BCG BOSTON CONSULTING GROUP

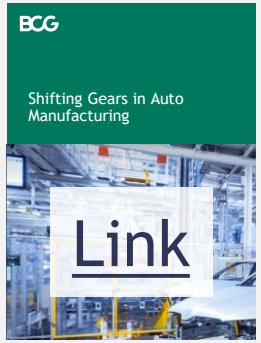
E-mobility: A green boost for European automotive jobs?

Results presentation

JUNE 2021

PLATFORM FOR electromobility

Study based on long journey around the topic



European Climate Foundation

Agora Verkehrswende

pspa

European Climate Foundation

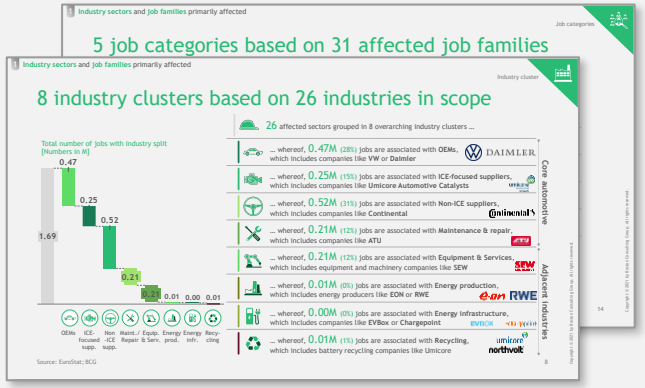
BCG Report "Shifting Gears"	Study on European level	Studies for Germany, Spain and Poland	*Additional country studies and scenarios*
September 2020	Start December 2020	Start April 2021	July 2021
BCG report about the shift in Automotive manufacturing	Study of the Automotive job development in Europe in collaboration with ECF	Dedicated country level studies in collaboration with local organizations	Additional country level studies for other important markets in consideration
Detailed analysis of the necessary labor units between ICEs and BEVs	Analysis of all major trends that are driving the Auto industry over next 10 years	Studies considering the highly different situation across EU countries	Idea for additional scenario analysis based on behavior in EU vs. China and USA

Study based on three important pillars

Interviews with various Auto experts

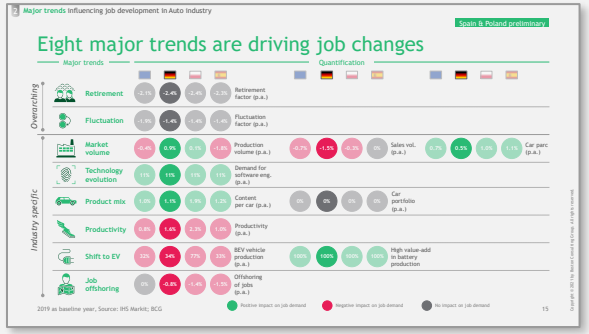
Over 45 interviews with platform members, industry and BCG experts

Job distribution across functions & industries



Job distribution across 26 industry sectors and 31 job families

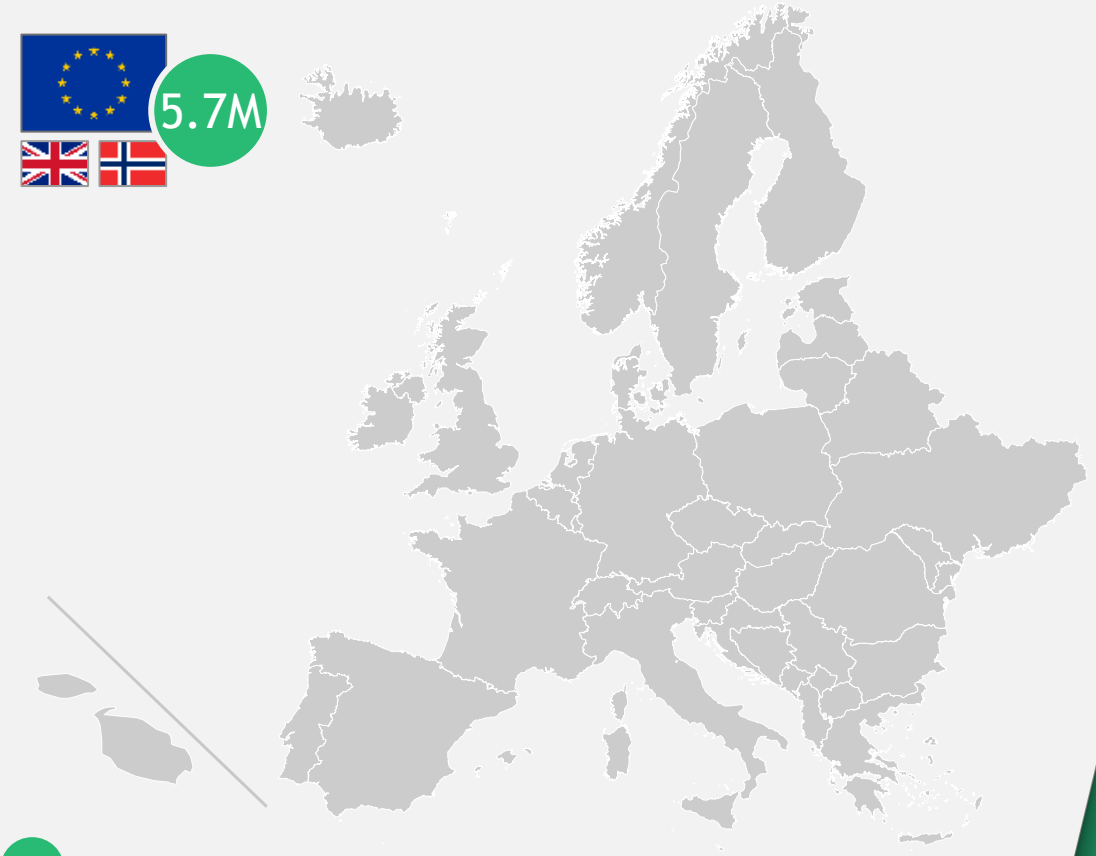
Trends along industry sectors and functions



Trends and industry-specific drivers for the next ten years

Source: BCG

Job development in Europe[1] from '20 – '30 …



X.XM Employees in scope (Basis 2020)

1. EU27 + UK + Norway
Source: BCG

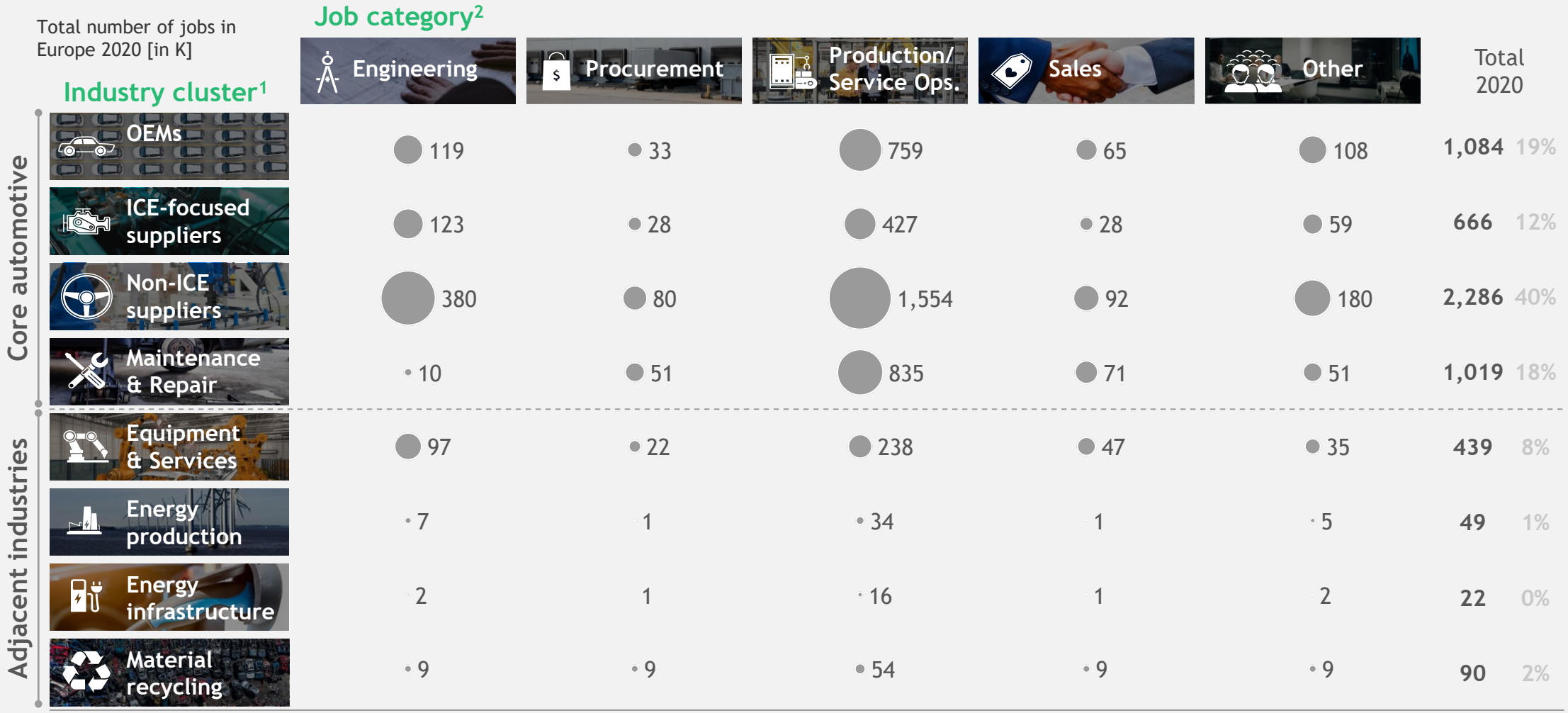
… presented along five building blocks

1. **Industry sectors** and **job families** primarily affected
2. **Major trends** influencing job development in Auto industry
3. **Net impact** of job development until 2030
4. **Shifts & replacements** in industry sectors and job families
5. **Recommendations** for companies and governments

Agenda

1. **Industry sectors** and **job families** primarily affected
2. **Major trends** influencing job development in Auto industry
3. **Net impact** of job development until 2030
4. **Transition** over time, across industries, job families, regions
5. **Recommendations** for companies and governments

5.65M employees across 8 industries and 5 functions

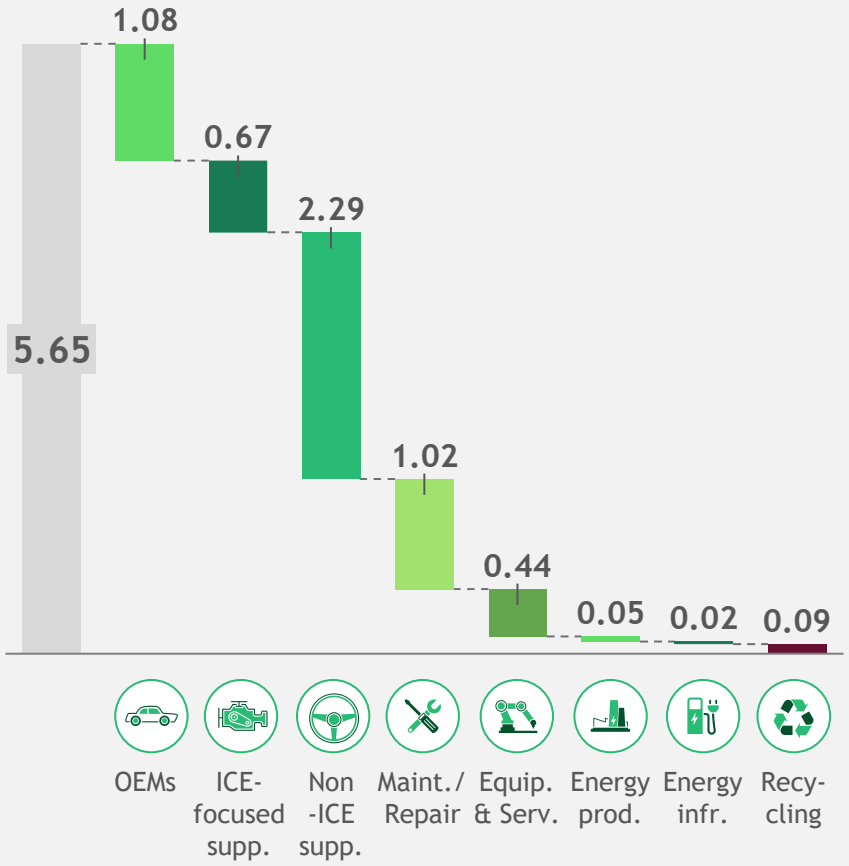


1. Based on 26 industries
2. Based on 31 jobs families

Source: EuroStat; BCG

8 industry clusters based on 26 industries in scope

Total number of jobs with industry split
[Numbers in M]



26 affected sectors grouped in 8 overarching industry clusters …

… whereof, 1.08M (19%) jobs are associated with **OEMs**, which includes companies like **Renault-Nissan** and **Tesla**

… whereof, 0.67M (12%) jobs are associated with **ICE-focused suppliers**, which includes companies like **Umicore Automotive Catalysts**

… whereof, 2.29M (40%) jobs are associated with **Non-ICE suppliers**, which includes companies like **Continental**

… whereof, 1.02M (18%) jobs are associated with **Maintenance & repair**, which includes companies like **Mobivia Groupe**

… whereof, 0.44M (8%) jobs are associated with **Equipment & Services**, which includes equipment and machinery companies like **SEW**

… whereof, 0.05M (1%) jobs are associated with **Energy production**, which includes energy producers like EON or RWE

… whereof, 0.02M (0%) jobs are associated with **Energy infrastructure**, which includes companies like **EVBox** and **Chargepoint**

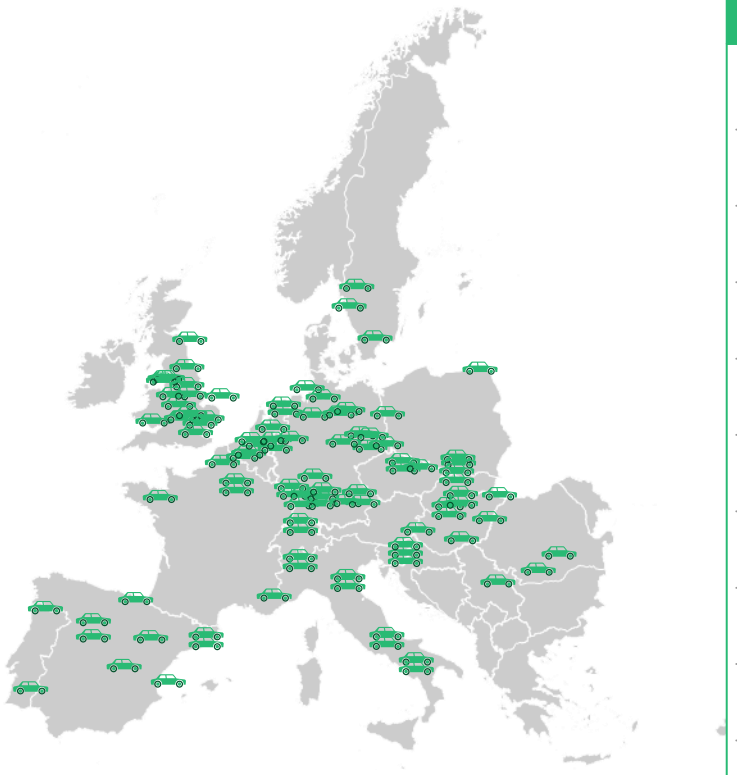
… whereof, 0.09M (2%) jobs are associated with **Recycling**, which includes battery recycling companies like Umicore

Core automotive

Adjacent industries

Source: EuroStat; BCG

Largest automotive OEMs account for ~1.1M jobs in Europe



Legend:

Light vehicle factories

Total employees of automotive OEMs in Europe

OEM	European employees '000	Factories (2021)
Volkswagen	417	26
Stellantis	172	11
Daimler	130	24
Renault-Nissan	103	13
BMW	88	6
Ford	45	4
Volvo	41	4
JLR	40	4
Toyota	25	3
Hyundai	15	2
Other	9	13
Total	**~1,084**	**110**

Source: IHS Markit 2021; OEM website and annual reports; Press search; ACEA; BCG

26 affected industries defined for detailed analysis along 8 industry clusters

Core automotive

OEMs

Manufacture of motor vehicles

ICE-focused suppliers

Manuf. bearings, gears & driving elements

Manuf. cooling & ventilation equipm.

Manuf. pumps & compressors

Non-ICE suppliers

Manufacture of bodies

Manuf. of electrical & electronic equip.

Manuf. rubber tires and tubes

Manuf. computers & equipment

Manuf. e-motors & generators ☆

Manuf. electric lighting equipm.

Manuf. of batteries & accumulators ☆

Shaping & processing flat glass

Manuf. of other parts & accessories

Maintenance & Repair

Maintenance & Repair of vehicles

Adjacent industries

Equipment & Services

Equipment & Machinery

Industrial Service provider

Energy infrastructure

Fuel infr. (Manuf. & Service)

Fuel infr. (Instal. & Ops.)

Charging infr. (Manuf. & Service) ☆

Charging infr. (Instal. & Ops.) ☆

Energy production

Manuf. of refined petroleum products

Production of electricity

Transmission of electricity

Distribution of electricity

Trade of electricity

Material recycling

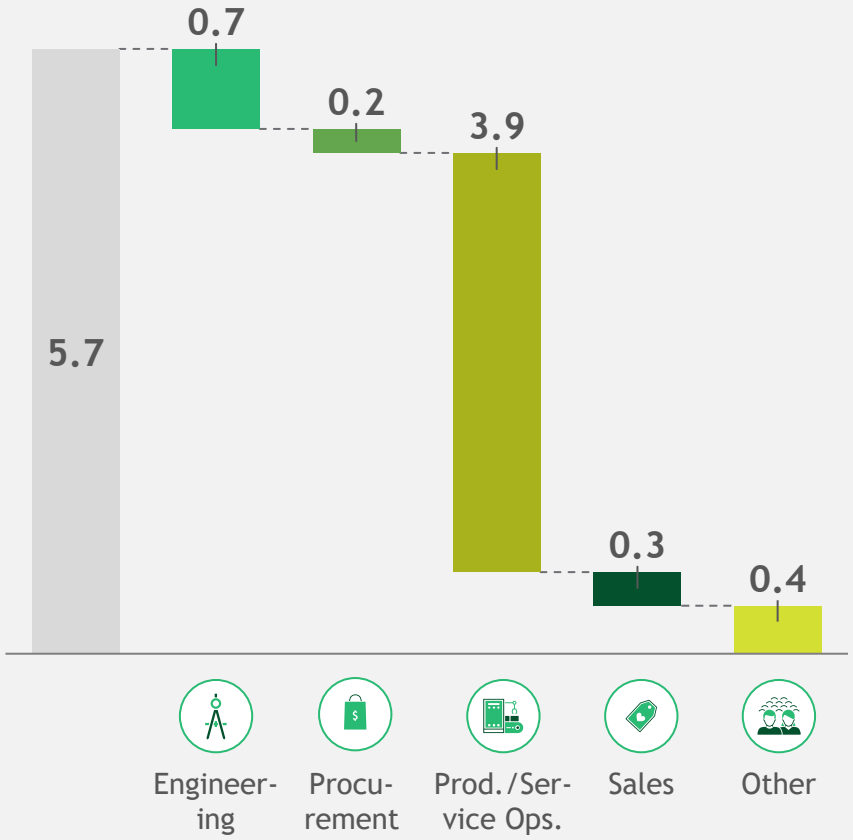
Recovery of sorted materials

☆ Extensive change in industry expected

Source: EuroStat; BCG

5 job categories based on 31 affected job families

Total number of jobs with funcitonal split in Europe [Numbers in M]



31 affected job families clustered in 5 categories along the value chain …

… whereof, 0.7M (13%) jobs are associated with **engineering,** which includes 9 company functions like Power units/electronics researcher

… whereof, 0.2M (4%) jobs are associated with **procurement**, which includes 5 company functions like Production material procurer

… whereof, 3.9M (69%) jobs are associated with **production & service ops.**, which includes 5 company functions like Production material procurer

… whereof, 0.3M (6%) jobs are associated with **sales**, which includes 5 company functions like sales analyst

… whereof, 0.4M (8%) jobs are associated with **other functions**, e.g., Human Resources

Source: EuroStat; BCG

31 job families defined within the affected company functions

Engineering

- Power units/electronics researcher
- Power units/transmission developer
  - **Electrical power unit developer** ☆
- (Vehicle) concept developer
  - **Thermal concept developer** ☆
- (Vehicle) feature developer
- **(Vehicle) Battery/Cell developer** ☆
- Software/system developer
- System/function developer
  - **Batterie mgmt. developer** ☆
- Electrical/mechatronic designer
- Development project manager
- Business partner manager

Procurement

- Production material procurer
- Production facilities procurer
- Services & transport procurer
- Vendor parts procurer
- Controlling/accounting staff

Production/Service

- Production planner
  - **E-motor production planer** ☆
  - **Battery/Cell production planer** ☆
- Operational production staff
  - **High voltage production staff** ☆
- Machine operator
- Logistics planner
- Operational logistics staff
- (Production) maintenance staff
  - **Charger maintenance staff** ☆
- (Vehicle) mechanic
- (Vehicle) electrician
  - **Charger installation staff** ☆

Sales/Marketing

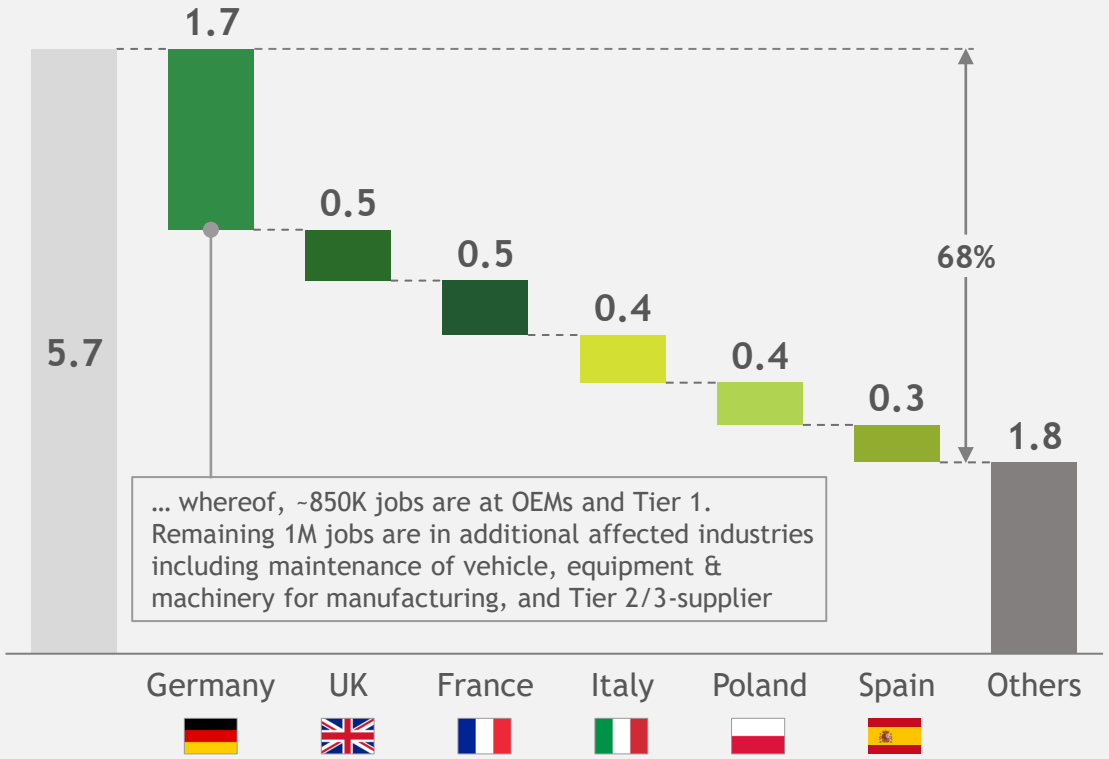
- Sales manager/planner
- Sales/after sales staff
- Sales analyst
- Marketing strategy staff
- Product marketing staff
- Digital Marketing staff
- Market analyst
- Service technology staff

Source: EuroStat; BCG

Upcoming/Growing (Sub)-Job families ☆

68% of jobs are in six European countries

Total number of jobs with country split in Europe [Numbers in M]

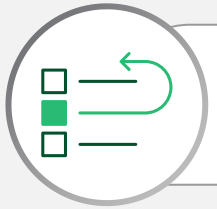


- ~1.7M employees in Germany, whereof ~0.8M for supplier and ~0.6M for OEMs
- ~0.5M employees in UK, whereof ~0.2M for supplier and ~0.2M for maintenance & repair
- ~0.5M employees in France, whereof ~0.2M for supplier and ~0.1M for OEMs
- ~0.4M employees in Italy, whereof ~0.2M for supplier and ~0.1M for maintenance & repair
- ~0.4M employees in Poland, whereof ~0.3M for supplier and ~0.1M for maintenance & repair
- ~0.3M employees in Spain, whereof ~0.2M for supplier and ~0.1M for maintenance & repair

