European Climate Foundation

Electromobility in the Visegrad region – Slovakia

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clarity from complexity

Final Report

February
2022

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Authorisation and Version History

Version	Date	Authorised for release by	Description
1.0	11/25/2021	János Hidi	First draft for review
2.0	12/10/2021	Dóra Fazekas	Final draft
3.0	02/03/2022	Dóra Fazekas	Final report

Contents

Executive Summary

EV sales policies in Slovakia's export markets

In the last few years governments and car manufacturers around the world announced regulations and strategies which all point towards an imminent phase-out of internal combustion engine (ICE) vehicles. The most likely technology to replace traditional powertrains in the next decades is electric vehicles (EV).

With these regulations in place 74% of Slovakia's export destination market value have confirmed ban on ICE sales by 2035, and for the remaining 26% a phase out of ICE in new sales is also taking place.

Slovakia's strong reliance on car manufacturing and exports makes it particularly vulnerable to EV adoption trends in its main export markets. If this trend continues, Slovakia's domestic producers will have to adopt to these trends, regardless of the local rate of the EV take-up.

Cambridge Econometrics were commissioned by the European Climate Foundation (ECF) to assess the likely economic impacts associated with, and the potential challenges to switching car production in Slovakia to EVs over the long term (to 2040).

10% of GDP under risk in the worst case scenario

- This technical report sets out the findings from our analysis of the impacts of Slovakia's successful or unsuccessful transition to the production of EVs and battery cells. It provides details about the EV manufacturing costs, productivity, the need for investments and the impact on employment by sector and by occupational category. The analysis compares best and worst case scenarios, representing a successful and an unsuccessful transition.
- Results show that the stakes are high for Slovakia. In a worst case scenario in which the switch to EV production does not take place, the GDP of Slovakia will be 10% lower than in a best case scenario. The overall net employment effect is also significant, with a 4% difference between the two scenarios.

The motor vehicles and electrical equipment production sectors directly impacted

- At a sectoral level the largest sectoral impacts are directly in the motor vehicle, electrical equipment, and services sectors as vehicle production supply chain transitions from ICE powertrains to electric powertrains. In the worst case scenario, the net employment in the motor vehicles sector can drop by 55,000 (87%), while in the services sector employment can decline by 30,000 (2%). In the best case, however, motor vehicle employment drops by 13,000 (21%), services employment shrinks by 4,000 (0.3%), while these negative effects are partly compensated by a net increase of 8,000 (18%) jobs in the electrical equipment sector.
- At job level, the largest negative impacts are expected with the motor vehicles sector, with a lower level of job creation in the transition compared to the business-as-usual scenario. In the electrical equipment sector, overall there are positive effects through job creation in occupations linked to the production process. Among occupations, the gainers of the transition to EVs are the engineering occupations such as engineering professionals and software developers. Assemblers, which constitutes the bulk of the workforce in the two sectors, might experience the sharpest drop in

employment, except in the scenario in which 100% of batteries are produced domestically.

Policy implications

The modelling results show that, as its key export markets shift from ICE's to EVs, Slovakia can suffer substantial GDP losses if it fails to adapt its automotive production capacities to EV production. To ensure growth the Slovakian government can play an important role in helping the transition by implementing a series of policies:

- Attract foreign investment to build factories producing batteries and electric vehicles
- Help transforming existing producing units from ICE to EV production
- Strengthen Slovakia's position by providing infrastructure and (re)skilled workforce suitable for the transition
- Support local SMEs and workforce to benefit from the transition
- Boost innovation to ensure high value-added production stages occur in Slovakia
- Securing access to raw materials and encourage recycling of EV parts
- Strengthen domestic markets for EVs to contribute to decarbonized transport.

Governments across the EU have implemented such policies and progress has been made. Some of these are short-run strategies, including direct government subsidies or loans to attract new production, typically battery factories to the country. Other policies are more long-term focussed, like investments in infrastructure and human capital, research, and the labour force. These of policies can ensure a sustained and long-term national competitiveness.

Slovakia must balance these short and long-term policies to preserve its central role in the automotive industry; to create favourable conditions for battery factories but also to invest in its skilled workforce to maintain its place in the global value chains in the wake of the green transition.

1 Introduction

1.1 Background

EV sales policies in Slovakia's export markets

In July 2021 the European Commission adopted a package of proposals to make the EU's climate, energy, and transport policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The motivation for this package was that it is crucial to achieve these emission reductions in the next decade and Europe should become the world's first climate-neutral continent by 2050. These policy steps will contribute to the success of the European Green Deal.[1]

For the road transport sector several measures are needed to put the road transport emissions on a declining path. Stronger CO2 emissions standards for cars and vans will be introduced, requiring average emissions of new cars to come down by 55% from 2030 and 100% from 2035 compared to 2021 levels. This means that all new cars registered as of 2035 will be zero-emission. The transition away from internal combustion engine (ICE) vehicles to electric vehicles (EVs) will be supported by a reliable EV charging network across Europe. The revised Alternative Fuels Infrastructure Regulation will require Member States to expand charging capacity in line with zero-emission car sales, and to install charging points at regular intervals on major highways.

Similar regulations are being adopted or discussed in other countries outside the European Union. In November 2020 the governments of the United Kingdom and China both decided to phase out ICE cars and vans from 2035. In the United States there is no such legislation at a federal level, but California announced that all new cars and passenger trucks sold in California be zero emission vehicles by 2035.

With these regulations in place 74% of Slovakia's export destination market value have confirmed ban on ICE sales by 2035, and for the remaining 26% a phase out of ICE in new sales is also taking place, although at a slower rate.

Motivation for the study

The transition towards zero emission vehicles, and especially that of battery electric cars (BEV) has been accelerating during 2020-2021. Governments, cities and car manufacturers announced regulations and strategies which all point towards an imminent phase-out of ICE vehicles. The most likely technology to replace traditional powertrains in the next decades is the battery electric solution.

Although countries in Central and Eastern Europe (CEE) are adopting the BEV technology domestically at a relatively slow pace, the CEE region's, and especially Slovakia's strong reliance on car manufacturing and exports makes it particularly vulnerable to BEV adoption trends around the globe, but especially in the EU and the UK. If the major export markets of Slovakia's car manufacturing sector accelerate the switch to EVs, domestic producers will have to adopt to these trends, regardless of the local rate of the EV take-up.

The purpose of this study is to evaluate the impact of domestic vehicle manufacturers' success or failure in switching to EV production on Slovakia's

[1] The European Green Deal, presented by the Commission in December 2019, sets the goal of making Europe the first climate-neutral continent by 2050.

GDP and employment outlook, highlighting the potential benefits and risks associated with this transition.

The study seeks to address questions about the investment requirements to successfully put in place manufacturing capacities needed to produce EVs and batteries. It looks at the employment implications by economic sector and by occupations. It evaluates the net impact of jobs creation and looks at the number of jobs lost and created in the process, highlighting the need for reskilling of employees to make the transition possible.

Since the transition from ICE to EV production carries many uncertainties, the study addresses this uncertainty by assessing several alternative scenarios and sensitivities around those scenarios, providing a wide range of possible outcomes.

1.2 Methodology

For this study we have designed a set of scenarios which cover a wide range of possible outcomes, from the worst case where Slovakia's car manufacturing sector fails to adjust to EV adoption trends in their main export markets, to the best case scenario where the switch to EV production is successful and Slovakia maintains its market share in its destination markets. The best case scenario assumes that vehicle producers located in Slovakia will decide to transform their production and adjust their value chains from internal combustion vehicle models to electric vehicles. This requires significant investment in new or redesigned production capacities along the parts of the supply chain which produce parts related to the power train, as well as a successful shift in the labour market to the supply of the required skilled workforce.

The role of battery cell manufacturing is especially important for EV production, but it is highly uncertain whether battery cells to supply the EV manufacturing in Slovakia will be produced locally or imported. To cover this uncertainty, we perform a sensitivity analysis to explore the implications of imported or locally produced battery cells on the value chains and employment.

This research consisted of three phases:

1. The work started with stakeholder consultations to agree on the main elements of the scenarios analysed and the modelling assumptions applied in each scenario.
2. In the next phase these assumptions have been applied to the E3ME macroeconomic model to assess the wider socio-economic implications of the switch to EV production.
3. The net employment impact derived from the E3ME model was decomposed into jobs gains and losses by economic sector and occupational category.

E3ME

Data inputs and assumptions have been applied to the E3ME, an integrated macro-econometric model, which has full representation of the linkages between the energy system, environment, and economy at a global level. The high regional and sectoral disaggregation allows modelling of scenarios specific to Slovakia and detailed analysis of sectoral relationships in key supply chains. E3ME was used to assess how the transition to EV vehicles production affects GDP, employment, investments, and consumption.

For more information and the full model manual, refer to www.e3me.com. A summary description of the model is also available in Appendix A.

Labour market analysis

The estimates of employment resulting from the scenario analysis are available by sector and broad occupation categories. Additional labour market analysis is performed to understand the changes in the workforce required by the two production processes. The aim of the analysis is to detail the substitution of occupations between the two production processes and the decline/increase in demand for certain occupations. It is based on the existing literature on the two production processes, the European Labour Force Survey (EU-LFS) and other data sources which detail the occupational structure of different sectors (e.g., ESCO, US Bureau of Statistics).

1.3 Structure of the report

The report is structured as follows:

- **Section 2** sets out the scenarios that were developed to evaluate the risks and opportunities that arise from the switching to electric vehicles in Slovakia's main export markets.
- **Section 3** presents the main modelling assumptions on EV take-up, manufacturing costs, investment requirements and growth in labour productivity.
- **Section 4** evaluates the results of the macroeconomic modelling, showing impacts on GDP, employment, and sectoral impacts of the electrification, and presents the results of the detailed labour market analysis.
- The report finishes with or conclusions in **Section 5**. These are the views of the report's authors and do not necessarily represent the views of the European Climate Foundation.

