Trucking into a Greener Future

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This is a summary of the Cambridge Econometrics report *Trucking into a Greener Future: The Economic Impact of Decarbonising Goods Vehicles in Europe*, which can be downloaded here.

Disclaimer

The stakeholders who contributed to this study shared the aim of establishing a constructive and transparent exchange of views on the technical, economic and environmental issues associated with the development of low-carbon technologies for vans and Heavy Goods Vehicles (HGVs). The objective was to evaluate the boundaries within which vehicle technologies can contribute to mitigating carbon emissions from trucks in Europe. Each stakeholder contributed their knowledge and vision of these issues. The information and conclusions in this report represent these contributions, but should not be treated as binding on the organisations involved.

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clarity from complexity

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European Climate Foundation

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Executive Summary

The transition towards efficient and zero emission Heavy Goods Vehicles (HGVs) with an increasing level of electrification will reduce capital outflow from the European economy. In terms of efficiency, advances in diesel engines, lighter construction materials and more efficient tyres, will significantly reduce European spending on oil, of which about 89% is imported from overseas. The gradual introduction of electric and hydrogen-fuelled propulsion systems will reduce energy import costs further. And while these technology changes will increase the upfront capital costs for hauliers, this will quickly be offset via lower spending on diesel, reducing the overall cost of road freight services. Even for advanced systems such as Battery Electric Vehicles (BEVs) and Fuel-Cell Electric Vehicles (FCEVs), the Total Cost of Ownership (TCO) can be very competitive compared to diesel vehicles over 5 years.

The transport sector has become Europe's biggest source of CO_2 at 27%, eclipsing the power sector. Air pollution caused by nitrogen oxides and particulate matters is a deadly problem. The transition to clean mobility requires a systemic approach and this transition will not be successful without important changes to the technologies used to power vehicles. Zero Emissions Vehicles (ZEVs) as well as zero emission infrastructure contribute to tackle climate change, air pollution and energy security issues.

At present Europe imports 89% of its crude oil, the vast majority of which is used for transport fuel. Reducing this capital outflow will allow Europe to reconcile the fight against climate change with the creation of new economic opportunities. By increasing the share of domestic energy, particularly electricity and hydrogen produced from renewable energy sources, Europe's energy trade balance will be improved, also limiting exposure to the price volatility of crude oil. If enacted at a global level in both the light-duty and heavy-duty sectors, the transition to low-carbon vehicles would help reduce the price of crude oil, further strengthening the economies of oil-importing countries[1].

By 2030, using more efficient diesel trucks, combined with the gradual integration of new electric and hydrogen vehicles and infrastructure, would lead to a cumulative reduction in imported oil and petroleum products of 1bn barrels of oil equivalent. The rapid and continued decline in cost and weight of batteries will also enable a much faster transition to zero-emission freight transport than was thought possible until recently. The Zero Emissions Vehicle scenarios in this study can save much higher quantities of oil: around 11bn barrels of oil equivalent cumulatively by 2050.

Altogether, these factors are likely to boost the European economy. The analysis presented in this report shows that switching to low-carbon trucks in Europe would lead to a consistent increase in GDP over 2030 and 2050. This transition could help to create over 120,000 net new jobs by 2030, depending on the balance achieved between various powertrain technologies, and the degree to which they are imported or produced in Europe.

However, there are many challenges to be overcome before these benefits can be realized. Hauliers will see a shift in costs away from fuel and towards capital assets, which might create financing challenges. The analysis also brings to light a significant need for spending on new energy infrastructure - a cumulative sum of between €80bn and €140bn by 2050, depending on the pathway followed. There will also be a change in the skills needed for manufacturing zero emission trucks and infrastructures, as well as the energy needed to power them. This highlights the need to invest in training or re-training in the fuels and auto sectors.

European policymakers should start working on forward-looking policies to help de-risk investments by hauliers and energy suppliers to support a successful transition to the technologies of the future.

These policies could take the form of a direct stimulus to infrastructure provision or a stimulus to vehicle uptake, which would have the knock-on effect of creating demand for charging infrastructure (for example, via subsidies, road toll exemptions, tighter CO_2 standards and public procurement policies). It could also support pilot projects on fleet scale, showing that zero emission solutions (vehicles and infrastructure) for HDVs can be profitable.

Introduction

The Paris Agreement seeks to hold average global temperatures to well below 2 degrees Celsius, largely through cutting the use of fossil fuels. The European Commission's "Strategy on Low Emissions Mobility" foresees a fundamental shift away from petroleum towards greener energy sources, and the EU institutions are currently debating a proposal for CO_2 standards for trucks[2]. It is clear that change is coming fast and efforts should cover all types of road freight, ranging from long-distance goods transportation with heavy-duty trucks to parcel delivery in cities with vans. This study focuses primarily on reducing the carbon content of fuel for heavy duty trucking with consideration of fuel efficiency technologies that can be fitted onto trucks.

It is inevitable that much of this change will be achieved via the adoption of new vehicle technologies. For Europe, with many national economies heavily invested in automotive production, such goals will have profound and far-reaching consequences. With this in mind, the European Climate Foundation (ECF) convened a project to examine the main social, environmental and economic impacts of a technology-led transition to low-carbon trucks.

While this study focuses on vehicle and infractructure technologies, we acknowledge that the transition to low-carbon mobility will also require many other solutions. To help inform the assumptions and review the emerging evidence, the ECF convened an expert panel comprised of individuals from industry and civil society. From industry were experts from Volvo, Tesla, Siemens, DB Schenker, Geodis and Michelin, and from civil society were experts from the Smart Freight Centre, European Climate Foundation and the European Federation for Transport & Environment.

This expert panel met on several occasions during 2017-2018 to advise an analytical team, which was tasked with answering the following key questions:

• *What are plausible deployment scenarios for clean technologies for trucks, and to what extent can they contribute to meeting the EU's climate goals?*

• *What is the range of possible impacts on hauliers from changes to vehicle purchasing costs and overall vehicle running costs?*

• *How much would the EU need to invest in charging infrastructure for the agreed technology scenarios?*

• *What is the likely range of overall impacts on the European economy and on society?*

It is also worth noting four potential impacts that this study has NOT attempted to quantify:

• *It has not tried to measure the impact on the competitiveness of the EU truck manufacturing industry, either from outpacing or from lagging behind the global transition to clean mobility.*

• *It has not tried to measure changes to the number of trucks that might result from potential changes in consumption.*

• *While the study does provide calculations of the net impact on the economy as a whole, it does not provide a detailed analysis of the changes in employment within the automotive sector itself.*

• *It has not tried to measure the effect of autonomous freight transport. The technology is in early phase but it has a very disruptive potential thanks to high utilization rates of trucks and a radical shift in operations. The integration of zero emission technologies to autonomous trucks is an important area for further analysis.*

As such, the main result of this study is an overview of a structural change to the road freight sector whereby there is an increase in efficiency, a change in drive-train technologies and energy infrastructure for trucks, and a shift from imported oil to domestically produced electricity and hydrogen.

Methodology

The modelling approach used in this project is described in detail in the technical report, and is summarised in Figure 2. An expert panel was convened to help construct a series of plausible technology deployment scenarios, considering historic evidence of diffusion rates for low-carbon technologies, as well as the range of existing projections for future technology diffusion.

These scenarios do not attempt to be forecasts, but instead they represent "what if?" scenarios that are designed to achieve long-term climate policy objectives. Such changes need to be driven by standards and economic instruments at least until the total cost of new technologies reaches parity with existing technologies. Some low-carbon technologies are already cost-competitive but the challenge they face is one of deployment.

The deployment of technologies which impact upon new vehicle efficiency is based upon the payback period of each technology. The analysis examined their deployment across four categories: Vans, Light Heavy Goods: (3.5 to 7.5 tonnes); Medium Heavy Goods Vehicles (7.5 to 16t); Heavy Heavy Goods Vehicles (>16t).