Source: EuroStat; BCG

Agenda

1 Industry sectors and job families primarily affected



2 **Major trends** influencing job development in Auto industry

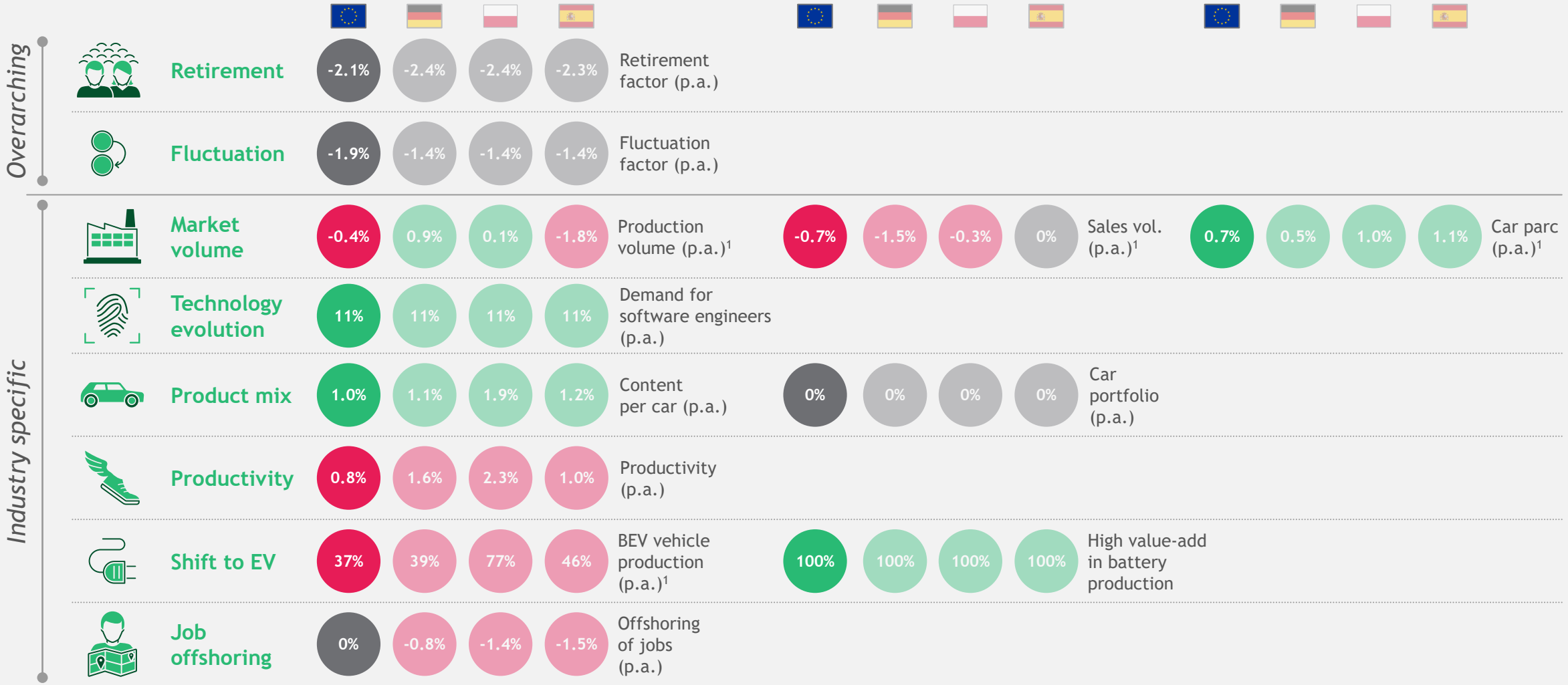
3 Net impact of job development until 2030

4 Transition over time, across industries, job families, regions

5 Recommendations for companies and governments

Spain & Poland preliminary

Seven major trends are driving job changes in Europe

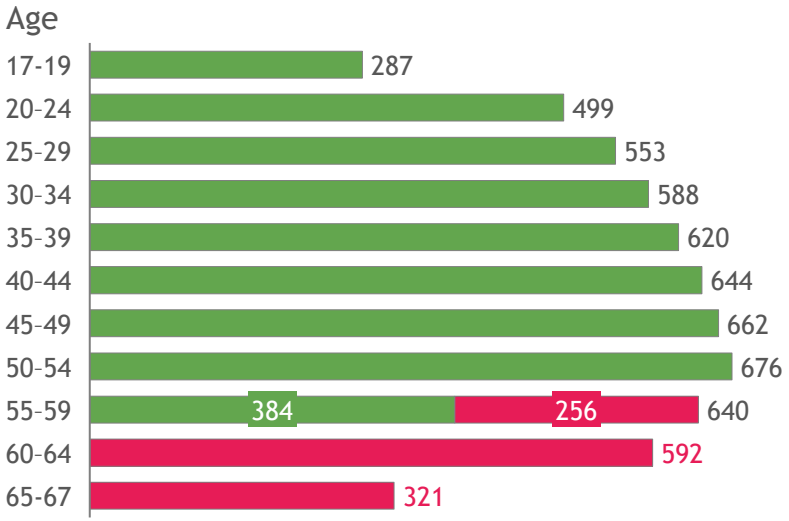


1. 2019 as baseline year, Source: IHS Markit; BCG

Positive impact on job demand
Negative impact on job demand
No impact on job demand

Retirement and fluctuation causing employee movement

Retirement factor
[Employees in K]



≈ **1.2M** retired employees until 2030 (**20%** of total employees)

Affected number of employees leads to a retirement factor of **2.1%** (y-o-y) until 2030

Fluctuation factor
[Employees in K]

≈ Fluctuation due to industry change lower for **OEMs (~0.6%)** than **rest of industry (~2.2%)**

Weighted average fluctuation factor (industry change) is **1.9%** y-o-y

1. Daimler used as proxy for European OEMs 2. German auto industry used proxy for auto industry
3. 23% of ended employments lead to industry change
Source: Company data; Stepstone; BCG

2.1% y-o-y

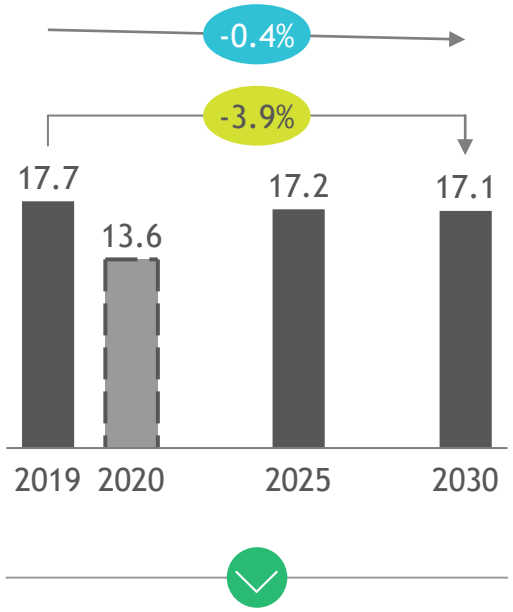
Share of workforce retiring y-o-y

1.9% y-o-y

Fluctuation in other industries y-o-y

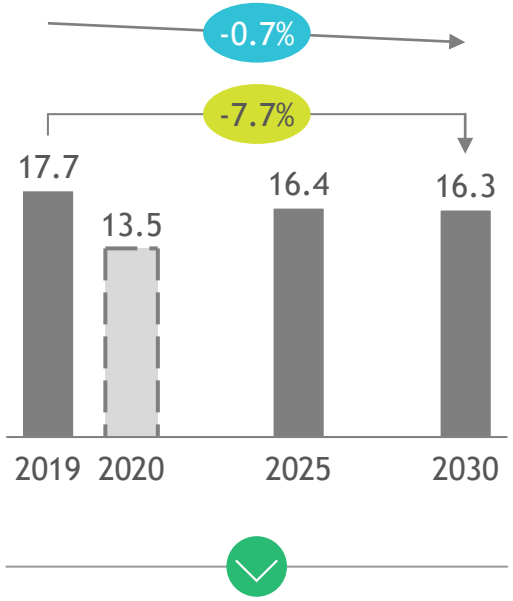
Recovery of production volume until 2030, sales declining

Forecast vehicle production [in M cars]



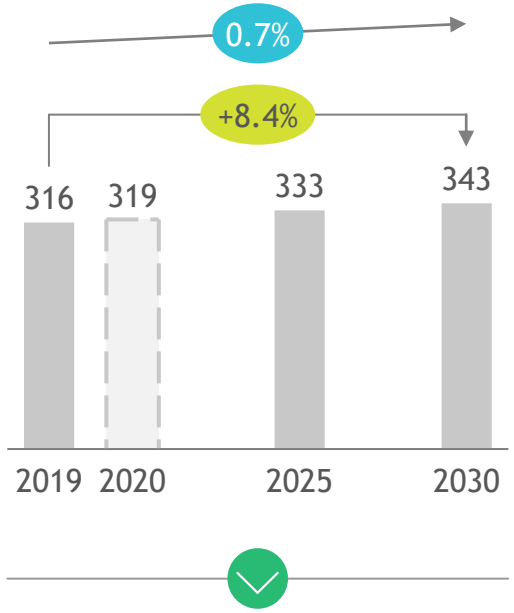
After a decline of -24% in '20, vehicle production will recover until 2030 (previously slight increase)

Forecast vehicle sales [in M cars]



After a drop in 2020, vehicle sales will recover until 2025 but not reach the pre-COVID levels

Forecast vehicle parc [in M cars]



~8% increase in car parc until 2030 with slowing growth from 2025 expected

Note: Forecast for light vehicle (<3,5t) in Europe
Source: IHS Market database; BCG

Legend: X.X% Year-over-year growth X.X% Growth from '19 to '30

Market volume

-0.4%
y-o-y

Production volume increase

-0.7%
y-o-y

Sales volume decrease

+0.7%
y-o-y

Vehicle parc increase

Technology trends influence employee movement

Change in vehicle components due to EV

Powertrain (BEV vs ICE)

1. Internal combustion engine
2. Alternator & starter
3. Fuel & exhaust system
1. Traction battery pack
2. Electric traction motor
1. Cooling system
2. Gearbox

Power electronics (BEV vs ICE)

3. DC/DC & DC/AC converters
4. Power electronics controller
5. High voltage wiring

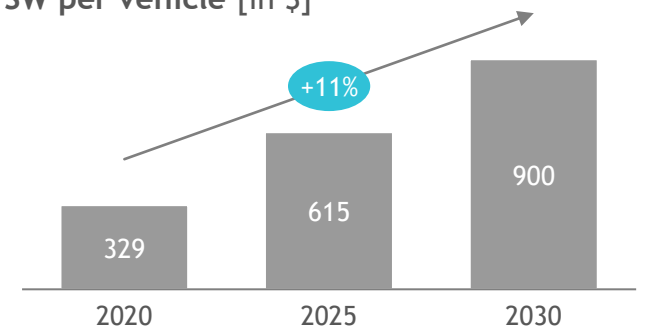
Labor demand for BEVs and ICEs is similar but new/omitted components lead to sector redistribution

Technology trends driving SW demand

Key technology trends

- Assistant/Autonomous driving
- Connectivity increase
- Analog to digital migration

SW per vehicle [in $]



New rising technologies (mainly SW based) are becoming crucial to manage for auto industry

Source: IHS Market database; BCG

Legend: x New component x Omitted comp. x Changed comp. X.X% Year-over-year growth

1:1

Labor demand ICE vs. BEV

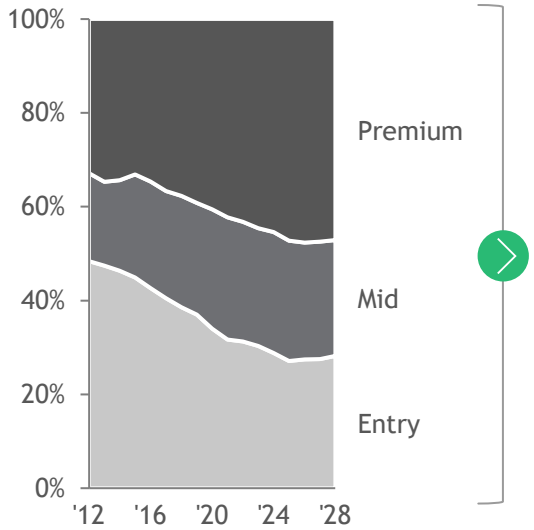
+11% y-o-y

SW cost per vehicle CAGR – demand for SW engineers

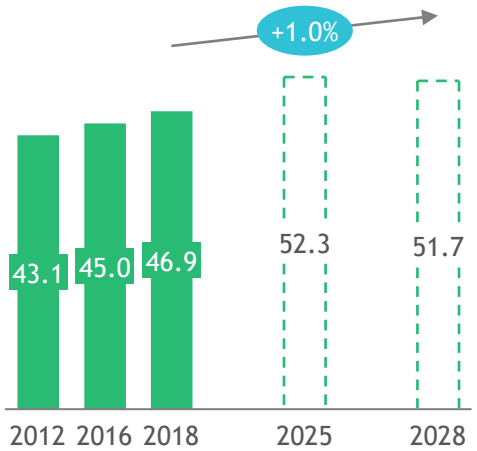
Product mix leads to increased content per car

Production: Trend of increasing content per car continues

Production mix



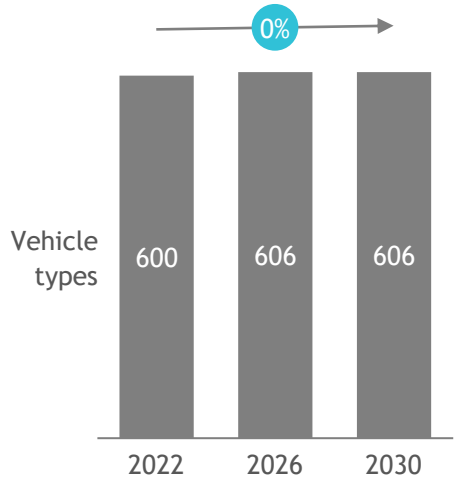
Average content per car [K€]



Growing mid and premium segment leads to increased average content per car –average growth of **~1.0% y-o-y** until 2030

Engineering: Constant number of vehicle types

Product portfolio forecast



Stable number of vehicle types in 2030 – **Stable** demand of **development engineers**

Note: Entry segment below €30K content per car, premium segment above €50K.
Source: IHS Market database; Eurostat, BCG

Legend: X.X% Year-over-year growth

1.0%
y-o-y

Content increase per car through product mix for suppliers

0.0%
y-o-y

Constant engineering demand due to stable vehicle types

Hours per unit within OEMs will nearly stay constant over next decade

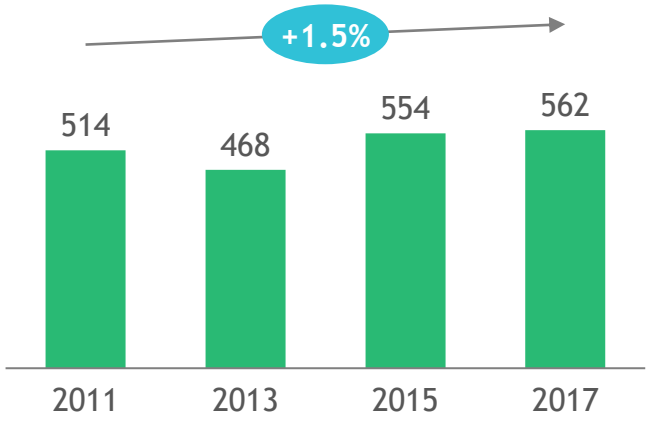
Vehicle Category	HPU	Production split 2020	Production split 2030
Mini cars (A)	29	5%	1%
Small cars (B)	31	17%	15%
Medium cars (C)	32	21%	20%
Large cars (D)	39	11%	10%
Executive cars (E)	56	7%	8%
Luxury cars (F)	100	0%	0%
Vans (HVAN/MVAN)	41	1%	0%
Multi-purpose vehicle (MPV)	32	3%	1%
Pick-up (PUP)	43	0%	0%
Sport utility vehicle (SUV)	34	35%	45%
Average HPU		**35.1**	**35.3**

Source: IHS Market database; BCG

Productivity improves by ~0.8% per year

Same productivity across industries

Production value per employee[1]
[K€ per employee]



	2011	2013	2015	2017
Employees in M	1.02	1.04	1.08	1.12
Production value in B€[1]	521	486	599	630

Based on production value **productivity increases ~1.5% per year**

Relevant input for model

Industry specific productivity

Gross value added per employee[1]
[Yearly average increase between 2014-2018]

Industry	
Manufacture of motor vehicles	1.2%
Manufacture of bodies (coachwork) for motor vehicles	1.2%
Manufacture of electrical and electronic equipment for motor vehicles	0.0%
Manufacture of other parts and accessories for motor vehicles	1.2%
Manufacture of rubber tyres and tubes	0.5%
Manufacture of computers and peripheral equipment	1.2%
Manufacture of electric motors, generators and transformers	0.0%
Manufacture of bearings, gears, gearing and driving elements	1.2%
Manufacture of cooling and ventilation equipment	1.2%
Manufacture of electric lighting equipment	0.0%
Manufacture of batteries and accumulators	4.7%
Manufacture of other pumps and compressors	1.2%
Shaping and processing of flat glass	1.2%
Recovery of sorted materials	3.1%
Equipment & machinery	0.0%
Industrial service provider	1.2%
Maintenance and repair of motor vehicles	0.0%
Charging infrastructure (Manf.&Service)	4.7%
Charging infrastructure (Operation&Maint.)	4.7%
Fueling infrastructure (Manf.&Service)	1.2%
Fueling infrastructure (Operation&Maint.)	1.2%

Based on industry weighted average **productivity increases ~0.8% per year**

1. Adjusted for inflation
Source: Eurostat; BCG

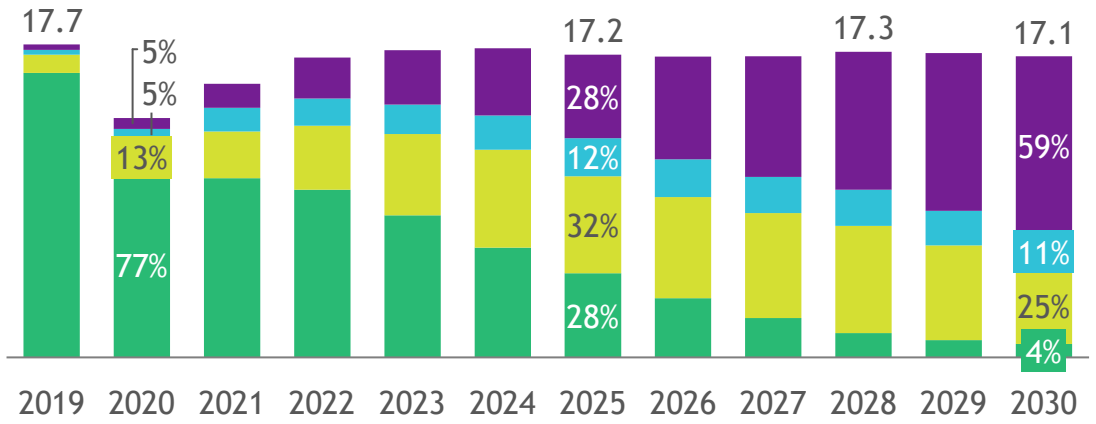
Legend: X.X% Year-over-year growth

0.8%
y-o-y

Productivity increase (adjusted for inflation)

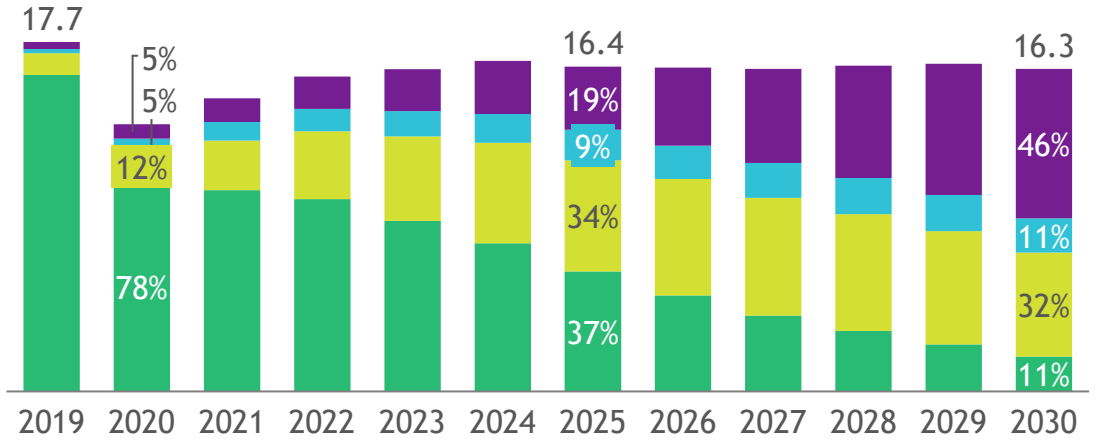
ICE production share declines to ~4% in Europe until 2030

Vehicle production [in M cars]



Total volume forecast based on latest IHS figures[1], production split based on IHS export gap and BCG sales forecast

Vehicle sales [in M cars]



Total volume forecast based on latest IHS figures[1], sales split based on BCG forecast in order to comply with latest climate regulations in Germany (i.e., ~14M BEV and PHEV by 2030)

Note: Only Europe, ICE = Internal combustion Engine; BEV = Battery electric; PHEV = plug-in hybrid electric; HEV = (mild) hybrid electric
Source: IHS Markit database; BCG

Legend: BEV PHEV HEV ICE

59%

BEV share in vehicle production in 2030

37%
y-o-y

Growth in BEV vehicle production

High value add in battery manufacturing forecasted

Trend towards production in Europe

"VW announced a plan for six battery gigafactories in Europe"

northvolt

"Towards 2030, we intend to produce 150GWh battery cells across several gigafactories in Europe"

Possible scenarios until 2030

	Share of prod. costs	Low value add	Medium value add	High value add
Battery production	~10%	✓	✓	✓
Module production	~12%		✓	✓
Cell production	~78%			✓
Share of jobs based in Europe		~10%	~22%	~100%

Forecasted scenario for 2030

100%

High value-add in battery production

Source: EU Commission; BCG

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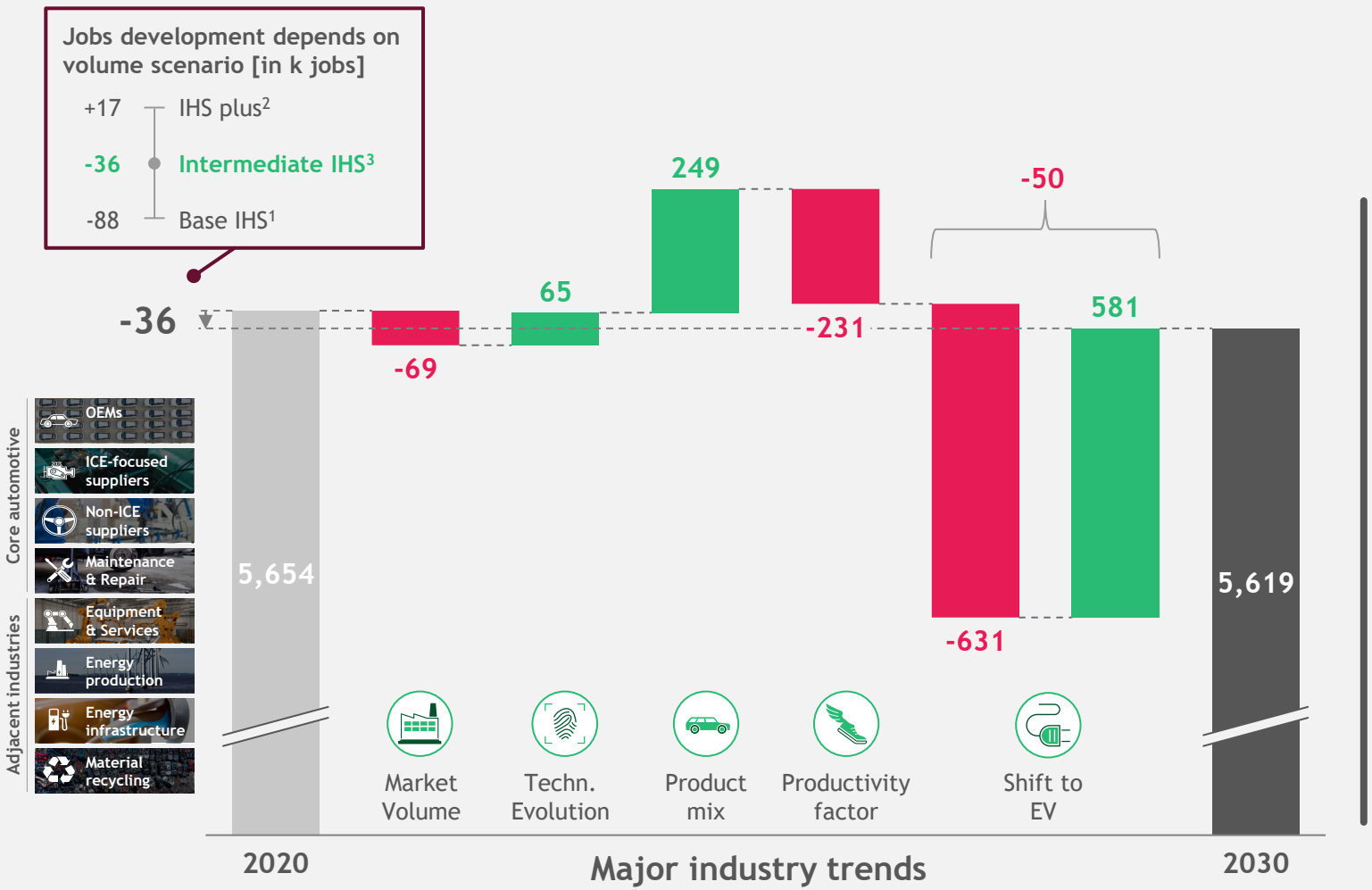
Nearly flat development of total jobs until 2030



-69k job reduction based on **market volume** change in Europe from '20 to '30

65k new jobs created based on **technology evolution** shift, driven by increased software in the car

249k new jobs created based on **product mix** driven by vehicle portfolio increase and linked complexity

-231k job reduction based on **increase in productivity**

-50k jobs lost through **shift to EV**, -631k driven by reduced efforts for OEMs and ICE-focused suppliers, +581k also driven by battery mfg. & charging infr.