2 Scenarios

2.1 Reference scenario

This scenario is a business-as-usual case where Slovakia maintains its current ICE Vehicle export markets. It is not meant to be a likely outcome but will be used only as a reference for the other scenarios to quantify the economic changes caused by the shift to EVs in the Slovakian car manufacturing. In this scenario it is assumed that the share of EVs in Slovakia's export markets remains unchanged throughout the forecast horizon.

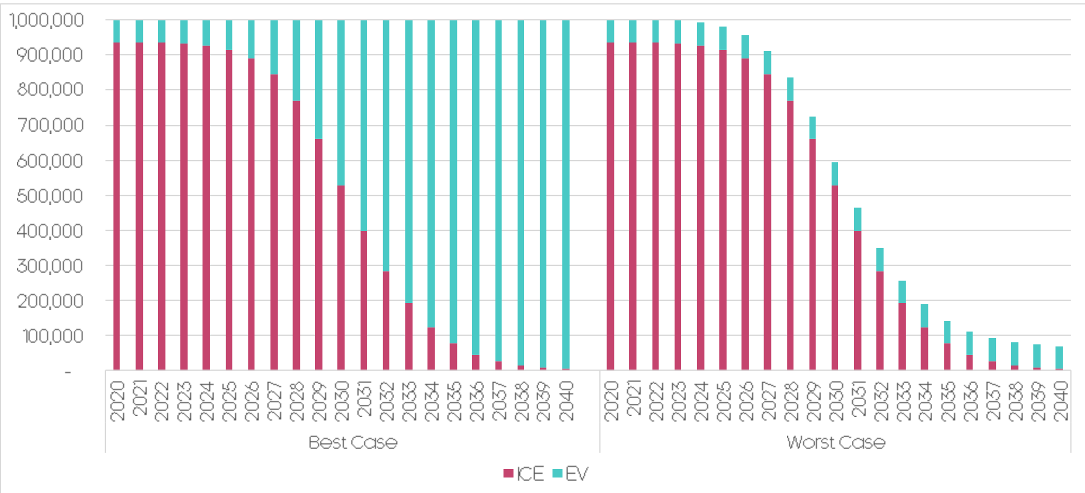
The occupational distribution of employment in automotive sector and its supply chain is based on the distribution of detailed occupations (3-digit level in the International Standard Classification of Occupations (ISCO)) in the European Labour force survey (EU-LFS) data for Slovakia.

2.2 Core scenarios

The central scenarios assume a high level of EV uptake. For the EU, EV sales will reach 100% EV by 2035 in line with recent European Commission policy announcements. For the rest of the world, we will align sales in the largest markets (UK, US, and China) with their announced target.

To explore the full range of potential outcomes for Slovakia from the deployment of EVs across its export markets, we will test two extreme outcomes for Slovakia as follows.

Figure 2-1: Vehicle Exports by powertrain in Core scenarios



Source: Cambridge Econometrics

Worst case scenario

This scenario assumes that as EV demand takes up, Slovakia is unable to adapt to demands from their export markets and so is unable to secure EV vehicle exports from its current vehicles export markets and loses market share in proportion to the EV share in that market.

Best case scenario

This scenario assumes that Slovakia can shift its vehicle production from ICE to EV to match export demands and is successful in securing battery manufacturing. As such, Slovakia maintains its market share for exporting vehicles. This includes Slovakia securing further domestic battery production.

2.3 Sensitivities

Battery cell manufacturing makes up a large proportion of the production value of an EV and so where the battery cells are produced, whether in Slovakia or abroad, makes a considerable impact on the economic outcomes from the transition to EVs.

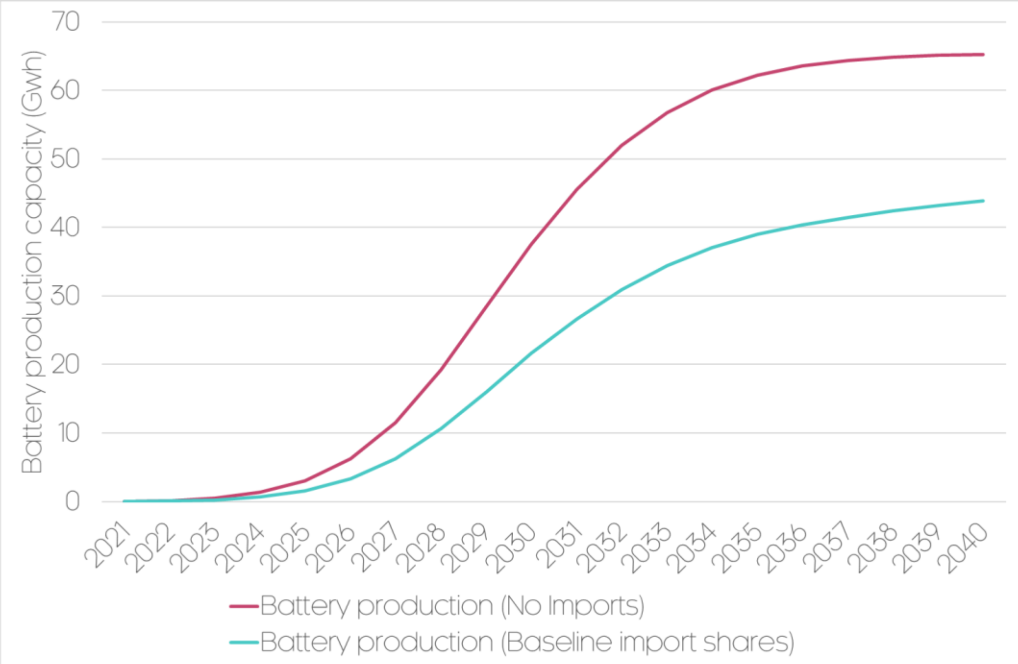
Slovakia does not currently have substantial battery production capacity as such, hence at least in the short-term Slovakia would be reliant on imports of battery cells to produce EVs.

This could change if Slovakia is successful in hosting a Gigafactory. There has been some suggestion that will happen in the coming years, but it is far from certain. In section 3.2 we show that by 2040, Slovakia would need 65 GWh of batteries annually to be able produce all the EVs in the best case scenario. If these batteries were to be produced within Slovakia it would require €5.6bn of investment. Although there are expectations that if Slovakia can secure EV manufacturing, they can also secure battery production as well there is potential competition from other countries in the CEE region. As such, we will test several sensitivities on the best case scenario to account for this uncertainty on battery cell production:

1. Slovakia is unable to secure battery production locally and so it is reliant on imported batteries for 100% of its battery demand from EV production.
2. Slovakia can secure battery production locally to meet 100% of its battery demand from EV production.
3. Slovakia can secure battery production capacity for 50% of its battery demand from EV production. (Import sources are available already in the neighbouring countries like Hungary or Poland.)

These sensitivities allow us to test the extremes of the potential outcomes for Slovakia in the best and worst case scenario.

Figure 2-2: Domestic battery capacity requirements for best case scenario under different import assumptions



Source: Cambridge Econometrics

However, the actual outcome for battery production is likely to sit somewhere between sensitivity 1) and 2). There have been announcements for 500 GWh of battery production capacity across Europe within the next 5 years including 10GWh of battery production in Slovakia[2].

Figure 2-2 shows that under the best case scenario, the proposed 10GWh capacity may be sufficient in the short term, but it is going to be insufficient to meet demand in the long term as battery demand to meet all additional EV production would reach 65 GWh by 2040[3]. As such Slovakia would need to secure additional battery production in the longer term. Given the continuing demand for battery production across Europe it is certainly possible for Slovakia to secure addition domestic production, but it is far from certain.

[2] https://www.addionics.com/post/car-manufacturers-are-understanding-that-post-covid-19-they-must-focus-on-electrification

[3] More details on calculating the battery production demand is outlined in chapter 3.

3 Modelling assumptions

3.1 Slovakia export market assumptions

In the reference case (all ICE vehicles) it is assumed that market shares for Slovakian exports remain constant across markets from today. The shares of each market are as follows[4]:

Table 3-1: Share of car exports by region

Region	Share of car exports (2019)
EU27	59%
France	13%
Germany	24%
Other EU	22%
United Kingdom	8%
China	7%
United States	10%
Other	16%

Source: Cambridge Econometrics

Current exports of motor vehicles in Slovakia are €16.4bn (2010 prices). E3ME baseline assumes motor vehicle exports remain flat between 2021 and 2030. This seems broadly in line with other projections of global and European motor vehicle sales projections reported by BCG and Deloitte[5,6].