The panel also advised on the most relevant input data on mobility, vehicles, energy, infrastructure and economy. These are described in later chapters. The agreed datasets were then fed into a stock model, which determined changes to Europe's overall stock of capital assets and energy consumption per drive-train technology on an annual basis under each of the scenarios. Finally, the outputs from the stock model were fed into the macro-economic model E3ME.

The E3ME model embodies two key strengths relevant to this project. The model's integrated treatment of the economy, the energy system and the environment enables it to capture two-way linkages and feedbacks between these components. Its high level of disaggregation enables relatively detailed analysis of sectoral effects. E3ME delivered outputs in terms of changes to household budgets, the energy trade balance, consumption, GDP, employment, CO_2, NO_x and particulates.

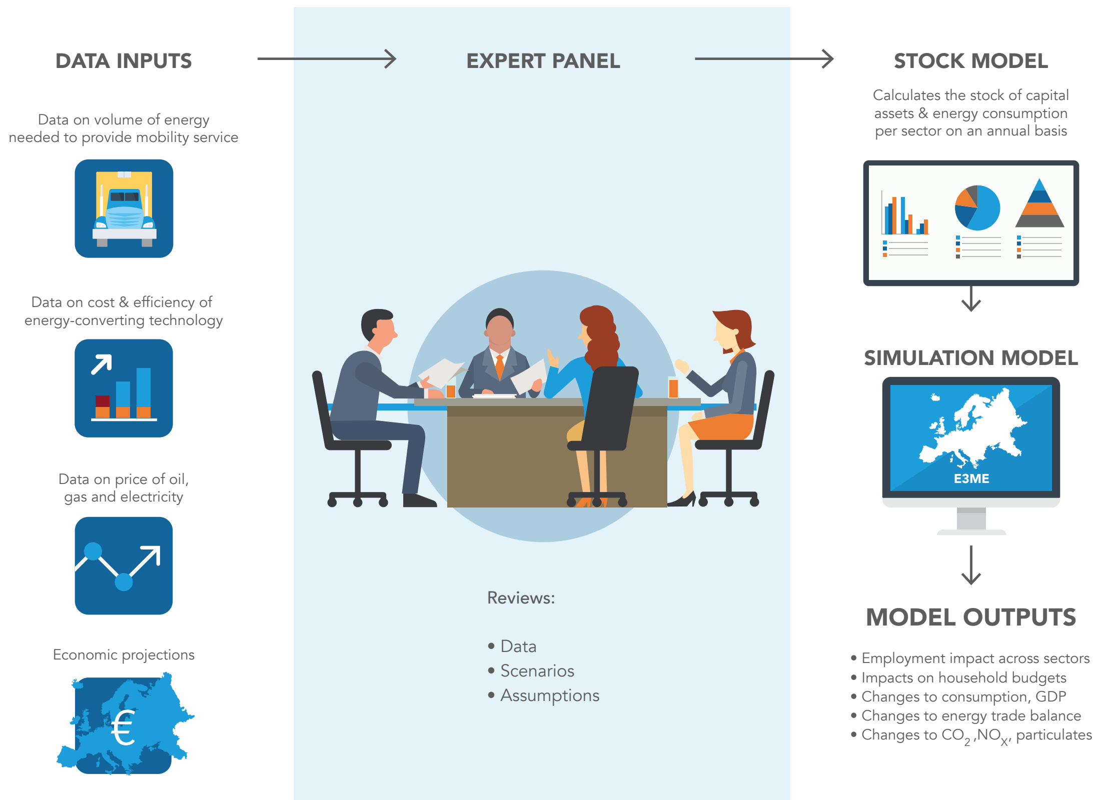


Figure 1. An overview of the modelling approach used.

Technology Deployment and Scenarios

There is a wide range of uncertainty about future deployment of low- and zero-emissions technologies, which will be impacted by changes to technology costs, energy costs, the level of taxes and incentives, and consumer preferences. The project therefore considered various scenarios for the deployment of the main technology options that are being considered:

• Increasingly efficient Internal Combustion Engine trucks (ICEs), similar to an very fuel efficient Volvo FH 420.

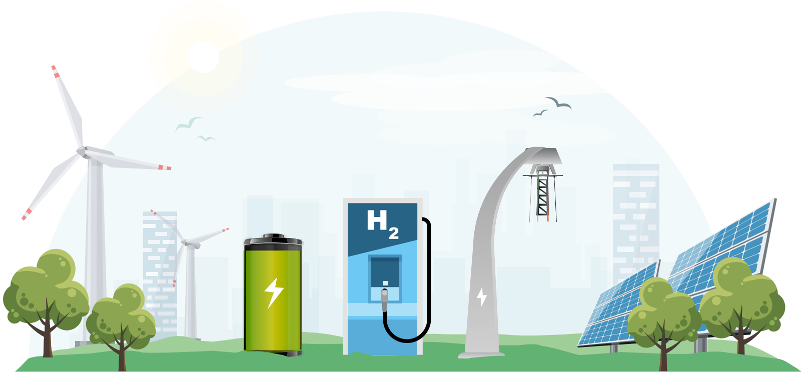
• Battery electric trucks (BEVs), similar to Tesla's Semi-truck or Volvo's medium heavy duty FL and FE lines.

• Fuel-cell electric trucks (FCEVs), similar to the Semi-truck recently launched by Toyota.

• Electric Road Systems (ERS) consist of infrastructure (e.g. catenary) which supplies electrical energy to trucks while they move. The trucks maintain their operational flexibility thanks to the ability to connect and disconnect while moving and by being able to operate outside of the infrastructure. This is possible either with a hybrid drive train (PHEV-ERS) or by having a sufficient battery (BEV-ERS).

The main goal of this analysis was not to predict the role and share of each technology, but to explore the potential impacts on the European economy. By 2050, it is likely the technology mix in the overall fleet will include a set of technologies options suitable for various uses. In this study, four comparable scenarios were designed in which each of the four technologies is dominant in order to more clearly show the difference between the impacts of each technology pathway.

In seeking to determine plausible deployment rates, the expert panel drew on past evidence of technology deployment rates in the auto sector, showing that previous engine technology improvements have taken around 10-15 years from first deployment to full mass-market penetration. The Zero-Emission Vehicles deployment scenarios are summarized in Figure 2.



SALES SHARES OF NEW HEAVY GOODS VEHICLES IN EUROPE

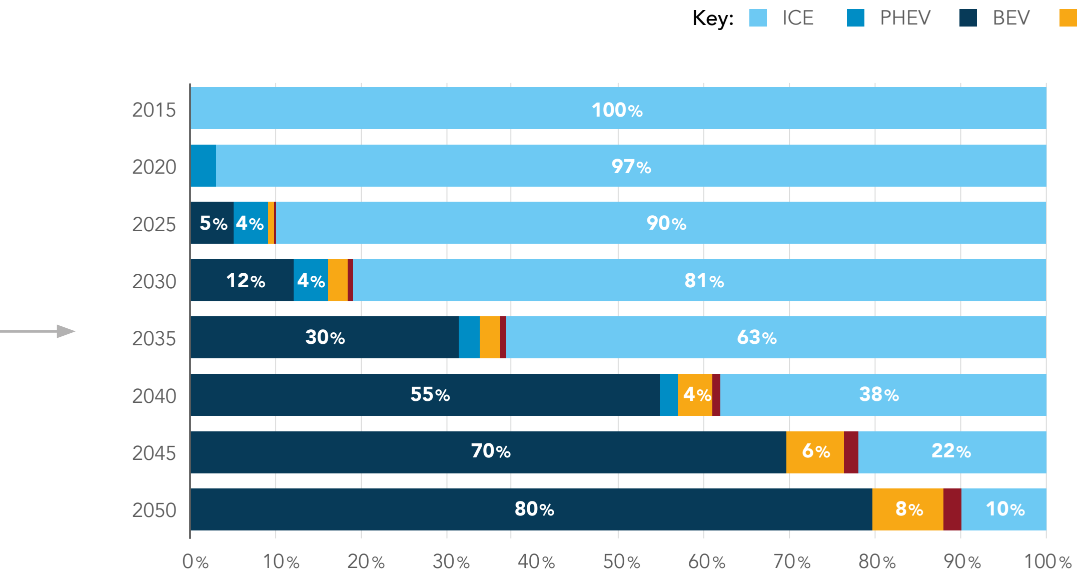


Figure 2a.
Evolution of new vehicles sales by technology type until 2050 in the TECH BEV scenario.