1. Base IHS = Volume according to IHS 2. IHS plus = Volume according to IHS with constant volume for 2028+ 3. Intermediate IHS = average of "base IHS" and "IHS plus"
Note: Impact on Jobs in k Source: EuroStat; BCG

Volume development impacts job demand – 5 scenarios

Scenario	Description	Production 2030	Sales 2030	Net job impact
1 Constant volume	2030 volume remains constant vs. 2019	17.7M	17.7M	+123k
2 Base HIS (as of June 2021)	Latest IHS forecast with drop in volume after 2028	16.8M	16.2M	-88k
3 Intermediate IHS	Average between scenario 2 and 4	17.1M	16.3M	-36k
4 IHS plus	Latest IHS forecast, adjusted to keep volume constant after 2028	17.3M	16.5M	+17k
5 Bloomberg Uplift (as of June 2021)	Uplifted production and sales forecast based on more positive outlook from Bloomberg	18.2M	17.5M	+201k

Basis for report

Source: BCG

Decrease for core and increase for adjacent industries

Total number of jobs in Europe 2030 [in K] and relative change to 2020

Industry cluster[1] | Job category[2]

	Industry cluster[1]	Engineering	Procurement	Production/ Service Ops.	Sales	Other	Total 2030	
Core automotive	OEMs	146 22%	27 -18%	527 -31%	57 -12%	108	865 -20%	
	ICE-focused suppliers	62 -50%	13 -53%	236 -45%	17 -41%	58	385 -42%	-5%
	Non-ICE suppliers	423 12%	86 8%	1,747 12%	89 -4%	179	2,524 10%	
	Maintenance & Repair	10	53	854	73	52	1,042	
Adjacent industries	Equipment & Services	96	28 28%	254 7%	41 -12%	33	453	
	Energy production	19 161%	2	78 128%	1	11	112 128%	34%
	Energy infrastructure	14 545%	9	96 507%	12	10	140 543%	
	Material recycling	9	10 9%	57	12 31%	9	97	
		779 4%	228 2%	3,849	302 -4%	461	5,619	

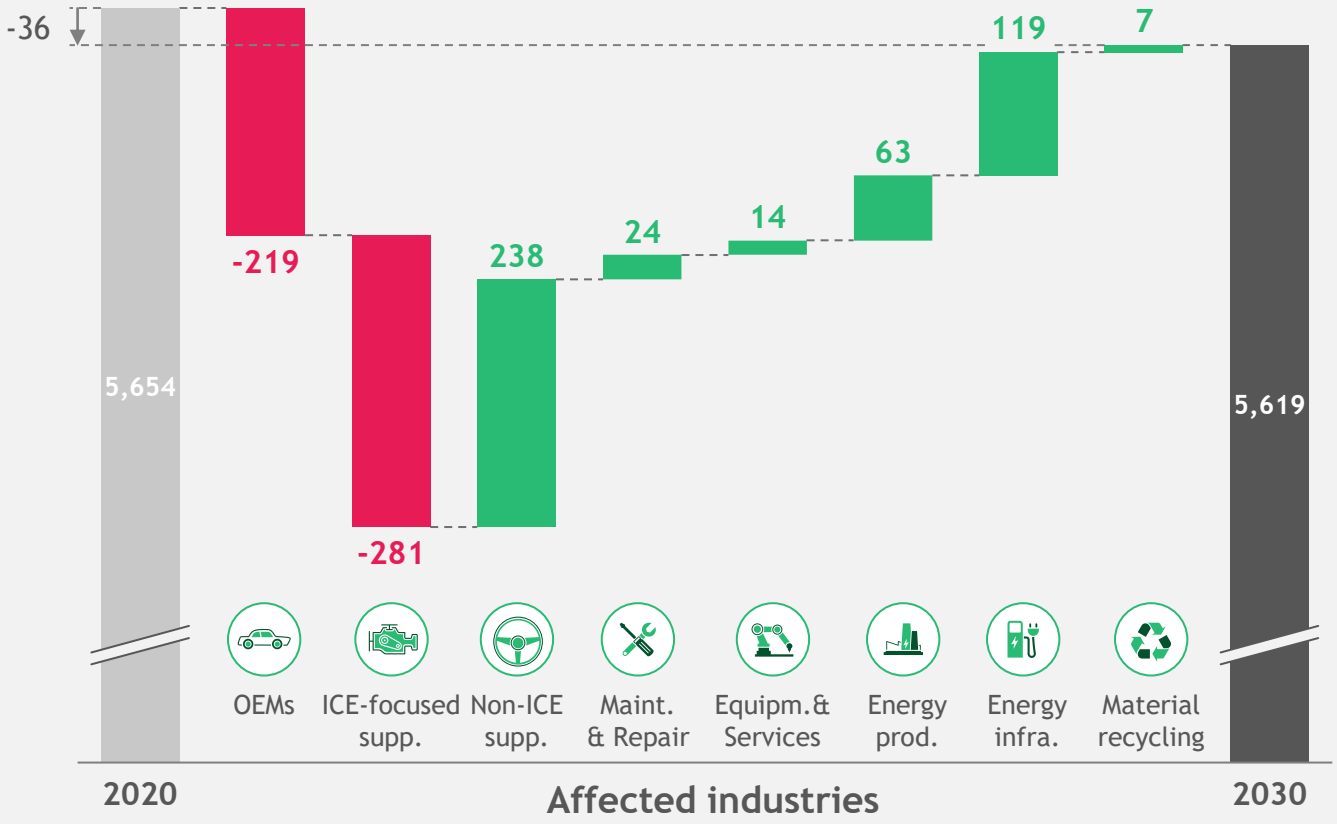
1. Based on 26 industries
2. Based on 31 jobs families

Source: EuroStat; BCG

Higher job demand compared to 2020 | Lower job demand compared to 2020 | Nearly constant job demand compared to 2020

Major movements within suppliers, OEMs slightly down

Impact on jobs in Europe [in k]



-219k **OEM** job reduction based on labor hours reduction per vehicle

-281k **supplier** job reduction driven by reduced ICE components, e.g. gears, pumps

238k new **supplier** jobs created, esp. in **battery manufacturing** and electrical motors

24k **maintenance & repair** job increase driven by aging car parc

14k **equipment & services** job increase, driven by equipment and machinery sector

63k new **energy production** jobs created in operations and maintenance for renewable energy

119k new **infrastructure** jobs created linked to service & operations of charging infrastructure

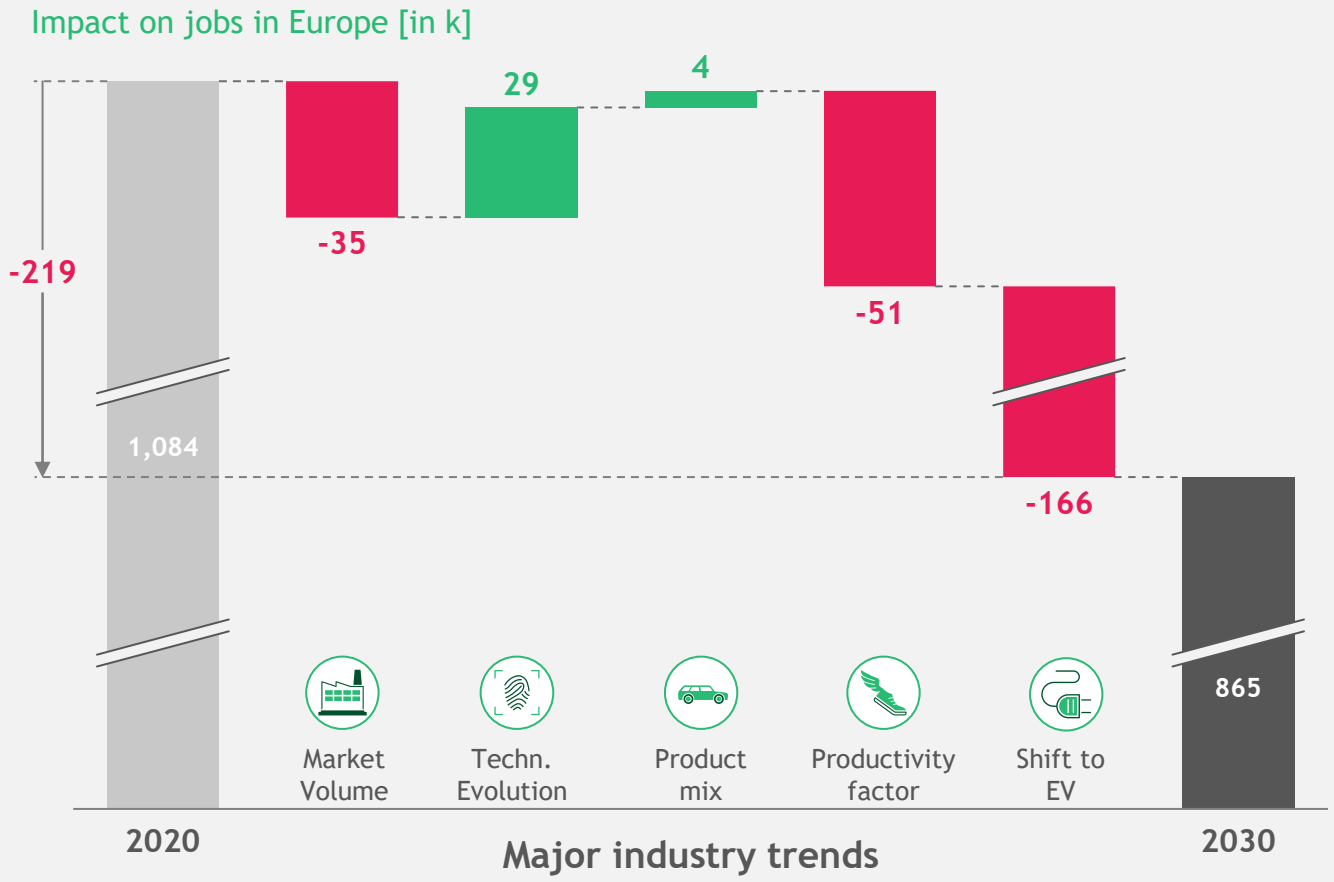
7k new **material recycling** jobs created in new battery recycling plants

Source: BCG

Deep dives across the 7 industry clusters

- OEMs
- ICE-focused Suppliers
- Non-ICE Suppliers
- Equipment & Services
- Maintenance & Repair
- Fuel/Charg. Infrastructure
- Material recycling

OEMs with negative impact by productivity and EV-Shift



-35k jobs lost based on a decreased production volume in Europe from '20 to 30'

29k additional jobs driven by the increased software technology in the car

4k job increase explained by the rising vehicle portfolio and the linked vehicle complexity

-51k job reduction based on overall increase in productivity and efficiency

-166k jobs lost through shift to EV driven by reduced labor hours in engine production

Source: BCG

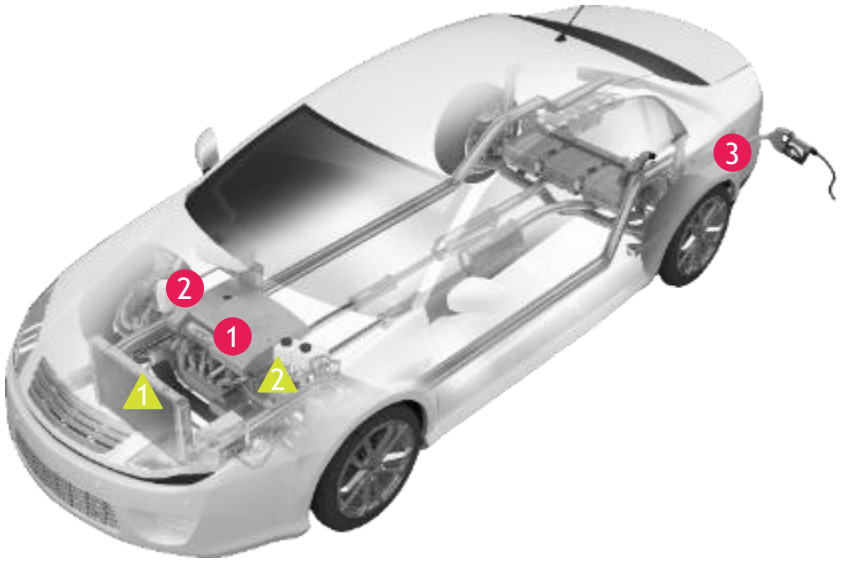
Productivity: OEM reduction programs target 6% of jobs within next few years

OEM	Scope	Timeframe	Workers	Announced reduction	Announced increase	Net-reduction
Audi	Ingolstadt & Neckarsulm	2020 - 2025	61,000	9,500	2,000	12.3%
BMW	Global	2020 -	126,000	6,000	-	4.8%
DAIMLER	Global	2020 -	300,000	15,000	-	5.0%
↳	Stuttgart	2020 - 2025	19,000	4,000	-	21.1%
↳	Berlin	2020 - 2025	2,500	1,000	-	40.0%
Ford	EU	2019 - 2020	53,000	11,000	-	20.8%
RENAULT NISSAN MITSUBISHI	Global	2020 - 2022	180,000	15,000	-	8.3%
VW	EU	2020 -	417,000	20,000	10,000	2.4%
↳	GER	2021 - 2023	120,000	4,000	-	3.3%
			1,137,000	**70,900**	**12,000**	**5.7%**

Note: Number not to be directly linked to study results as multiple effects and longer timeframe have been considered.
Source: Press announcements; BCG

Powertrain & power electronics main differentiators between BEV and ICE

Internal combustion engine vehicle (ICEV)



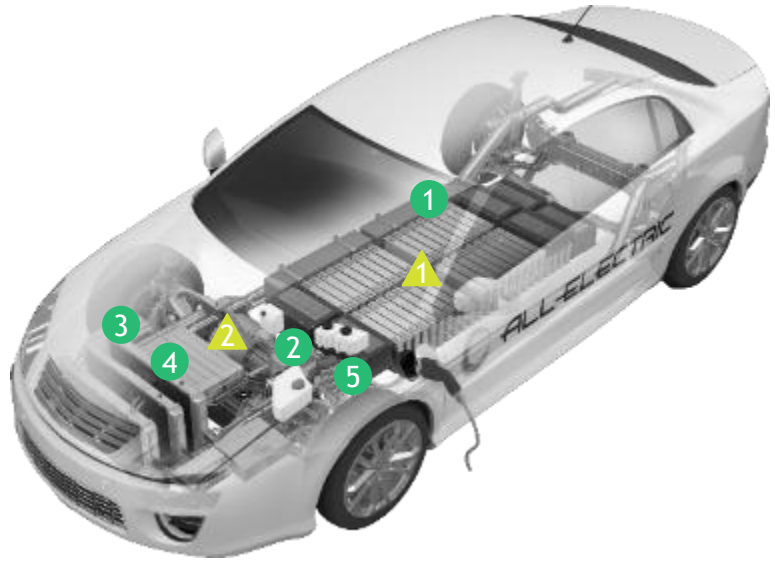
Powertrain

1. Internal combustion engine
2. Alternator & starter
3. Fuel & exhaust system
1. Traction battery pack
2. Electric traction motor
1. Cooling system
2. Gearbox

(Power) electronics

3. DC/DC & DC/AC converters
4. Power electronics controller
5. High voltage wiring

Battery electric vehicle (BEV)



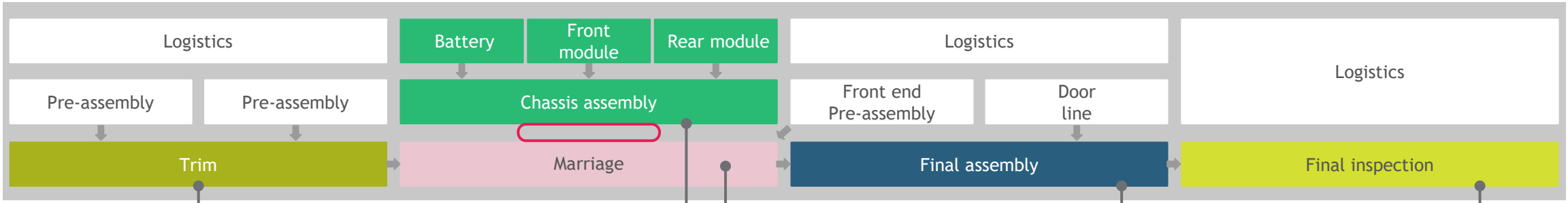
Legend: (x) New component/system in BEV vs ICEV (x) Omitted component/system in BEV vs ICEV (x) Changed component/system

1. Changes in case of native BEV or xEV platform; not applicable in case of mixed ICEV/BEV platform

Source: BCG

Many changes in vehicle assembly – effort for BEV & ICEV similar

Vehicle assembly & final inspection of automotive OEM (BEV only)



Trim line

- ⊖ Fuel piping
- ⊕ Front trunk assembly
- ⊕ Secondary aggregates (air cond. pump, PTC heater)

Chassis assembly

- ⊖ Exhaust system
- ⊖ Propeller shaft
- ⊖ Fuel tank
- ⊖ Gearbox
- ⊖ Engine
- ⊕ Motor + inverter
- ⊕ Battery module
- ⊕ Control module[1]
- ⊕ High voltage cables
- ⊕ Charging unit
- ⊕ Cooling tubes connect

Final assembly

- ⊖ Fuel, oil, coolant filling
- ⊕ HV module joining
- ⊕ Battery pre-charging

Marriage line

- ⚠ Higher load on conveyor system

Final inspection

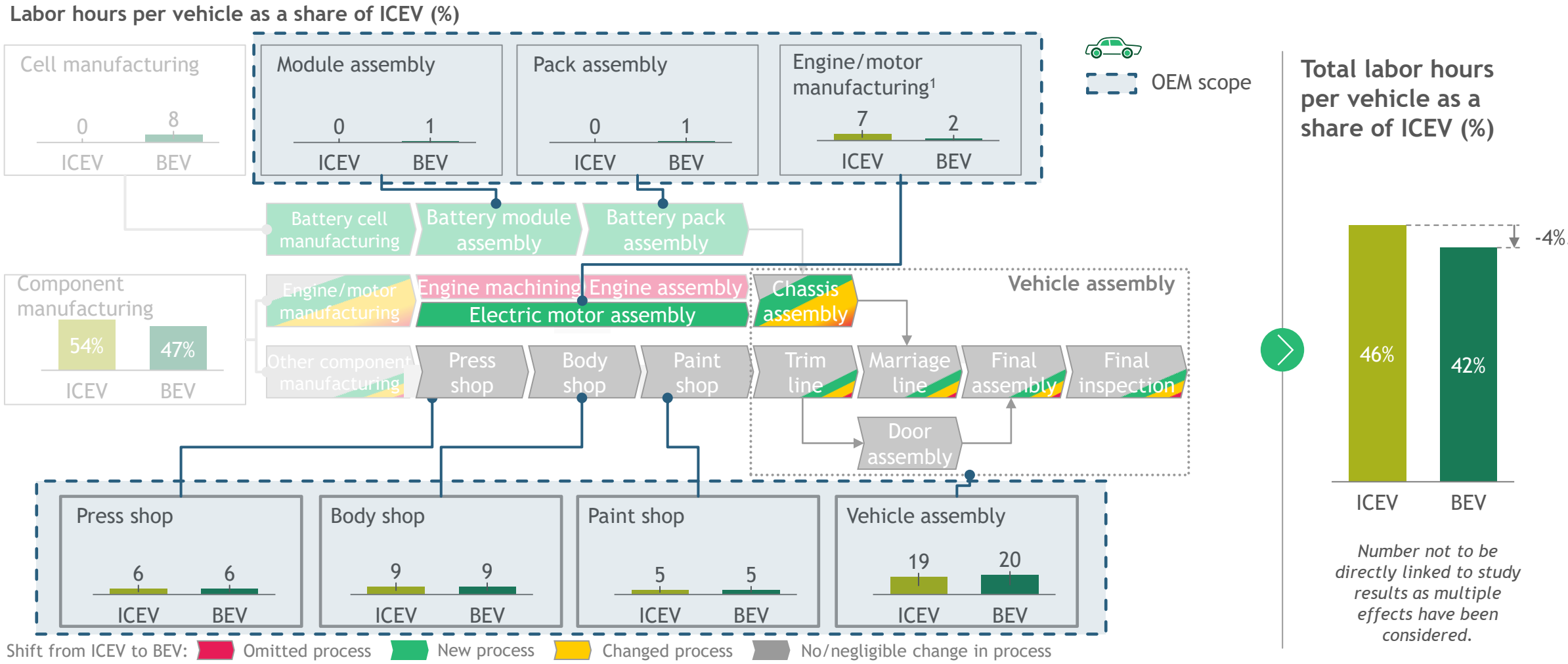
- ⊖ Exhaust extraction system
- ⊖ Engine performance test system
- ⊕ Motor performance test system

1. Control module mostly integrated in battery

Source: BCG

Legend: ⊕ New component/system in BEV vs ICEV ⊖ Omitted component/system in BEV vs ICEV ⚠ Changed component/system

Shift to EV: OEM labor requirements for BEVs and ICEVs decrease by 4pp



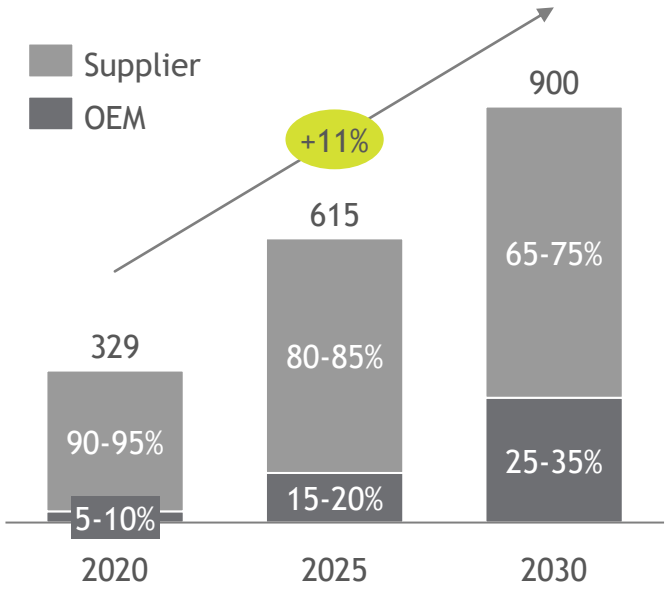
Number not to be directly linked to study results as multiple effects have been considered.

