

C A G E

Background Brief

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The Costs and Benefits of the Renewable Transport Fuel Obligation

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Summary

The Renewable Transport Fuel Obligation (RTFO) is a key policy in the UK aimed at reducing carbon emissions by mandating the blending of biofuels with fossil fuels. This briefing examines the policy's costs for petrol consumers, decomposes the impact of biofuel prices and the obligation rate, evaluates the benefits to carbon emissions, and calculates the implied cost of carbon.

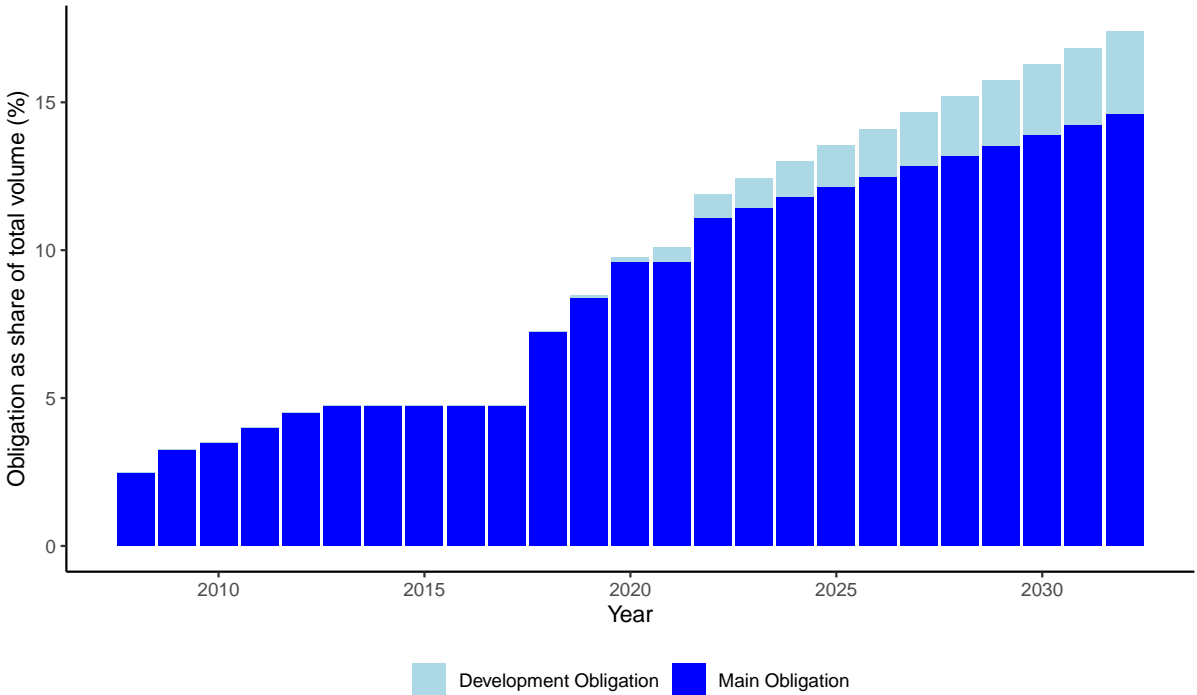
This work assumes that the biofuels used to meet the RTFO adhere to the relevant government rules and regulations on their composition and sourcing.

Over the past 5 years, the RTFO has, on average, added 3.5 pence per litre (ppl) to unleaded petrol prices and 6 ppl to diesel prices at the pump. Additionally, biofuel price volatility has contributed to greater price fluctuations at the pump. The implied cost of carbon varies significantly with biofuel prices, ranging from £228 per tonne in 2021 to negative levels when biofuel prices fell below fossil fuel prices. However, the benefits of reduced carbon emissions under the RTFO far outweigh the policy's cost to consumers, based on the UK government's current social cost of carbon emissions. Despite the overall benefit, policy adjustments to reduce the volatility of biofuel prices creating increasingly volatile consumer petrol prices should be considered.

1 What is the RTFO?

Domestic transport accounts for over one quarter of the UK’s greenhouse gas emissions (GHG). The Renewable Transport Fuel Obligation (RTFO) is a UK policy aimed at reducing GHGs that came into force in 2008, following its announcement 3 years earlier. Although aspects of its implementation can be complex, its core requirement is straightforward: transport fuel suppliers must meet the obligation that a certain proportion of the fuel they supply comes from renewable sources, namely biofuels.

As shown by Figure 1, the total obligation started at 2.5% of total fuel volume in 2008, and currently sits at 13.55%. It is expected to increase to 17.4% over the next 7 years. The bulk of this obligation comes from the Main Obligation while a small part comes from the Development Obligation (these are described below).



Source: Renewable Transport Fuel Obligations Order 2007 and subsequent amendments

Figure 1: RTFO obligations over time

Suppliers meet their main obligation by supplying fossil fuel (i.e. diesel or unleaded) blended with biofuels (i.e. biodiesel and ethanol) and claiming renewable transport fuel certificates (RTFCs) for each unit of supplied biofuel. They may also meet their obligations by buying certificates from other suppliers who have over-met their requirements or from “buying out” part of their obligation, however discussions with industry insiders suggests this latter option rarely occurs.