EV take up in Slovakian Export markets

For the core scenarios EV uptake, we will assume exports reflect the trend of new sales in each destination market which is based on the recent policy announcements of the phase out of ICE vehicles:

- EU27 = 2035 phase out of ICE vehicles[7]
- UK = 2035 phase out of ICE and hybrid vehicles[8]
- US = No clear target but some states have discussed bans including California setting a target of 2035[9]
- China 2035 phase out of ICE vehicles[10]

Based on these policy announcements, and the export market share in Table 3-, 74% of Slovakia's export destination market value have confirmed ban on ICE sales by 2035. For the remaining 26%, we would assume a slower rollout

[4] https://oec.world/en/profile/country/svk?depthSelector1=HS4Depth&yearSelector1=exportGrowthYear25

[5] https://www2.deloitte.com/uk/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html

[6] https://web-assets.bcg.com/82/0a/17e745504e46b5981b74fadba825/is-e-mobility-a-green-boost.pdf

[7] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541

[8] https://www.gov.uk/government/news/government-takes-historic-step-towards-net-zero-with-end-of-sale-of-new-petrol-and-diesel-cars-by-2030

[9] https://www.forbes.com/sites/pikeresearch/2020/11/04/ice-bans-begin-to-take-shape-in-the-us/?sh=112580c23e17

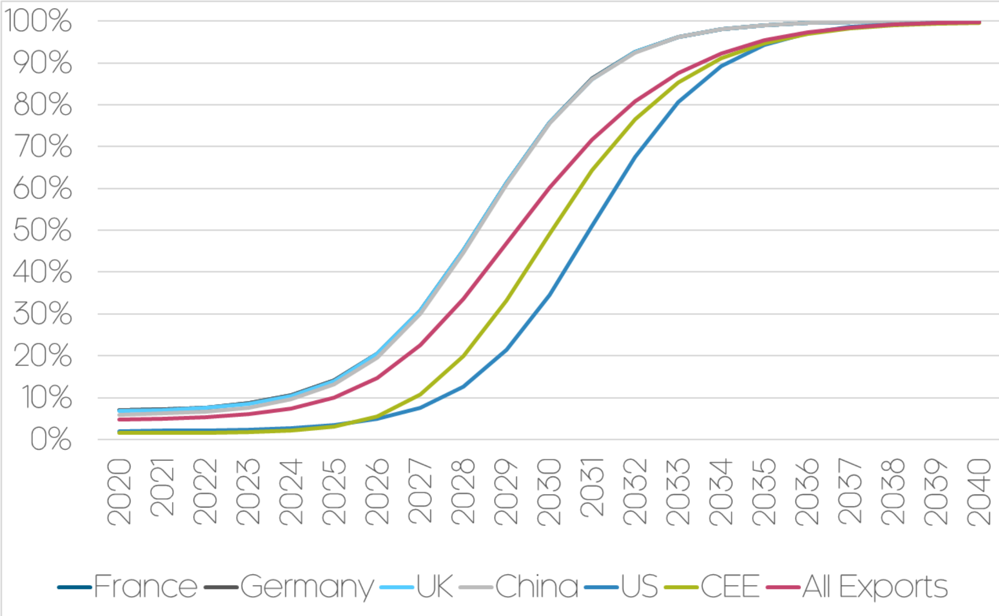
[10] https://www.weforum.org/agenda/2020/11/china-bans-fossil-fuel-vehicles-electric/

overall of EVs with a phase out of ICE in new sales for which we have assumed an average of a 2040 phase out.

Within the EU, while the end target is 100% EV by 2035, there is likely to be different speed of uptake between regions. From stakeholder consultation, we have differentiated the speed of uptake of EVs between Western Europe and Central and Eastern Europe (CEE). Western Europe has a more accelerated uptake in the short to medium term to reach 100% EV sales by 2035 while CEE could be delayed in uptake by 5 years but will eventually accelerate EV uptake to comply with EU regulations by 2035.

With the overall target for EV uptake set for each country, we need to develop a suitable pathway from EV sales today to the 100% EV sales in the policy target year. This was done using an S-curve formula to reflect the initial slower uptake of EVs which will then accelerate until we reach the 100% target.[11] In Figure 3-1, we show the estimated EV pathway for several key export destinations.

Figure 3-1: EV sales projections for Slovakia's export markets



Source: Cambridge Econometrics

3.2 Impacts of transition on the motor vehicle supply chain

The shift in motor vehicle production in Slovakia from ICE to EV will result in a wide range of changes within the motor vehicle sector that we will have to account for in the modelling.

[11] This approach follows the theory and experience of the diffusion of innovations. New ideas and technologies spread as successive groups of consumers adopt the new technology. The categories of adopters are innovators, early adopters, early majority, late majority, and laggards. This process results in a market share which follows an S-shape which will eventually reach the saturation level.

Shift in production value from traditional motor vehicle manufacturing to EV/electrical equipment.

Under the best case scenario, we need to estimate how the production value changes between an ICE and EV production. To do this, we focus on the largest difference between an ICE and EV which is the powertrain. In the conversion from motor vehicles to electric vehicles we replace the ICE engine, transmission exhaust etc. with an electric powertrain and battery pack.

To estimate the change in the production, we use the breakdown of vehicle production costs from an ICCT report which shows that for a typical ICE vehicle, the ICE powertrain makes up 29% of the vehicle production cost. $6,800 from a total cost of $23,500. For an electric vehicle, the EV powertrain is $15,000 which is equivalent to 63% of the ICE vehicle cost.

However, battery costs have been falling rapidly and are expected to continue to fall. BNEF reports[12] that by 2030 battery pack costs will have fallen from $137 per kWh to $58 per kWh. Applying the cost reduction to the share of current ICE vehicle production cost would see the EV battery and powertrain value fall from 63% to 34% by 2030.

We can use these shares of production value for the powertrains to estimate the value of Slovakia's vehicle production that is lost in the motor vehicle sector (ICE powertrain share of vehicle cost) to the electrical equipment sector (electric powertrain and battery share of vehicle cost). The EV powertrain production is shifted to electrical equipment as this better reflects to the production supply chain for batteries and electrical components in the powertrain.

Labour productivity assumptions

When evaluating the employment impacts on changes in the vehicle supply chain, we need to consider how productivity is likely to progress in the key economic sectors for vehicle production.

First, we consider the recent trends in productivity in the motor vehicle and electrical equipment sector. This was collected from Eurostat Structural Business Survey data (Eurostat SBS) which reports production and employment at a detailed sectoral level for Slovakia. This allows us to capture the observed productivity trend in Slovakia. We estimate the real productivity growth (persons employed per €m production) between 2014 and 2018. For motor vehicles productivity growth was 1.8% per year while for electrical equipment the productivity growth was 0.3%. We assume this average growth in productivity for the whole period to 2040.

The second assumption on labour productivity is the relative productivity of battery production compared to the wider electrical equipment sector. From Eurostat SBS data we find that battery production is less labour intensive than electrical equipment sector as a whole. As Slovakia currently has a very limited battery production industry, we took an estimate of relative productivity from the four EU member states with substantial battery production (Germany, Spain, Italy, and Poland). The data from these countries shows that on average battery production is 32% less labour intensive than electrical equipment.

For the labour productivity of EV assembly relative to ICE assembly, we do not assume any changes in labour productivity. This is based on analysis by BCG

[12] https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

which showed that the overall labour hours to produce an EV was very similar in aggregate to an ICE vehicle[13].

Investment in EV and battery production facilities

To transition from ICE to EV vehicle production it would require substantial investments to build new EV production facilities or retrofit existing ICE production facilities. In addition, if battery production is to occur in Slovakia this will require investments in battery cell production facilities.

To estimate the investment requirements, we investigated recent industry data on the investment costs for EV production facilities. The availability of such data is quite limited, but we did find data from Volkswagen on the investments to convert their existing Zwickau vehicle plant in Germany from ICE to EV production. The plant has a production capacity of 330,000 vehicles a year and costed €1.2bn to convert to EV production. We can combine this metric with the increases in EV production in the best case scenario to estimate the total investment required which reaches €3.4bn by 2040. The estimation is broken down for select year in Table 3-2.

Table 3-2: Calculation of investment in EV production capacity

	2025	2030	2035	2040
EV Share of exports	10%	60%	95%	100%
Additional EV share of exports (compared to 2020)	4%	54%	89%	93%
Vehicle production	1,000,000	1,000,000	1,000,000	1,000,000
EVs produced	43,287	536,740	889,079	932,121
EV production investment per annual vehicle production capacity (€m/vehicle)	0.0036	0.0036	0.0036	0.0036
EV Production Cumulative investments (€m)	157	1952	3233	3390

Source: Cambridge Econometrics

For battery manufacturing, we similarly needed the investment cost for additional battery production investment. We sourced this from an analysis by Schroders which showed that investment of around €85million per GWh of annual production was needed. To determine the total battery capacity to meet EV production requirements in the best case scenario, we assumed an average battery size per EV of 70kWh as reported in a recent T&E study.[14] Table 3.3 shows that by 2040, Slovakia would need 65 GWh of batteries annually to be able produce all the EVs in the best case scenario. If these batteries were to be produced within Slovakia it would require €5.6bn of investment.

Table 3-3: Calculation of investment in EV battery production capacity

	2025	2030	2035	2040
Additional EV share of exports	4%	54%	89%	93%
Vehicle production	1,000,000	1,000,000	1,000,000	1,000,000

[13] BCG, 2021. E-mobility: A green boost for European automotive jobs? Platform for electro mobility.

[14] Transport & Environment (2021). 'Commitments but no plans: How European policymakers can make or break the transition to zero emission cars' https://www.transportenvironment.org/discover/commitments-but-no-plans-how-european-policymakers-can-make-or-break-the-transition-to-zero-emission-cars/

EVs produced	43,287	536,740	889,079	932,121
Battery size (kWh)	70	70	70	70
Total battery requirements (GWH)	3	38	62	65
Cost of investment per GWH capacity (€m per GWH)	85	85	85	86
Cumulative investments (€m)	258	3,194	5,290	5,611

Source: Cambridge Econometrics

Changes in the workforce

A 2020 study by the BCG (Küpper et al., 2020)[15] analyses in detail the labour content of EVs production compared to ICE vehicles, for each phase of the production process. In contrast to the information provided by other studies, the distribution of jobs in the construction of EVs and ICE vehicles is almost identical. As already mentioned, ICEs and EVs are made of different components. Notably, ICE powertrain's main components are the internal combustion engine, the alternator and starter, and the fuel and exhaust system, while the EV's powertrains are made of the battery pack, the battery management, the on-board charger and the electric motor. Additionally, EVs are endowed with electronics such as converters and high voltage wiring absent in ICEs. Components such as cooling systems and gearbox are present in both type of vehicles but differ in design. Adding together the labour distribution in these various phases, the BCG study concludes that the fewer jobs required in component manufacturing and engine assemble is broadly offset by more jobs required in battery production and assemble. Notably, EVs' labour requirement is only 1% lower than for an ICE.