1. Engine/motor manufacturing including transmission assembly
Note: The reference vehicle for this analysis is a D-segment premium passenger car with one electric motor and an advanced driver-assistance system.
Marriage is the joining of body sections, chassis, and powertrain
Source: BCG

Technology Evolution: Emerging job categories like software engineers

Software content in car increases…

Estimated SW cost per vehicle [in $]



… and OEMs react with SW engineer recruiting - example VW

5-10K FTE

Software engineers in Volkswagen's **Car.Software unit** by 2025

Volkswagen Car.Software unit	Module 1	Module 2	Module 3	Module 4	Module 5
	Connect-ivity	Intelligent body and cockpit	Automated driving	Vehicle & energy perform.	Mobility service/ platform
FTEs today	~200	~150	~150[2]	N/A[3]	N/A[3]
FTEs by 2025[1]	>800	>1,200	>1,800	>500	>500
Investment focus	Medium	High	Very High	Lower	Lower

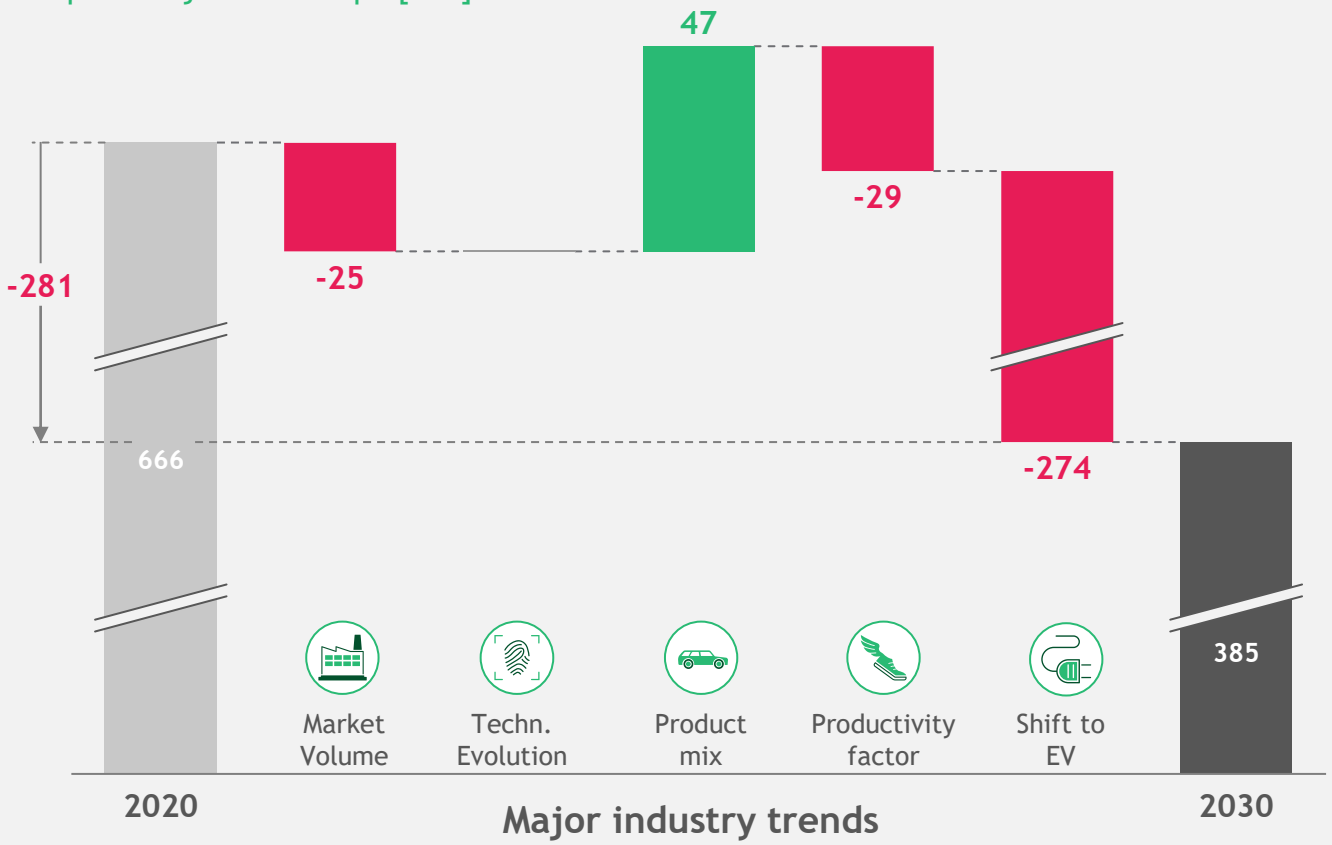
Volkswagen OS

Module 6	Core services and infrastructure (enabler software across modules)	FTEs today: ~80	FTEs by 2025: >200

1. Including human resources from close software partnerships 2. Driver assistant teams (e.g., lane assist, cruise control) not yet integrated
3. Not part of the car
Source: Industry reports; Company announcements; Expert interviews; BCG

ICE-focused suppliers with significant negative impact

Impact on jobs in Europe [in k]



-25k jobs lost based on a decreased production volume in Europe from '20 to 30'

Insignificant impact of new technologies developments for ICE-focused components

47k job increase explained by rising vehicle complexity

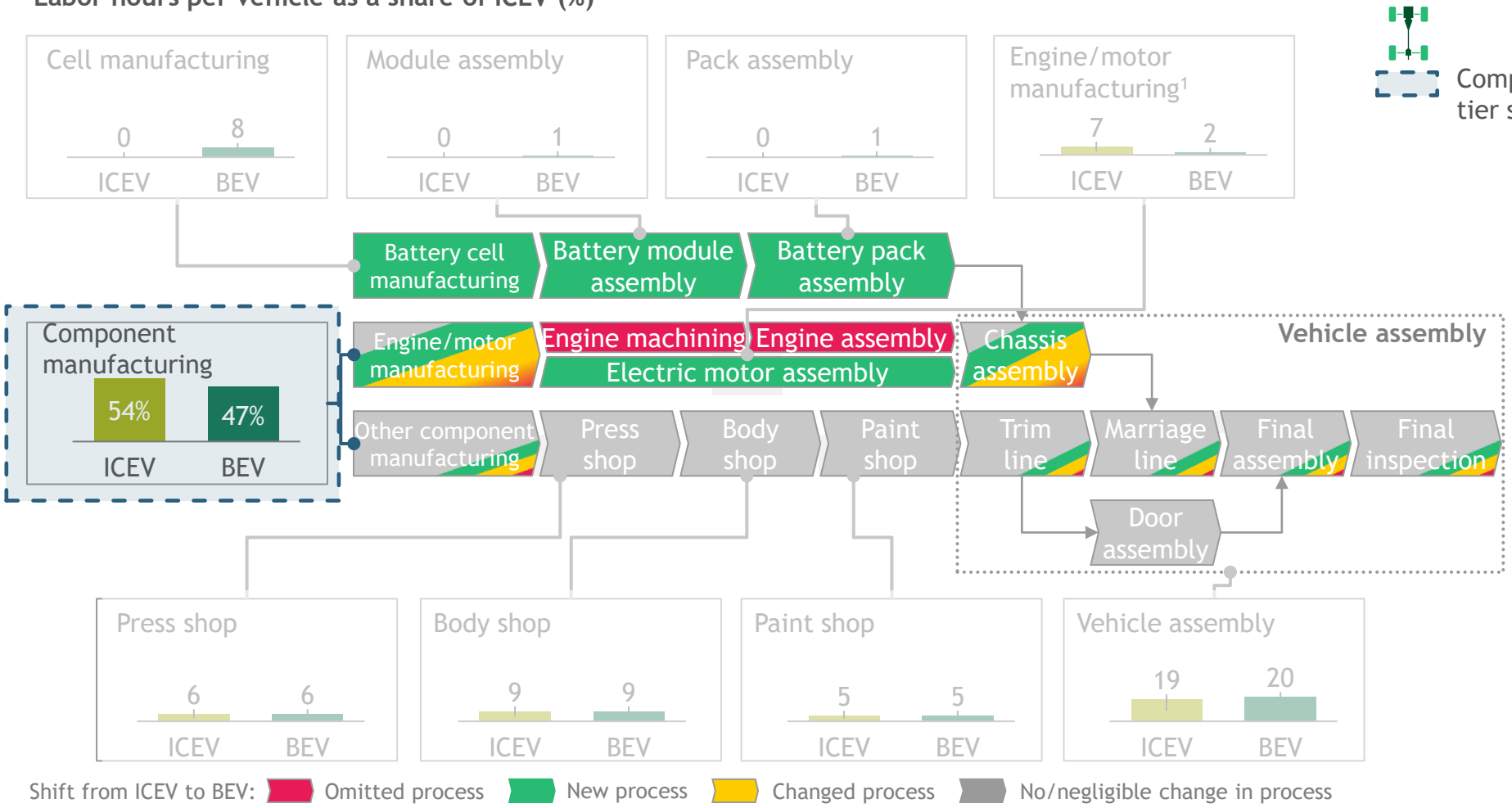
-29k job reduction based on overall increase in productivity and efficiency

-274k major jobs lost through shift to EV driven by reduced number of components

Source: BCG

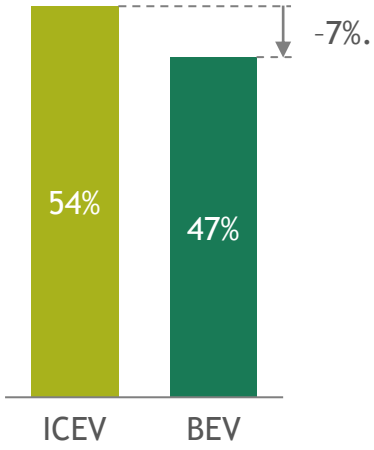
Shift to EV: Component labor requirements for BEVs and ICEVs decrease by 7pp

Labor hours per vehicle as a share of ICEV (%)



Shift from ICEV to BEV: Omitted process | New process | Changed process | No/negligible change in process

Total labor hours per vehicle as a share of ICEV (%)

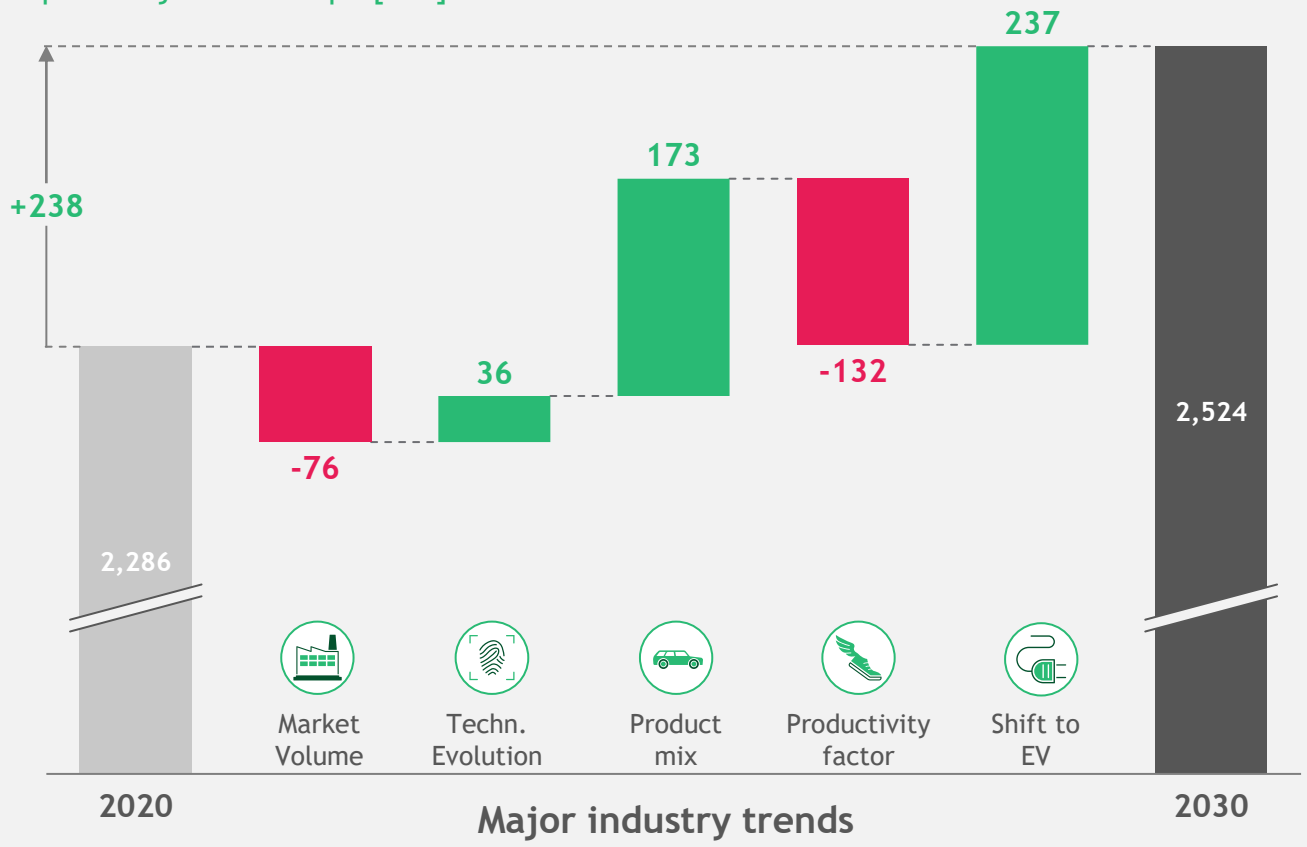


Number not to be directly linked to study results as multiple effects have been considered.

1. Engine/motor manufacturing including transmission assembly
Note: The reference vehicle for this analysis is a D-segment premium passenger car with one electric motor and an advanced driver-assistance system.
Marriage is the joining of body sections, chassis, and powertrain.
Source: BCG

Non-ICE suppliers with positive impact

Impact on jobs in Europe [in k]



-76k jobs lost based on a decreased production volume in Europe from '20 to 30'

36k additional jobs mainly driven by electrical & electronics software extents

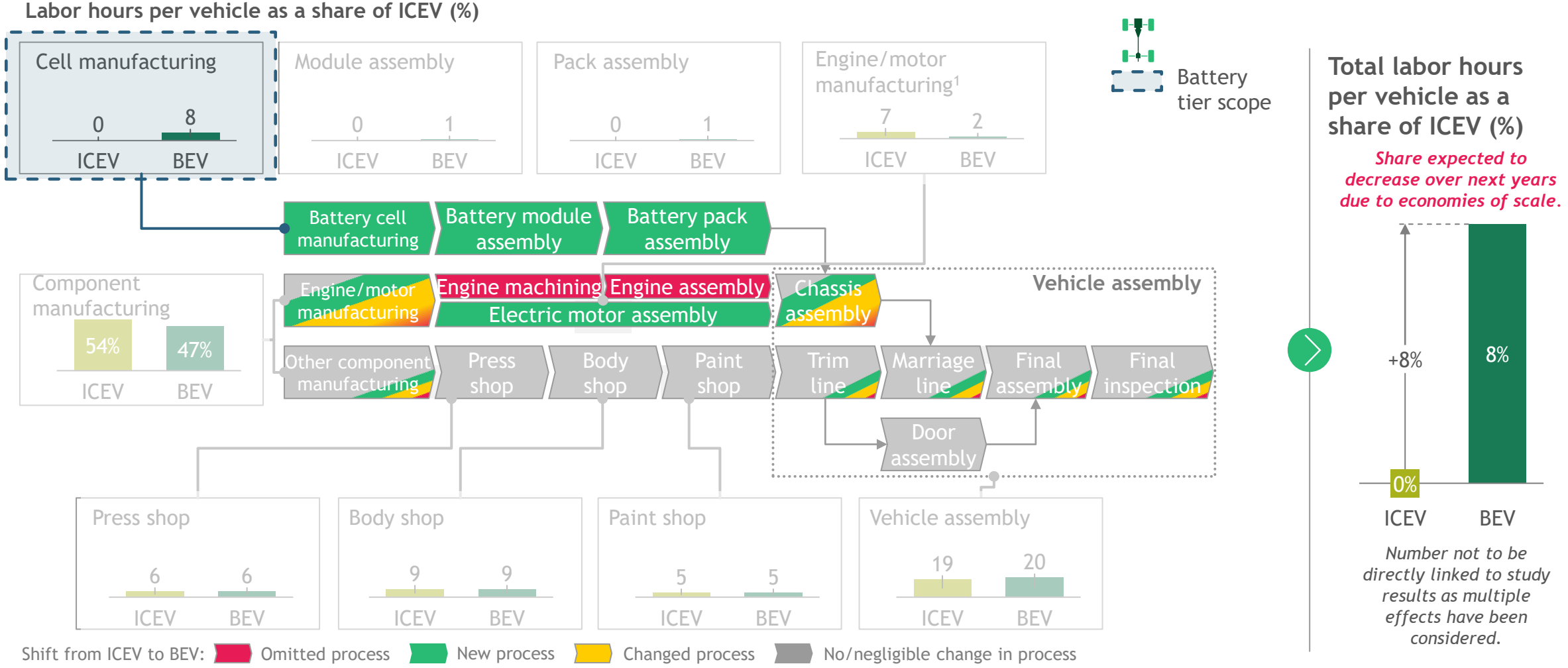
173k job increase explained by the rising vehicle portfolio and the linked vehicle complexity

-132k job reduction based on overall increase in productivity and efficiency

237k major job increase driven by battery manufacture and electric motors

Source: BCG

Shift to EV: Battery tier labor requirements for BEVs and ICEVs increase by 8%



Total labor hours per vehicle as a share of ICEV (%)

Share expected to decrease over next years due to economies of scale.

Number not to be directly linked to study results as multiple effects have been considered.

1. Engine/motor manufacturing including transmission assembly
Note: The reference vehicle for this analysis is a D-segment premium passenger car with one electric motor and an advanced driver-assistance system.
Marriage is the joining of body sections, chassis, and powertrain.
Source: BCG

Shift to EV: Cell production can create up to 60K jobs in Europe till 2030

Battery cell production (started & planned plants by 2030)

UK — 43 GWh

Plant site	OEM	Size (GWh)
Coventry	AMTE	~5
Sunderland	AESC	3
Blyth	Britishvolt	35

Germany — 291 GWh

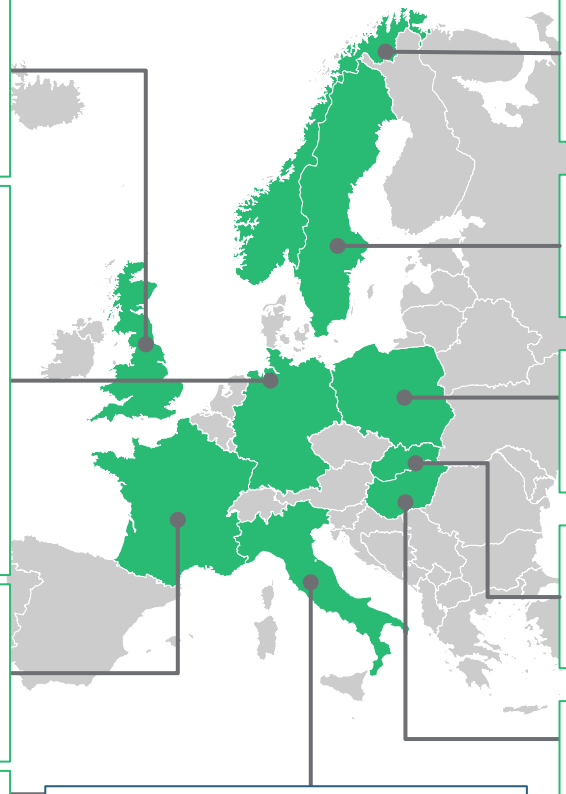
Plant site	OEM	Size (GWh)
Erfurt	CATL	100
Grünheide	Tesla	100
Saarland	Svolt	24
Salzgitter	Northvolt-VW Group	24
Kaiserslautern	ACC (PSA/SAFT)	24
Anhalt	Farasis	10
Brandenburg	Microvast	6
Dresden	Leclanche	3

France — 74 GWh

Plant site	OEM	Size (GWh)
Dourvin	Acc (Total/PSA)	24
Rodez	Verkor	16 (50)

Italy — 48 GWh

Plant site	OEM	Size (GWh)
Teverola	FAAM	3
Scarmagno	Italvolt/Manganese	45



Norway — 75 GWh

Plant site	OEM	Size (GWh)
Mo i Rana	Freyr	43
Agder	Morrow	32

Sweden — 40 GWh

Plant site	OEM	Size (GWh)
Skelleftea/Ett	Northvolt-VW	40

Poland — 70 GWh

Plant site	OEM	Size (GWh)
Wroclaw	LG Chem	70

Slovakia — 10 GWh

Plant site	OEM	Size (GWh)
Košice	Inobat	10

Hungary — 88 GWh

Plant site	OEM	Size (GWh)
Göd	Samsung	40
Komárom	SKI	8
Komárom 2	SKI	10
Iváncsa	SKI	30

Latest announcements

*VW plans 4 additional gigafactories ~**190GWh** in Spain, Germany and Eastern Europe*

*Northvolt plans 150 GWh (add. ~**90GWh**) mfg. capacity in Europe by 2030*

740 GWh concretely planned until 2030

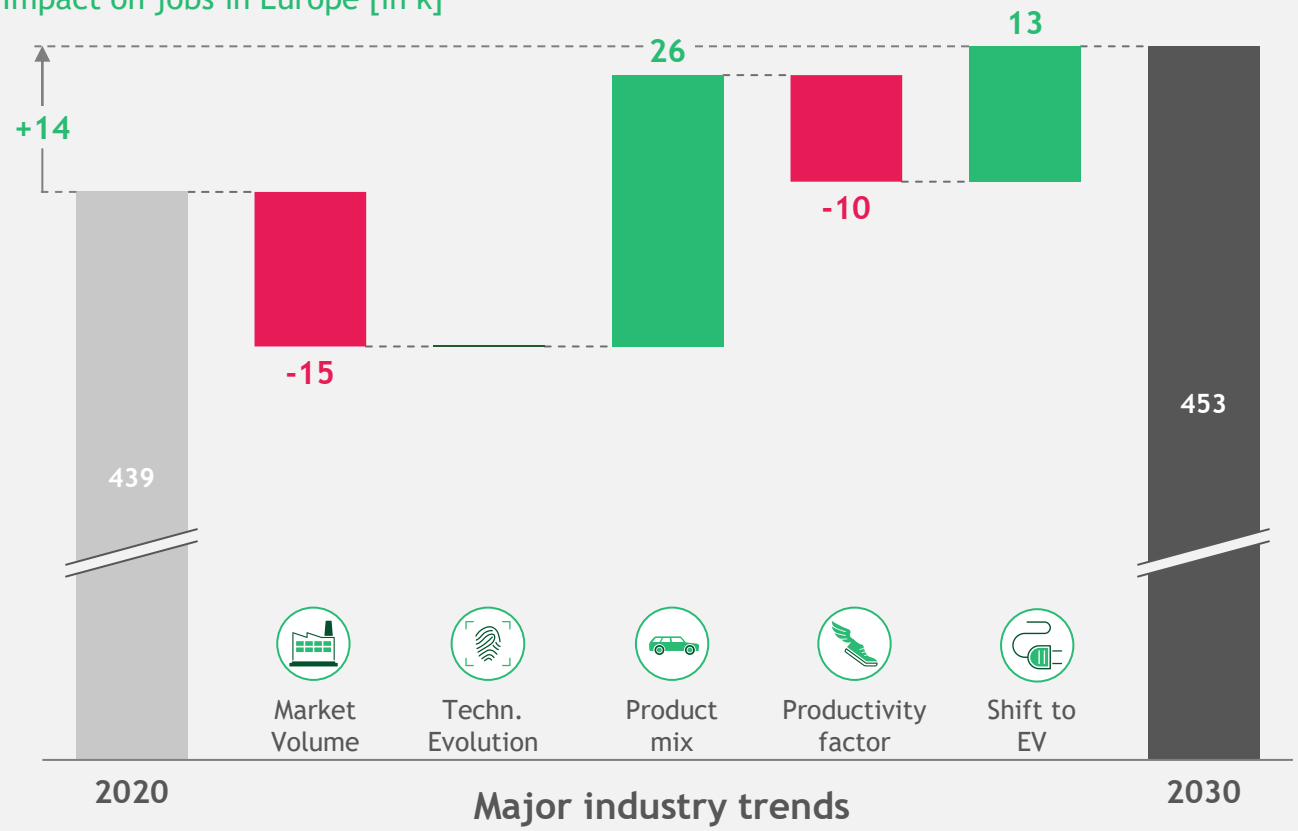
280 GWh additionally announced until 2030

Up to 60k employees by 2030[1]

1. Direct and indirect employees within cell manufacturing based on published battery plant projects and #employees/GWh production
Note: Existing and planned battery cell production
Source: Press search; OEM announcements; BCG

Equipment & Services stable until 2030

Impact on jobs in Europe [in k]



-15k jobs lost based on a decreased production volume in Europe from '20 to 30'

