The Impact of Improved Vehicle Efficiency on Energy Dependency in Europe

A report for the European Climate Foundation

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1. Introduction

Given that carbon emissions from vehicles are produced from the combustion of hydrocarbon molecules in fossil fuels, measures aimed at reducing emissions are achieved by reducing the amount of hydrocarbon consumed per unit of energy produced. This means that policies with the primary purpose of mitigating climate change will also deliver significant co-benefits from reducing the dependence of Europe's economy on imported oil, as well as its exposure to volatile oil prices.

In December 2013, European legislation was passed requiring the efficiency of new vehicles to average 95gCO_2/km by 2021. Moreover, the European Transport White Paper requires that emissions from road transport are reduced by 60% on 1990 levels by 2050. Following a trajectory that meets this pathway will lead to a substantial reduction in the demand for oil in Europe.

In light of this, Cambridge Econometrics was commissioned by the European Climate Foundation to assess the implications of falling oil demand from light-duty and heavy-duty vehicles on Europe's energy dependency.

This short report summarizes the main findings from the analysis.

- Section 2 presents the context and background
- Section 3 presents the analytical approach and key results on energy demand
- Section 4 presents an analysis of economic resilience to oil price spikes
- Section 5 draws together the key conclusions from the analysis

All monetary values in the report are expressed in real terms (2014 price base).

2. Context

Light-duty vehicles in Europe consume around 112m tonnes of gasoline and 75m tonnes of diesel annually; heavy-duty vehicles consume an additional 71m tonnes diesel per annum. Limited domestic oil extraction opportunities means that most of the oil supplied to the EU is imported. In 2014, Europe imported around 489m tonnes of crude oil at a value of €271bn. Figure 1 shows the source of European oil imports by country. Imports from the top ten sources (by volume) account for over 90% of European oil imports. Roughly one-third of oil imports were sourced from Russia, which is more than the next three largest import sources combined (Norway, Libya, and Nigeria).

Figure 1: EU Oil Imports, by source

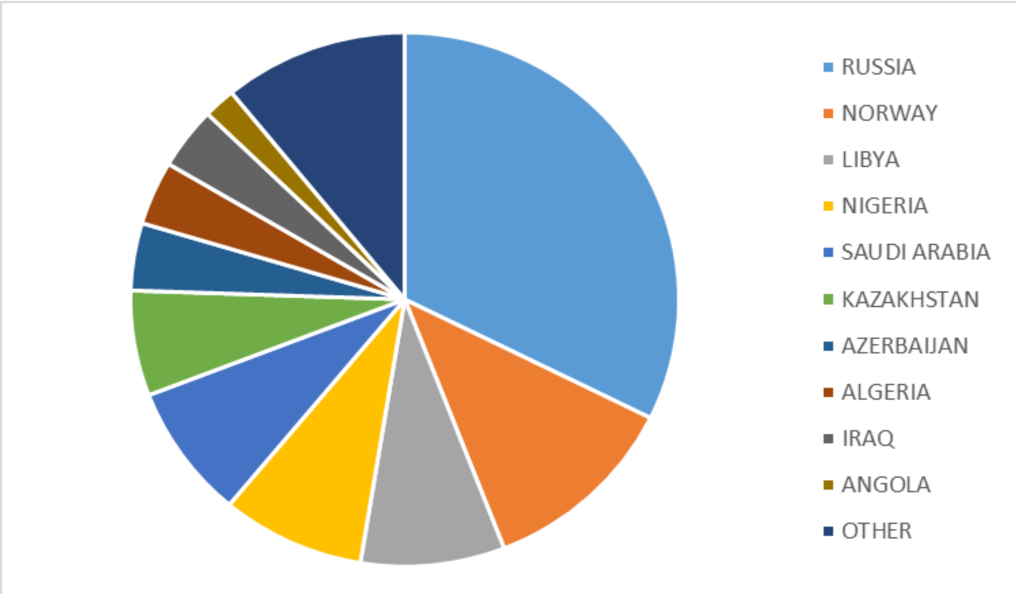


Figure 2 shows the volatility of oil prices over recent decades. After a period of relatively stable oil prices in the late 1980's and 1990's, the oil price rose sharply in the 2000's, peaking in 2008 before the global economic downturn. The price spike in 2008 caused considerable price inflation across the major energy consuming economies because of its impact on the cost of mobility in these economies, which cannot be easily substituted in the short term. In the latter half of 2014 and early 2015, oil prices plummeted to below $50/barrel. This sudden fall in the oil price reflected expectations of reductions in demand, due to the drive towards decarbonising the global economy, and increases in supply, partly as a result of the shale gas and oil boom in the US. The decrease also reflected a decision by OPEC to refrain from withholding supply, which it would normally have done in the past to shore up prices.

