BEVs is lower than that of ICEs and the labour intensity of PHEVs is higher than that of ICEs.[9] The impact of stricter emission targets on employment, therefore, depends on whether the shift is towards PHEVs or BEVs.

2.16 Table 2-4 below sets out the shares of ICE, PHEV, BEV and FCEV vehicles in registrations in 2030 for different emission targets. It can be seen that in each scenario the share of PHEVs is modelled to increase faster than the share of BEVs compared to the baseline.

Table 2-4: Share of powertrains in total passenger car registrations and employment impact (compared to baseline), 2030

Emission target (beyond 2020 targets)	ICE	PHEV	BEV	FCEV	Employment impact (000s)
Baseline	88.7%	6.7%	3.9%	0.7%	
20% reduction	82.6%	9.3%	6.4%	1.7%	+31
30% reduction	80.2%	10.8%	7.1%	1.9%	+71
40% reduction	72.0%	15.7%	9.7%	2.6%	+88

Source: EC Impact Assessment pages 73 and 74.

2.17 Table 2-4 shows that the share of PHEV powertrains is much higher in the 40% scenario than in the 30% scenario. The EC notes that the high share of PHEVs modelled for the 40% emission target is the reason for stricter emission targets having a positive impact on employment:

> *"As a consequence of the changes in the powertrain shares in the fleet, the impact [of stricter emission targets] remains positive".*[10]

8 A no-regrets option: What discussions in the European Parliament spotlight about a light-duty 2025–2030 CO2 standard for the EU, ICCT, April 2018

9 EC Impact Assessment page 95.

10 EC Impact Assessment page 95.

3. Key differences between ICE and BEV technologies point to large negative impact on automotive employment

3.1 As discussed in Section 2 the EC did not explain its assumptions regarding the following factors:

(1) BEVs consist of fewer and less complex components;

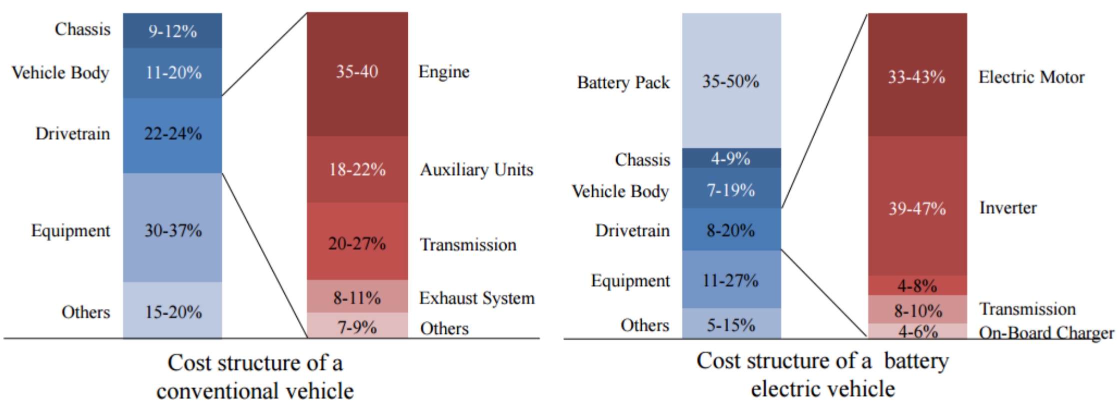
(2) BEVs require less maintenance and fewer spare parts; and, as a result,

(3) labour intensity of BEV production and maintenance is lower than that of conventional technologies.

Key differences between ICE and BEV technologies

3.2 For illustrative purposes, Figure 3-1 below shows the key components and the cost structure of ICE vehicles.

Figure 3-1: Vehicle components, ICE versus BEV



Source: Fuchs et al (2014), An overview of costs for vehicle components, fuels and greenhouse gas emissions

3.3 ICE vehicles contain components which BEVs do not require such as the fuel system, the injection system and the exhaust system. They also contain components which are significantly less complex than in conventional vehicles, such as the engine and the transmission system.