Insignificant impact of new technologies developments for equipment and services

26k job increase explained by the rising vehicle complexity

-10k job reduction based on overall increase in productivity and efficiency

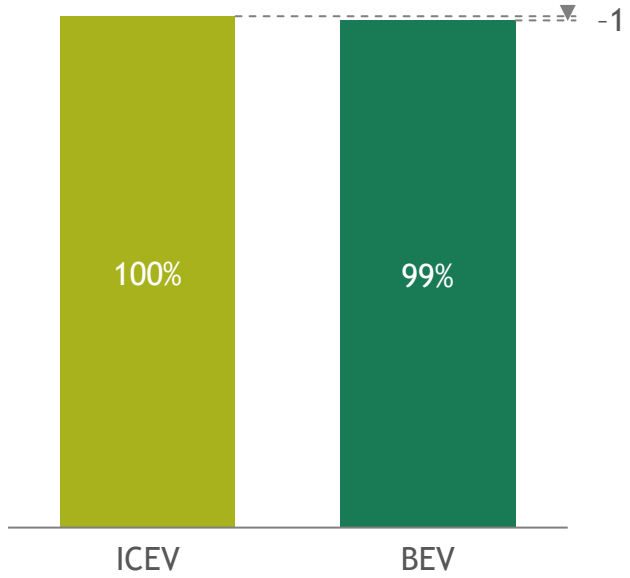
13k job increase driven by equipment demands for battery manufacturing and electric motor factories

Source: BCG

Shift to EV: Limited impact on demand for equipment and services sector

Total labor requirements for BEVs and ICEVs are comparable

Total labor hours per vehicle as a share of ICEV (%)



Automotive automation level already high, remaining barriers similar for BEVs and ICEVs

Average automation level in automotive production (%)

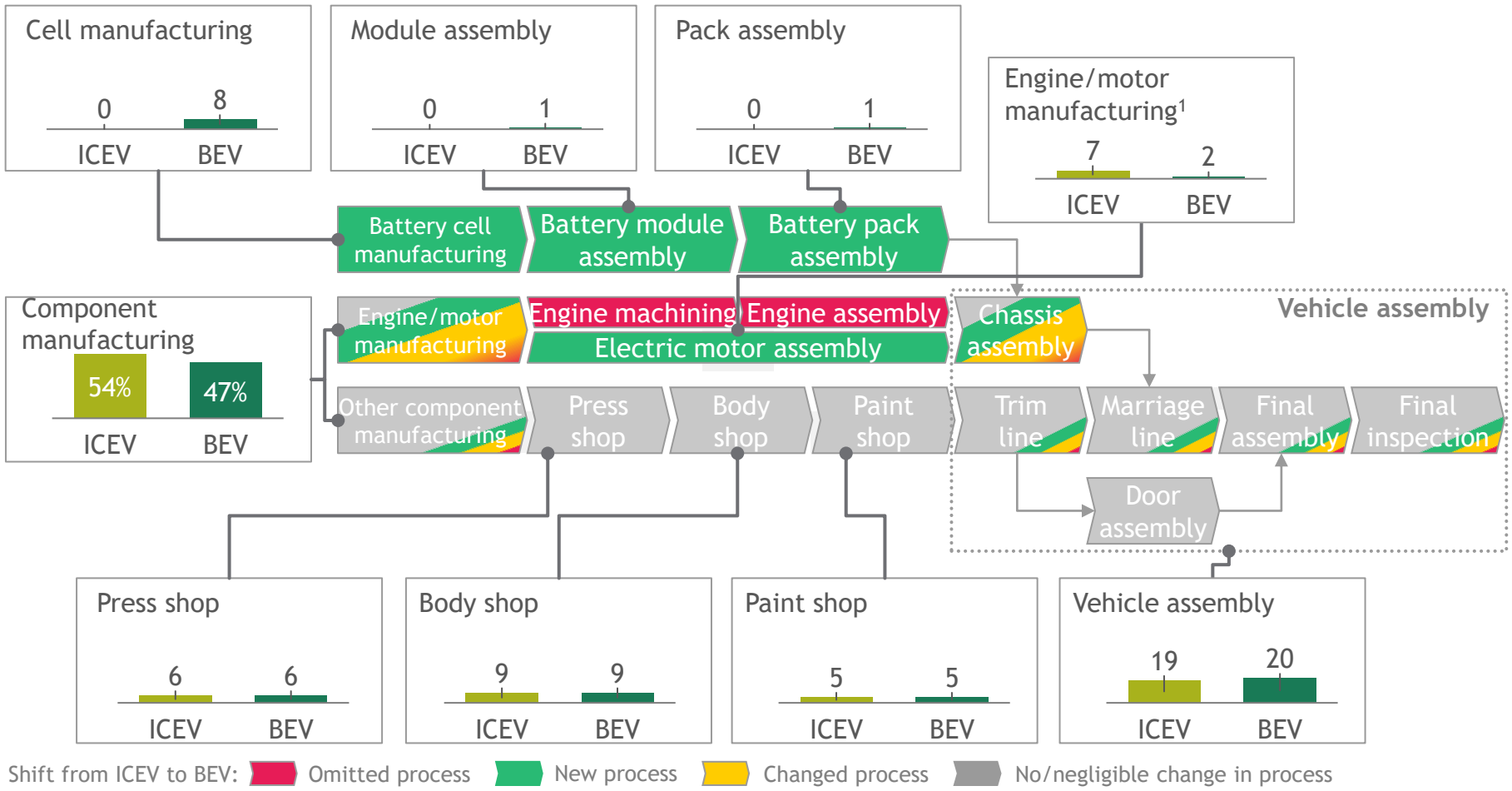
80%+	95%+	90%+	20%
Press shop	Body shop	Paint shop	Assembly

- Press shop, body shop and paint shop already with very high automation levels and limited potential for further advancements
- Assembly process still mainly manual
- Recent trials to further push assembly automation (e.g., Tesla) have all failed due to very low reliability of automated processes
- Progress in upcoming years expected, but automation barriers in assembly (e.g., flexible components) similar between BEVs and ICEVs

Note: The reference vehicle for this analysis is a D-segment premium passenger car with one electric motor and an advanced driver-assistance system. Marriage is the joining of body sections, chassis, and powertrain.
Source: BCG

Shift to EV: Total labor requirements for BEVs and ICEVs are similar

Labor hours per vehicle as a share of ICEV (%)



Shift from ICEV to BEV: Omitted process | New process | Changed process | No/negligible change in process

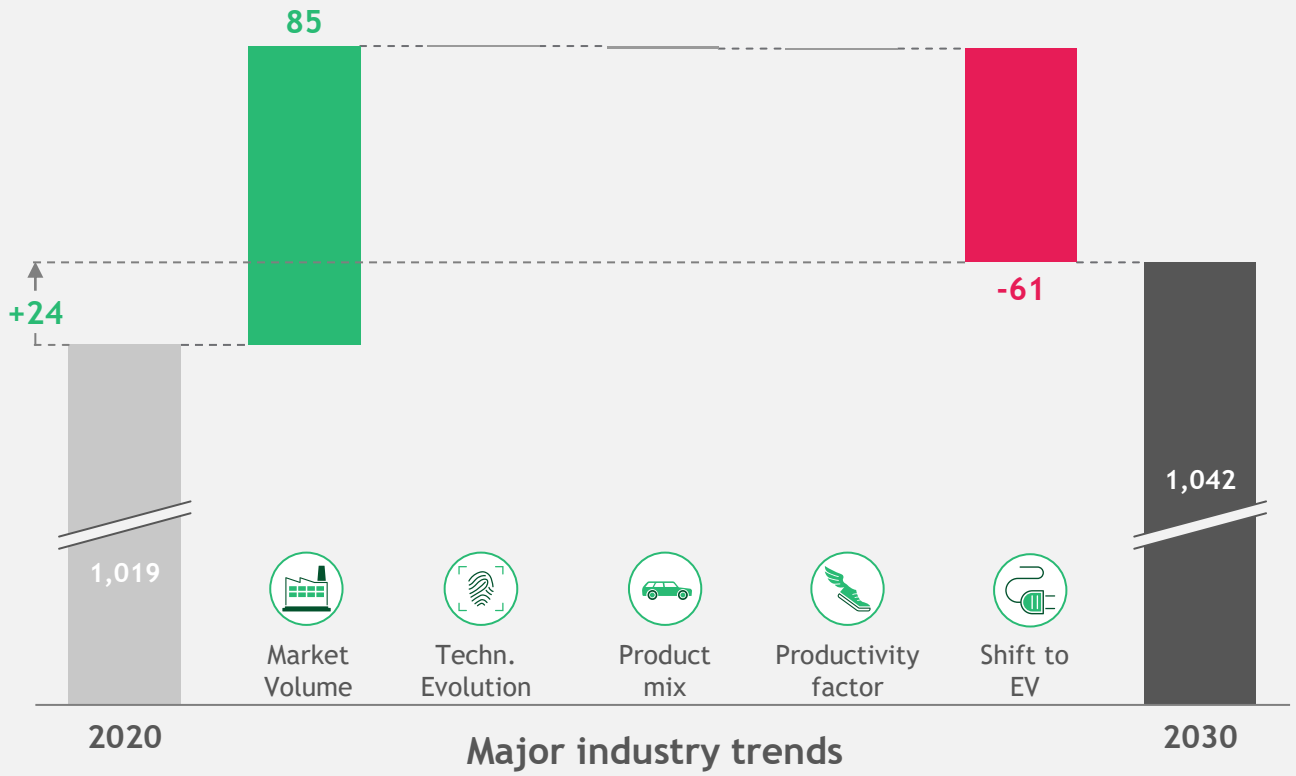
Total labor hours per vehicle as a share of ICEV (%)

Number not to be directly linked to study results as multiple effects have been considered.

1. Engine/motor manufacturing including transmission assembly
Note: The reference vehicle for this analysis is a D-segment premium passenger car with one electric motor and an advanced driver-assistance system.
Marriage is the joining of body sections, chassis, and powertrain.
Source: BCG

Maintenance & Repair with slight positive impact

Impact on jobs in Europe [in k]



85k new jobs created based on an increased car parc in Europe until 2030

Insignificant impact of new technologies developments for maintenance & repair

Insignificant impact by the product mix explained by the small share of new cars in the overall car parc

Insignificant impact by the productivity explained by very limited historic productivity gains

-61k jobs lost through shift to EV driven by reduced labor hours in battery vehicle maintenance and repair

Source: BCG

Shift to EV: Decline in repair shop employees by increased e-mobility

	Area of focus for Maintenance & Repair	ICEV	PHEV	HEV	BEV
Maintenance	Oil change	✓	✓	✓	✗
	Cooling liquids	✓	✓	✓	✗
	Sparking plugs	✓	✓	✓	✗
	Air filter change	✓	✓	✓	✗
	Toothed belt	✓	✓	✓	✗
	Fuel filters	✓	✓	✓	✗
	Break fluid	✓	✓	✓	✓
	Power electronics	✗	✓	✓	✓
	Battery cooling	✗	✓	✓	✓
Repair	Brake pad	✓	✓	✓	✓
	Exhaust system	✓	✓	✓	✗
	Clutch	✓	✗	✗	✗
	Average effort per ehicle compared to ICEV	100%	-6% (~94%)	-10% (~90%)	-15% (~85%)

✓ Existent ✓ Less complex/wear down ✗ Non-Existent

Key Takeaways:

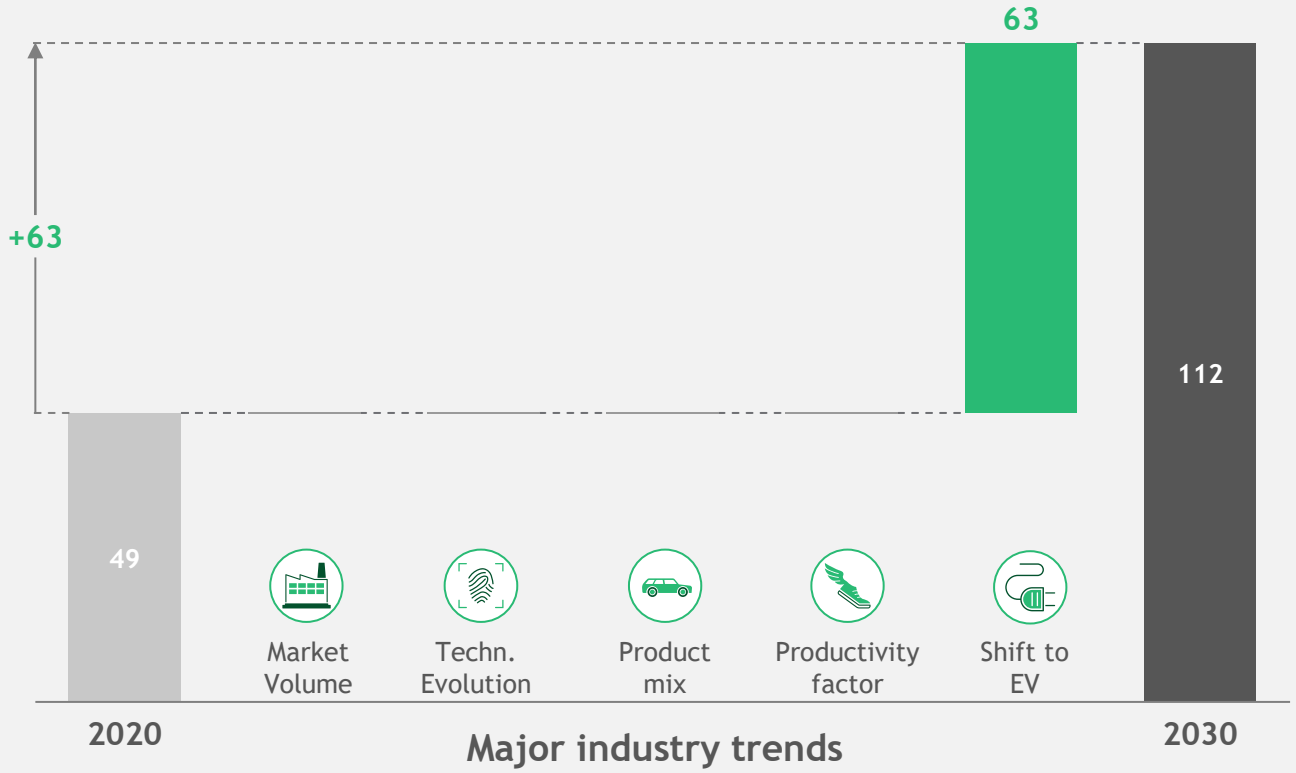
- Propulsion type determines the average effort per vehicle
- Reduce break wear down crucial for diff. between ICE & HEV/PHEV
- BEV with reduced and changed scope compared to ICE

Numbers not to be directly linked to study results as multiple effects have been considered.

Source: BCG

Significant increase for energy production industry

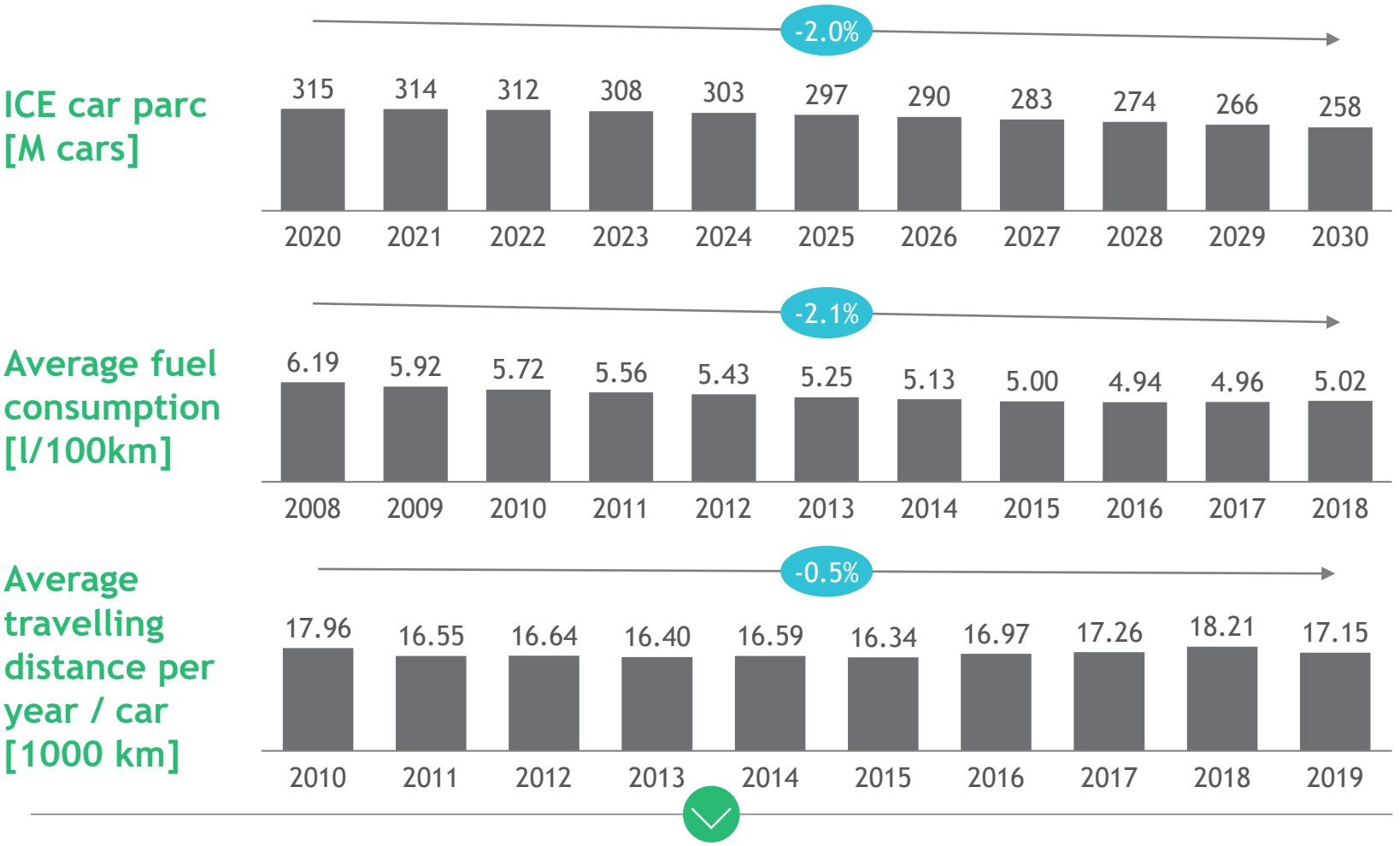
Impact on jobs in Europe [in k]



- Minimal impact by overall market volume development - shift between propulsion systems is the main driver
- Technology evolution in the car with no impact on energy production
- Product mix (content per car) has no impact on energy production
- Minor job reduction based on productivity
- **63k** job increase by shift to EV due to rising demand of clean energy for BEVs

Source: BCG

Decrease in fuel consumption driven by three effects



~43% of capacity can be shifted towards other products, remainder leads to a job **decrease of 2.6% per year** (CAGR)

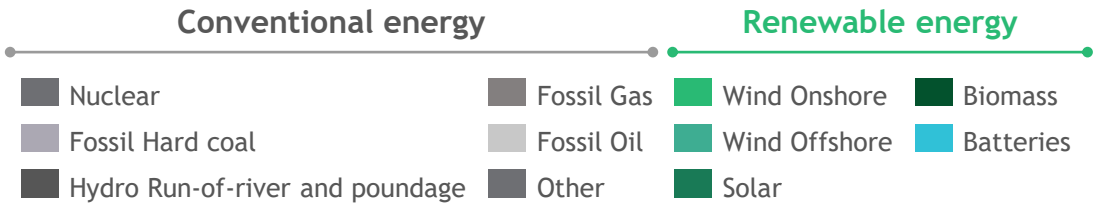
Source: BCG

Legend: X.X% Year-over-year growth

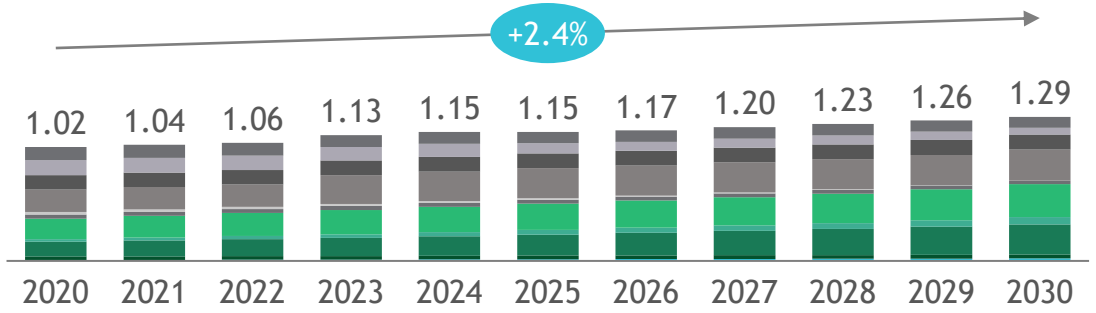
2.6%
y-o-y

Decrease in ICE related employment in Energy production

Renewable energy switch strongly increases O&M[1] jobs

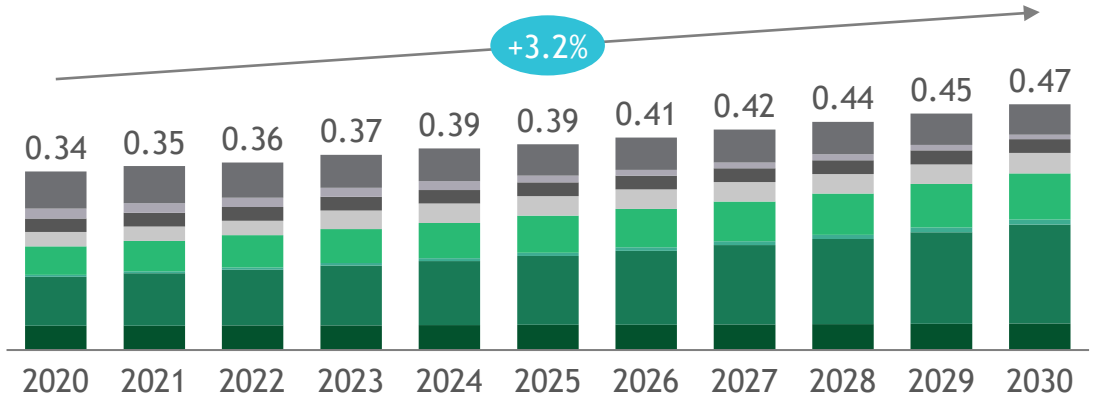


Energy capacity [TW]



Steady increase in share of renewable capacity

Employment for O&M[1] [in M]



Huge increase in O&M employment for on-/offshore wind, solar and Biomass

1. Operations & Maintenance
Source: BCG

Legend: X.X% Year-over-year growth

2.4%
y-o-y

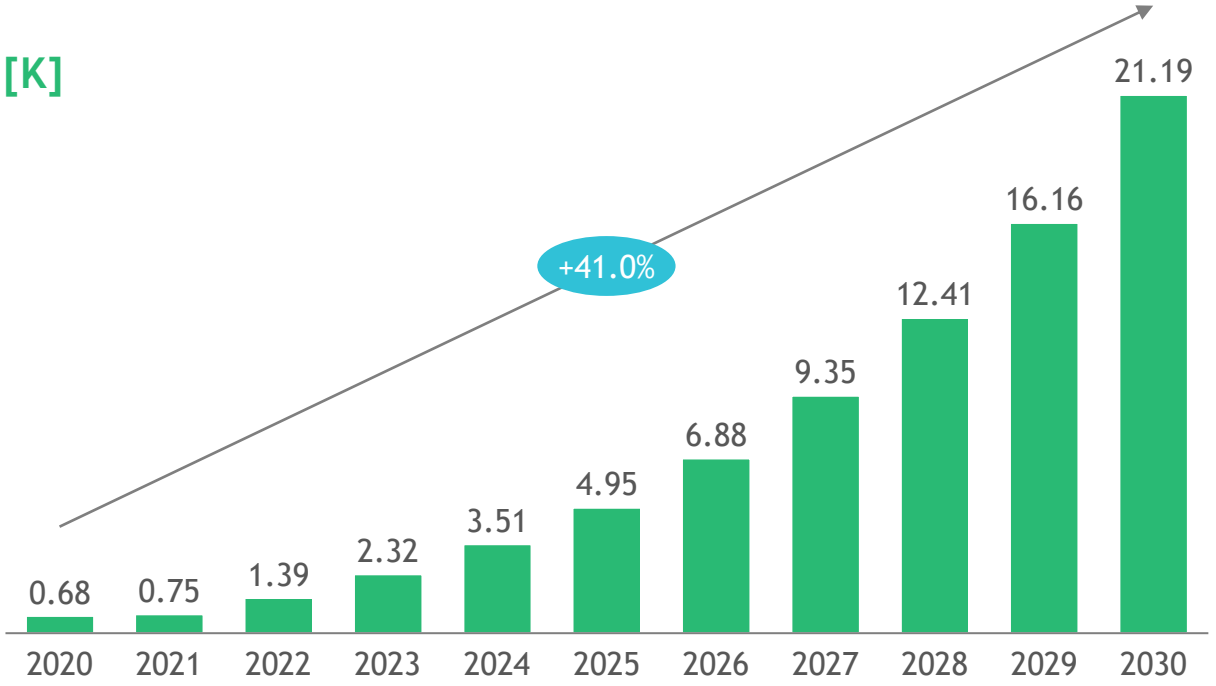
Increase in total energy capacity

3.2%
y-o-y

Increase in O&M employment for energy production

EV energy production jobs will massively grow

O&M[1] employment for EV energy [K]