Figure 2: Crude Oil Price (Brent spot price)

3. Impact on transport energy demand

This short report builds on analysis presented in the report *Fuelling Europe's Future*. Data on the potential for improving the fuel efficiency of Internal Combustion Engine (ICE) is taken from car industry submissions to the European Commission for its impact assessment on the 2021 efficiency standard of 95g CO2/km. This data was submitted in 2011 to the European Commission by the car manufacturers' association ACEA and the automotive parts suppliers group CLEPA. This data only covers improvements to the Internal Combustion Engine, including hybridization, and therefore further data was sourced on the potential of alternative powertrain vehicles. The starting point for analyzing the cost of advanced technologies, such as fuel-cells and batteries, was research for the UK government's Committee on Climate Change. The overall dataset was also supplemented with data from research conducted for the US Environmental Protection Agency (EPA).

These data were reviewed by automotive experts at Ricardo-AEA and the International Council on Clean Transportation (ICCT), both of which have a substantial track record in automotive analysis. The data were also reviewed by members of the "Fuelling Europe's Future" Working Group with direct experience in the automotive industry.

The assumptions about efficiency improvement for the heavy-duty vehicle stock are based from the 'Cost Effective' and 'Challenging' scenarios from AEA's analysis for the European Commission: 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles'[1].

Deployment Scenarios

Three scenarios are compared to a reference scenario. The details of the scenarios are as follows:

- **REF**; this is the reference case scenario against which the other scenarios are compared in order to establish their potential marginal economic impacts. The scenario assumes that the CO_2 efficiency of new vehicles sold in Europe remains at recent levels; that the current diesel/gasoline split remains unchanged; and that no further technology is introduced to improve efficiency. Some small efficiency improvements do occur in this scenario due to fleet turnover as older vehicles are replaced by newer vehicles. Vehicle costs increase in the near term, due to the application of measures to further reduce air pollutant emissions. There are assumed to be some small efficiency improvements for heavy-duty vehicles due to the introduction of the Euro VI standards, however, there is also an increase in the heavy-duty vehicle stock and activity over the period to 2030, which leads to a net 15% increase in fuel consumption from heavy-duty vehicles by 2030.[2] This simple reference scenario has

[1] AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.

[2] Our assumptions on the efficiency of HDVs are based on the BAU scenario from AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.

been chosen as it provides a clean baseline against which to compare the other scenarios.

- **CPI**; this scenario follows current policy and as such the CO_2 standard for cars of 95 g/km in 2020[3] and a target for vans of 147 g/km in 2020 are met. It assumes that no further policy targets are set after 2020 but there will be some further progress in reducing fuel consumption beyond 2020. This progress is driven by consumer concern about CO_2 emissions, fuel price pressure and a continuation of the existing momentum in technology development. It is assumed that these factors will lead to a rate of improvement of less than 1% per annum after 2020. In the Current Policy Initiatives scenario, Hybrid Electric Vehicle (HEV) deployment in the new car fleet reaches 5% in 2020 and 12% in 2030. In this scenario, direct CO_2 emissions from cars are 95 g/km in 2020 and 85 g/km in 2030. The assumptions about the heavy-duty vehicle stock are identical to those used for the REF scenario.

- **TECH 1**; the characteristics of the light-duty vehicle stock in this scenario has been adapted and further developed from one of the scenarios used in the European Commission project "EU Transport GHG: Routes to 2050", which explores various pathways to achieve the Transport White Paper goal of reducing overall transport emissions by 60% in 2050. The scenario seeks to explore the impact of ambitious HEV deployment, while taking account of practical limitations. It assumes market penetration of HEVs of 10% of new vehicle sales in 2020 and 50% penetration in 2030. In this scenario, reductions in CO_2 are initially driven by, but not limited to, the 2020 CO_2 targets for cars and vans. The direct CO_2 emissions of cars are 90 g/km in 2020 and 60 g/km in 2030.