Building on these findings, BCG (2021)[16] estimates the amount of job creation/destruction by sector and occupation of the two types of production processes. This is the only study identified by the authors which details both sectoral and occupational impacts. Other studies looking only at the EV supply chain, e.g. by the European Association of Electrical Contractors (AIE, 2018) estimates the jobs creation from the construction of the power infrastructure needed to operate EVs by sectoral breakdown. Another study by ACEA (2021) provides only the distribution of jobs in the sectors involved in the automotive supply chain. The classifications of the automotive sector supply chain is provided also in the Blueprint for Sectoral Cooperation on Skills by the European Commission, which aims at bringing together relevant stakeholders in order to address skills gaps in selected sectors (European Commission, 2021). Two EU-funded projects, DRIVES[17] and ALBATT[18] implement the Blueprint in the automotive and battery sectors respectively. Through a mixture of desk research and stakeholders' interview, the relevant NACE rev.2 sectors and

[15] Küpper, D., Kuhlmann, K., Tominaga, K., Arora, A., Schlageter, J., 2020. Shifting Gears in Auto Manufacturing. BCG.

[16] BCG, 2021. E-mobility: A green boost for European automotive jobs? Platform for electro mobility.

[17] The Development and Research on Innovative Vocational Educational Skills project (DRIVES) delivers the human capital solutions to the whole automotive supply chain through the establishment of an Automotive Sector Skills Alliance, covering all levels of the value chain (vehicle production, automotive suppliers and automotive sales and aftermarket services). https://www.project-drives.eu/en/home

[18] The Alliance for Batteries Technology, Training and Skills (ALBATTS) project aims contribute to the green mobility in Europe. https://www.project-albatts.eu/en/home

ISCO occupations in demand are identified, but without providing a quantification of the impacts.

Our assumption is that within the motor vehicle sector and the manufacture of electrical equipment sector (which is also the supplier of batteries), we will observe a change in the distribution of occupations. Based on BCG (2021), Table 3-4 shows the potential job creation and destruction from the switch of production process from ICEs to EVs that is used to disaggregate the net employment effects for the two sectors. The rows display the broad sectors used in the analysis, while the columns show broad occupations.

Table 3-4: Distribution of job creation/ destruction

Sectors/ Occupations	Engineering	Procurement	Production/service	Sales
Where the jobs creation is likely to happen				
OEM	28%	0%	0%	0%
ICE-focused	0%	0%	0%	0%
Non-Ice suppliers	46%	24%	54%	0%
Maintenance	0%	12%	5%	19%
Equipment and services	0%	24%	5%	0%
Fuel/charging	25%	36%	35%	63%
Material recycling	0%	4%	1%	19%
	100%	100%	100%	100%
Where the jobs destruction is likely to happen				
OEM	0%	29%	55%	27%
ICE-focused	98%	71%	45%	40%
Non-Ice suppliers	0%	0%	0%	13%
Maintenance	1%	0%	0%	0%
Equipment and services	2%	0%	0%	20%
Fuel/charging	0%	0%	0%	0%
Material recycling	0%	0%	0%	0%
	100%	100%	100%	100%

Source(s): Adapted from BCG (2021)

The broad occupations mentioned in Table 3-4 were mapped to ISCO occupations[19] at the 3-digit level was implemented, with the help of European Skills, Competences, Qualifications and Occupations (ESCO) list[20], which was examined by looking for occupations with similar names to those mentioned in BCG (2021). This activity was complemented by the analysis of the descriptions of the 3-digit level ISCO occupations[21] and by cross-checking the identified list of occupations with data from the US Bureau of Labour Statistics, to verify that we captured a significant part of the automotive occupational structure. Figure 3-2 summarises the mapping approach just described. This mapping was further checked against the list of occupations expected to play

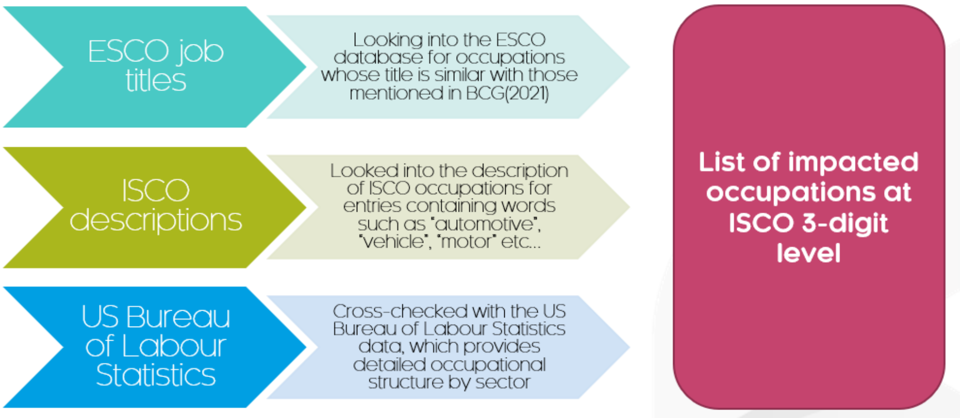
[19] We use the International Standard Classification of Occupations (ISCO) from 2008 that is used in classifying jobs in the EU-LFS.

[20] ESCO has a higher detail of occupational titles and each occupation is mapped to exactly one ISCO-08 code. Detailed database: https://ec.europa.eu/esco/portal

[21] https://www.ilo.org/public/english/bureau/stat/isco/isco08/

a significant role along the automotive supply chain from the DRIVES project (DRIVES, 2019a and 2019b)[22] and ALBATTS (2021)[23].

Figure 3-2 Approach for mapping occupations from BCG (2021) into 3-digit level ISCO



Source(s): Cambridge Econometrics

The list of 3-digit ISCO occupations can be found in Table 3-5. The share of employment in the two sectors was calculated based on EU-LFS 2019.

Table 3-5: Employment share of detailed occupations by sector

Occupation name in BGG (2021)	ISCO-08 3-digit	ISCO Occupation name	Manufacture of electrical equipment/ Manufacture of motor vehicles (%)
Engineer	121	Business Services and Administration Managers	1.0
Engineer	122	Sales, Marketing and Development Managers	1.3
Production/ service	132	Manufacturing, Mining, Construction and Distribution Managers	4.5
Engineer	214	Engineering Professionals (excluding Electrotechnology)	1.6
Engineer	215	Electrotechnology Engineers	0.4
Sales	243	Sales, Marketing and Public Relations Professionals	0.1
Engineer	251	Software and Applications Developers and Analysts	1.1
Production/ service	312	Mining, Manufacturing and Construction Supervisors	8.2
Procurement	331	Financial and Mathematical Associate Professionals	1.7
Procurement	332	Sales and Purchasing Agents and Brokers	3.7
Sales	351	Information and Communications Technology Operations and User Support Technicians	0.7
Sales	522	Shop Salespersons	1.1
Production/ service	712	Building Finishers and Related Trades Workers	1.1
Production/ service	713	Painters, Building Structure Cleaners and Related Trades Workers	1.1

[22] DRIVES, 2019a. Insights of the Automotive Sector 2019 - Deliverable 2.7 Forecasting Dissemination Report. European Union. DRIVES, 2019b. Preliminary strategic analysis - Deliverable 2.9.1 Automotive Skills strategic Roadmap. European Union.

[23] ALBATTS, 2021. Survey results for battery sectors - Deliverable D3.4 Survey Results for Battery Sector. European Union.

Production/ service	721	Sheet and Structural Metal Workers, Moulders and Welders, and Related Workers	7.5
Production/ service	722	Blacksmiths, Toolmakers and Related Trades Workers	16.3
Production/ service	723	Machinery Mechanics and Repairers	2.9
Production/ service	741	Electrical Equipment Installers and Repairers	2.5
Production/ service	753	Garment and Related Trades Workers	5.7
Production/ service	812	Metal Processing and Finishing Plant Operators	5.1
Production/ service	821	Assemblers	28.0
Production/ service	834	Mobile Plant Operators	4.2

Source(s): Cambridge Econometrics based on EU-LFS 2019.

Key assumptions

Table 3-6 summarises the key assumptions made for the modelling.

Table 3-6: Transition of the motor vehicle supply chain assumptions

Modelling element	Modelling assumptions
Shift in production value from traditional motor vehicle manufacturing to EV/electrical equipment	The main shift in production value from ICE to EV is mostly from the substitution of the internal combustion engine with electric motor and battery. Currently the battery accounts for about 35% of the vehicle cost[24]. Based on expected battery cost reduction from \$137 /kWh in 2020 to \$58/kWh in 2030[25] the value of the battery could fall to ~15% of the vehicle cost. Data from the ICCT shows that in 2017 a conventional powertrain makes up about 29% of the vehicle[26] while an EV powertrain cost around 63% of the value of a conventional ICE vehicle today. Overall cost of ICE powertrain is currently much lower than an EV (\$15000 for electric powertrain vs \$6,800 (2017 prices). Adjusting for recent battery cost reductions, the battery cost has already fallen to 49% of a conventional ICE vehicle today. By 2030, this reaches 28% of ICE vehicle costs. Import requirements for batteries come in the form of battery cells which are then assembled as part of EV production. Battery cells make up 70% of the overall battery cost[27]
Import share of ICE engines	To calculate the domestic production impact of the reduction in ICE powertrain production, we assume that import of ICE engines is equivalent to the current import share of production for the motor vehicle sector as a whole which is around 25%.