Massive growth of EV related energy production jobs

Based on share of energy consumption for EVs, employment **increases 41% per year** (CAGR)

41% y-o-y

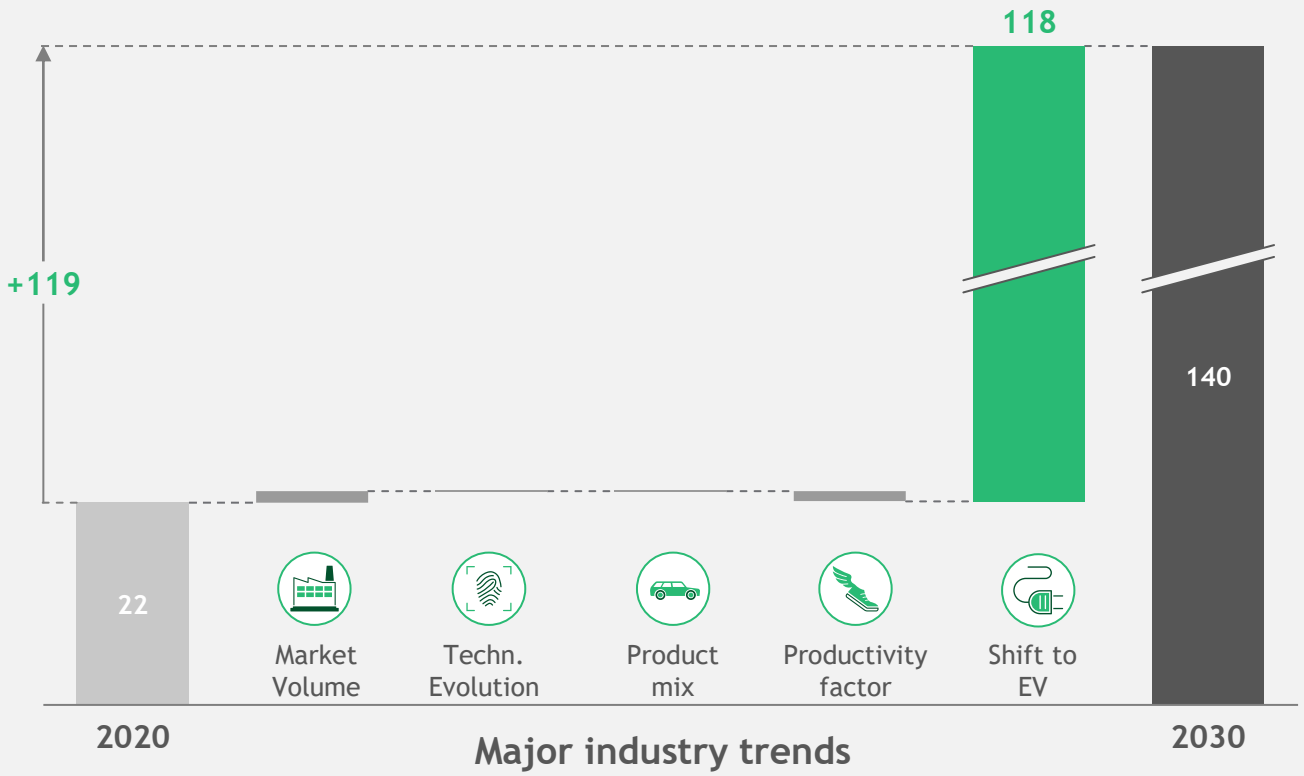
Increase in EV related employment in Energy production

1. Operations & Maintenance
Source: BCG

Legend: X.X% Year-over-year growth

Energy infrastructure will have strong job growth

Impact on jobs in Europe [in k]



Minimal impact by overall market volume development - shift between propulsion systems is the main driver

Technology evolution in the car with no impact on energy infrastructure

Product mix (content per car) has no impact on energy infrastructure

Small job reduction based on productivity in fuel infrastructure

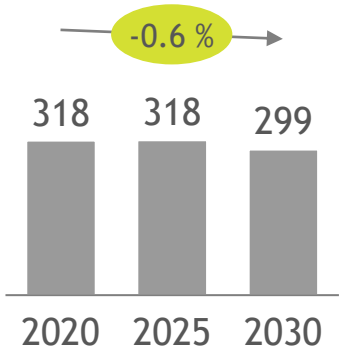
118k job increase by shift to EV due to rising charging infrastructure need for BEV

Source: BCG

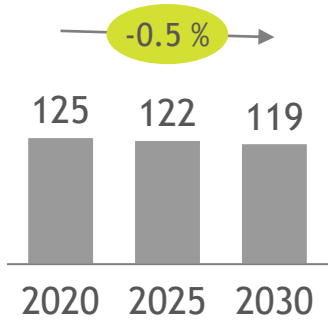
Shift to EV: Charging infrastructure strongly replaces fuel until 2030

Fuel infrastructure in Europe

ICEV/HEV car parc [in M]



Petrol stations [in K][1]

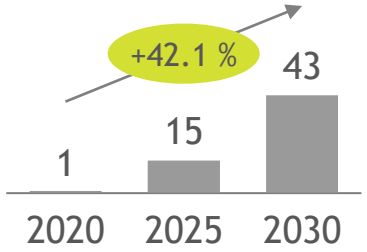


Total number of petrol stations slowly decreases by **~0.5% y-o-y** following total ICEV car parc trend.

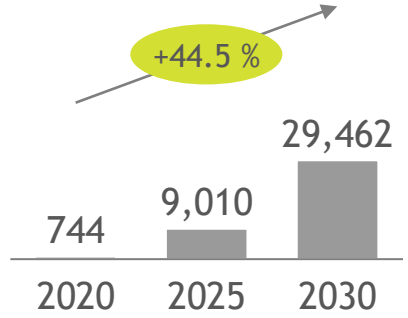
Jobs related to fuel infrastructure in manufacturing & maintenance are expected to decrease proportionally by **~0.5% y-o-y.**

Charging infrastructure in Europe

BEV/PHEV car parc [in M]



Electric charging points [in K][2]



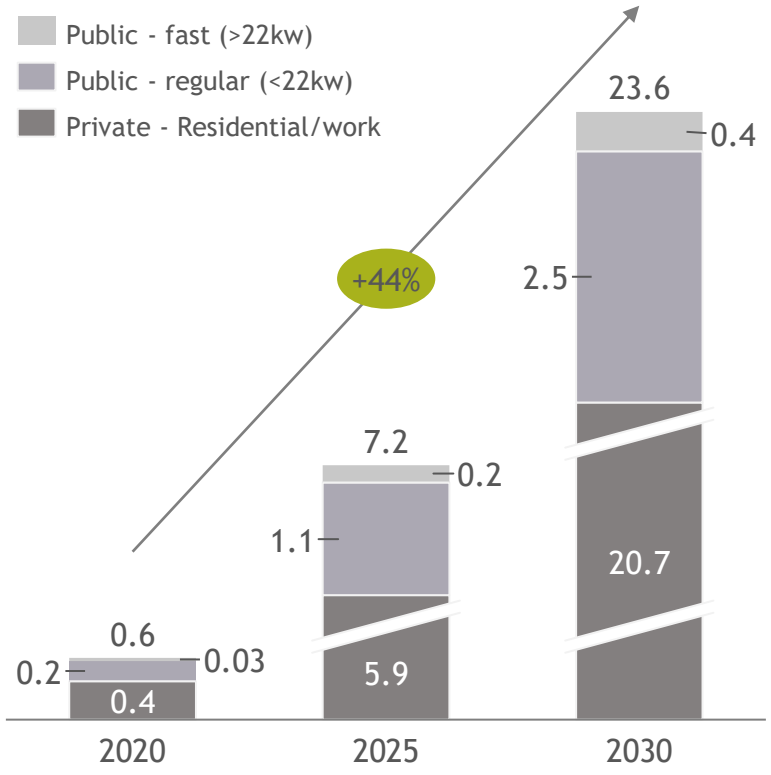
Total public and private charging points strongly increases in Europe driven by public investments in cities/hubs and subsidies for private setups

Jobs in charging manufacturing and maintenance are therefore expected to reach ~155k in 2030 from ~7k in 2020, with a **37%** y-o-y increase

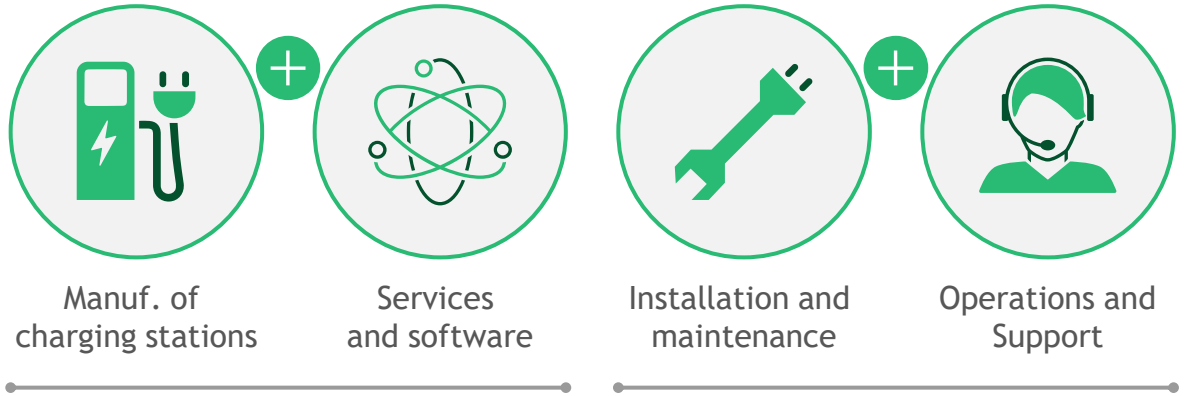
1. Yearly reduction of 0.5% of in petrol stations due to network consolidation 2. included public fast & normal (<22kW) as well as private charging points
Source: European Alternative Fuels Observatory; MWV – Mineralölwirtschaftsverband e.V.

Shift to EV: Charging infrastructure jobs will grow by up 38% YoY until 2030

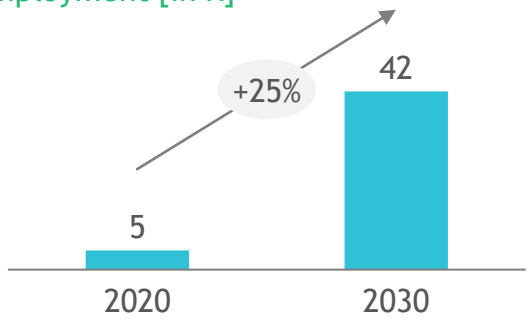
Fast growing charging infrastructure forecasted [in M]



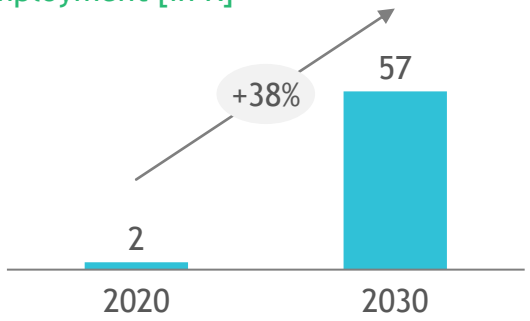
Charging infrastructure companies need to set up a wide-ranging EV charging ecosystem



Charging infrast. (Manf. & Service) employment [in K]



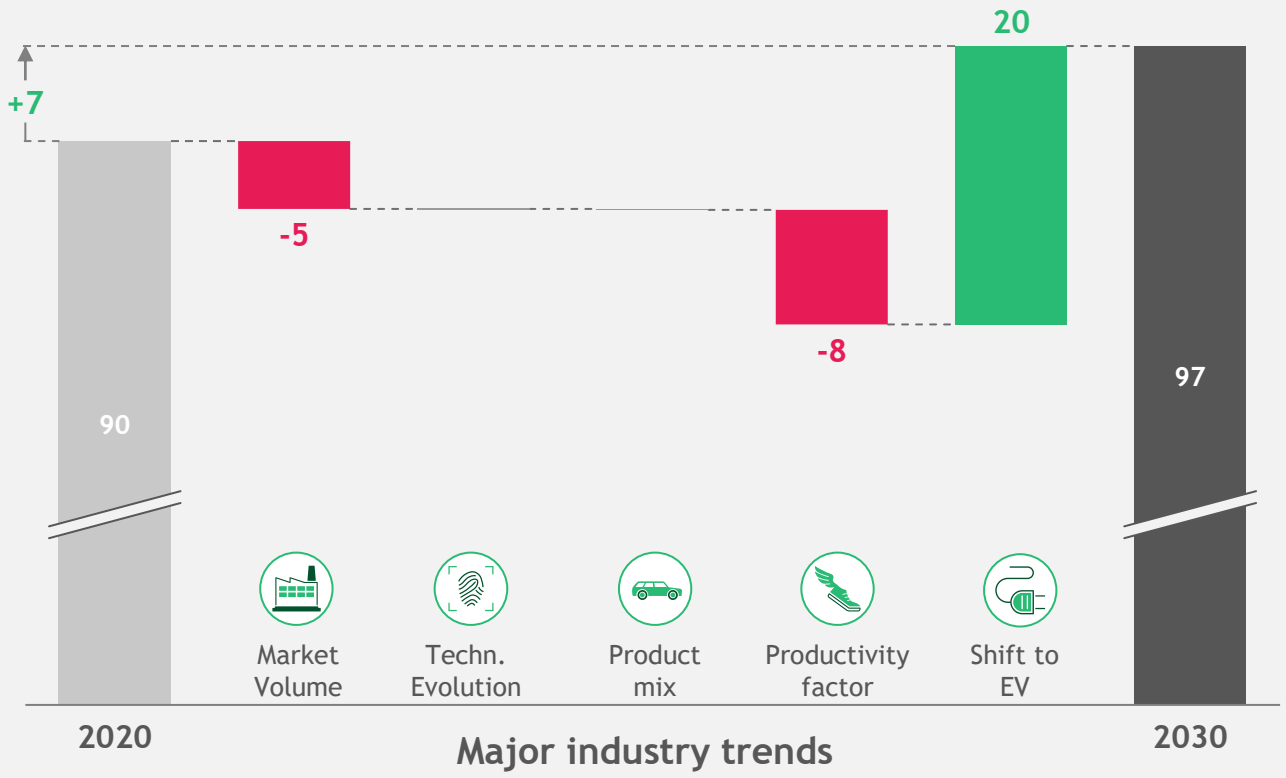
Charging infrast. (Instal & Ops.) employment [in K]



Source: BCG

Material recycling shows job increase due to BEV extent

Impact on jobs in Europe [in k]



-5k slight decrease in jobs based on reduced number of sold cars in Europe until 2030

Insignificant impact of new technologies developments for material recycling

Product mix (content per car) has no impact on charging infrastructure

-8k job reduction based on increase in productivity

20k significant job increase by shift to EV due to rising charging infrastructure need for BEV

Source: BCG

Shift to EV: Battery recycling becoming mandatory for producers in EU & China

Europe

Ambitious plans to become global leader in sustainable battery production

EU introduced 'The Battery Directive', making producer of batteries responsible for financing costs of collection and recycling at end-of-life of battery

No regulation dealing explicitly with Lithium-ion batteries yet

China

Passed significant reforms in 2017 making EV manufacturer responsible for battery recycling

Manufacturers responsible for recovery of EV-batteries and set up of recycling channels

Battery makers are encouraged to adopt standardized and easily dismantled product designs, to help automate recycling process

USA

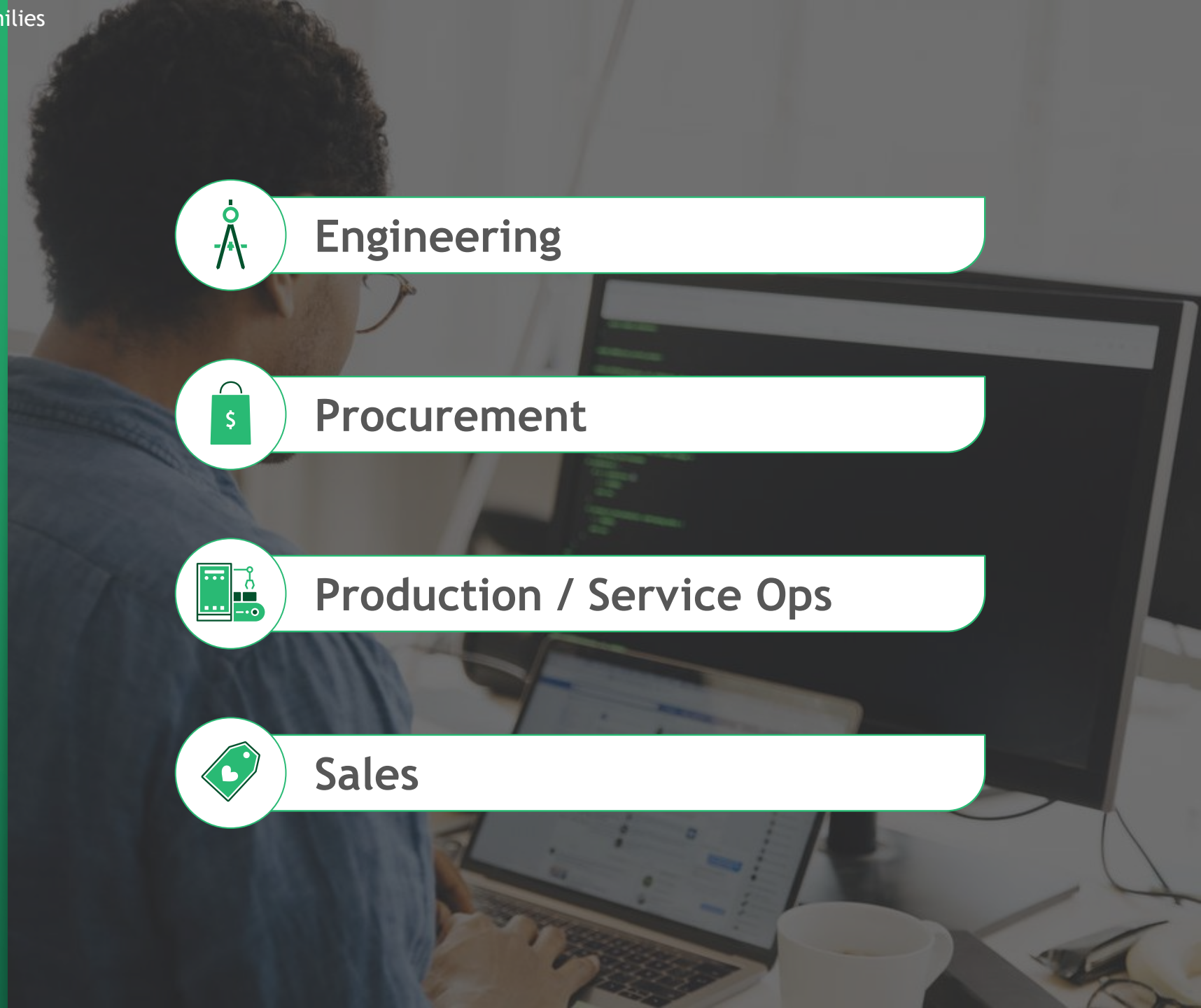
Subsidized Lithium-ion battery recycling

No EV battery recycling regulation on federal level – few states passed regulations

USA is attempting to pass regulation on battery recycling; currently conducting research

Source: Johnson Matthey Technology; Reuters; Clean technologies and environmental policies; BCG

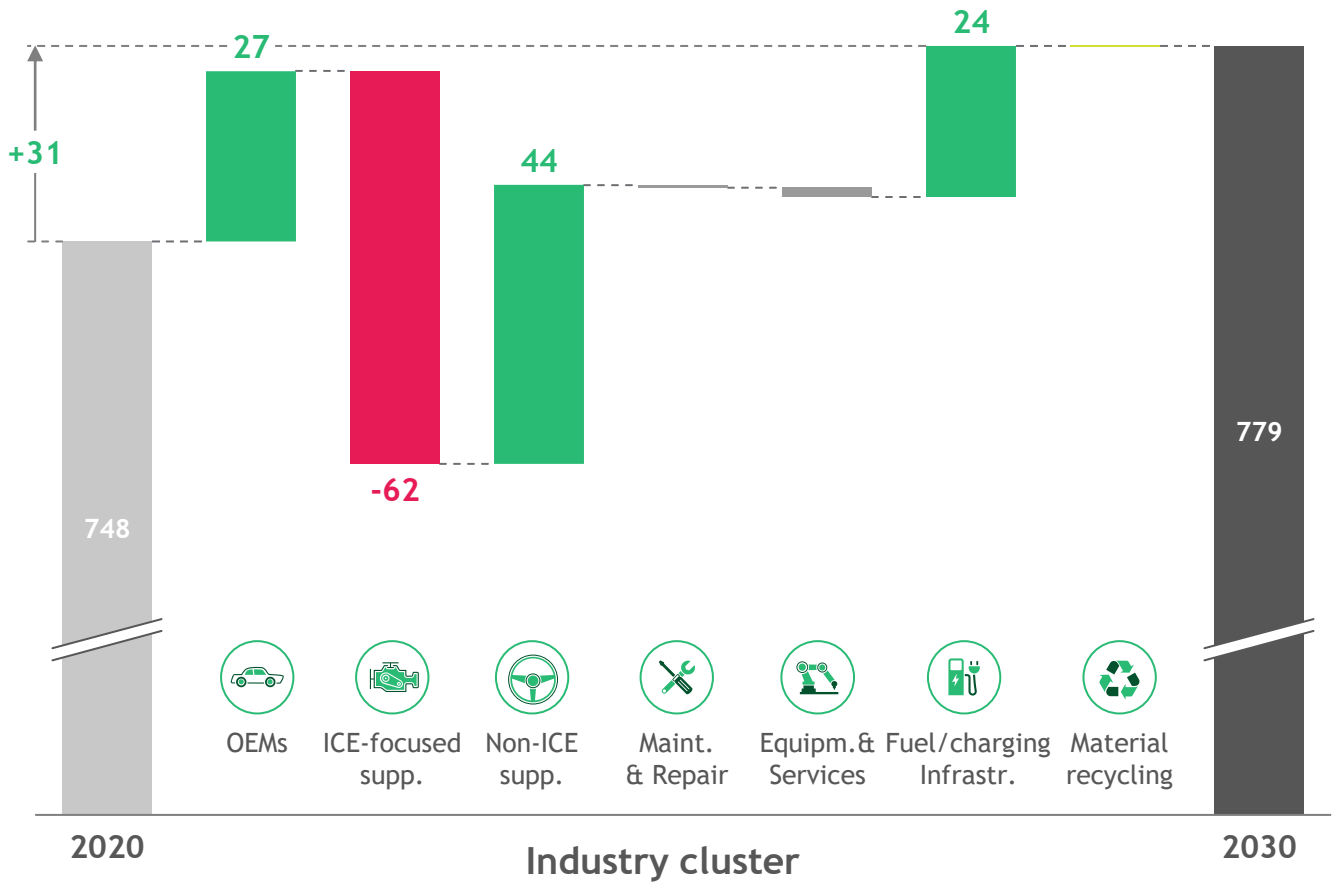
Deep dives across the 4 job families



- Engineering
- Procurement
- Production / Service Ops
- Sales

Strong engineering demand for non-ice suppliers and charging infrastructure

Total of job alteration in Europe [in k]



27k OEM job increase based on development of new BEV vehicles

-62k supplier job reduction driven by reduced number of ICE components

44k new **supplier** jobs created due to need for development of new BEV components