  In this scenario, there are also greater efficiency improvements for heavy-duty vehicles than in REF and CPI. The assumptions about efficiency improvement for the heavy-duty vehicle stock are based from the 'Cost Effective' scenario from AEA's analysis for the European Commission: 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles'[4]. By 2030, demand for diesel from heavy-duty vehicles is assumed to be 6% lower than in the REF and CPI scenarios, due to an increase in energy-efficient technologies installed in trucks and an increase in hybridisation. By 2030, 18% of buses, 10% of urban delivery vehicles and 5% of utility and regional delivery trucks are assumed to use hybrid powertrains. A further 1% of new buses and service delivery HDVs are assumed to be electric. There is also a higher deployment of other fuel-efficient technologies in HDVs, including stop-start and aerodynamic improvement.

- **TECH 2**; this scenario has also been adapted and further developed from one of the scenarios used in the European Commission project "EU Transport GHG: Routes to 2050". The original scenario was based on

[3] The scenarios for Fuelling Europe's Future were developed before the agreement on CO_2 standards to meet 95g/km in 2021 rather than the proposed 2020.

[4] AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.

sensitivity analyses to explore how quickly advanced powertrain vehicles must be deployed to achieve necessary reductions in CO_2 without the long-term use of biofuels at significantly greater levels than expected in 2020 (i.e. ~10 per cent substitution for conventional fossil fuels). For example, it is now more commonly accepted that available bioenergy for transport would be most effectively utilised in long-distance heavy-duty vehicles and aviation. This scenario assumes market penetration of HEVs of 20% of new car and van sales in 2020 and 42% penetration in 2030. Advanced electric vehicles (EVs) are deployed at 2.5% of new sales in 2020 and 37% in 2030. Figure 3 shows the share of advanced electric vehicles in new vehicle sales that is assumed for this scenario. The direct CO_2 emissions of cars are 88g/km in 2020 and 41 g/km in 2030.

Fuel consumption by HDVs in the Tech 2 scenario is based on the 'Challenging' scenario from AEA's analysis on GHG emissions from HDVs for the European Commission[5]. By 2030, 15% of new buses and delivery trucks are assumed to be fully electric, 25-40% are hybrids and 10-15% are use dual fuel powertrains (gas CNG and diesel). This transition towards advanced powertrains, together with further vehicle technology improvements, leads to a 15% reduction in HDV emissions relative to the REF and CPI scenarios in 2030.