TECH BEV

Advances in battery packs and other electric components can already enable shorter distance urban commercial duty vehicles to become plug-in electric, similar to cars. In this scenario, BEVs emerge as the dominant technology in the MHGV and HHGV segment.

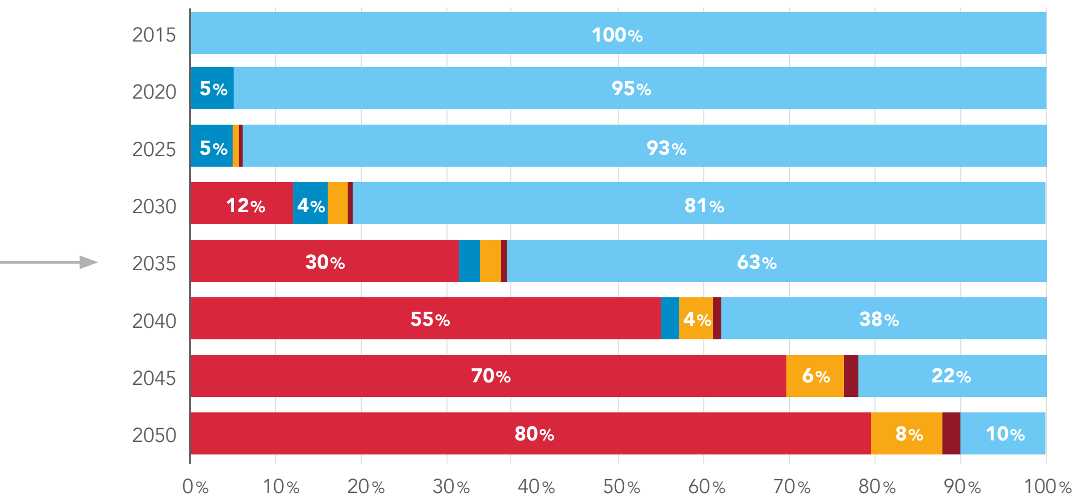


Figure 2b.
Evolution of new vehicles sales by technology type until 2050 in the TECH FCEV scenario.

TECH FCEV

Hydrogen fuel cell technology might be especially key for longer-distance duty cycles. It can also be a potential solution to applications like suburban delivery trucks, drayage trucks, and shuttle buses where flexibility and long range is needed.

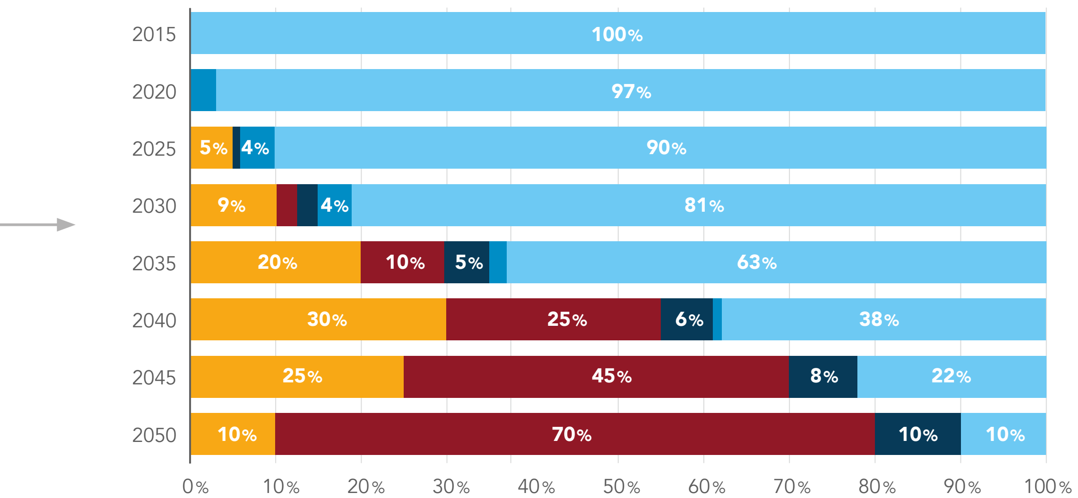


Figure 2c.
Evolution of new vehicles sales by technology type until 2050 in the TECH ERS scenario.

TECH ERS

Battery electric vehicles with overhead catenary or in-road charging can enable electric zero-emission goods transport on and around heavily traveled freight corridors.

The deployment of low-carbon technologies will lead to an increase in the upfront capital cost of trucks, as summarized in Figure 3. The upfront cost of buying a diesel truck will increase by 2030, as more technologies are deployed to meet EU CO_2 targets. All four of the electrified technologies considered have considerably higher purchasing costs. Initially, there is a significant difference between the upfront costs of different powertrains, but this difference will be reduced by 2050 as scale economies reduce the cost of new technologies, and technologies improve, leading to a convergence of capital costs.

However, it is insufficient to merely consider the capital costs of trucks in future, as haulage companies also consider the other costs of ownership, such as fuel costs. This changes the picture considerably, as shown in Figure 4, which shows the 5-year total cost of ownership for new heavy trucks in 2030 and 2050. All scenarios assume costs based on mature technologies.

This analysis indicates that BEV trucks will be cost competitive with diesel trucks, on a Total Cost of Ownership (TCO) basis, before 2030, if battery costs continue to fall as anticipated. FCEV trucks will remain more expensive than battery-electric systems to 2050, but may find applications in specific (long distance) use cases. Vehicles using ERS systems have the lowest TCO for routes where such systems are available. Thus a system where ERS is installed on the busiest corridors and used by BEVs that have sufficient range to go to and from the ERS network would offer the lowest TCO.

However, other factors also affect vehicle purchasing decisions. For example, each technology option has different challenges with infrastructure deployment. In addition, the haulage sector contains a large number of very small operators that have constrained access to finance, which means that the increase in upfront costs could prove to be a barrier. This highlights the importance of forward-looking policies to help drive technology deployment.