Stable demand within **maintenance & repair**

Stable demand within **equipment & services**

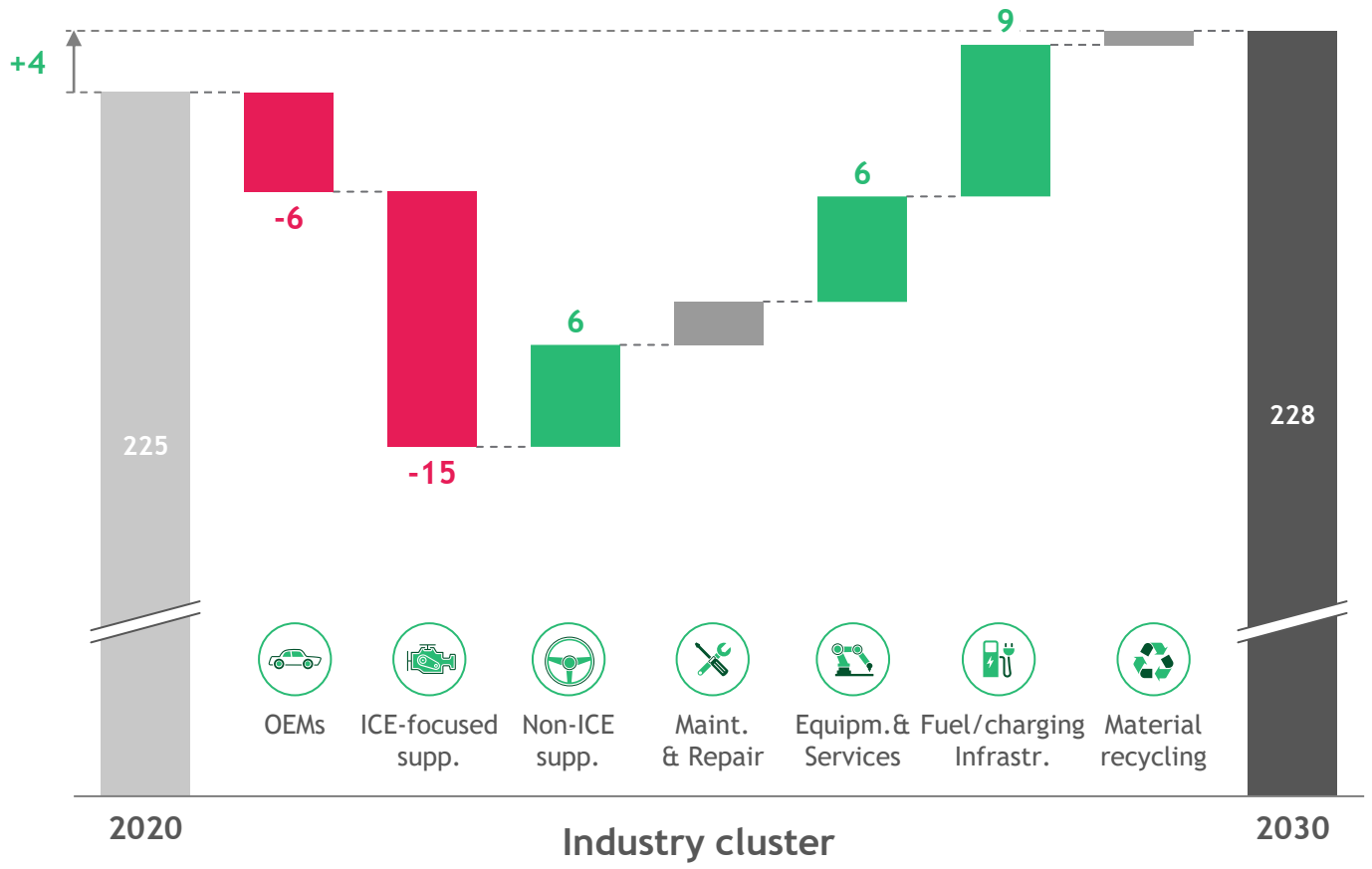
24k new **infrastructure** jobs created due to massive increase in planned installations

Stable demand within **material recycling**

Source: BCG

New procurement jobs for infrastructure, switch within ICE and BEV suppliers

Total of job alteration in Europe [in k]



-6k slight **OEM** job reduction

-15k **supplier** job reduction driven by reduced demand for ICE components

6k new **supplier** jobs created driven by increased demand for BEV components

Stable demand within **maintenance & repair**

6k slight demand increase within **equipment & services**

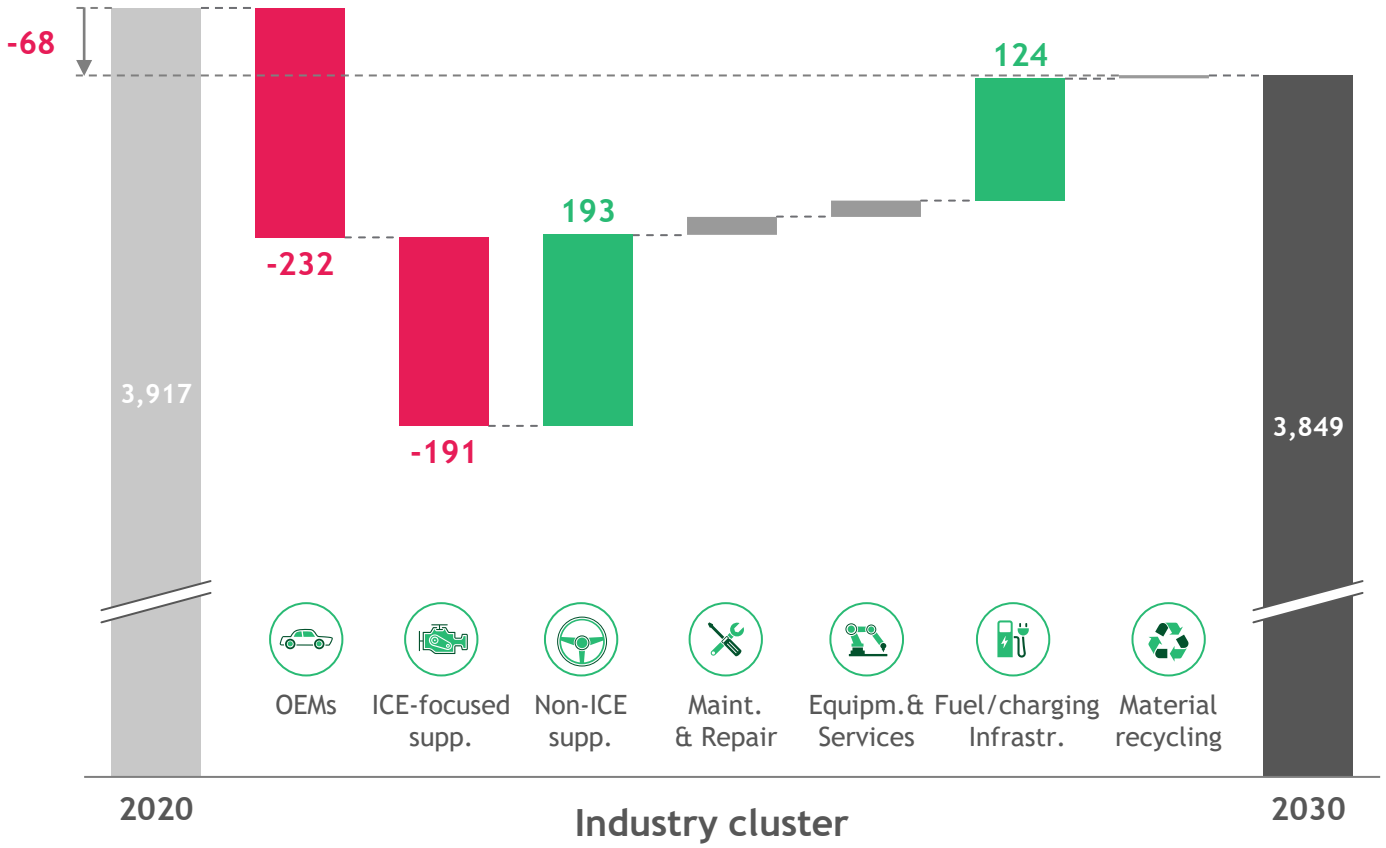
9k new **infrastructure** jobs created linked to procurement of charging infrastructure

Stable demand within **material recycling**

Source: BCG

Strong reduction for production/service ops within OEMs and ICE suppliers

Total of job alteration in Europe [in k]



-232k **OEM** job reduction based on increased labor productivity

-191k **supplier** job reduction driven by reduced demand for ICE components

193k new **supplier** jobs created driven by increased demand for BEV components

Stable demand within **maintenance & repair**

Stable demand within **equipment & services**

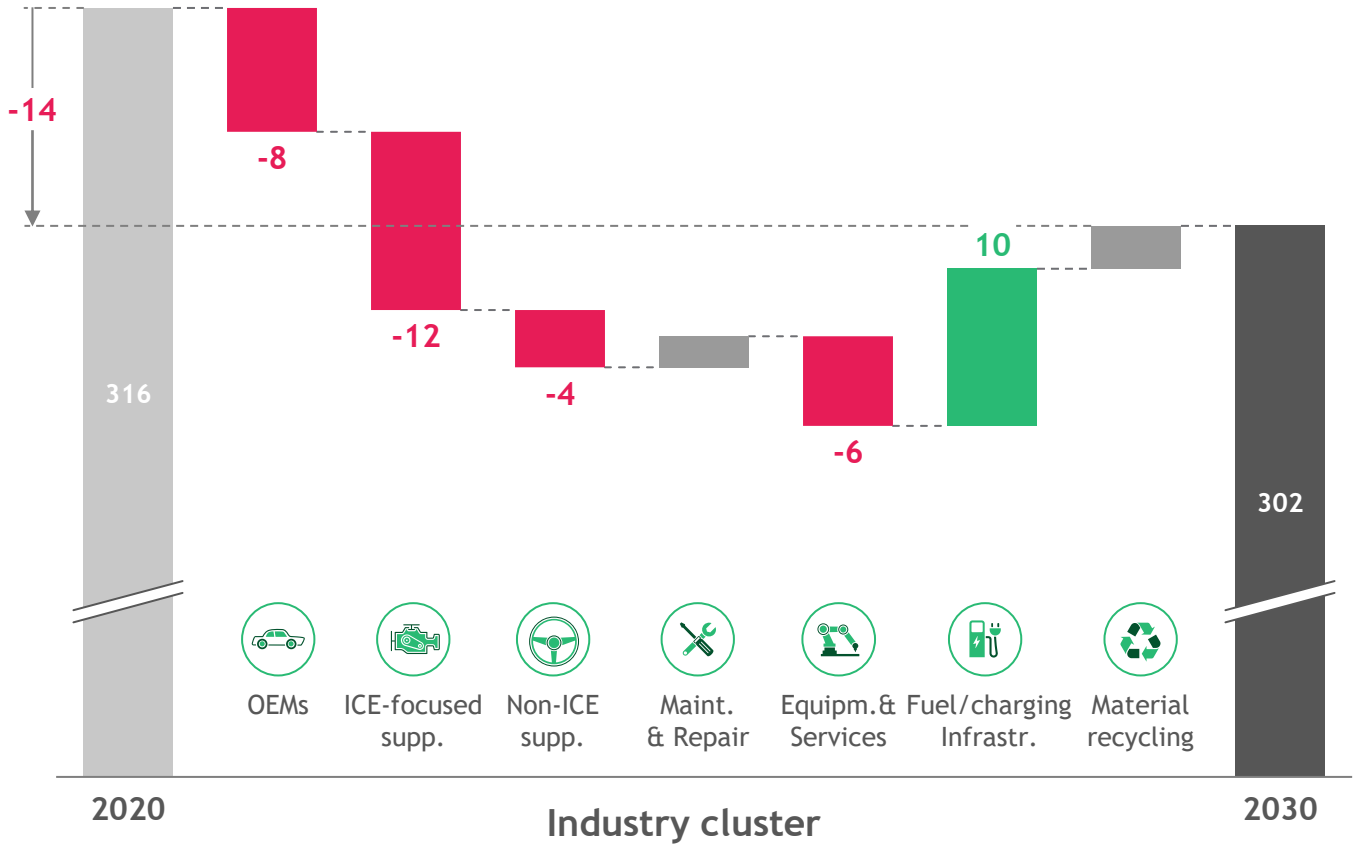
124k new **infrastructure** jobs created based on massive increase in planned installations

Stable demand within **material recycling**

Source: BCG

Decline in sales jobs for OEMs and ICE-focused suppliers

Total of job alteration in Europe [in k]



- **-8k** **OEM** job reduction based on shift towards online sales channels
- **-12k** **ICE-focused supplier** job reduction driven by reduced demand for ICE components
- **-4k** sales jobs within **non-ice suppliers** due to shift towards online sales
- Stable demand within **maintenance & repair**
- **-6k** sales jobs within **equipment & services** due to shift towards online sales
- **10k** new **infrastructure** jobs created based on massive increase in planned installations
- Stable demand within **material recycling**

Source: BCG

Agenda

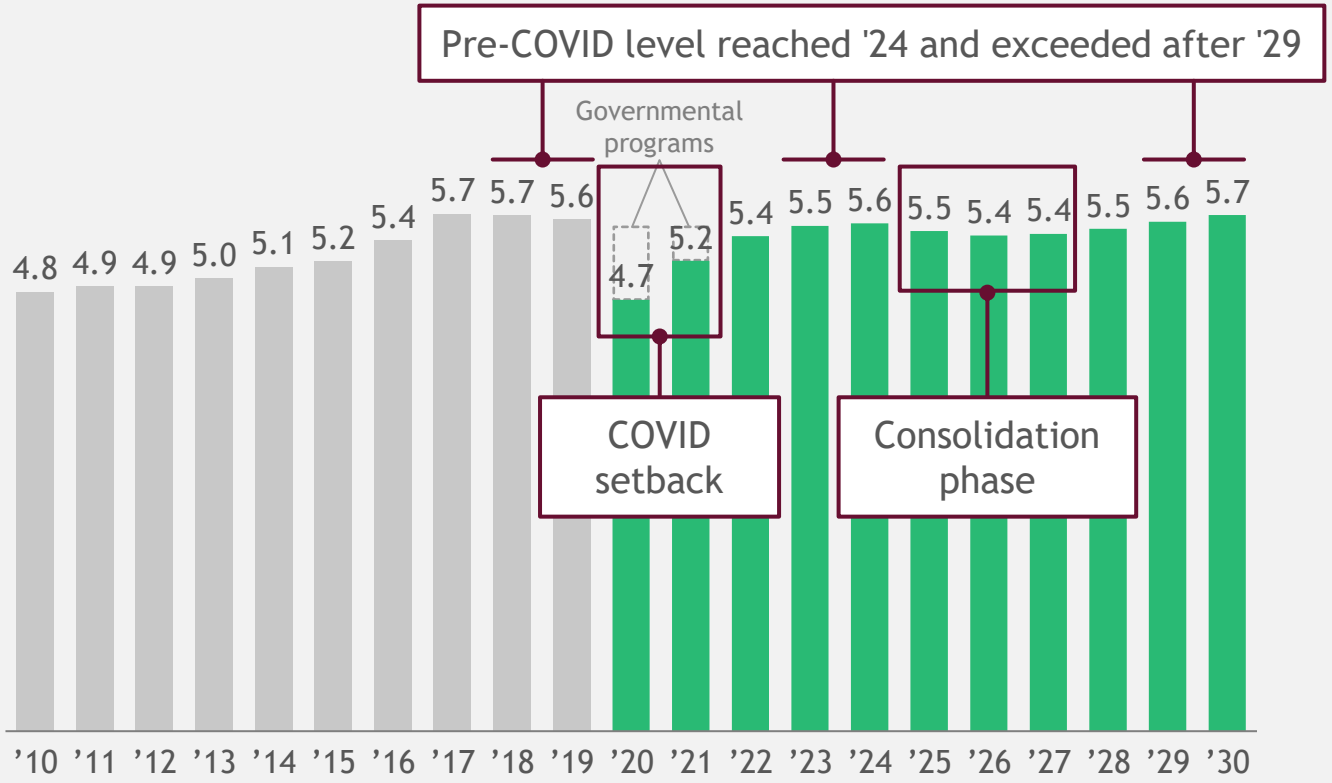
1. **Industry sectors** and **job families** primarily affected
2. **Major trends** influencing job development in Auto industry
3. **Net impact** of job development until 2030
4. **Transition** over time, across industries, job families, regions
5. **Recommendations** for companies and governments

Transition of job positions in 3 perspectives

1. Transition over time
   - Pre-COVID level of ~5.7M jobs will by reached by 2024
2. Transition between industries & job families
   - ~0.8M jobs to be shifted to & from industry clusters in Auto & adjacent industries
3. Transition across regions
   - Job growth in Germany expected, slight decline in rest of Europe

Employee demand with sideways movement till 2030

Total of job development 2010 - 2030 in Europe [in k]



Key characteristics 2020-30

- No return to previous growth trajectory until 2030
- Recovery from COVID setback expected until ~2023
- Consolidation phase 2025-27 due to total volume decline

Source: BCG

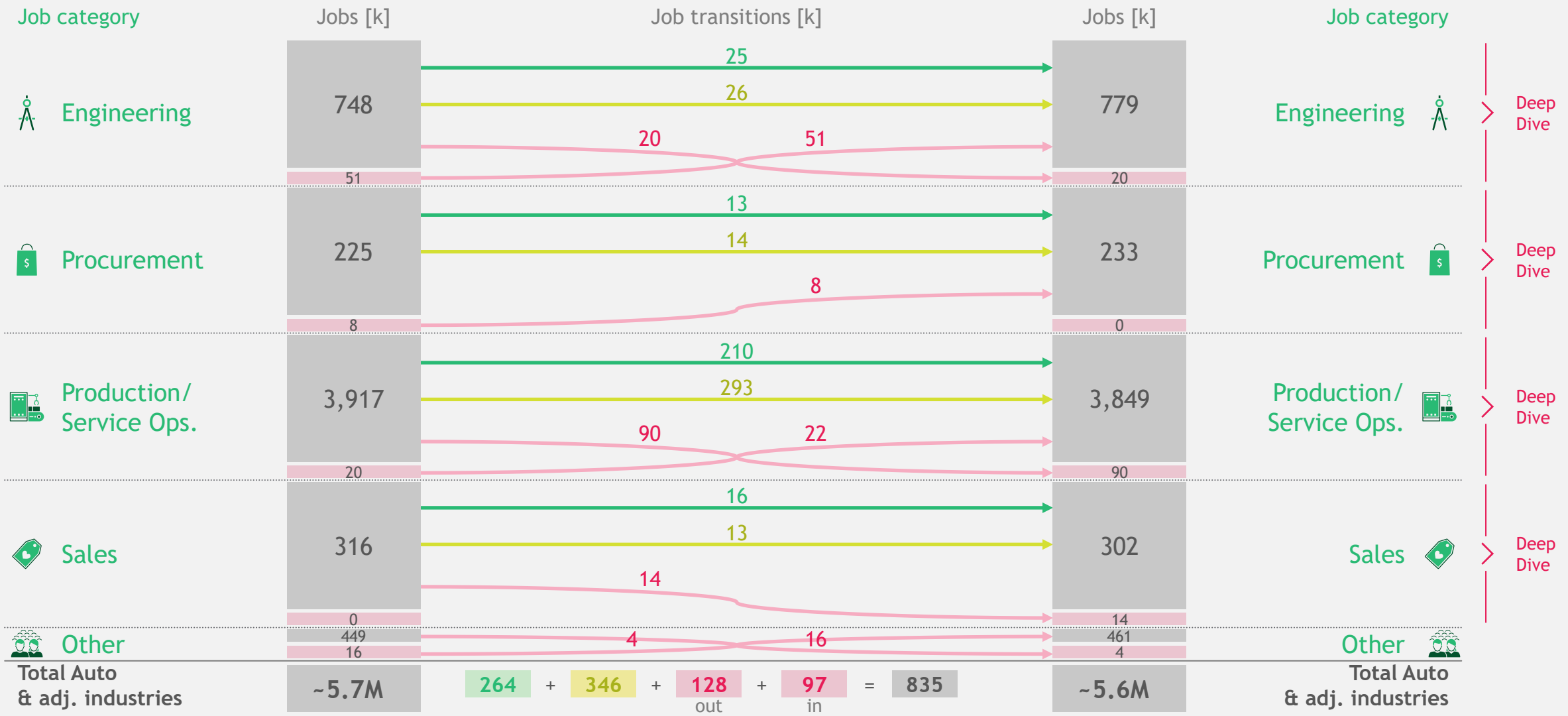
1.6M trainings, plus 0.8M transitions with varying effort

	Staying	Small transition	Large transition	Industry exit
Industry	*No transition*	same industry cluster	similar industry cluster	other industries
Job family		same job family	same / similar job family	same / similar job family
Transition effort	●●● No effort	●●● Low effort, minor re-qualification needed	●●● Medium effort, re-qualify-cation & incentives needed	●●● High effort, intense re-qualification & support needed
Priority	0 Prepare employees for future job demands through training	1 1st choice transition – as many jobs shifted within industry as possible	2 2nd choice transition – only if shift within industry not possible	3 3rd choice transition – only if shift in Auto/adj. Industry not possible
Affected Positions	~4,800K: ~1,600K with major retraining; ~3,200K with no/minor retraining	~264K	~346K	~225K

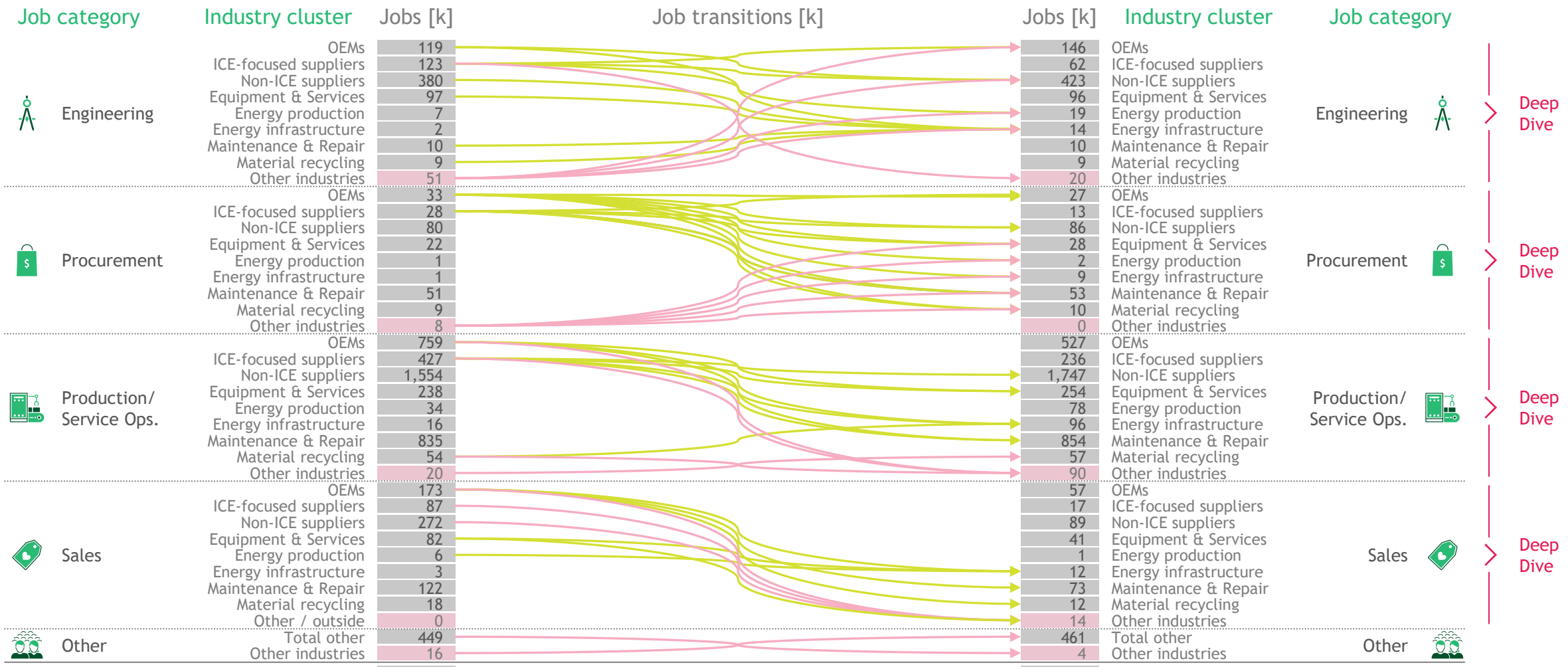
Focus of this chapter

Source: BCG

~835k total job shifts between industry clusters



Jobs transition mainly from OEM and ICE-focus suppliers to other clusters



Transition within same industry cluster | Transition in between Auto or adjacent industry | Transition to/from other industries

Highest demand increase in non-ICE production staff

Top 10 job families
highest demand increase

Industry cluster	Industry	Job family	Change
Non-ice	Manufacture of batteries and accumulators	Operational (production) staff	79,733
Non-ice	Manufacture of electric motors, generators and transformers	Operational (production) staff	64,477
Non-ice	Manufacture of electrical and electronic equipment for motor vehicles	Operational (production) staff	30,790
OEM	Manufacture of motor vehicles	Software/system developer	28,440
Non-ice	Manufacture of batteries and accumulators	Operational (logistics) staff	27,600
Energy infrastructure	Charging infrastructure (Operation&Maint.)	Operational (production) staff	23,523
Non-ice	Manufacture of electric motors, generators and transformers	Operational (logistics) staff	22,319
Energy infrastructure	Charging infrastructure (Manf.&Service)	Operational (production) staff	18,487
Equipment & Services	Equipment & machinery	Operational (production) staff	18,403
Non-ice	Manufacture of electrical and electronic equipment for motor vehicles	Software/system developer	17,164