3.4 Analysts at UBS prepared a detailed comparison between the Chevy Bolt, *"the first real mass-segment"* battery electric vehicle and the Volkswagen Golf (a comparable ICE vehicle)[11]. Their key conclusions can be summarised as follows:

(1) Mechanical complexity of BEVs is much lower, whereas their electronic complexity is higher. UBS counted 24 moving parts in the Bolt's powertrain, versus 149 in the Golf.

(2) Semiconductor content is about 6-10 times higher in the Bolt's powertrain than in the Golf's.

(3) The number of moving and wearing parts is significantly smaller in the Bolt compared to the Golf: only 3 moving parts in the e-motor versus 113 in the Golf's engine; only 12 moving parts in the Bolt's gearbox versus 27 in the Golf's; total moving and wearing parts in the Bolt are 35 versus 167 in the Golf.

(4) The Golf requires emissions after treatment components (catalysts, particulate filters) which wear down, whereas the Bolt does not.

(5) The Bolt requires service after 240,000 km (or after 5 years, whichever is sooner), whereas the Golf requires servicing after every 16,000 km.[12] UBS estimates that aftermarket revenues (service and parts replacement) could shrink by 60% in case of a full switch to battery electric vehicles.

3.5 Table 3-2 below summarises the above key findings.

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11 UBS Evidence Lab Electric Car Teardown, UBS, 2017

12 Excluding tyre rotation and cabin filter change.

Table 3-2: Key differences between ICEs and BEVs

Aspect	ICEs (VW Golf)	BEVs (Chevrolet Bolt)
Mechanical complexity	More complex due to ~6-times more moving parts in the powertrain	Fewer moving parts, especially in engine and transmission
Complexity of electronics	Less complex	More complex: 6-10-times more semiconductor content
Spare parts	More spare parts required	Around 60% fewer spare parts required
After treatment equipment	Catalysts, filters which wear	None
Maintenance[13]	More maintenance needed First service after 16,000 km	Around 60% less maintenance First service after 240,000 km

Source: UBS Evidence Lab Electric Car Teardown, UBS, 2017

3.6 As a result of their lower mechanical complexity and fewer parts, the production and maintenance of BEVs are less labour intensive than those of conventional vehicles (as was noted by the EC). For, example, Daimler notes that *"80-90% fewer jobs are necessary to produce electric engines than to produce combustion engines"*.[14] UBS also finds that *"e-motors are significantly easier and less costly to manufacture compared to engines and transmission, with lower costs and less labour input required"*.[15]

13 This excludes tyre rotation and cabin filter change.

14 Industriemagazin (2016), Daimler-Betriebrat: Für Elektromotoren brauchst es nur ein Zehntel der Jobs. Heise Autos (2017), E-Auto: Daimler-Betriebsrat kämpft für Motoren-Jobs

15 UBS Evidence Lab Electric Car Teardown, UBS, 2017.

3.7 Similarly, Roland Berger expects that *"electrification will have a dramatic effect on the whole independent aftermarket value chain. Electric powertrains will consist of different technical components compared to the conventional combustion engine. An electrical powertrain will have less maintenance parts (e.g. oil filter) and less service fluids (e.g. motor oil). Also other vehicle systems, for example, the braking system, will be less used by electrical vehicles due to kinetic energy recuperation. This will have an impact on the spare parts volume, especially for high runner maintenance parts (e.g. oil filter, fluids, brake discs and pads). Parts suppliers of conventional combustion engine parts (e.g. filters, oil and engine components) will lose volumes and have to reposition or will even not exist any longer"*.[16]

Employment dependent on ICE technology

3.8 As mentioned above, some components of ICEs are not necessary for BEVs (e.g. fuel injection systems) while others are simpler in BEVs (e.g. transmission). A 2017 study by the IFO Institut focussing on Germany estimated the number of people engaged in manufacturing products which would be directly affected by the transition to BEVs (i.e. products are only useful for ICEs) and products which would be indirectly affected (i.e. the products would be simpler for BEVs than for ICEs).