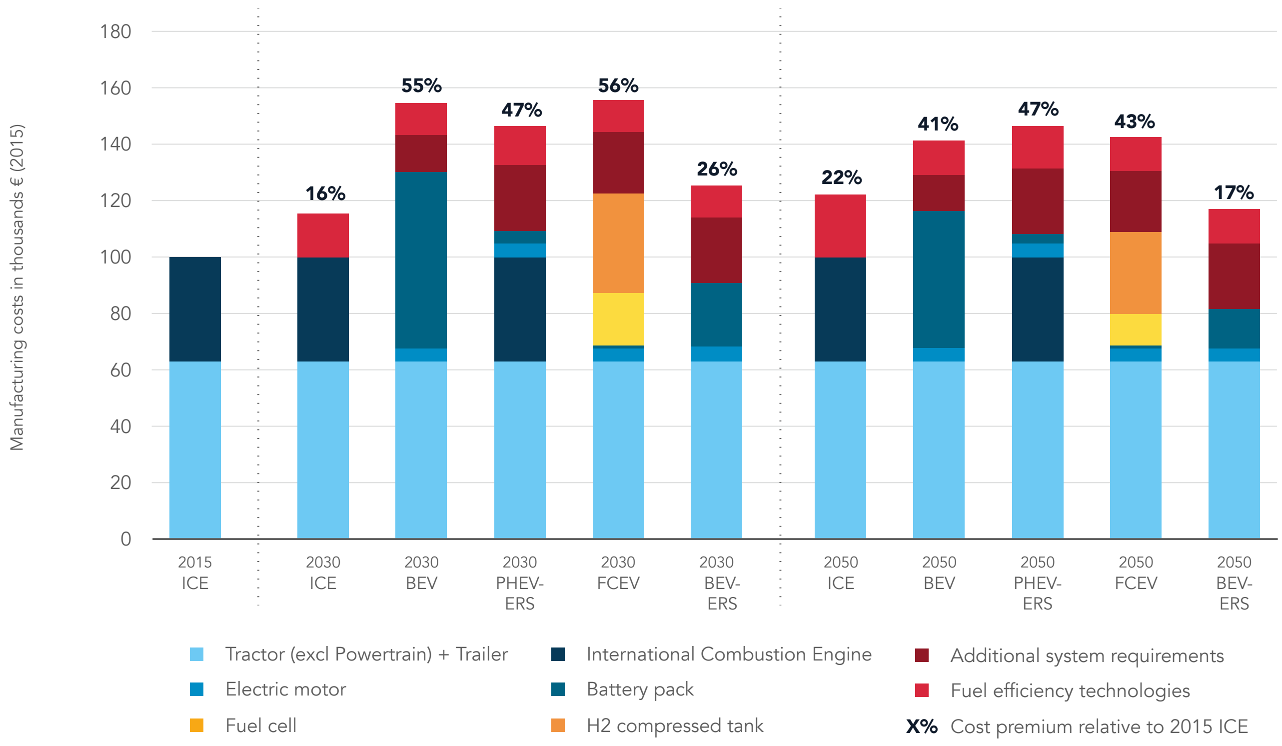


Figure 3. Upfront capital cost of various Heavy Heavy Good Vehicle (HHGV) types in 2030 and 2050 compared to a 2015 Internal Combustion Engine (ICE) technology.

BEVs have a very competitive running cost, which leads to a competitive TCO over 5 years. However, the challenges are the higher vehicle purchase price; the need for policymakers to develop EU-wide charging standards; the need for a major investment in rapid charging infrastructure; and the increased load on the electricity grid at certain times of the day and in certain locations.

BEVs or PHEVs are at least as cheap to run using ERS systems, with the lowest 5-year TCO of all. Also this pathway faces the challenge of investment in ERS infrastructure, which will require substantial public-sector intervention for deployment. The additional load on the electricity system is unlikely to vary much throughout the day, which might help minimize the challenge of grid integration.

FCEVs might look the most costly among the ZEV options on a TCO basis, but from the perspective of a haulier the upfront purchase costs are similar to those of other ZEV technology options. The challenges for this pathway are the relatively expensive hydrogen, compared to electricity, and the need for a large upfront investment in hydrogen refueling infrastructure.

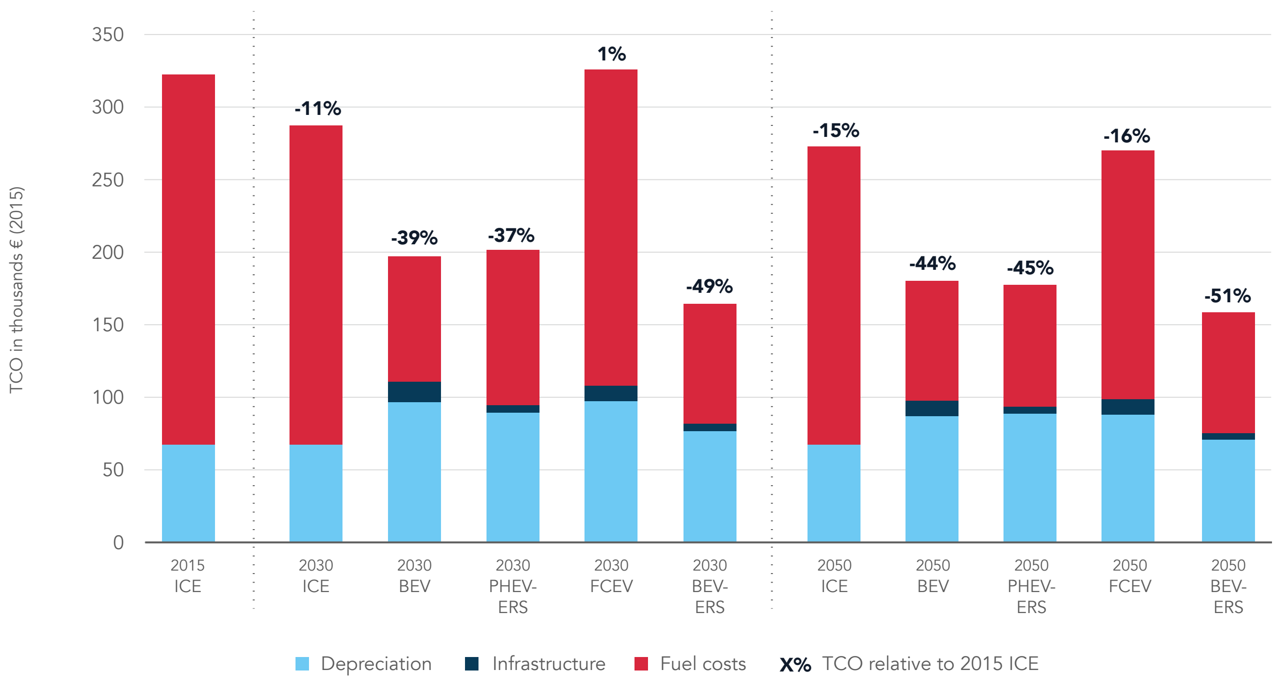


Figure 4. Total Cost of Operating a Heavy Heavy Good Vehicle over 5 years of various powertrains in 2030 and 2050 compared to a 2015 ICE truck.

Infrastructure Investment

In order to determine the economic impact of the transition to low-carbon trucks, it is also important to account for investments in charging and fueling infrastructure. This chart shows the calculated cumulative investment in charging infrastructure to service the energy demand of the ZEVs in each scenario. For BEVs, this represents the cost of both depot chargers and rapid chargers. For the ERS, this represents the cost of the ERS infrastructure, such as catenary, substations and grid connections. In this scenario, Electric Road Systems are deployed across the core TEN-T network. For FCEVs, this represents the costs of hydrogen refueling stations.

Firstly, this analysis shows that the infrastructure costs are relatively similar for all technology scenarios. TECH FCEV and TECH BEV have the highest infrastructure cost reflecting the higher costs of establishing a network of hydrogen refueling stations relative to the deployment of ERS for an equivalent rollout of ZEVs. Secondly, it is clear that the investment requirements are substantial, but manageable, and will all require sustained and extensive infrastructure investments by government and industry. To give a point of comparison, these costs are around half the size of the infrastructure investment required for a fleet of zero-emissions cars[3].