[24] https://www.globsec.org/publications/slovakia-an-automotive-industry-perspective/

[25] https://about.newenergyfinance.com/electric-vehicle-outlook/

[26] https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

[27] https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

	We acknowledge there are limitations with this assumption as the amount of domestic engine production varies across the big 4 OEMs with Kia carrying out substantial engine production (435,000 engines in 2019)[28] for the other OEMs, the production of engines is not disclosed. As such it is possible that the import dependence may be lower than the sector average. Unfortunately without more data, we cannot estimate the true import share.
Labour productivity of electric powertrain versus electrical equipment sector	Labour productivity of electric powertrain is estimated based on the relative productivity between electrical equipment as a whole and the manufacture of batteries from EU data from Eurostat SBS[29]. This data suggest battery production is 46% more productive per worker than the wider electrical equipment sector.
Labour productivity growth assumption	Real labour productivity (output per worker employed) for motor vehicles and electrical equipment is assumed to continue to grow based of recent historical productivity growth between 2015 and 2018. Motor vehicle labour productivity grows by 1.8% per annum and electrical equipment grows by 0.3% per annum.
Labour market impacts	E3ME sectoral detail allows us to look at impacts to the direct jobs in the motor vehicle sectors in which are around 80,000 people employed (Eurostat SBS). However, the data from a Globsec report[30] shows that the wider vehicle manufacturing supply chain supports 177,000 jobs (Big 4 and Tier 1) and a further 98,000 tier 2 suppliers. These are captured in other economic sectors within E3ME, and they will be accounted for in the wider supply chain impacts.
Investment in battery production facilities	Analysis by Schroders showed that investment of around €85million per GWh of annual production.[31] Total investments required calculated based on Slovakia vehicle exports and the share of batteries that are domestically produced. We assume a 70kWh battery for each vehicle produced[32].

[28] Kia Slovakia Annual report 2019

[29] https://ec.europa.eu/eurostat/databrowser/view/sbs_na_ind_r2/default/table?lang=en

[30] https://www.globsec.org/publications/slovakia-an-automotive-industry-perspective/

[31] https://www.brighttalk.com/resource/core/365961/responsible-company---how-can-batteries-enable-a-sustainable-transition-to-a-greener-economy_795040.pdf

[32] Transport & Environment (2021). Promises, but no plans https://www.transportenvironment.org/discover/commitments-but-no-plans-how-european-policymakers-can-make-or-break-the-transition-to-zero-emission-cars/

Investment in EV production	We assume transition to EVs is achieved from investment in existing plants to transition from ICE to EV manufacturing plants. Initial estimates based on Volkswagen's conversion of the Zwickau plant investment of €1.2 billion to convert existing ICE vehicle plant producing 330,000 vehicles to full EV production. The investment ratio is then applied to total EV production based of the EV export market share.

Source: Cambridge Econometrics

4 Macroeconomic Impacts

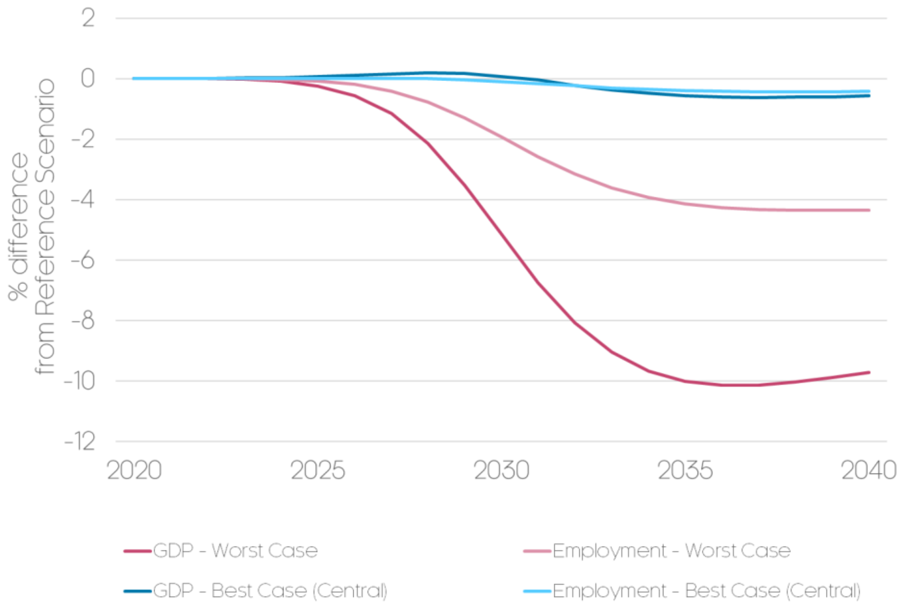
4.1 Main macroeconomic indicators

The impacts of increasing EV demand from Slovakia's export markets on the Slovakian economy are modelled. The results are compared to a business-as-usual reference scenario where Slovakia maintains its existing ICE and EV vehicle production.

Worst case

From the results, it is clear that if Slovakia was unable to adapt to the increasing electrification of vehicle production, it would stand to lose considerable economic output as shown under the worst-case scenario with almost 10% reduction in GDP by 2040 and a 4.5% reduction in total employment. This large impact on GDP is due to how large a share of the Slovakian economy is made up of the motor vehicle industry representing 14% of domestic output in 2019.

Figure 4-1: GDP and Employment impact in central scenarios



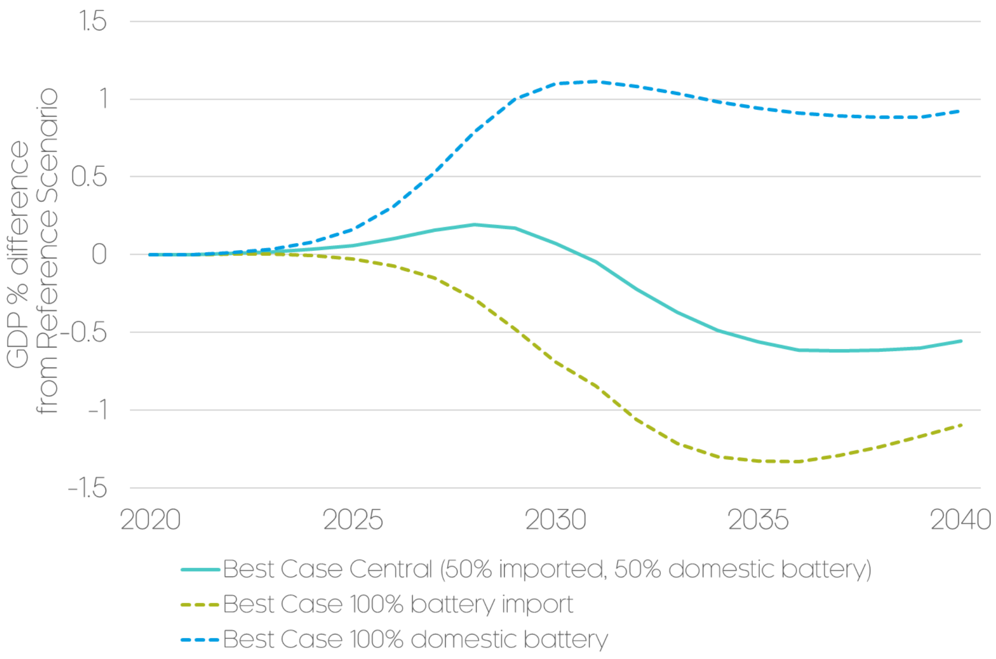
Source: Cambridge Econometrics

Best case

Under the best case scenario, the economic impacts are more limited as Slovakia shifts production from traditional motor vehicle production to EV. Overall production of vehicles is maintained, but under the central case Slovakia is reliant on imports for 50% of battery cells and other equipment for the electrical powertrain. The import intensity of the electrical equipment is higher than for the traditional motor vehicle sector, hence less value is captured within Slovakia. This results in a small reduction in GDP relative to the reference case.

However, the supply chain impacts of the transition to EV production is sensitive to what is assumed about how much battery production Slovakia can secure. If Slovakia can secure battery production domestically at a level to meet all domestic vehicle production, then this would allow Slovakia to capture more of the EV production value chain as a result. Though even in the best case scenario, this would only lead to a small increase in GDP.

Figure 4-2: GDP impacts from battery cell production sensitivities



Source: Cambridge Econometrics

4.2 Sectoral employment impacts

Worst case

Under the worst case scenario, the largest sectoral impact is in the motor vehicle sector. By 2040 output and employment fall by about 87% as Slovakia loses most of its vehicle production demand from exports.

In the rest of the economy, there are some indirect losses from the reduction in motor vehicle activity. In the rest of manufacturing sectors there is a moderate loss of output reaching around 9% by 2040 which leads to a loss of 10,000 jobs.

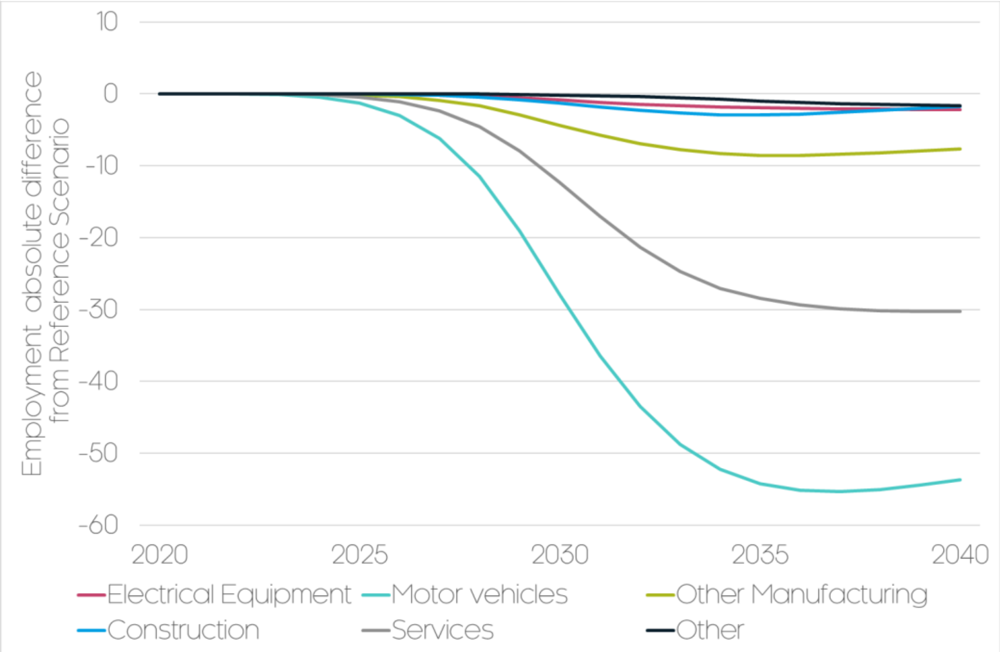
The rest of the reduction in employment is in the various services sectors (Retail, Hospitality, Business, Professional and government services etc) while many of the losses in these sectors is attributed to service jobs that support the motor vehicle sector. Some of the loss in service jobs are driven by the reduction in overall household incomes from lower employment in the motor vehicle sector.