3.9 The key findings of the study are summarised in Table 3-3 below. Out of around 800,000 people employed in automotive manufacturing in Germany in 2015, 426,000 people depended directly and 44,000 indirectly on ICE production (52.4% and 5.5% respectively). In the metal sector, another large employer, 70,190 people or 10.7% are estimated to be indirectly dependent on the production of ICEs. Taking all sectors into account, the study finds that in Germany around 457,000 people are employed in production of products which are only useful for ICEs and around 163,000 people work on products which would be less complex in BEVs.

[16] Roland Berger, 2016, The IAM in 2030

Table 3-3: German employment directly and indirectly dependent on ICE technology

Category	Product group	Employment dependent on ICE technology	Share of total sector employment
Directly dependent	Automotive manufacturing	425,780	52.4%
	Electronic equipment	3,380	0.8%
	Machinery equipment	27,810	2.7%
	Total direct	***456,970***	
Indirectly dependent	Automotive manufacturing	44,470	5.5%
	Refinery of mineral products	8,140	44.4%
	Plastic equipment	8,150	2.4%
	Metalworking	32,140	12.5%
	Metal products	70,190	10.7%
	Total indirect	***163,090***	
Total		**620,060**	

Source: Auswirkungen eines Zulassungsverbots für Personenkraftwagen und leichte Nutzfahrzeuge mit Verbrennungsmotor, Falck et al., 2017, pages 26-27.

Employment in battery production

3.10 The transition to ECVs may increase employment in the EU in the production of batteries. There is, however, uncertainty as to whether batteries will be produced in the EU or will be imported.[17]

3.11 Even if batteries are produced in the EU, the employment impact in the EU would be small, according to the EC's estimates. The impact of producing batteries in the EU on employment is shown for the EC's different emission target scenarios in Table 3-4 below. The estimated impacts reveal an odd pattern: the impact is largest when emissions are reduced by 30% and lowest, only 2 thousand jobs, when emissions are reduced by 40%.

17 FTI Consulting, The Impact of Electrically Chargeable Vehicles on the EU Economy, March 2017

Table 3-4: Impact of battery cell manufacture location on employment

Emission target (beyond 2020 targets)	Impact of battery production in EU, 000 jobs
Baseline	26
20% reduction	11
30% reduction	51
40% reduction	2

Source: EC Impact Assessment, page 95.

3.12 Research and development of batteries is high skilled work which cannot replace lower skilled ICE employment such as maintenance and sales of parts. Production of batteries, likewise, requires skills which current employees in ICE manufacturing are not likely to have (see Section 4).

4. The negative impact on regions, SMEs and employees with less relevant skills will be larger

4.1 As discussed in Section 2, the EC pointed out that the transition to ECVs will have a larger negative impact on certain regions, SMEs and employees with less relevant skills:

(1) Regions with industry clusters built around conventional powertrains or with a strong refining industry may be more negatively affected.

(2) SMEs that are highly specialised in certain elements of conventional powertrains may need more time to identify and develop new business opportunities.