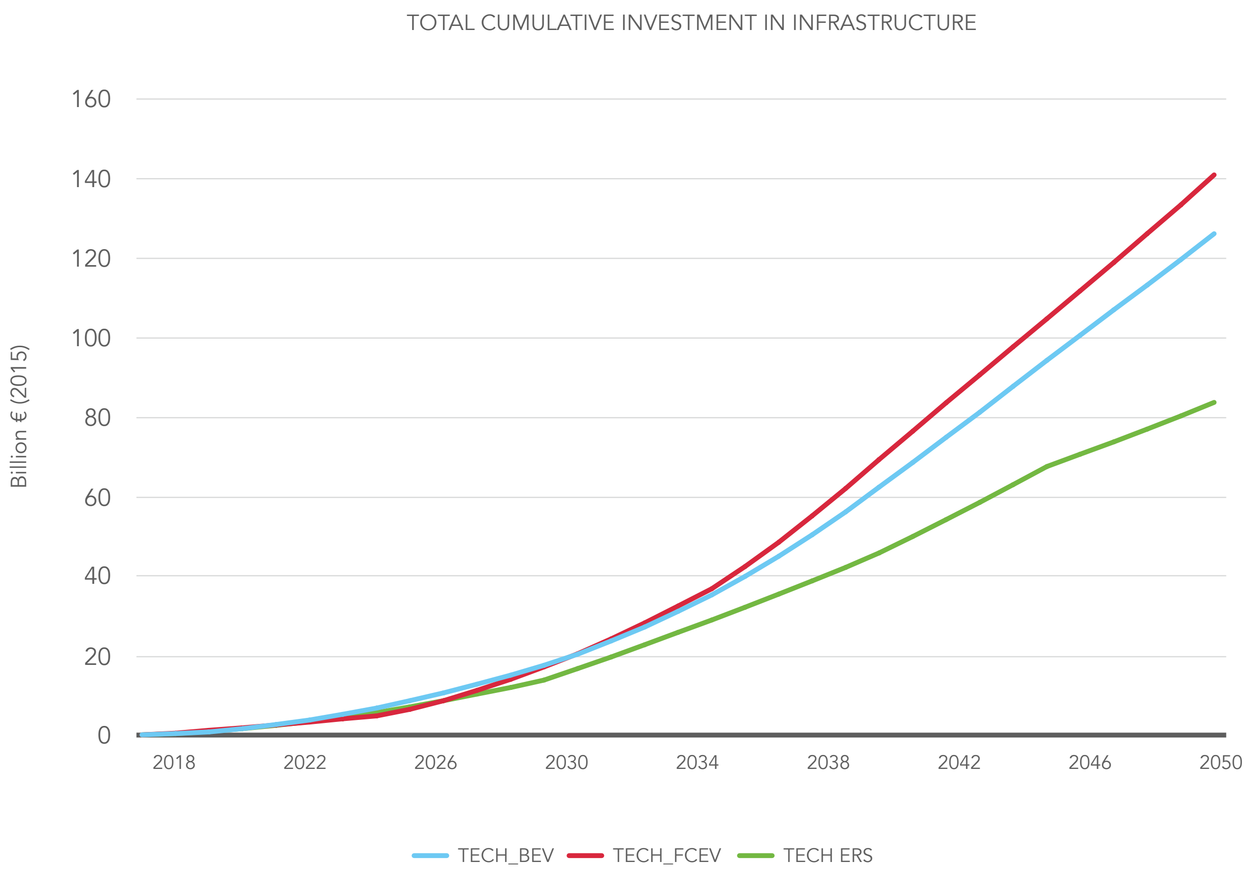


Figure 5. Total cumulative investment needs in infrastructure in each scenario.

Economic Impacts

While there is uncertainty about many of the factors within this transition, we have tried to capture this uncertainty within the range of assumptions used for the macro-economic modelling. This has allowed us to identify the main changes that would occur within the European economy during the transition to low-carbon road freight.

Firstly, there is increased investment in capital assets. The shift towards efficient diesel trucks, vehicles using electric road systems, BEVs and FCEVs increases the investment in automotive technology and on average generates additional value for Europe. This is especially the case if European companies can establish a competitive position in the manufacturing of battery cells. Already, some initiatives have been taken to lay the foundations for battery cell manufacturing in Europe (LG Chem in Poland, Northvolt in Sweden). While these trucks are more expensive for hauliers to purchase, this is quickly offset by savings on fuel spending.

The second major economic impact is an efficiency gain throughout the road transport system. The vehicle fleet becomes increasingly efficient, due to improved diesel engines, more hybrids, and because electric motors are inherently more efficient in their own right. This occurs both as a result of existing climate policies (e.g. the proposed EU CO_2 standards), and anticipated policies to meet future climate goals. More efficient use of energy leads to lower costs for logistics companies, which is then distributed to the rest of the economy via a reduction in the cost of retail products.

The third main economic impact is the shift away from petroleum, which is imported from outside Europe, towards electricity and hydrogen, which are largely produced domestically, meaning that Europe starts to capture a greater share of the value from energy used in mobility. Figure 6 shows the cumulative saving on oil and petroleum imports in each of the core scenarios compared to a scenario in which trucks are unchanged from today (REF).

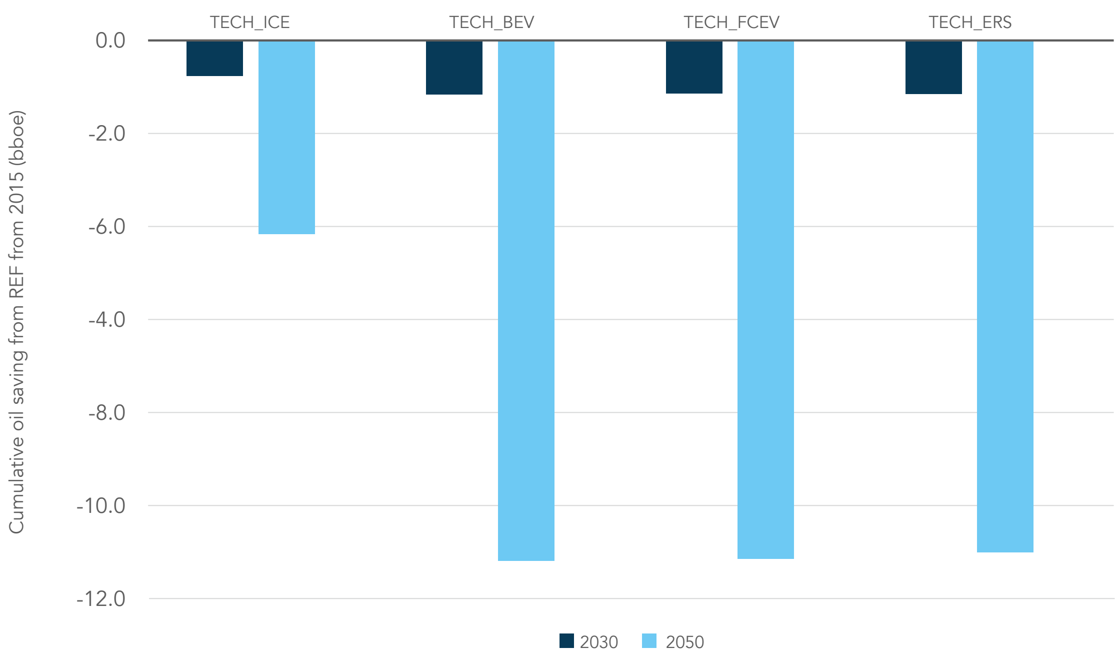


Figure 6. Impact of the ZEV scenarios on EU oil imports in 2030 and 2050, compared to 2015.

By 2030, the lower demand for petrol and diesel from vans and HGVs in the Zero-emission vehicle technology (ZEV) scenarios leads to a total reduction in imported oil and petroleum of 1bn barrels of oil equivalent. By 2050, a much greater saving in oil imports is achieved, saving around 11bn barrels of oil equivalent cumulatively. In comparison, the final energy consumption of petroleum products across the EU28 was 1.98bn barrels of oil equivalent in 2015[4].

Using the macro-economic model E3ME, we have measured the net economic impact of this transition, again compared to a reference case in which trucks remain unchanged from today (REF) (Figure 7). This chart shows that all scenarios lead to a mild increase in GDP, which results from a reduction in spending on petroleum and an increase in spending on technologies and electricity and hydrogen that are produced in Europe.

Improving the efficiency of diesel engines (TECH ICE) leads to a small increase in GDP, which levels off as technologies reach the limits of their potential and as oil import reductions stabilize. Only the transition to ZEV technologies leads to a consistent increase in GDP over the period studied. By 2050, European GDP is around €52bn - €58bn higher in all ZEV scenarios than in the reference case.