Figure 3: New car fleet share: Tech 2

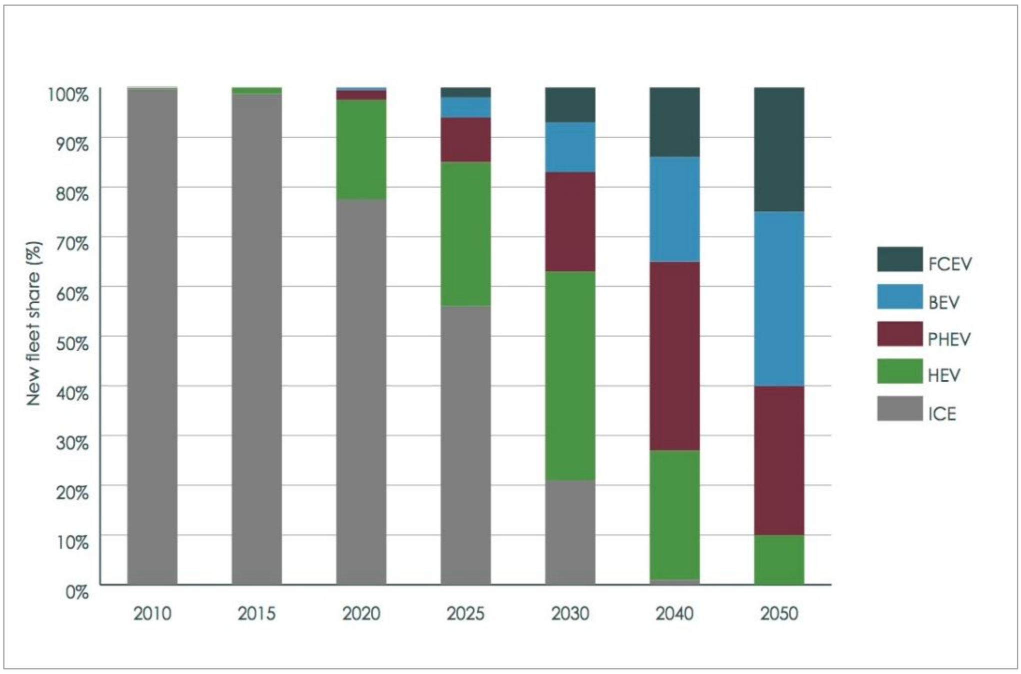


Figure 4 and Figure 5 shows the reduction in demand for petrol and diesel as a result of the improvements in light-duty and heavy-duty vehicles, respectively, in the various scenarios.

[5] AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.

Figure 4: Demand for petrol and diesel from LDVs (mtoe)

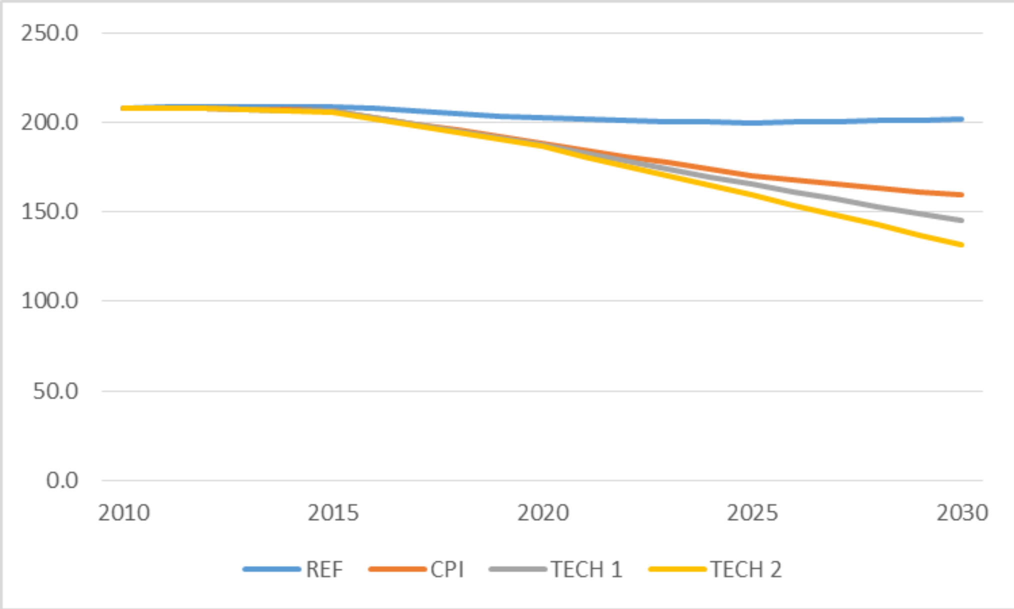
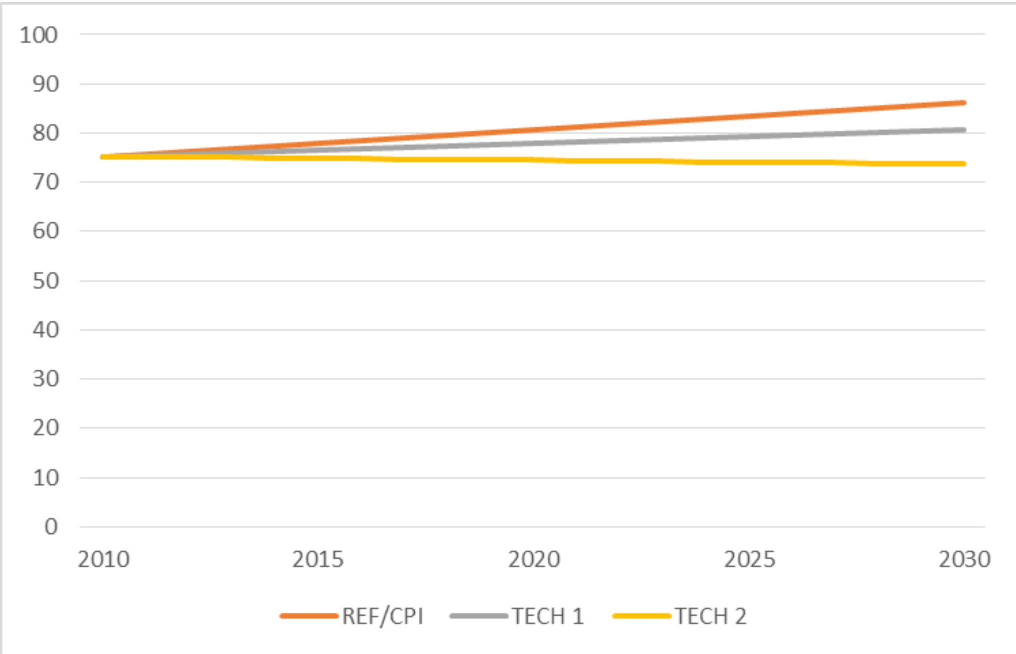