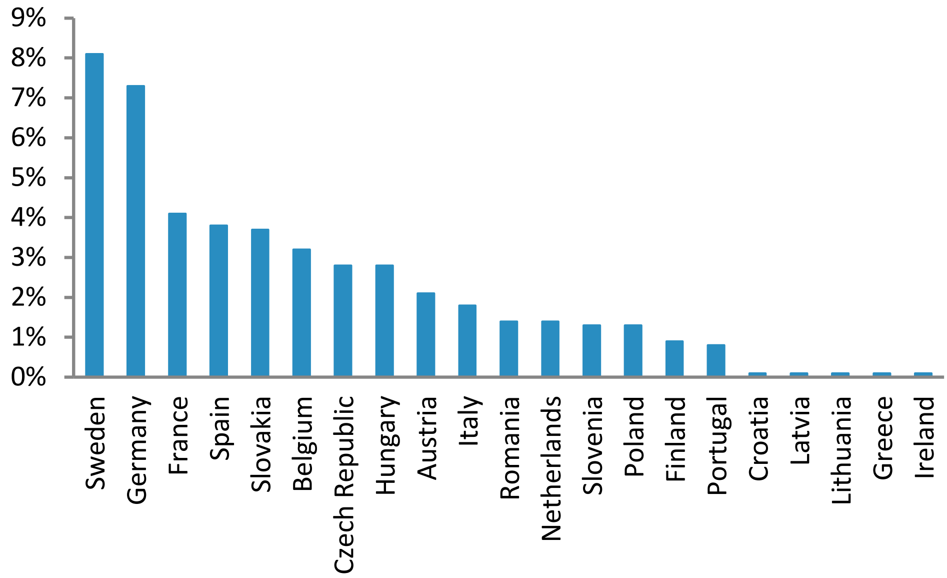
(3) A higher share of electronic components will require different and additional skills compared to the skills needed for the development, manufacturing and maintaining of conventional powertrains ('reskilling').

(4) Unqualified or low qualified workers may have more difficulties in acquiring the new skills and qualifications needed.

Regional concentration of the automotive sector

4.2 Automobile manufacturing takes up a significant share of total manufacturing employment in certain Member States. Figure 4-1 below shows motor vehicle manufacturing employment as a share of total manufacturing employment in 2015 in different Member States in the EU. Direct motor vehicle manufacturing varies from 0.1% in Ireland to 8.1% in Sweden.

Figure 4-1: Motor vehicle manufacturing share of manufacturing employment



Source: Eurostat, sbs_na_ind_r2.
Note: this only includes direct motor vehicle manufacturing.

4.3 Automobile manufacturing is important for a large number of European regions:[18]

(1) in 125 regions (nearly 40% of total) identified by Eurostat it accounts for more than 10% of manufacturing employment and in 54 regions (17%) it accounts for more than 15% of manufacturing employment;

(2) in 14 regions in the EU, including regions in the Czech Republic, Germany, Italy, Slovakia, Hungary, Romania, Sweden and the UK, the automotive sector has more than 20% share of the total manufacturing employment and in several regions people working for the automotive sector account for more than 5% of all employment (see Table 4-2).

[18] Eurostat, sbs_r_nuts06_r2.

Table 4-2: EU regions with more than 20% share of automotive in total manufacturing

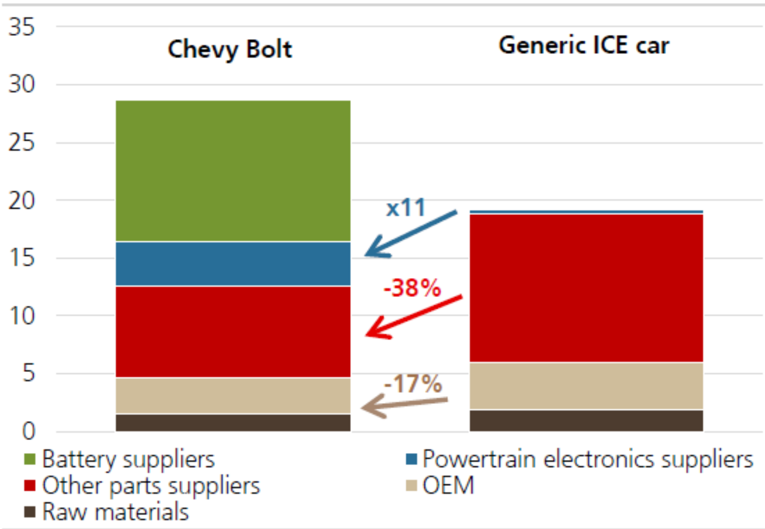
Name of the region	Country	Automotive employment	Share of manufacturing employment	Share of total employment
Strední Cechy	Czech Republic	43,888	29%	7%
Stuttgart	Germany	160,445	28%	8%
Oberbayern	Germany	110,595	28%	5%
Niederbayern	Germany	38,869	27%	6%
Saarland	Germany	20,281	20%	5%
Leipzig	Germany	11,803	22%	2%
Molise	Italy	2,799	24%	3%
Basilicata	Italy	7,993	36%	4%
Dunántúl	Hungary	60,781	21%	5%
Sud - Muntenia	Romania	35,684	21%	3%
Macroregion 4	Romania	66,486	26%	4%
Bratislavský kraj	Slovakia	18,650	36%	6%
Västsverige	Sweden	35,822	25%	4%
West Midlands	UK	27,476	20%	2%