This study did not look at questions about the future location of production of batteries for trucks. Sensitivities that explored the difference in GDP outcomes when only half of domestic demand was met through domestic production, and a case where all battery cells are imported from outside of Europe were conducted in the Fuelling Europe's Future report on light-duty vehicles[5].

Figure 7 shows a combined positive impact of decarbonizing the trucking sector on GDP of around 0.23% by 2050 in all scenarios compared to Business as Usual.

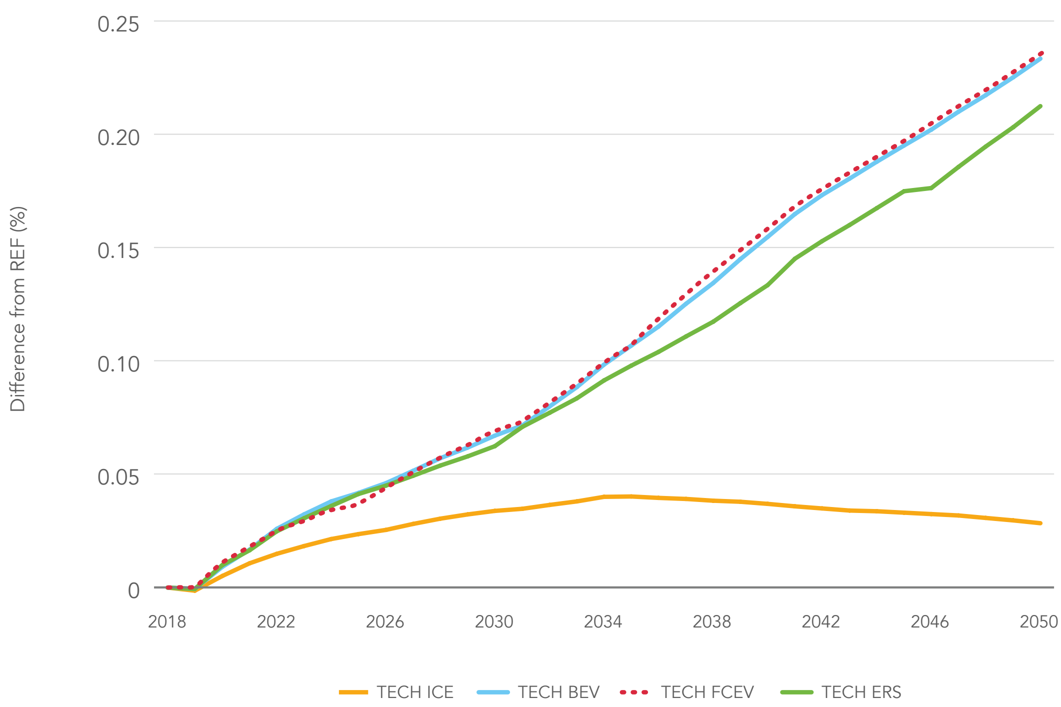


Figure 7. Impact of the Zero Emission Vehicles scenarios on EU GDP.

Jobs Impacts

It is also important to consider the impact of this transition on employment. The impact reflects the changes in value added between sectors described above, but it also needs to take account of variations in employment intensity between sectors. These employment intensities are taken from Eurostat data and are shown in Figure 8. At the low end of the range is the extraction and refining of petroleum, which creates 4-6 jobs per million euros of value added. At the high end of the range is the construction sector, creating 27 jobs per million euros of value added.

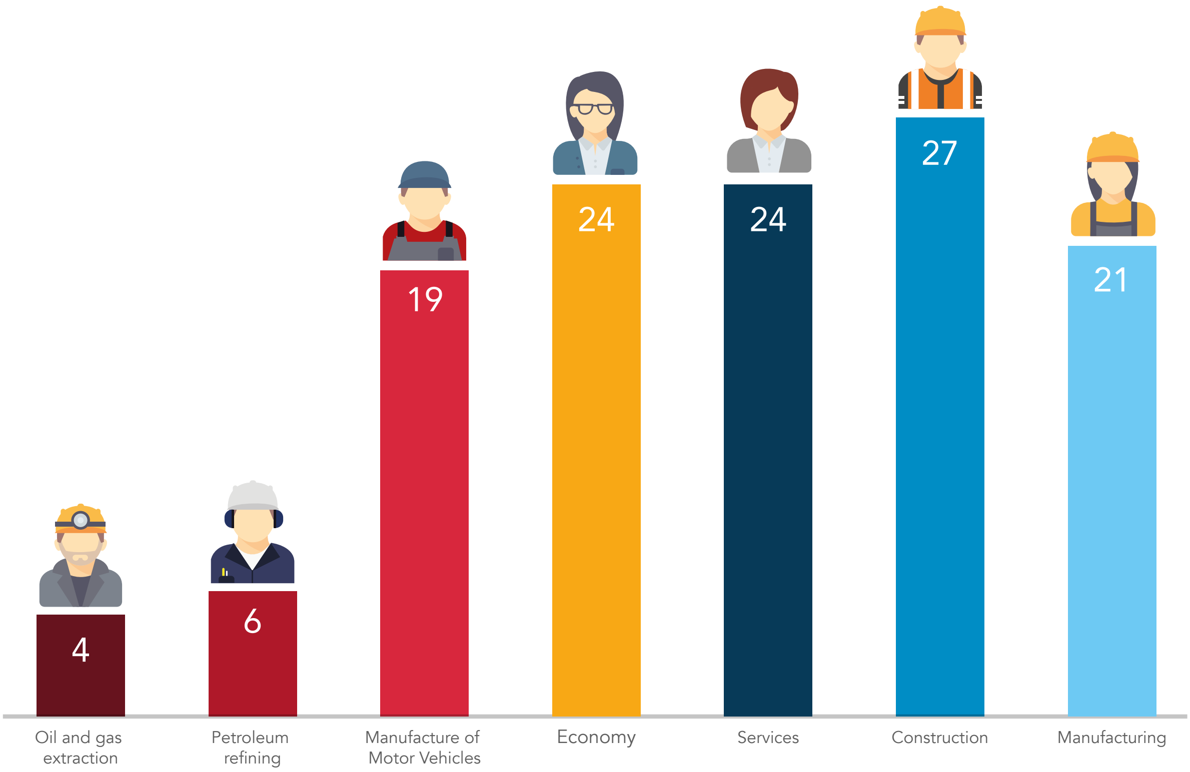


Figure 8. EU job intensities for selected sectors, jobs per million euros of value added.

There is an underlying trend towards increasing automation of the auto industry, which reduces the number of jobs, regardless of the low-carbon transition. There are also nuances between different vehicle types. Building BEVs is expected to be less labour-intensive than building the diesel vehicles they will replace. Our modelling accounts for this by taking the (lower) labour-intensity of manufacturing electrical equipment and applying it to parts of the automotive value chain within the model. In contrast, constructing hybrids, PHEVs and FCEVs is expected to be more labour intensive than building traditional combustion trucks. The net employment impact for the automotive sector from this transition therefore depends on the balance achieved between these various powertrain technologies, and the degree to which they are imported or produced in Europe.

As investment is increased in new value chains such as for electrical equipment and construction, this also leads to increased employment in these sectors, depending on the employment intensity in each sector.

Analysis in this project shows revenues are reduced in the oil and gas sectors, but these have low employment intensity so job losses are relatively small and they are spread over several decades. In the automotive sector, due to the greater complexity of more fuel-efficient diesel vehicles within the fleet mix, there are more jobs until 2030. After 2030, however, jobs in automotive start to decrease as the transition to ZEVs begins and production shifts from the traditional motor vehicles sector to the electrical equipment sector. At the same time, the deployment of infrastructure leads to more jobs in the electrical equipment and construction sectors.

The shift in spending from petroleum to other areas of the economy leads to a overall macro-economic improvement, and the consequent spending of higher incomes explains the increase in service sector employment across the overall economy.