Table 4-1: Employment impact in 2040 relative to reference (%)

	Worst case	Best Case Central	Best Case 100% battery import	Best Case 100% domestic battery
Electrical Equipment	-4.7	17.9	10.7	39.6
Motor vehicles	-87.1	-20.7	-20.7	-20.6
Other Manufacturing	-2.1	-0.2	-0.2	0.0
Construction	-1.4	-0.2	-0.2	0.0
Services	-2.1	-0.3	-0.3	-0.2
Other	-1.3	-0.1	-0.1	0.0

Source: Cambridge Econometrics

Figure 4-3 Employment by sector impact under the worst case scenario



Source: Cambridge Econometrics

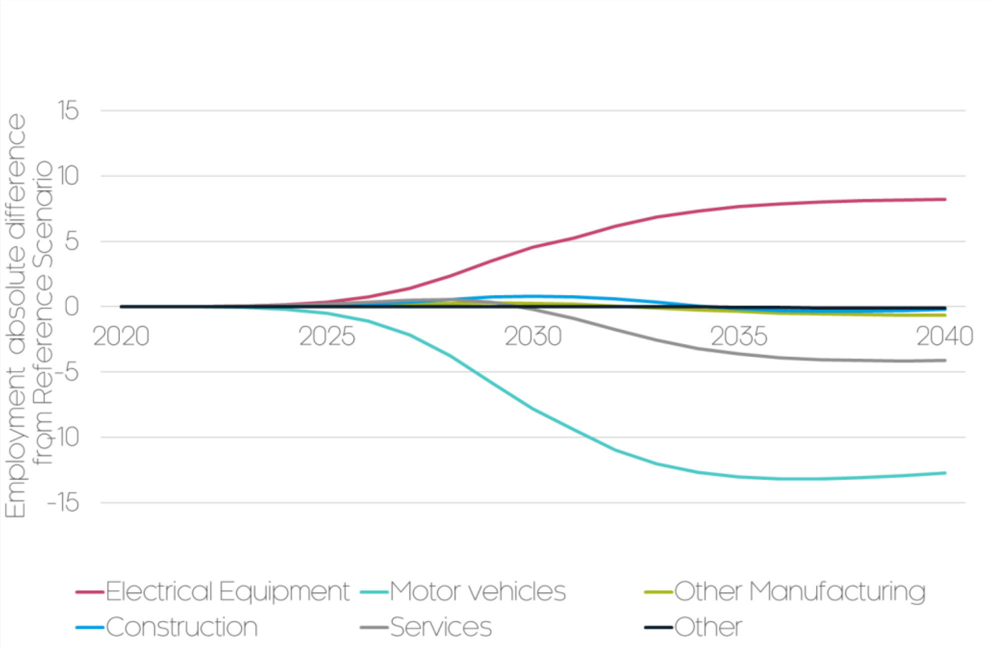
Best case

Under the best case scenario, the sectoral impacts show that although the net impacts are small, there are clear winners and losers from the transition from ICE to EV production.

The largest sectoral impacts are directly in the motor vehicle and electrical equipment sectors as vehicle production supply chain transitions from ICE powertrains to electric powertrains. Overall, between these two sectors the loss in the motor vehicle sector is estimated to be larger than the additional jobs generated in electrical equipment. The main factor that leads to the net loss in employment is that Slovakia is more dependent on imports for electrical equipment than the motor vehicle sector as based on current industry data for Slovakia. This means that even though the same number of vehicles are produced, more of the EV production supply chain activity occurs outside of

Slovakia, generating less employment than in case of the ICE production. There are also impacts by the differences in labour productivity. Electrical equipment production is more labour intensive than motor vehicle production, which mean more jobs are generated per $m of domestic output that is generated from electric powertrain and battery production, but this impact is outweighed by the increased import dependency of the electrical equipment sector.

Figure 4-4: Employment by sector impact in best case (central scenario)



Source: Cambridge Econometrics

Outside of the direct impact from the transition to EV production, in the long term there is a small loss in services, which is driven by the net reduction in output and employment from the vehicle production, reducing demand from the supply chain for the related services, but also from losses in consumer spending due to lower incomes.

In the short term, out to 2030, these indirect losses from the transition in production are offset by the additional demand from the investment in EV and battery production capacity. This short-term investment boost has the largest impact on the construction sector.

Impact of battery cell production

The net impact from the central best case scenario shows that the economic benefits of EV production to the electrical equipment sector do not outweigh the losses to the motor vehicle sector in response to the loss of ICE powertrain production.

The main driver of this relative impact is the import intensity of supply for the motor vehicle relative to electrical equipment. In the motor vehicle sector, today Slovakia's import share of total supply is about 25%. In the electrical equipment sector, it is around 50%. This means that even if the final production value is similar in the long term, less of EV powertrain value is retained in Slovakia's domestic supply chain.

The largest part of the EV powertrain by value is the battery pack as such the impact of whether battery cells are produced in Slovakia makes a difference on the overall net impact of the transition to EV production. In Table 4-2, we show if Slovakia was able to secure enough battery production to meet 100% of the EVs it would produce in the best case, then the net employment impact would be positive due to the additional jobs generated in battery production. However, in the other extreme, if Slovakia was unable to secure battery production, this would reduce the additional economic activity in the domestic electrical equipment sector increasing the net loss of jobs.

Table 4-2 Employment impact in 2040 relative to reference (000s)

	Worst case	Best Case Central	Best Case 100% battery import	Best Case 100% domestic battery
Electrical Equipment	-2.2	8.2	4.9	18.3
Motor vehicles	-53.7	-12.8	-12.8	-12.7
Other Manufacturing	-7.7	-0.6	-0.8	0.0
Construction	-1.7	-0.2	-0.3	0.0
Services	-30.2	-4.1	-5.0	-2.8
Other	-1.6	-0.1	-0.2	0.0
Total	-97.2	-9.5	-14.2	2.8

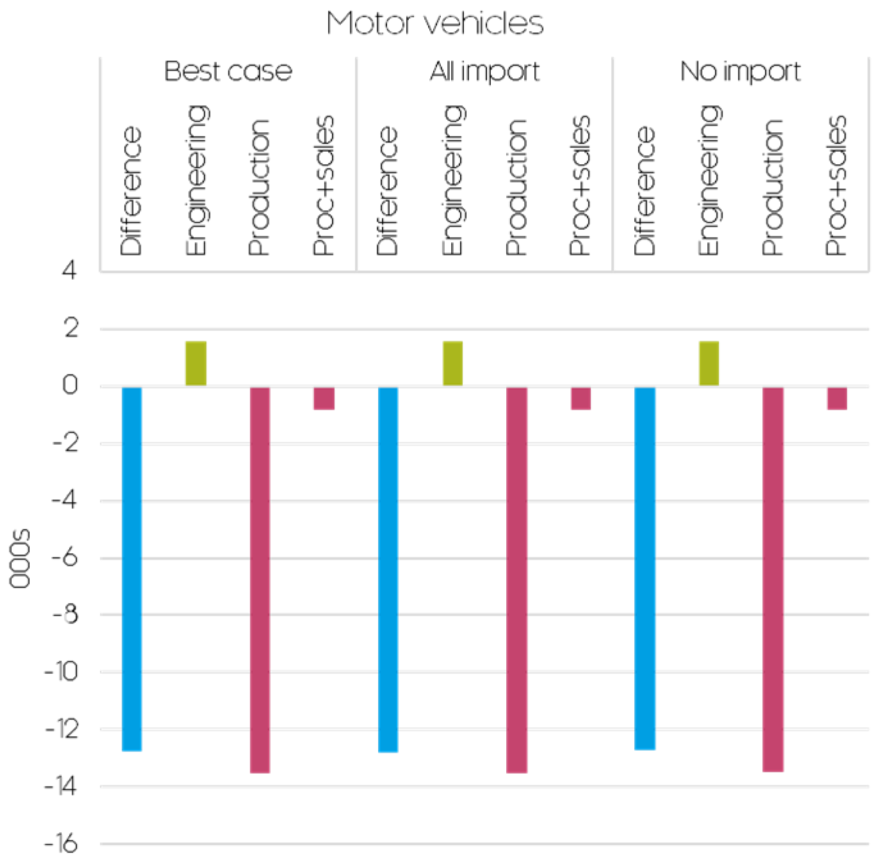
Source: Cambridge Econometrics

4.3 Occupational employment impacts

The net employment impact presented in Table 4-2 is further disaggregated to analyse the potential structural changes by occupation in the two most affected sectors: electrical equipment and motor vehicles. No occupational change is modelled in the worst case scenario, since in that case the drop in employment highlighted in Table 4-2 is caused entirely by the decline in output and not by the transition to EVs production, meaning that the occupational structure of the sectors is unchanged.

In all scenarios, Figure 4-5 shows that the number of jobs created is much less than the numbers of jobs destroyed in the manufacture of motor vehicles, while more jobs are created in manufacture of electrical equipment. Among broad occupations, the engineers are the ones benefiting the most from the transition to EVs. This result is in line with the literature, i.e., the occupations in demand by 2040 are likely to be high-skill and specialised. By 2040, the workers in the production and service part of the process are those that are expected to shrink in the motor vehicle sector and expand in the manufacture of electrical equipment sector.