Source: Eurostat, sbs_r_nuts06_r2. Note: this only includes direct employment in manufacture of motor vehicles, trailers and semi-trailers.

Traditional part suppliers and SMEs will be particularly negatively impacted

4.4 The study comparing the Chevy Bolt and the VW Golf by UBS we referred to in Section 3 found that 56% of the Bolt's vehicle content came from outside the traditional auto supply chain. (For the Bolt, LG supplies the battery and the powertrain electronics.) Figure 4-3 below, reproduced from the UBS study, shows that OEMs will lose some of the vehicle content that they currently capture but traditional part suppliers will lose significantly more.

Figure 4-3: Vehicle content on tier-1 level by sub-sector ($k)



Source: UBS Evidence Lab Electric Car Teardown, UBS, 2017

4.5 Many of the part suppliers in the EU are small and medium enterprises (SMEs). According to Eurostat, of over 10,000 firms involved in the manufacturing of parts and accessories for motor vehicles in the EU, over 9,000 firms are SMEs accounting for over 250,000 employees.[19] This does not take into account SMEs involved in maintenance and repair which will be equally affected as discussed in Section 3.

4.6 The study prepared by the IFO Institut we referred to in Section 3 provides some details on the share of employment by SMEs in Germany that directly and indirectly depend on the ICE technology. As can be seen in Table 4-4 below, the IFO Institute estimates that of the 620,000 people employed in the production of parts directly and indirectly dependent on the ICE technology, around 21% are employed by SMEs.[20]

19 SMEs are defined here as companies with fewer than 250 employees. Eurostat does not publish detailed data for the number of firms with at most 500 employees.

20 SMEs are defined by IFO Institut as companies with at most 500 employees.

Table 4-4: German employment directly and indirectly dependent on ICE technology

Category	Product group	Employment dependent on ICE technology	% employed by SMEs
Directly dependent	Automotive manufacturing	425,780	4%
	Electronic equipment	3,380	47%
	Machinery equipment	27,810	48%
	Total direct	***456,970***	***7%***
Indirectly dependent	Automotive manufacturing	44,470	35%
	Refinery of mineral products	8,140	43%
	Plastic equipment	8,150	65%
	Metalworking	32,140	63%
	Metal products	70,190	80%
	Machinery equipment	Data missing	48%
	Total indirect	***163,090***	***62%***
Total		**620,060**	**21%**

Source: Auswirkungen eines Zulassungsverbots für Personenkraftwagen und leichte Nutzfahrzeuge mit Verbrennungsmotor, Falck et al., 2017, pages 26-27.

Skills

4.7 The EC notes two challenges of the transition to ECVs relating to skills:[21]

(1) A higher share of electronic components will require different and additional skills compared to the skills needed for the development, manufacturing and maintaining of conventional powertrains ('reskilling').

(2) Unqualified or low qualified workers may have more difficulties in acquiring the new skills and qualifications needed.

[21] EC, IA, pages 95, 97, 98.