Figure 5: Demand for petrol and diesel from HDVs (mtoe)



It is clear from the figures above that whilst there are assumed to be substantial potential efficiency improvements for the LDV stock, opportunities to decarbonise HDVs are currently assumed to be more limited. Growth of the HDV stock is expected to lead to an increase in total emissions from HDVs over the period to 2030 in the REF, CPI and Tech 1 scenarios, however there is potential for efficiency improvements in new HDVs to curtail this increase in HDV emissions. Almost all HDVs on the road are diesel fuelled, and therefore make a substantial contribution to local air pollution and particulates, which can lead to adverse health impacts. Furthermore energy-efficiency measures that lead to fuel-bill savings for owners of HDVs, in many cases, will be passed on to final consumers by means of lower delivery charges and lower costs of final goods. This might imply the need for further research on the potential for reducing the use of petroleum fuels by HDVs.

The average motorist's fuel bill is significantly reduced in both the CPI Scenario and the Tech 1 and Tech 2 scenarios, when compared to the REF scenario. This is particularly the case for cars and vans, where EU-wide consumer expenditure on fuel (incl. tax) is reduced by €104bn (35%) by 2030 in the Tech 2 scenario, relative to in REF. As alluded to in the previous paragraph, the limited potential for efficiency measures in HDVs means that fuel savings for HDVs is somewhat lower, with a saving of around €18.5bn.

As an illustration of reduced spending on fuel, in the CPI scenario the owner of the average car in 2030 would save around €283 each year when compared to the REF scenario, which also factors in some efficiency improvement due to fleet renewal. This is an average across the vehicle fleet, and drivers of new cars in 2030 will be saving significantly more.

For Tech 1 and Tech 2 the average annual fuel bill saving against REF for the average car in the stock is €388 and €420 by 2030, respectively. This estimate is based on using constant fuel prices and an assumption of around 12,000 km driven annually, which is the current EU average. In reality, new cars are driven longer distances than older cars, so the annual savings will likely be higher initially.