Figure 9 shows the impact on employment by sector in zero emission vehicles scenarios. The largest change in jobs is in services. This is because households benefit from lower costs of goods due to more efficient logistics chains, and the money they save is redirected to other areas of the economy, dominated by services. This effect is stronger than the boost to the electrical equipment sector arising from the change in the motor vehicles supply chain. In total, employment is around 120,000 higher in each ZEV scenarios in 2030 than in the reference case.

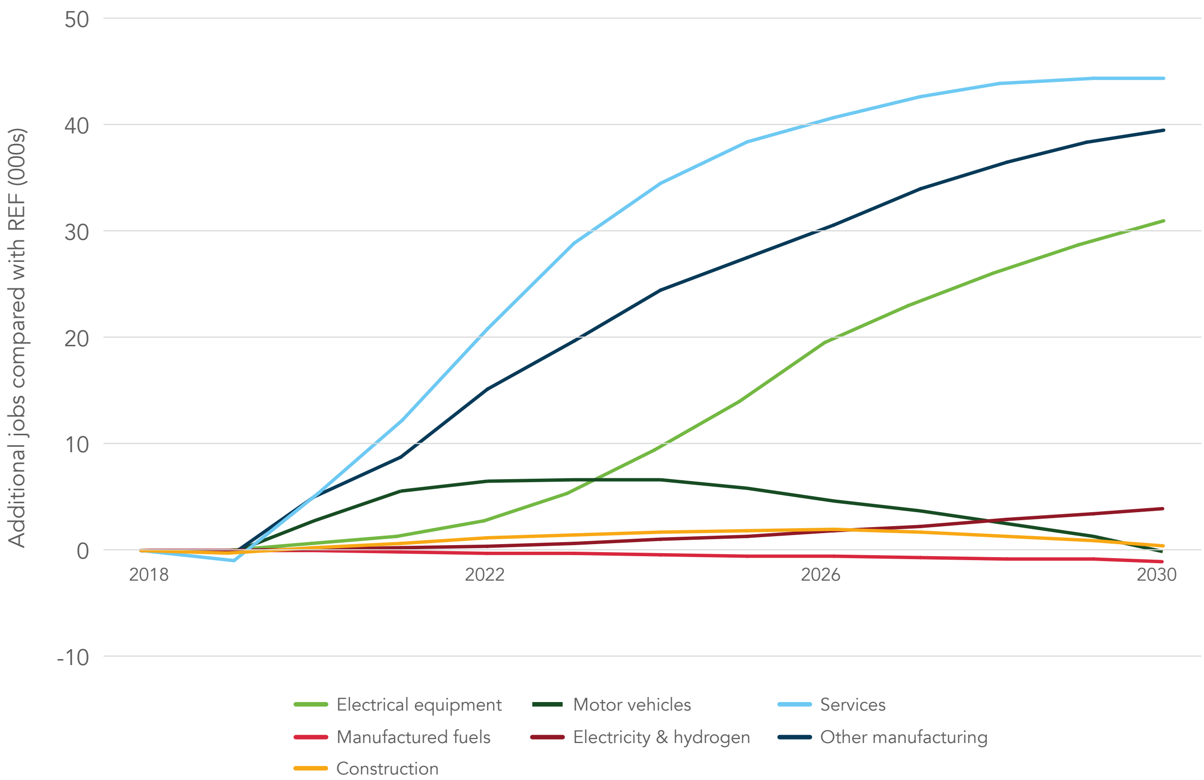


Figure 9. The employment impact per sector in Europe of the transition to low-carbon road freight (thousands) until 2030.

Environmental Benefits

Figure 10 shows the impact of a growing share of low-carbon vehicles in new sales on the tailpipe CO_2 performance of the average new truck sold. Expected improvements in the efficiency of diesel engines (TECH ICE) would bring about significant reductions in the next 5-10 years, amounting to a 30% fall in CO_2 per kilometre driven by the late 2020s, but the assumed rate of technological advance tails off thereafter. In the other scenarios, the emissions levels of the average HGV drops sharply as ZEVs take up a larger share of new sales.

Figure 10. Impact of the ZEV scenarios on EU CO_2 emissions from the average new HGV in each scenario.

For each heavy goods vehicle introduced on to the market, equipped either with energy efficiency systems, an electric engine or a fuel cell, average emissions are decreasing. In the case of electric or fuel cell vehicles, the reduction will come from the expected changes in the way energy is produced and the increased importance of renewable and carbon-free energy sources.

Reductions in emissions from internal combustion engines are mainly driven by stricter standards in the EU.

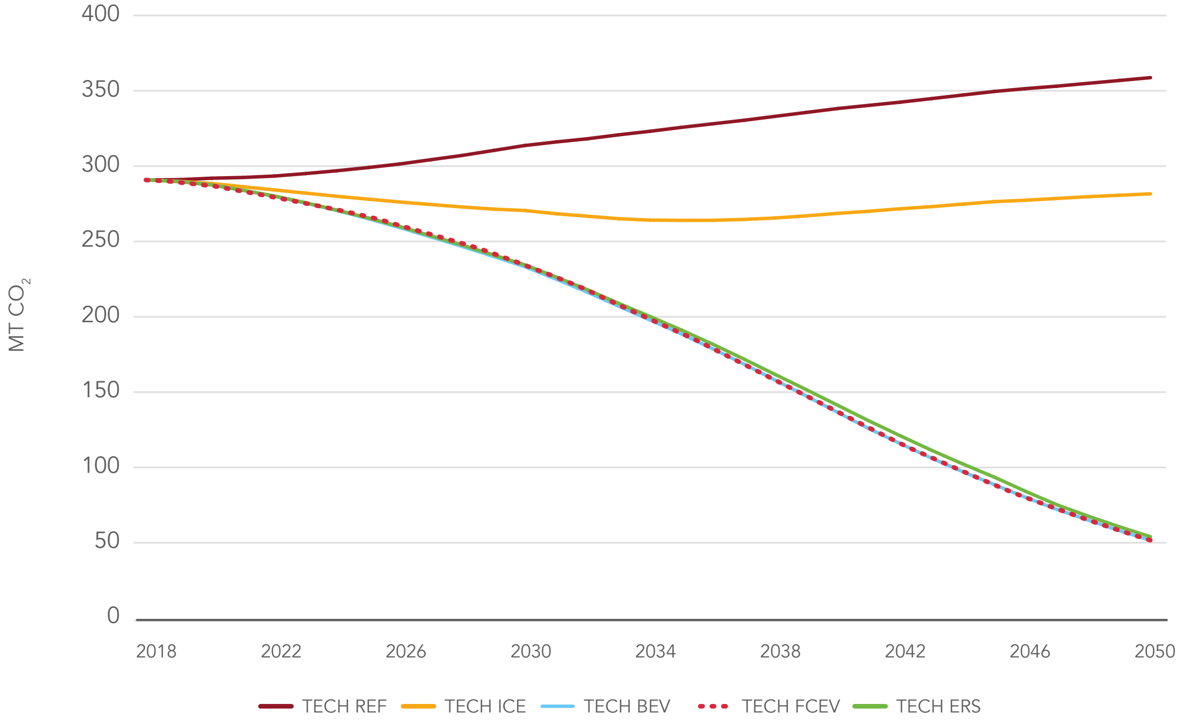


Figure 11. Impact of the ZEV scenarios on EU CO_2 emissions from the overall HGV fleet in each scenario.

Figure 11 shows the tailpipe CO_2 emissions from the entire stock of road freight vehicles in each scenario. In the REF case, an assumed increase in the demand for road freight services drives an increase in CO_2 emissions, given the assumption of no further improvement in engine efficiency. In the other scenarios, emissions from the HGV fleet fall in the period to 2030 reflecting the diffusion of more efficient new vehicles through the stock. However, beyond 2030, the deployment of advanced powertrains is required to deliver continued emissions reductions in the face of growing demand for road freight services (shown by the fact that emissions start to rise again in TECH-ICE) .