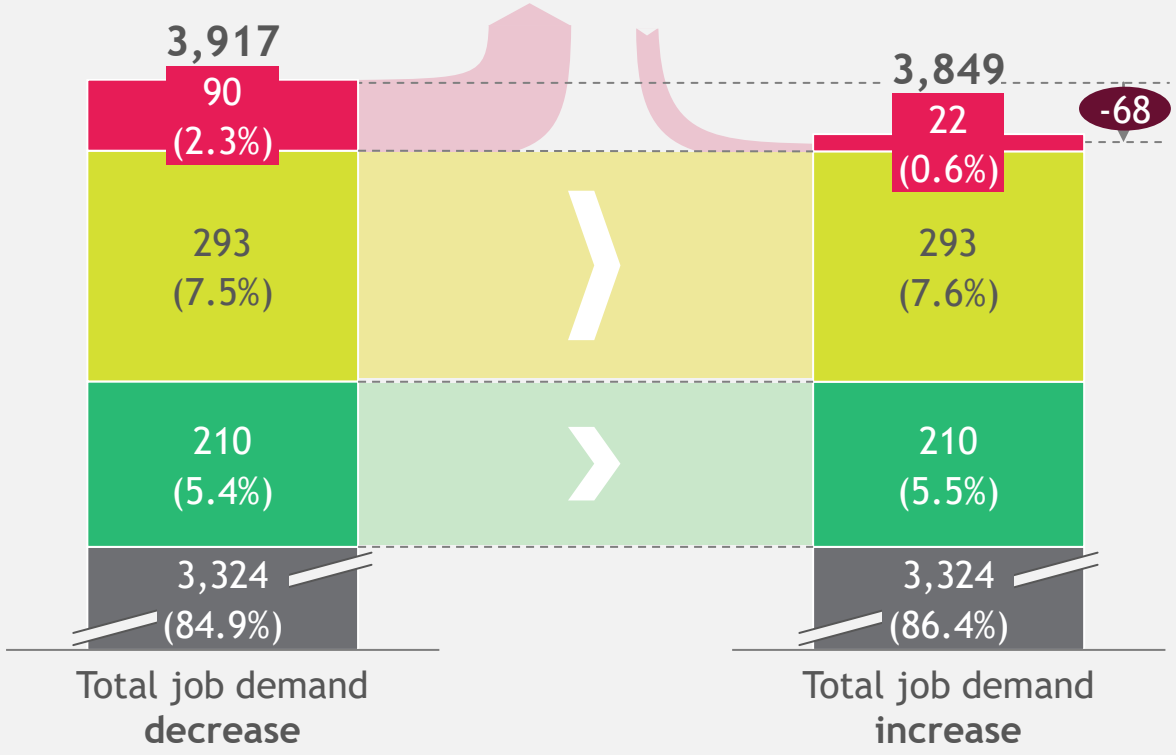
Bottom 10 job families
highest demand decrease

Industry cluster	Industry	Job family	Change
OEM	Manufacture of motor vehicles	Operational (production) staff	-154,612
Non-ice	Manufacture of other parts and accessories for motor vehicles	Operational (production) staff	-79,805
ICE-focused	Manufacture of cooling and ventilation equipment	Operational (production) staff	-51,133
ICE-focused	Manufacture of bearings, gears, gearing and driving elements	Operational (production) staff	-50,443
OEM	Manufacture of motor vehicles	Operational (logistics) staff	-42,612
Non-ice	Manufacture of other parts and accessories for motor vehicles	Operational (logistics) staff	-27,625
ICE-focused	Manufacture of other pumps and compressors	Operational (production) staff	-18,941
ICE-focused	Manufacture of bearings, gears, gearing and driving elements	Operational (logistics) staff	-13,599
ICE-focused	Manufacture of cooling and ventilation equipment	Operational (logistics) staff	-13,289
OEM	Manufacture of motor vehicles	Machine operator	-10,977

Production: ~293k lost jobs shifted across industries

Production/Service Ops.

Transition of jobs in Production & Service Ops. [in k]



68k **net job loss** in Production/Service Ops.

210k lost jobs can be compensated by new jobs **in the same industry cluster**

293k los jobs can be compensated by new jobs in other **Auto and adjacent industries**

90k lost jobs cannot be compensated within Auto or adjacent industries due to **missing demand match**

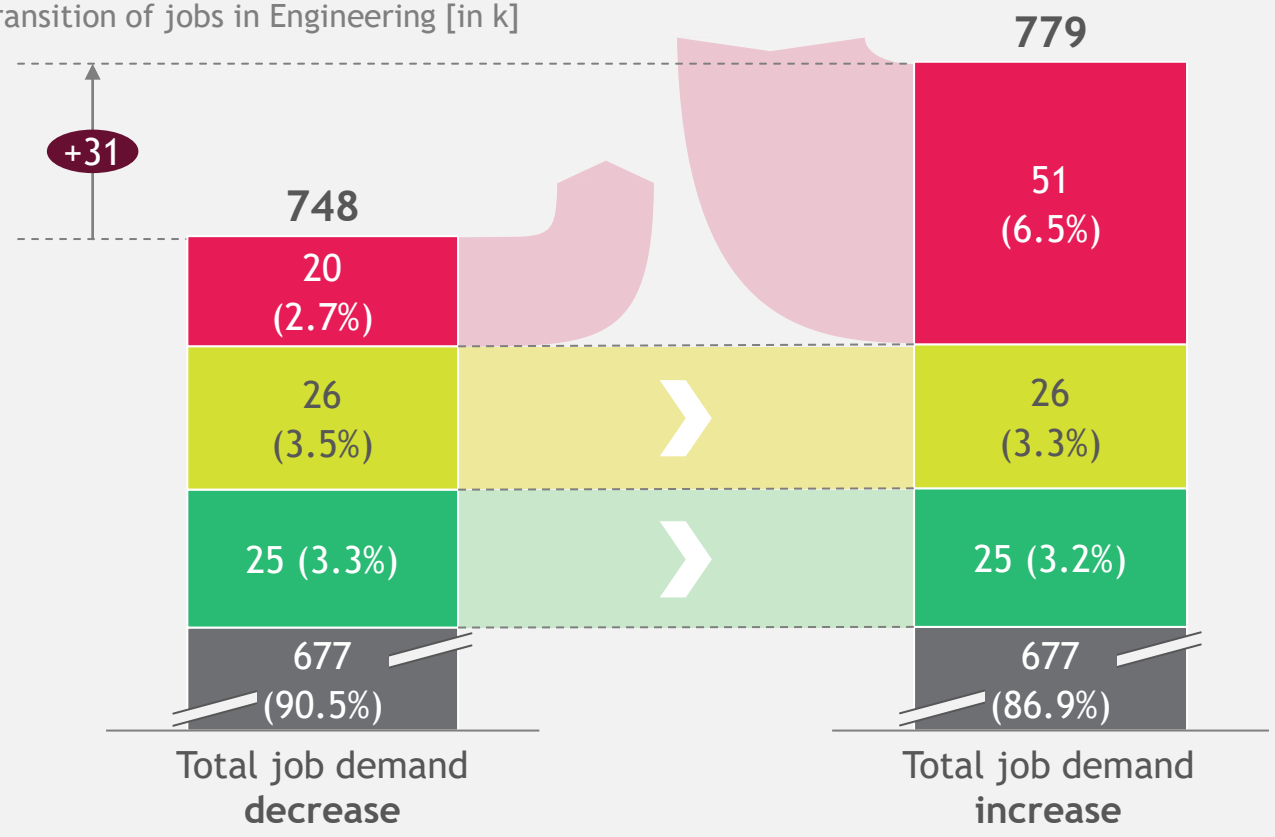
22k new jobs cannot be filled by transition from Auto or adjacent industries – compensation from outside needed

Transition within same industry cluster | Transition in between Auto or adjacent industry | Transition to/from other industries

Engineering: ~51k addl. jobs to be compensated

Engineering

Transition of jobs in Engineering [in k]



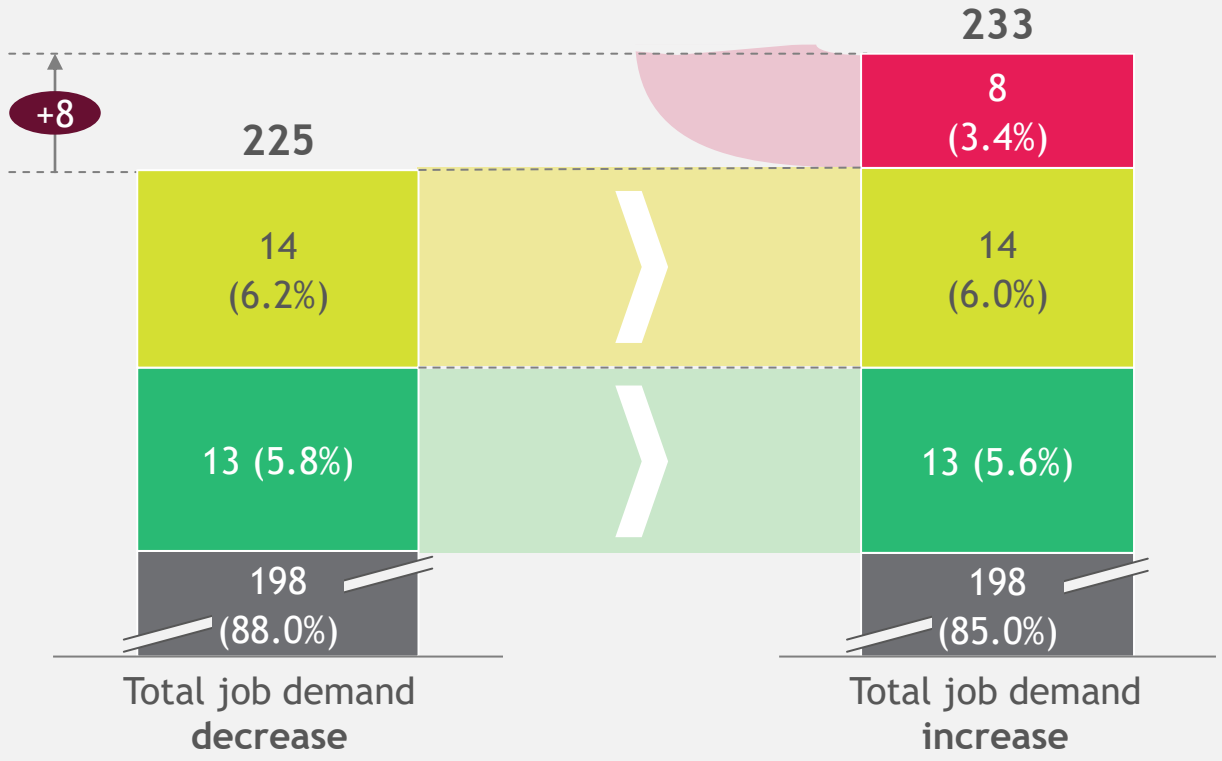
- **31k net job increase** in Engineering
- **25k** lost jobs can be compensated by new jobs **in the same industry cluster**
- **26k** los jobs can be compensated by new jobs in other **Auto and adjacent industries**
- **20k** lost jobs cannot be compensated within Auto or adjacent industries due to **missing demand match**
- **51k** new jobs cannot be filled by transition from Auto or adjacent industries – **compensation from outside** needed

Transition within same industry cluster | Transition in between Auto or adjacent industry | Transition to/from other industries

Procurement: ~8k of additional jobs to be compensated

Procurement

Transition of jobs in Procurement [in k]



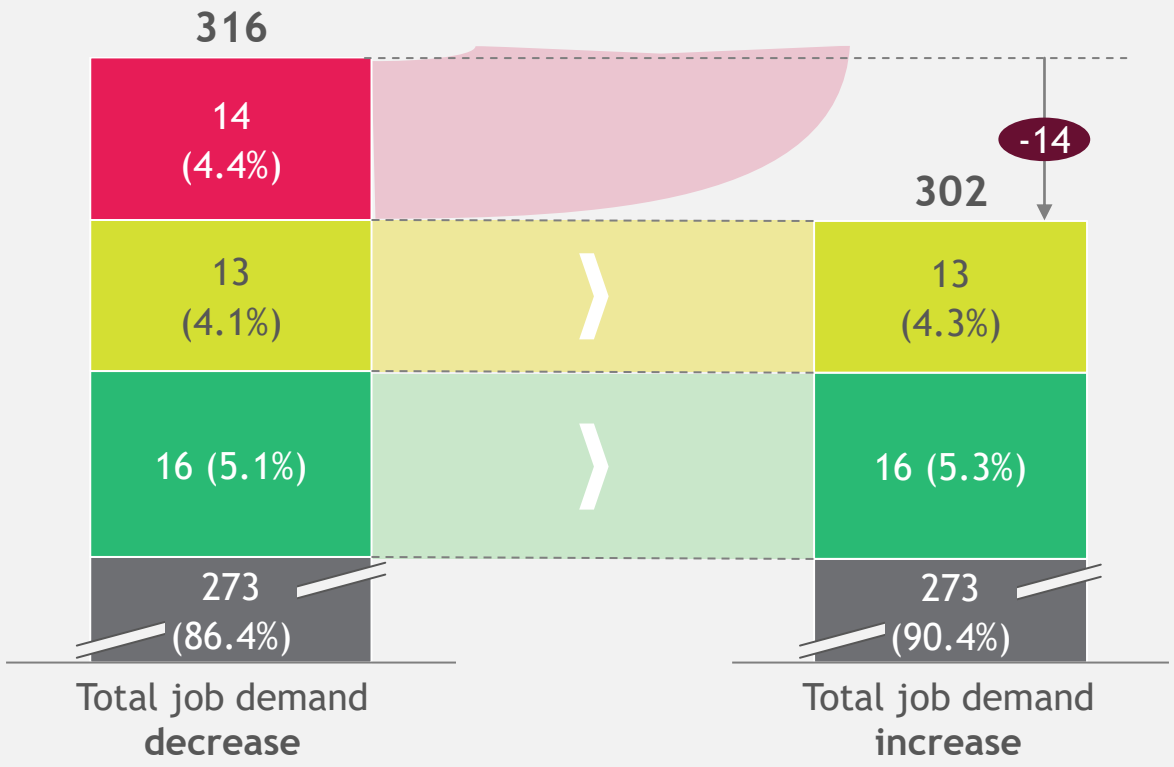
- **8k net job increase** in Procurement
- **13k** lost jobs can be compensated by new jobs **in the same industry cluster**
- **14k** los jobs can be compensated by new jobs in other **Auto and adjacent industries**
- **No** need to compensate lost jobs outside of Auto or adjacent industries due to **missing demand match**
- **8k** new jobs cannot be filled by transition from Auto or adjacent industries – **compensation from outside** needed

Transition within same industry cluster | Transition in between Auto or adjacent industry | Transition to/from other industries

Sales: ~14k of lost jobs to be compensated outside

Sales

Transition of jobs in Sales [in k]



14k **net job loss** in Sales

16k lost jobs can be compensated by new jobs **in the same industry cluster**

13k los jobs can be compensated by new jobs in other **Auto and adjacent industries**

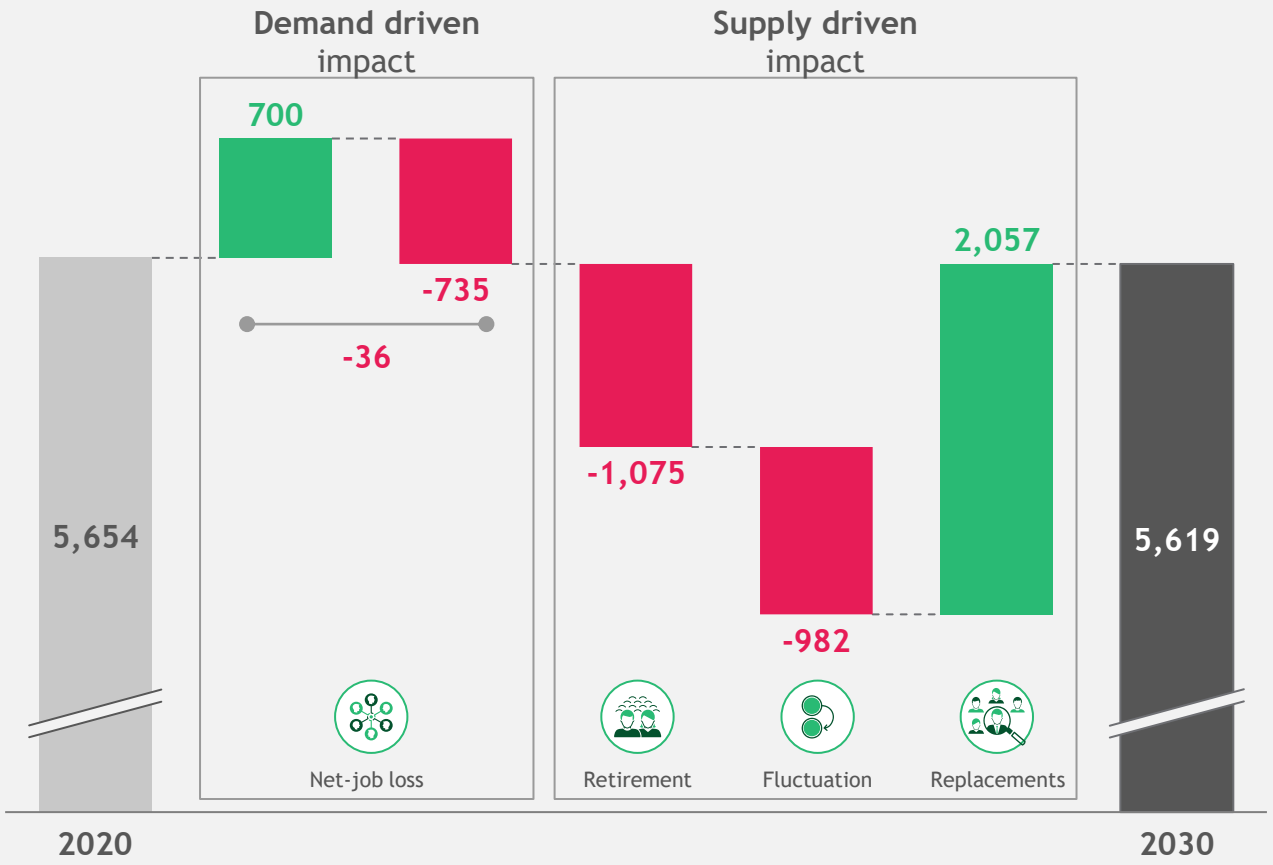
14k lost jobs cannot be compensated within Auto or adjacent industries due to **missing demand match**

No need to fill new jobs by **transition from outside**

Transition within same industry cluster | Transition in between Auto or adjacent industry | Transition to/from other industries

2.8M employees need to be hired overall

Impact on jobs in Europe [in k]



Demand driven impact

-36k jobs lost in with ~700k new & ~735k lost jobs

Transitions as shown on previous slides

Supply driven impact

2.1M replacements needed to compensate retirement/fluctuation

Additional shifts to be managed

~2.8M employees need to be hired in affected industries until 2030

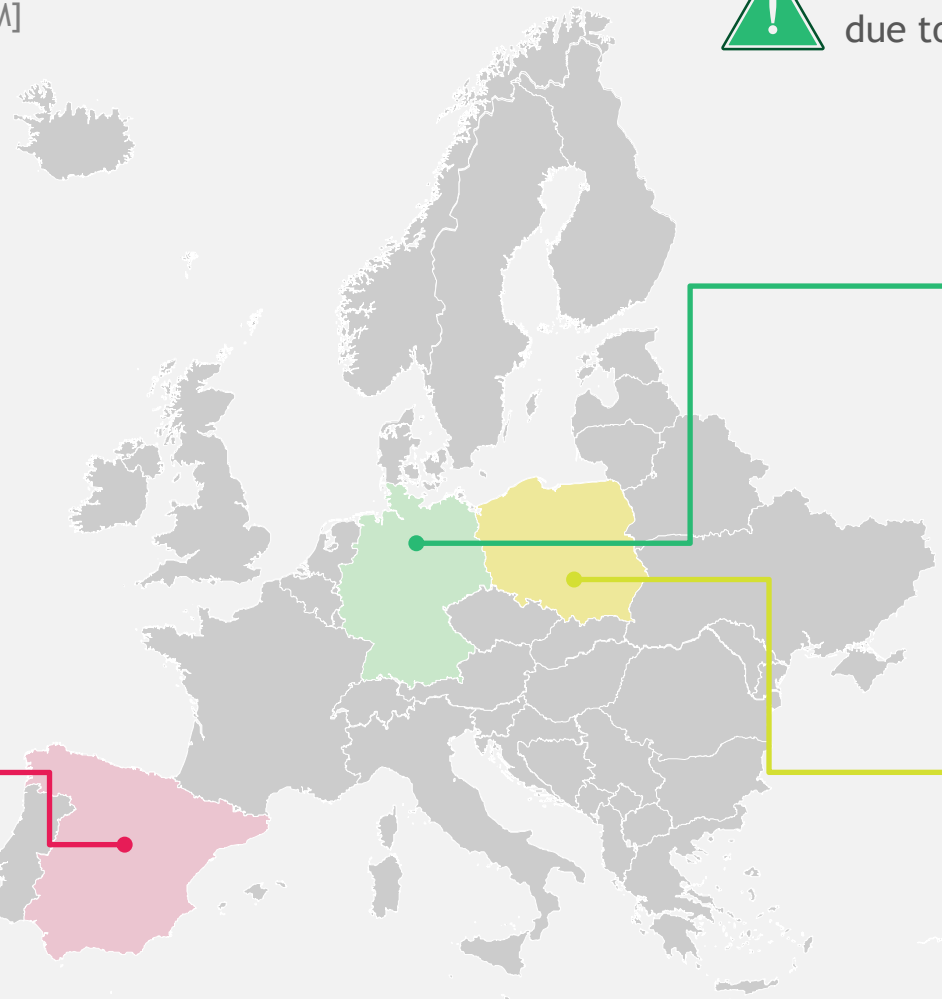
Source: BCG

Results for Spain & Poland preliminary

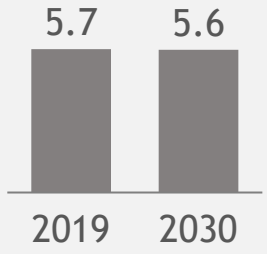
Germany with increase, Spain with high decrease

Regional distribution of jobs across Europe [in M]

Limited transitions across European countries due to political & cultural barriers

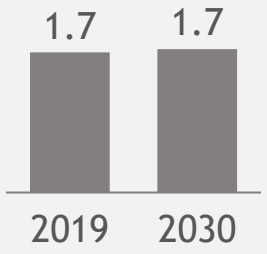


Europe



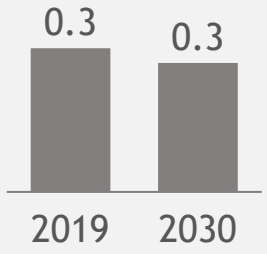
-36k (-1%)
Jobs in 2030 vs. 2019

Germany



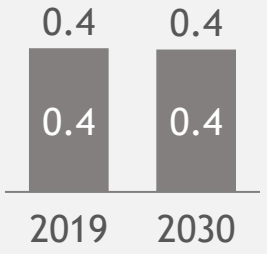
+25k (+2%)
Jobs in 2030 vs. 2019

Spain



-35k (-10%)
Jobs in 2030 vs. 2019

Poland

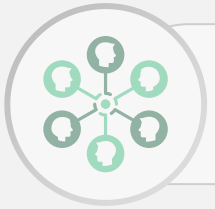


-4k (-1%)
Jobs in 2030 vs. 2019

Agenda

Industry sectors and **job families** primarily affected 1

Major trends influencing job development in Auto industry 2

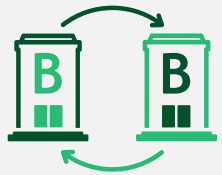


Net impact of job development until 2030 3

Transition over time, across industries, job families, regions 4

Recommendations for companies and governments 5

Companies, governments & NGOs need to **act now** to **master the transition**!



Companies

- Analyze status-quo with regards to future product evolutions and demands, operations, job profiles
- Design a company-specific 2030 target picture based on a clean-sheet, "zero-based" approach
- Revisit make-or-buy decisions (e.g., battery cell mfg.)
- Determine additional adjustments on job demands and profiles as well as operations
- Design re-qualification/upskilling programs and hiring as well as restructuring programs

Governments & NGOs

- Create awareness within sectors and companies about the upcoming changes and necessary transition
- Provide incentives to affected sectors and companies in order to master the transition
- Tailor educational curricula towards new technologies and specifically train job seekers accordingly
- Ensure globally leading position of European automotive industry to maintain status as EU job motor

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