(1) Electronic components will require different and additional skills

4.8 ECVs contain more electric and electronic parts but are mechanically less complex than ICEs.[22] The transition to ECVs therefore decreases employment in mechanical and metal production while increasing employment in production of electric an electronic parts.[23] The skills required for mechanics and metalworking are different from the skills necessary for the production of electric and electronic parts. For example, workers in Germany are trained to handle electric circuits up to 60 volt. However, circuits of ECVs have voltages up to 1,000 volts, so further training is necessary to handle these parts.[24]

4.9 Table 4-5 below sets out the skills which are necessary to produce various components of ECVs.

Table 4-5: Skills necessary for the production of ECV components

Component	Skills required
Battery	Joining, joining technology, quality assurance, testing
Electric engine	Setting up, operation, monitoring and maintenance as well as testing and quality assurance
Power electronics	Training in electronics or mechatronics required for those who supervise and maintain highly automated systems as well as semi-skilled employees for assembly
Fuel cells	Technical competencies in the field of thin-film processing and electrochemical coating as well as competencies in terms of care, purity, quality assurance. Knowledge in lightweight construction and high pressure for hydrogen tanks.

Source: Elektromobilität und Beschaftigung, Hans Bockler Stiftüng, 2012, page 41.

4.10 Table 4-5 above shows that a number of skills are necessary for ECV components which are not required for ICE technologies, such as skills in electronics and electrochemical coating. Large-scale reskilling will therefore be necessary during the transition to ECVs.

22 UBS Evidence lab electric car teardown, UBS, May 2017.

23 Elektromobilität und Beschaftigung, Hans Bockler Stiftüng, 2012, pages 36 and 37.

24 Elektromobilität und Beschaftigung, Hans Bockler Stiftüng, 2012, pages 38.

(2) Unqualified or low qualified workers may find it difficult to acquire the new skills and qualifications needed

4.11 The new jobs which will be created in ECV production are largely skilled and semi-skilled jobs. Table 4-6 below shows the job profiles in the ECV industry described by the U.S. Bureau of Labor Statistics.

Table 4-6: Job profiles in the ECV industry[25]

Field of activity	Skilled	Semi-skilled	Un-skilled	Representative job profiles
Scientific research of batteries				Chemists, material scientists
Design & development of automobile technology				Engineers, software developers, industrial designer
Manufacturing				Assemblers, machinists, production managers
Vehicle maintenance				Automotive service technicians, mechanics
Infrastructure development				Urban and regional planners, power-line installers/repairers, electricians
Sales and support				Retail salespersons, customer service representatives

Source: Analysis of the Electric Vehicle Industry, International Economic Development Council, 2013, page 23.

4.12 Table 4- above shows that only two job profiles in the ECV industry involve un-skilled workers: maintenance and sales and support. The lower number of moving parts in ECVs compared to ICEs directly affects employment in maintenance and the sale of spare parts.[26] UBS estimates that maintenance and service for ECVs are 60% lower than for ICEs.[27] The transition to ECVs will therefore significantly decrease the number of un-skilled jobs in the automotive industry.

4.13 Employment created by increased research into batteries, one of the potential benefits of the transition to ECVs, will be skilled and inaccessible to semi-skilled or un-skilled workers. Similarly, employment created in infrastructure development will require skilled or semi-skilled workers.

25 This table includes PEVs as defined by the U.S. department of energy: https://www.afdc.energy.gov/laws/9355

26 Paragraph 3.2 to paragraph 3.6.

27 UBS Evidence lab electric car teardown, UBS, May 2017, page 7.

5. The transition poses challenges for the development of charging infrastructure and the grid

5.1 The transition to ECVs will pose a number of challenges for the EU's charging and electricity infrastructure:

(1) Millions of public charging points will have to be developed at high cost;

(2) The electricity network to households will need to be improved even for slow charging;

(3) Faster charging will require stations to connect to the high-voltage distribution network;

(4) The electricity demand of ECVs will require increased grid capacity.