Whereas the more efficient potential diesel technologies can reduce carbon emissions by about 40%, electric-drive technologies powered by renewable sources can achieve over an 80% reduction in emissions[6].

Opportunities and Policy Barriers to Overcome

All low-carbon scenarios have barriers but also bring formidable opportunities to accelerate the transition to a prosperous low-carbon society.

The low-carbon transition in road freight offers the prospect of large reductions in CO_2 emissions even as more freight is moved across Europe's road system. It can be achieved with efficiency gains and cost reductions for hauliers and net benefits for the European economy in terms of value added and jobs. But even as technological improvements reduce the purchase cost of advanced powertrains and allow hauliers to take advantage of lower running costs, there is a clear role for public policy to address potential obstacles to uptake. Zero emission vehicles and infrastructure can prove themselves to fullfil the operational requirements of the trucking companies, and do so economically. Opportunities for deployment of low-carbon trucks in Europe will start to emerge when a switch is made to new technologies, if a supportive policy environment can be put in place.

• A first challenge is the promotion of common standards, notably in charging technologies, and including harmonization between trucks and coaches.

• The second challenge is promoting coordinated roll-out of the charging and refueling infrastructure. Clearly hauliers need to be confident that they will be able to run vehicles over a wide geographical network across national boundaries. Energy supply companies also need to be confident that operating the infrastructure for zero emission trucking can be profitable.

For BEVs and FCEVs this means the availability of recharging / refueling sites with sufficient frequency and scale to support demand. In the early stages of uptake, when the scale of demand is uncertain, the risks to private sector operators to develop the infrastructure will be high. Without public intervention, the result could be a self-reinforcing cycle of limited roll-out of infrastructure and limited uptake of ZEVs. For ERS the challenge is to establish multiple shuttle applications across Europe in order to act where production volumes increase, as well as to link up with industrial clusters.

• A third challenge is presented by the large number of small operators in the haulage sector. These operators work on tight margins and have constrained access to finance. Even if adoption of advanced powertrains offers the prospect of substantially lower running costs, the higher upfront cost of vehicle purchase could be a significant barrier in the early stages of the transition when perceived risks are high.

This highlights the importance of forward-looking policies to help de-risk investments by hauliers and leasing companies, which would help drive technology deployment. Examples could include fiscal incentives such as reduced sales tax.

The low-carbon transition in road freight transport, whether it comes from improved diesel engine efficiency or uptake of advanced powertrains, will obviously have an impact on government fuel tax revenues. This will be mitigated slightly by the small boost to incomes and spending and the associated tax take coming from greater efficiency and substitution of European production of ZEVs, their components and fuels for imported petroleum.

Figure 12 shows annual government tax revenues in 2050 in the REF and TECH_BEV scenarios. The figure shows that fuel duty revenues are €23bn lower in 2050 in the TECH_BEV case. However, the figure also shows that fuel duties form only a small part of the Member State government tax base (estimated at 1.4% in 2050 in the REF case). Changes will take place relatively slowly in line with the steady deployment of advanced powertrains into new sales. Hence, the lost revenues can be recouped through gradual changes to other taxes, which is the approach taken in the analysis underpinning Figure 12.

As government revenues from the taxation of diesel and gasoline are reduced, it seems plausible that treasuries might seek to tax other energy sources for mobility, most notably electricity and hydrogen. On the other hand, the European Union has ambitious CO_2 reduction goals and transport has become the biggest source of emissions. It therefore seems unlikely that taxes will be set in such a way that significantly impedes the deployment of clean vehicle technologies. Road charging, tailored to reflect the carbon-intensity of vehicles, or a bonus-malus approach could be potential solutions to address this issue without creating economic distortions. For the purposes of this economic analysis, the approach is not important provided it is done in an equitable and revenue neutral manner.

By introducing appropriate provisions or a stimulus to vehicle uptake (for example, via subsidies, road toll exemptions, tighter CO_2 standards and public procurement policies) government would contribute to overcome some of the main challenges of the transition to zero emission trucks in Europe.

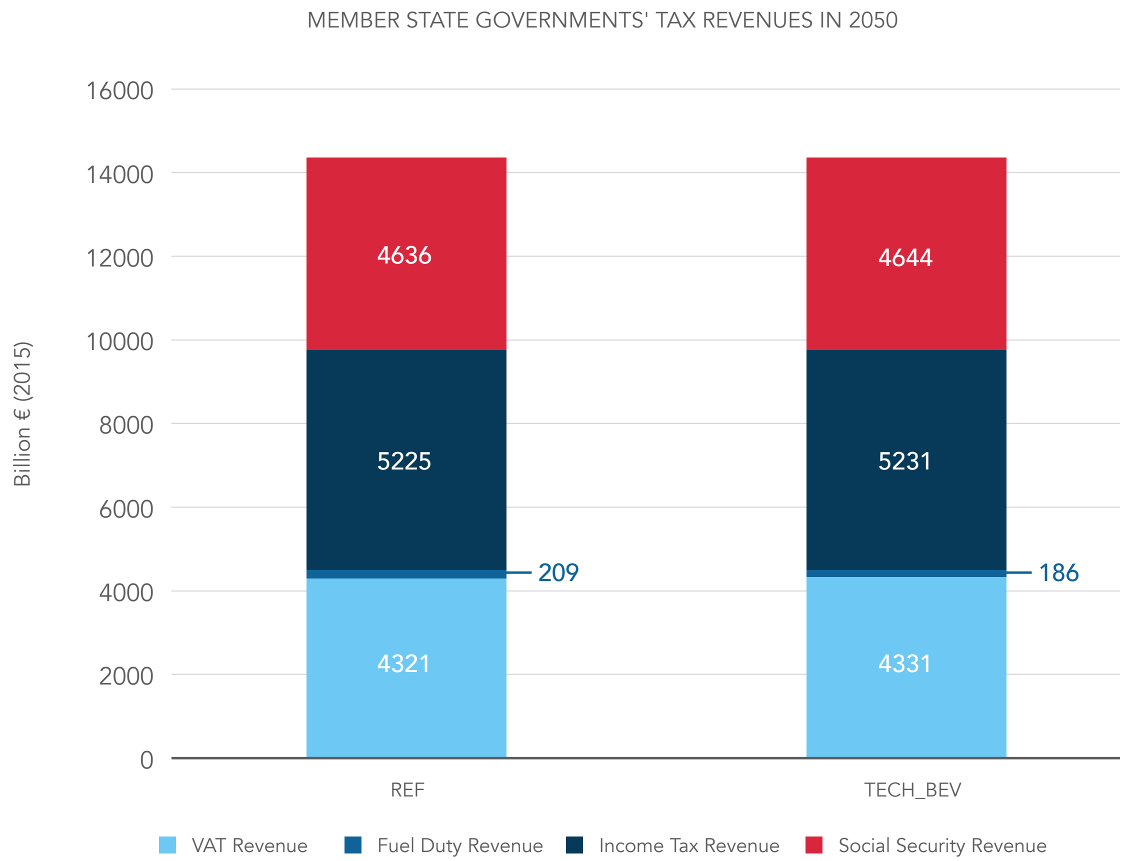


Figure 12. Loss of fuel duty revenue is manageable.

Conclusion

This project has explored the economic impact of the transition to low-carbon vehicles, while using a mid-range set of cost assumptions and acknowledging the inherent uncertainties. It has found that the transition from petroleum-based energy sources to renewably sourced energy will strengthen Europe's economy, with mild increases to both net GDP and net employment. However, there will be signicant transition challenges along the way. Electricity and gas (for sustainable hydrogen) grids will need to be modernized as part of sectoral integration, and a determined multi-sectoral effort is needed to deploy sufficient charging infrastructure. Efforts must be made to ensure workers who are currently producing legacy technologies are retrained for quality jobs in producing the technologies of the future.

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TRUCKSPOTTING

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