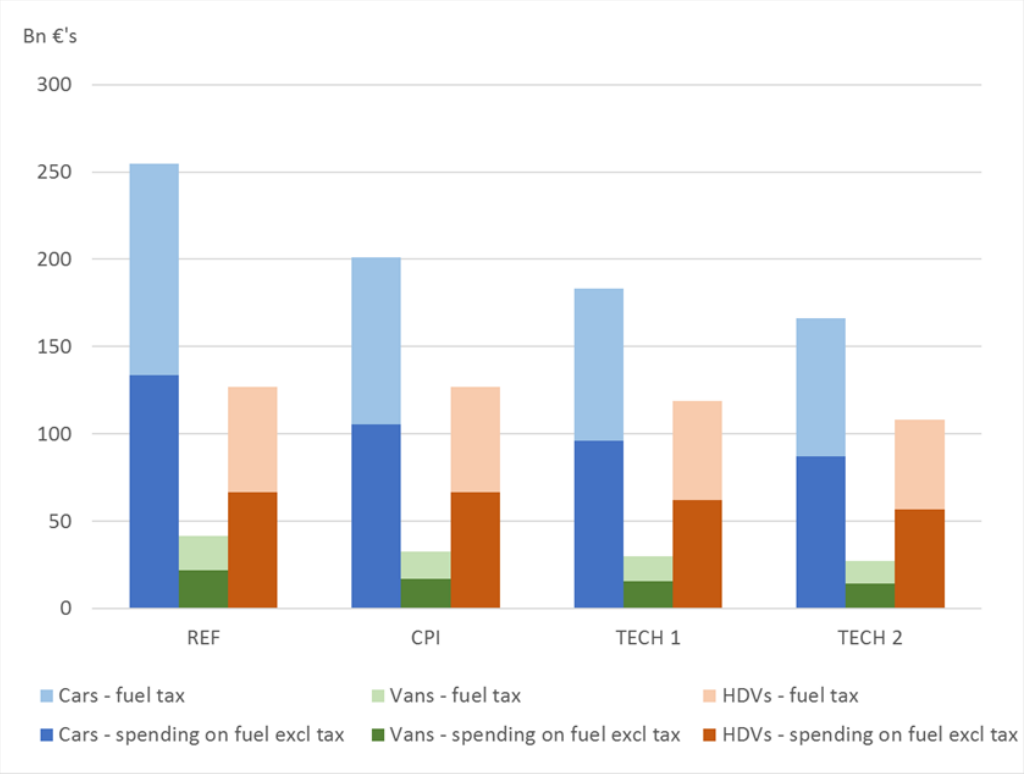
To estimate potential fuel savings for HDVs, we used projections for total EU HDV diesel consumption under different HDV efficiency scenarios from AEA's analysis for the European Commission[6]. This was then shared out between EU member states based on historical data for road transport fuel consumption by country.

Examining the impact at a societal level requires excluding fuel taxes, duties and VAT. A step-change in fuel costs is observed after 2015 under the Current Policy Initiatives scenario, as the vehicle fleet switches from an annual rate of improvement of around 2 per cent a year to a rate of around 4 per cent annual improvement to reach the EU's 2020 efficiency goals. At the EU level, the total annual fuel bill for LDVs is reduced by €33bn in 2030 under the CPI scenario (excluding taxes and duties) versus the REF scenario. Corresponding fuel savings in the Tech 1 and Tech 2 scenarios reach around €45-€55 billion in 2030.

Figure 6 shows total spending on fuel and fuel tax in the EU under each scenario.

[6] AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.

Figure 6 Total EU spending on fuel in 2030 in each scenario



4. Resilience to oil price spikes

The economic analysis to test Europe's resilience to oil price spikes was undertaken using E3ME[7], a macro-econometric model of the economy, the environment and the energy system. This is the same model that was used to assess the macroeconomic implications of the transition to low carbon light duty vehicles in the *Fuelling Europe's Future* and *Fuelling Britain's Future* reports.

For the economic modelling, oil prices were updated using 2014 data, and oil price growth projections from the IEA 'Current Policies' scenario[8] were used to project oil prices in the period up to 2030. In each of the four scenarios, two sensitivities were tested:

- A one-off 50% increase (shock) to the oil price in 2030, to quantify the extent to which decarbonising light duty vehicles reduces the effects of the price increase on consumer bills and the economy more generally.
- A sustained low oil price projection, in which oil price growth was lowered to test the economic outcomes with lower oil prices in the future.

The table below shows the oil price assumption in each sensitivity tested.

Table 1 Nominal oil price assumptions for each sensitivity ($/barrel)

	2010	2020	2030
Central oil price assumption	78	118	179
Low oil price sensitivity	78	108	141
Oil price shock (2030)	78	118	260

Source: central oil price assumptions are based on the latest oil price data projected forwards using the latest oil price forecast from IEA's World Energy Outlook 2014

Under the IEA 'Central Polices' oil price, total annual expenditure on petrol and diesel in the EU in 2030 (incl. tax) is €423bn in the REF scenario and a 50% oil price shock increases the annual cost by €131bn to €554bn (a 30% increase). The 50% oil price shock only leads to a 30% increase in the cost of fuel to the consumer in the REF scenario because fuel duty accounts for around half the cost of vehicle fuel and this does not increase with the oil price shock (although VAT does).[9]