Public charging will have to be developed

5.2 Public charging points are necessary for two reasons. Firstly, many households do not have off-street parking and therefore cannot charge at home. Secondly, public charging facilities are necessary to increase the range of ECVs and facilitate longer journeys. Table 5-1 below sets out the EC's estimate of the number of recharging points that would be needed in the EU if the share of ECVs in registration increased to 7% by 2025. The overall investment needed to develop the necessary charging points is estimated at around €17-23 billion.

Table 5-1: The EC's estimate of the required public recharging points

Year	Number of charging	Estimated costs of expansion
2017	118,000	n/a
2020	440,000	€3.9 billion
2025	2,000,000	€13.5-19.0 billion
Total costs		**€17.4-22.9 billion**

Source: EC, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure, 2017.

5.3 The EC's emissions targets proposed in 2017, however, require ECVs to reach a registration share of 13% by 2025, rather than the 7% assumed in the table above.[28] The actual costs of public charging points by 2025, therefore, will likely be significantly higher than those set out in Table 5-1 above.

5.4 The EC's cost estimates include chargers but do not take into account the necessary grid reinforcements.[29] The French grid operator estimates necessary investments of €930 million for low voltage and medium voltage grid reinforcements per every million ECVs.[30]

Electricity networks require upgrades already at slow charging

5.5 The charging of ECVs will put pressure on the grid through household charging and public charging points. Household charging of ECVs together with the use of household appliances such as ovens or washing machines can lead to the fuse being tripped. Therefore the electric infrastructure of houses will need to be upgraded.

5.6 Substation and peripheral routes and branches within a local distribution network may also not be able to deal with ECV chargers. Pilot projects identified voltage issues when five common household chargers (3.5 kW) were connected to a network cluster of 134 dwellings and were charging at the same time.[31] In Britain, around 32% of local electricity networks (312,000 circuits) will require upgrading when 40% - 70% of customers have ECVs.[32] The French grid operator estimates that the cost of low voltage reinforcement for home charging for every million ECVs is €200 million.[33]

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28 European Commission Impact Assessment, November 2017, page 73. Note: PHEV, BEV and FCEV are included in the 12.8%.

29 The EC estimates costs of slow charging points of €5,000 and costs of fast charging points of €30,000. Source: EC, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure, 2017.

30 Note: these are global estimates and do not take into account smart charging. Calculated as €930 million = €200 million + €650 million + €80 million. Source: Smart charging: steering the charge, driving the change, Eurelectric, 2015.

31 Forecourt thoughts: Mass fast charging of electric vehicles, National Grid, 2017.

32 My Electric Avenue Project: http://myelectricavenue.info/

33 Note: these are global estimates and do not take into account smart charging. Source: Smart charging: steering the charge, driving the change, Eurelectric, 2015.

Faster charging will require stations to connect to the high-voltage distribution network

5.7 The time it takes to charge a battery depends on the capacity of the battery and the speed of the charger. Table 5-2 below shows the battery capacity of the latest model of a number of ECVs.

Table 5-2: Battery capacity of recent BEVs[34]

Car	Year	Battery capacity, kWh
Renault Zoe	2017	41
Nissan Leaf	2018	40
BMW i3	2018	43
Tesla S	2017	75-100
Jaguar iPace	2018	90

Source: Footnote 38.

5.8 Table 5-2 above shows that the latest model of the Nissan Leaf, a small ECV model, has a 40 kWh battery.[35] A larger battery is necessary for a larger range. The 2018 Jaguar iPace will have a range of 310 miles with a battery capacity of 90 kWh.[36] Similarly, the Tesla S has a 75-100 kWh capacity. Given consumers' range anxiety, many ECVs in the future can be expected to be equipped with at least 90 kWh batteries.

5.9 Common household chargers are 3.5 kW chargers and 7 kW chargers.[37] Using these chargers it would take 19.3 hours and 9.7 hours to charge a 90 kWh car, respectively. A faster speed of charging would help to ensure batteries can be fully charged overnight and would help to spread the load on the grid: charging can be turned off when demand is the highest.