Figure 4-5 Motor vehicles and Electrical equipment, jobs created/destroyed compared to the baseline in 2040, by broad occupational groups (000s)



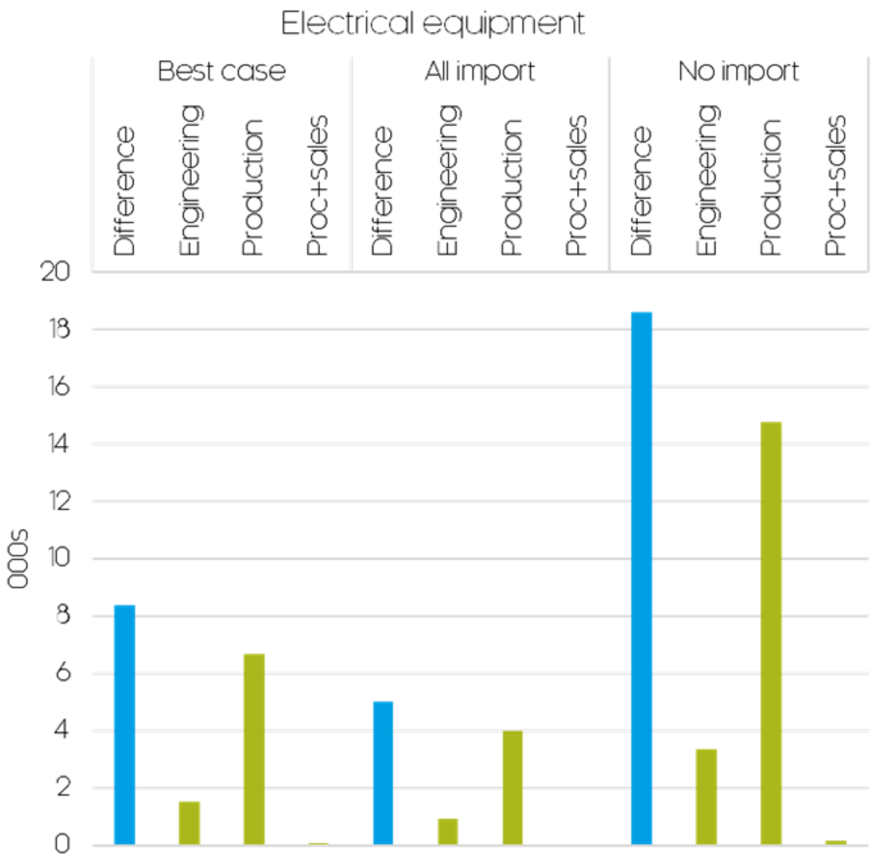


Table 4-3 shows the net impact by detailed occupation and scenario in the two sectors by 2040. In the case of the 100% domestic battery production scenario, the number of jobs destroyed in motor vehicle sectors is offset by the job creation in the same occupation in the electrical equipment sector. In the other two scenarios, skilled manual occupations such as trade workers and assemblers are the ones which are expected to be in less demand from the production of EVs.

Table 4-3: Employment impact by occupation in 2040 relative to reference (000s)

	Manufacture of electrical equipment			Manufacture of motor vehicles		
Occupation name	**Best Case - Central**	**Best Case 100% battery import**	**Best Case 100% domestic battery**	**Best Case - Central**	**Best Case 100% battery import**	**Best Case 100% domestic battery**
Business Services and Administration Managers	0.3	0.2	0.6	0.3	0.3	0.3
Sales, Marketing and Development Managers	0.4	0.2	0.8	0.4	0.4	0.4
Manufacturing, Mining, Construction and Distribution Managers	0.3	0.2	0.8	-0.7	-0.7	-0.7
Engineering Professionals (excluding Electrotechnology)	0.5	0.3	1.0	0.5	0.5	0.5
Electrotechnology Engineers	0.1	0.1	0.2	0.1	0.1	0.1
Sales, Marketing and Public Relations Professionals	0.0	0.0	0.0	0.0	0.0	0.0
Software and Applications Developers and Analysts	0.3	0.2	0.7	0.3	0.3	0.3
Mining, Manufacturing and Construction Supervisors	0.6	0.4	1.4	-1.3	-1.3	-1.3
Financial and Mathematical Associate Professionals	0.1	0.0	0.1	-0.1	-0.1	-0.1
Sales and Purchasing Agents and Brokers	0.1	0.1	0.3	-0.2	-0.2	-0.2
Information and Communications Technology Operations and User Support Technicians	-0.1	0.0	-0.1	-0.2	-0.2	-0.2
Shop Salespersons	-0.1	0.0	-0.2	-0.3	-0.3	-0.3
Building Finishers and Related Trades Workers	0.1	0.1	0.2	-0.2	-0.2	-0.2
Painters, Building Structure Cleaners and Related Trades Workers	0.1	0.0	0.2	-0.2	-0.2	-0.2
Sheet and Structural Metal Workers, Moulders and Welders, and Related Workers	0.6	0.3	1.3	-1.2	-1.2	-1.2
Blacksmiths, Toolmakers and Related Trades Workers	1.2	0.7	2.8	-2.5	-2.5	-2.5
Machinery Mechanics and Repairers	0.2	0.1	0.5	-0.5	-0.5	-0.5
Electrical Equipment Installers and Repairers	0.2	0.1	0.4	-0.4	-0.4	-0.4
Garment and Related Trades Workers	0.4	0.3	1.0	-0.9	-0.9	-0.9
Metal Processing and Finishing Plant Operators	0.4	0.2	0.9	-0.8	-0.8	-0.8
Assemblers	2.1	1.3	4.7	-4.3	-4.3	-4.3
Mobile Plant Operators	0.3	0.2	0.7	-0.7	-0.7	-0.7
Total	8.2	4.9	18.3	-12.8	-12.8	-12.7

Source: Cambridge Econometrics

The results in Table 4-3 are based on the assumptions made in the BCG (2021) study which is showing the view at the EU level. The exact re-distribution of jobs among different occupations in Slovakia might be different than the EU average. Therefore, the above results should be considered as indicative of the skills level of occupations required that are less or more likely to gain from the transition from ICEs to EVs. The training for the engineers and re-training of the other occupational groups should happen over the next 10-15 years. Policymakers should ensure that the necessary skills are in place to avoid that the transition in the two sectors is slowed by a lack of skilled workforce.

Limitations of the approach

The approach is based on several assumptions. First, the results assume no change in the occupational distribution of sectoral employment over time and that both sectors have the same occupational structure. Digitalisation and automation could further negatively impact on the employment prospects of different occupations within the two sectors, changing their occupational structure. Secondly, the modelling results assume the labour force will have the necessary skills to fill the jobs created. This is not a strong assumption given that 15 years is enough time to skill the workforce if the training policies are in place. Thirdly, the job creation/destruction assumptions are based on the results of the BCG (2021) study which shows findings at a European level. This is a strong assumption as Slovakia might require less engineering occupations and more production-related occupations (e.g., assemblers) than the European average.

5 Policy recommendations

5.1 Key tasks and challenges for the government

The modelling results show that, as its key export markets shift from ICE's to EVs, Slovakia can suffer substantial GDP losses if it fails to adapt its automotive production capacities to EV production. To ensure growth the Slovakian government can play an important role in helping the transition by implementing a series of policies.

- Attract foreign investment to build factories producing batteries and electric vehicles
- Help transforming existing producing units from ICE to EV production
- Strengthen Slovakia's position by providing infrastructure and (re)skilled workforce suitable for the transition
- Support local SMEs and workforce to benefit from the transition
- Boost innovation to ensure high value-added production stages occur in Slovakia
- Securing access to raw materials and encourage recycling of EV parts
- Strengthen domestic markets for EVs to contribute to decarbonized transport.

5.2 Government tools to ensure production shift to EVs

Governments have several tools to work towards these goals and ensure the competitiveness of their motor-vehicles production sectors. Table 5-1 illustrates some key government action in this area based on recent news.

Table 5-1: Government action in Europe to transform the motor vehicles production sector, 2020-2021

	Region	Type	Policy
1	UK	Direct investment subsidy	Large-scale direct investment to attract battery manufacturing gigafactory (£800m)
2	HU	Direct investment subsidies	Large-scale direct investment to attract battery manufacturing gigafactory (€108m) with plans for more support in the coming years up to 10% of the total investment costs
3	SW, DE, EU	Government loan	European Investment Bank loan ($350m) and financial support from the state-funded Swedish Energy Agency as well as the German government
4	UK	Retraining support	Government funding to deliver training of electric vehicle technicians (£2.4m)
5	PL (+EU)	Direct investment subsidy and loan	Government investments (€95m) and EBRD loan to guild battery manufacturing gigafactory (€250m)
6	HU	Direct investment subsidy	State support to refurbish assembling plant for production of EVs (HUF15bn)
7	DE	Regulation, state aid for innovation	National Industry strategy to allow and support mergers, to foster innovation and boost competitiveness
8	EU	Regulation	Battery recycling requirement to ensure healthy battery value chains

9	12 EU MS (incl. SK)	Innovation support for battery technology	European Battery Alliance to support innovative, competitive and sustainable battery value chain in Europe
10	PL	Partially state-owned domestic EV manufacturer	ElectroMobility Poland is formed to develop and produce EVs using local suppliers, to spur R&D. The company is owned by state-owned energy sector giants.
11	UK	Government secured innovation loan for EV R&D of private firms	UK government to secure commercial bank loan for Jaguar Land Rover for EV research and development (£0.5 bn)
12	UK	Innovation loans to SMEs	Innovate UK will deliver a new three-year programme of £150m in new flexible and affordable Innovation Loans to help British SMEs commercialise their latest R&D innovations.
13	UK	Supporting green hydrogen research	Direct support to develop UK's largest electrolyser (£9.4 m)
14	DE	Government to match private sector e-mobility efforts: announcing subsidies at plant opening	Germany announces doubling EV purchase subsidies and extending charging infrastructure to raise domestic demand and signal support as Volkswagen opens EV manufacturing gigaplant
15	FR	Direct investment & loans	France 2030 program to revive France's industrial sector and innovation, with a special focus on EV production (€30 bn)
16	UK	Research funding	Investment into battery technology research (£30 bn)
17	DE	Research funding	Government funding for battery technology research
18	FR	Direct investment subsidy	Government funding plan for battery manufacturing (€700 m)
19	HR	Tax credit and government support to foster profitability, R&D	Tax credit to help local EV manufacturer firm and support to build headquarters and R&D centre in Zagreb
20	RO (+EU)	Loan for refurbishing assembly to produce EVs and for R&D	Loan for the expansion and refurbishment an existing car assembly plant and loan to finance research, development and innovation (€400m and €200m)

Source(s): Cambridge Econometrics review

Note that beyond industry subsidies most of the listed regions have introduced consumption incentives as well. These include purchase subsidies, tax exemptions (registration tax, VAT), free or subsidies charging options and parking discounts as well. Additionally, large-scale public investments have been seen into the charging infrastructure. However, consumption subsidies only have a substantial impact on production sector transition in case of large domestic markets and strong local purchasing power. For small economies producing to export markets like Slovakia does, direct industry policies play a stronger role in sectoral transition than consumer subsidies.