The effect of the oil price shock on consumer bills is reduced incrementally in each scenario relative to the reduction in oil consumption. In the Tech 2 scenario, which sees the largest reduction in oil consumption by the light-duty and heavy-duty vehicle stock relative to the REF scenario, the oil price shock only increases total annual fuel costs by €93bn, from €302bn to €395bn. It is

[7] For more details see www.e3me.com

[8] IEA (2014), 'World Energy Outlook'

[9] An oil price shock is likely to lead to a reduction in demand for oil from cars and vans, but this demand response was not modelled. The results from the oil price shock sensitivities are therefore reflective of the upper limit of the impact of a price shock on fuel bills.

worth noting, however, that these figures represent total expenditure for the entire stock of LDVs and HDVs. Purchasers of more energy-efficient vehicles would have more protection against fossil fuel price volatility.

Of course, oil prices could fall and then drivers of the least efficient vehicles would gain most (relatively). However, it is clear that in general consumers can reduce their exposure to oil price volatility by purchasing more efficient cars and vans.

Figure 7 and Figure 8 show the effect of a 50% oil price shock and a sustained low oil price on fuel bills for LDVs and HDVs, respectively. The diamond shows fuel bills in each scenario based on IEA's 'Current Policies' oil price assumptions, while the arrows show how fuel bills could be affected by a sustained low oil price or a 50% oil price shock in 2030 (at the upper bound). For cars and vans, in particular, there is a noticeable reduction in consumer exposure to oil price volatility, as we move to increasingly more ambitious vehicle efficiency scenarios.

Figure 7 Total EU spending on fuel by LDVs (incl tax) in 2030 in each scenario and under different oil price sensitivities (€bn)

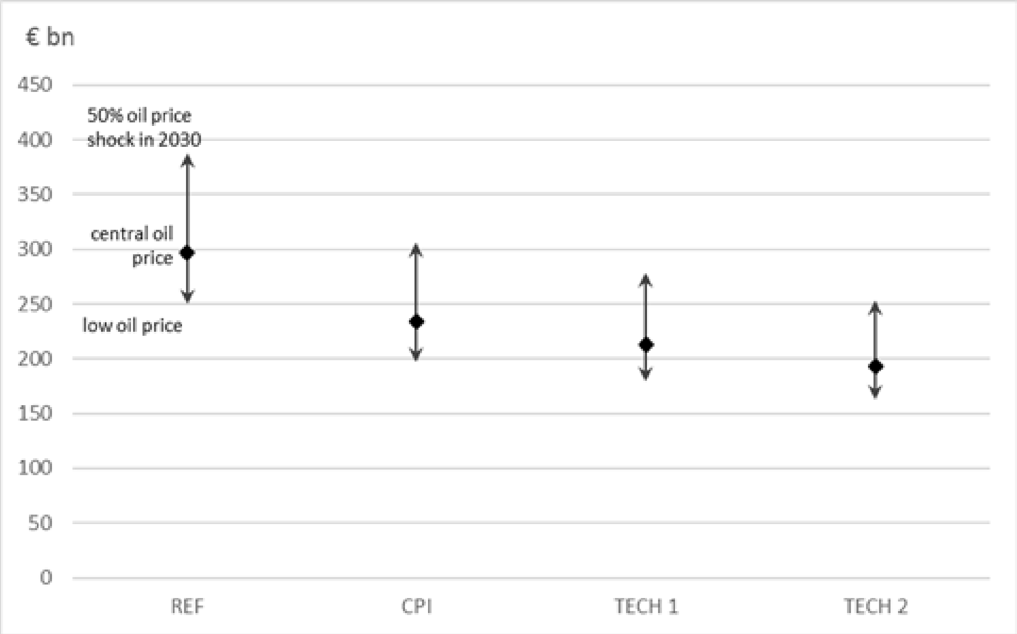
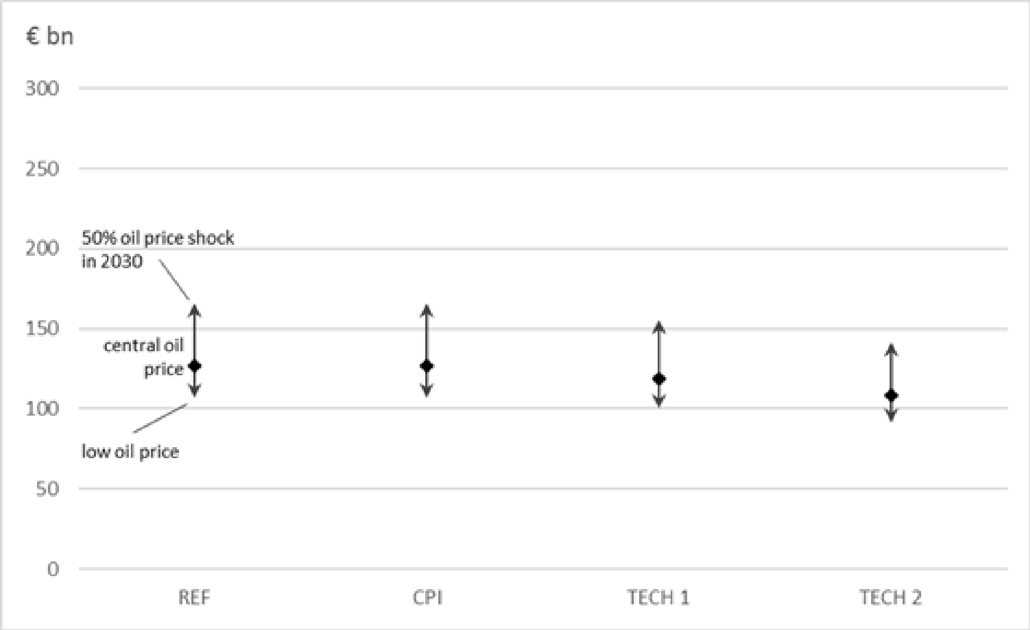