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34 Renault Zoe https://insideevs.com/new-2017-renault-zoe-ze-40-400-km-range-41-kwh-battery/; Nissan Leaf https://www.nimblefins.co.uk/nissan-leaf-battery-capacity-range; BMW i3 https://cleantechnica.com/2017/10/10/bmw-i3-get-43-2-kwh-battery-pack-late-2018-rumor/; Tesla S http://www.thedrive.com/sheetmetal/12820/tesla-is-silently-putting-bigger-battery-packs-in-its-entry-level-model-s; Jaguar iPace https://media.jaguar.com/2018/jaguar-i-pace-art-electric-performance.

35 https://insideevs.com/2018-nissan-leaf-debuts-recap-range-specs/

36 Forecourt thoughts: Mass fast charging of electric vehicles, National Grid, 2017.

37 Forecourt thoughts: Mass fast charging of electric vehicles, National Grid, 2017.

5.10 Fast chargers at public charging points currently go up to 50 kW, requiring 80 minutes to charge a 90 kWh car battery, a long time compared to the time it takes to fuel an ICE vehicle. To make charging at public charging points more attractive, power needs to be improved significantly. 350 kW chargers would take only 12 minutes to fill up such a battery.

5.11 Fast charging points are significantly more expensive than slow charging points.[38] Furthermore, the high-voltage grid will need to be reinforced and extended to allow for fast charging points. A charging point with nine installations with 350 kW capabilities would require an infrastructure capable of handling 3.1 MW, enough power to supply 1,000 average households. Such sites will be significant connections to the grid and would warrant a direct connection to the high-voltage distribution network.[39]

The electricity demand of ECVs will require increased grid capacity

5.12 The charging of ECVs will increase the daily electricity demand. In particular, it will increase the peak demand on the network (as charging of ECVs at home will be clustered as people start charging after arriving home from work), requiring an increase in the capacity of the grid.[40]

5.13 To manage the increase in overall electricity demand, electricity generation will need to be increased. This may be through renewable energy sources, but may in the short run also lead to an increase in consumption of other fuels.

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38 The EC estimates that the cost of fast charging points is 5-times higher than the cost of slow charging points. Source: EC, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure, 2017.

39 Forecourt thoughts: Mass fast charging of electric vehicles, National Grid, 2017.

40 Impact of uncoordinated plug-in electric vehicle charging on residential power demand, Matteo Muratori, 2018

5.14 As regards to peak demand, the timing of ECV charging will need to be managed. One way of doing so is through smart chargers, chargers which interact with the grid to decrease demand of ECVs charging during peak hours.[41] However, this will increase the threat of cyber-attacks on electricity networks and the chance of private information gathered by the ECV being hacked.[42]

5.15 Cambridge Econometrics suggested that one of the benefits of ECVs is Vehicle-To-Grid (V2G) charging, where the charge of batteries in ECVs is supplied to the grid during peak demand to supply other consumers.[43] However, there are several obstacles to this happening:[44]

(1) Drivers need cars mostly or fully charged in order to use vehicles, limiting the energy that can be supplied to the grid.

(2) Between 10% and 25% of the energy is lost between charging the battery and then using the same energy for the grid.[45]

(3) Using batteries for the grid would cause battery degradation.

(4) To compensate drivers, metering infrastructure will be necessary.

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41 https://www.cleanenergynews.co.uk/news/transport/all-electric-vehicle-chargers-sold-in-the-uk-to-be-smart-under-government-p

42 Challenges and opportunities of grid modernization and electric transportation, U.S. Department of Energy, 2017

43 Fuelling Europe's Future, Cambridge Econometrics, 2018, page 19.

44 Electric vehicle grid integration, ICCT, 2013

45 https://energymag.net/round-trip-efficiency/