5.3 Recommended policy tools to transform the motor vehicles sectors

Table 5-1 provides an overview of key government actions in different European countries to transform their industries to the produce electric vehicles and batteries. These subsidies can be categorized to two types:

Short-run strategies include direct government subsidies or loans to attract new production, typically battery factories to the country.

- These government actions are often seen as ones bringing quick and large success in creating workplaces and securing EU's battery supply chains. They are important pillars of job creation and growth, especially in the Central Eastern European region. However, these investments are often contested by EU competition authorities as governments need to justify that the aid is necessary to attract the given investment to the region. Additionally, it must be ensured that the subsidy does not distorts competition at the expense of taxpayers and other regions (European Commission (2021)[33]). It is argued that that most private investments and expansions would occur without state help involved.
- These government actions are considered as short-run strategies based on the workplaces and value added they create. The new factories are often assembly plants of large producers with headquarters in their country of origin. Therefore, the gigafactories tend to create low- and mid-skilled workplaces and low value added. Although, both factors are important for domestic product in the short-run this strategy may lock regions in their assembly status without the ability to capture high value-added elements of the value chain in the long-term (Grieveson et al. (2021)[34]).

Long-term strategies include investments in infrastructure and human capital, research and the labour markets.

- These types of investments may have a longer maturity but ensure sustained and long-term competitiveness without unnecessary subsidies which crowd out private investments. Providing the underlying infrastructure that supports competitive companies and training a skilled workforce adapting well to digital and green transition are keys to attract and keep production for each country. By investing in training and R&D, countries are able to attract the high-profit components of the supply-chain including headquarter services (Grieveson et al. (2021)). Human capital and infrastructure investments also have strong positive spillover effects on the productivity of other sectors and foster general growth. This reduces exposure to structural breaks and changing trends in a singke sector.

Slovakia has to balance the short and long-term policies to preserve its central role in the automotive industry; to create favourable conditions for gigafactories but also to invest in its skilled workforce to maintain its place in the global value chains in the wake of the green transition.

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[33] European Commission (2021). State aid: Commission approves €2.9 billion public support by twelve Member States for a second pan-European research and innovation project along the entire battery value chain, Press release on 26 January 2021. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_226

[34] Grieveson, R. et al. (2021). Avoiding a Trap and Embracing the Megatrends:Proposals for a New Growth Model in EU-CEE. wiiw Research Report 458. https://wiiw.ac.at/avoiding-a-trap-and-embracing-the-megatrends-proposals-for-a-new-growth-model-in-eu-cee-dlp-5987.pdf

6 Conclusions

The modelling shows that Slovakia will see almost all of Slovakia's export market shift from ICE to EV vehicles over the next 20 years.

If Slovakia is unable to adapt its automotive production capacity to producing EVs, this would represent a substantial loss of output for the Slovakian economy with the output falling by almost 10% relative to business-as-usual case. These impacts are mostly driven by direct losses in the motor vehicle sector but will also have wider impacts on the rest of the supply chain and the wider economy due to the large loss in employment.

Even if Slovakia can adapt to EV production, there is still likely to be some small losses in GDP and employment as Slovakia becomes more reliant on imports for electrical equipment. However, the net impact of the transition to EV production is very sensitive to whether Slovakia can secure substantial domestic battery production capacity to meet the demand for the EVs to be produced:

- The modelling shows that if Slovakia can secure battery production to meet its EV production demand it would offset the losses from the ICE vehicle supply chain.
- However, this would require Slovakia securing substantially more battery production than current planned in the short term.

The job creation/destruction because of the transition to EVs varies among the four scenarios, with the two extremes represented by the worst case and the best case with no battery import scenarios:

- In the worst case scenario, the net employment effect is entirely based on the job destruction (no job creation takes place).
- In the best case with 100% battery import scenario, the job creation is expected for skilled manual occupations such as assemblers in the manufacture of electrical equipment and high-skilled non-manual occupations such as engineering professionals and software and applications developers and analysts in the motor vehicles sector. Overall, the job creation in manufacture of electrical equipment is not expected to offset the job destruction in motors vehicles for skills manual occupations.
- In the best case with no battery import scenario (all batteries produced domestically), the increase in skilled manual occupations in manufacture of electrical equipment is expected to offset the job destruction in motors vehicles for the same type of occupations.

Appendix The E3ME Model

E3ME is a computer-based model of the world's economic and energy systems, and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used for policy assessment, forecasting and research purposes. E3ME was used to assess the European Commission's 2030 and 2050 emission reduction targets. It was also recently used by the World Bank to model different pathways to carbon neutrality in China.

The full model manual is available at the model website www.e3me.com.

Main purpose

E3ME has been designed to assess the impacts of climate change mitigation policy on the economy and the labour market. The basic model structure links the economy to the energy system to ensure consistency between economic and physical indicators.

E3ME can provide comprehensive analysis of policies in each of its 70 regions:

- direct impacts, for example reduction in energy demand and emissions, fuel switching and renewable energy
- secondary effects, for example on fuel suppliers, energy prices and competitiveness impacts
- rebound effects of energy and materials consumption from lower prices, spending on energy or other economic activities
- overall macroeconomic impacts: on jobs and the economy at a high level of sectoral detail and (where data allow) household income group

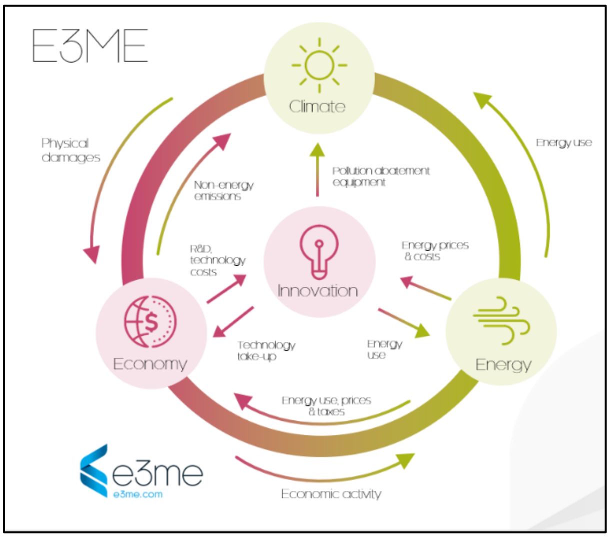
Theoretical underpinnings

E3ME is designed primarily as an empirical tool. It draws on the Cambridge (UK) tradition of macroeconomics, supplemented by more recent applications of complexity theory to economics. The key properties of the model include recognition of fundamental uncertainty, possible non-rational behaviour and market structures determined by the available data.

The model has been shaped to meet the needs of policy makers, both in terms of the types of scenarios assessed (e.g. a wide range of market-based and regulatory climate policies) and output indicators (e.g. detailed employment, unemployment and measures of inequality).

E3ME incorporates bottom-up technology models of four major energy-using sectors[35] (power, personal transportation, steel and household heating). These models follow the 'S-shaped' diffusion paths of new technologies as they gain market acceptance and incorporate cost reductions through learning rates.

[35] Called the FTT (Future Technology Transformation) models. See e.g. Mercure et al (2014) for details.



E3ME is often compared to Computable General Equilibrium (CGE) models. In many ways the modelling approaches are similar; they are used to answer similar questions and use similar inputs and outputs. However, there are important underlying differences between the modelling approaches.

In a typical CGE framework, optimising behaviour is assumed, output is determined by supply-side constraints and prices adjust fully so that all the available capacity is used. In E3ME the determination of output comes from the demand side of the economy, and it is possible to have spare economic capacity. It is not assumed that prices always adjust to market clearing levels.

The differences have important practical implications, because they mean that in E3ME regulation and other policies could potentially lead to increases in output if they are able to draw upon the available spare economic capacity. The role of the financial sector is key (see the model manual for further details).

The econometric specification of E3ME gives the model a strong empirical grounding. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g. in Covid-19 recovery).

Basic structure and data used

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. The other econometrically estimated equations cover the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by region and by sector.

E3ME's historical database covers the period 1970-2018 and the model projects forward annually to 2050. Apart from the IEA energy balances and prices, the model's data is based entirely on freely available information from international sources and national statistical agencies. Gaps in the data are estimated using customised software algorithms.

The main dimensions of E3ME are:

- 70 regions – all major world economies, the EU28 and candidate countries plus other countries' economies grouped
- 44 industry sectors, based on standard international classifications

- 28 categories of household expenditure
- 22 different users of 12 different fuel types
- 22 power generation technologies
- 14 types of air-borne emission (where data are available) including the 6 GHG's monitored under the Kyoto Protocol