Figure 8 Total EU spending by HDVs on fuel (incl tax) in 2030 in each scenario and under different oil price sensitivities (€bn)



The effect that light duty vehicle efficiency has on macroeconomic resilience to the oil price shock is more limited. The more that vehicle owners are protected from spikes in fossil fuel prices, the more they are able to spend on other goods and services in real terms. However, oil is used throughout the economy in industrial processes, aviation, shipping and domestic heating. The scenarios assume the same use of oil in these sectors and so the effects of an oil price shock on the economy remains reasonably similar across the scenarios.

In 2030, the oil price shock in the REF scenario reduces GDP by 0.46% (€76bn). As a result of the increased fuel efficiency and reduced exposure of consumers to oil in the CPI, Tech 1 and Tech 2 scenarios, the impact on GDP is reduced to 0.41% (€68bn), 0.38% (€64bn) and 0.36% (€59bn) respectively. EU economic resilience to oil price volatility would be further improved if steps were taken to improve the efficiency with which oil is used in industrial processes, aviation, shipping and domestic heating.

5. Concluding remarks

European imports of oil dwarf domestic supplies; 489m tonnes of crude were imported into the EU-28 in 2014 and only 92m tonnes were extracted domestically. Using 2014 oil prices, this equates to €271 bn of oil imports and €50 bn from domestic extraction. Although Europe's import supply is reasonably well diversified across countries, suggesting that supplies are reasonably secure, a large proportion (nearly one-third) was supplied by one single country (Russia) in 2014.

By improving the efficiency of cars, vans, trucks and buses, oil consumption in the EU can be reduced, leading to lower demand for imported crude oil and improving Europe's energy independence. Moreover, consumers' exposure to oil price shocks would be reduced, leaving them better-off in the event of oil price spikes, with small positive implications for the wider economy.

Recent literature[10][11][12] suggests that, although there is great potential to improve the fuel efficiency of light-duty vehicles, the potential to improve the fuel efficiency of heavy-duty vehicles is somewhat limited until 2030. More ambitious efforts to reduce fuel consumption by trucks and buses could lead to greater economic benefits and greater protection from fossil fuel price volatility as, in most cases, the fuel costs for heavy-duty vehicles are eventually passed onto consumers in some form.

[10] ICCT (2011), 'European Union Greenhouse Gas Reduction Potential for Heavy-Duty Vehicles'

[11] The National Academies (2010), 'Technologies and approaches to reducing the fuel consumption of medium- and heavy-duty vehicles'

[12] AEA (2011), 'Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy'.