Not all biofuels are equal in terms of RTFCs. Ethanol and biodiesel are often made directly from food products, ethanol from grain, corn, and sugar crops and biodiesel from vegetable oils and animal

fats, which can have impacts on food prices. Those which are deemed more sustainable and have further GHG savings can be double counted, such as those deriving from waste (e.g. used cooking oil). These forms of biofuel often play a key role, as there are limits to the amount of ethanol that can be blended in unleaded and biodiesel in diesel, which the RTFO requirements have exceeded as they have been increased over time. These limits have stood at 10% for unleaded (E10) since 2011, however, in practice all forecourts continued to sell a blend including only up to 5% ethanol (E5) up until 2021, when E10 became the national standard. The limit for biodiesel in the diesel blend has been 7% for over 15 years. As a result, the RTFO should be understood as setting a share of fuel for which suppliers have to provide certificates, rather than defining the actual share of biofuel in any litre of blended fuel, which is capped by fuel specifications.

The Development Obligation was newly introduced in 2019 and designed to encourage use of advanced renewable fuels. In practice there is very little redemption of development-RTFCs and almost all supply utilises a buyout (this stood at 85% in 2022). Thus, the Development Obligation in practice functions as a tax, and its level is determined by the buyout price, which is currently equivalent to a 1.2 pence per litre (ppl) tax at the pump.

2 How much does it cost the consumer?

Figure 2 illustrates the additional cost added to wholesale fuel prices over the past 12 years due to the RTFO. It contrasts this with a hypothetical scenario where the RTFO was not implemented, and fuels available at the pump were composed entirely of fossil fuels¹.

¹The calculation assumes that the UK RTFO does not affect global commodity prices. This is a reasonable assumption given that the UK consumes approximately 1% of the global oil share, and represents less than 1% of the global population (see <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf>).

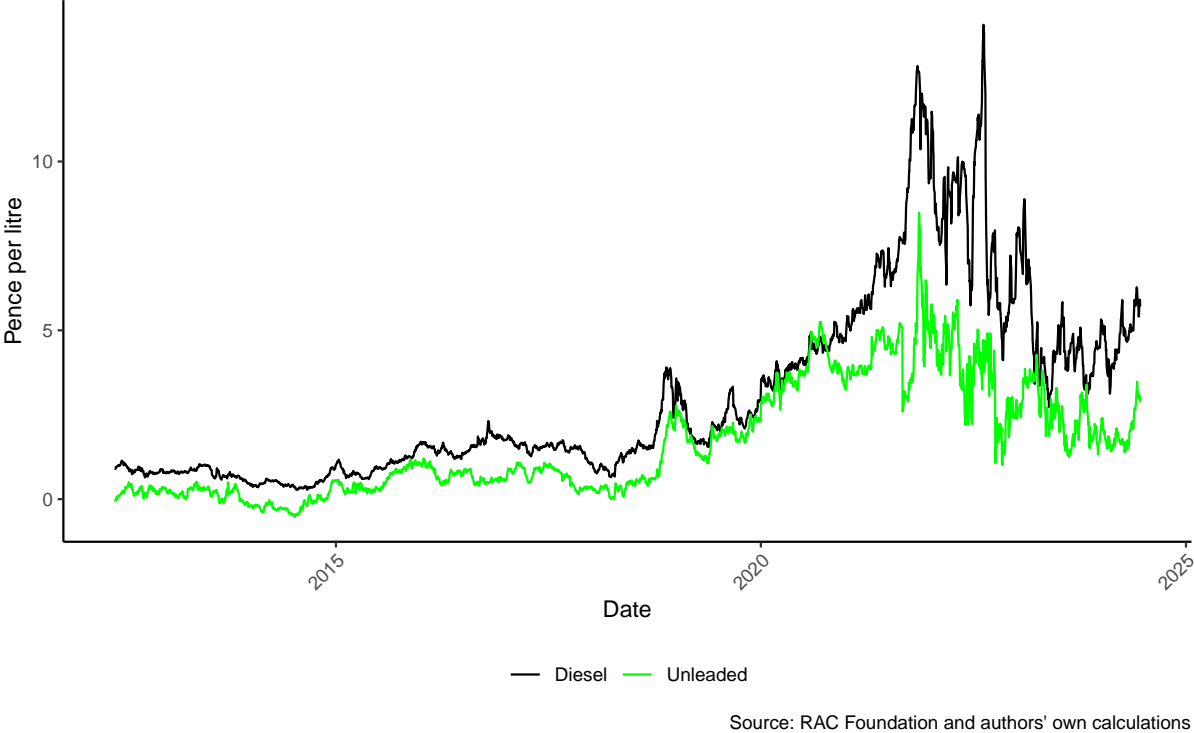


Figure 2: Additional cost per litre

The calculation considers multiple factors, including the costs of diesel, unleaded fuel, and biofuels, as well as the main and Development Obligations and the biofuel blending limits. It follows the standard wholesale pricing formula detailed in the appendix. The process is complex, accounting for maximum biofuel shares in composite fuel blends and the use of double-counted biodiesel certificates to offset the single-counted ethanol certificates required for composite unleaded².

The RTFO impact on the wholesale price for unleaded has ranged from negligible, to adding up to about 8 ppl, peaking in late 2021. The impact on diesel prices has been larger, with price increases ranging from about 1 ppl in prior to 2015, and peaking at adding on 14 ppl in mid 2022. Over the past 5 years, RTFO requirements have, on average, increased wholesale prices for unleaded by 3.5 pence, and for diesel by 6 pence. The figure is also suggestive that the RTFO has increased the volatility of wholesale prices.

As shown in Figure 3, pump prices closely track wholesale prices, albeit with some smoothing. Consequently, the impact on consumer prices is nearly 1:1, with much— but not all—of the additional volatility passed on to consumers. Further research of ours suggests that full pass-through from wholesale to pump prices takes about 60 days, with most of the change occurring early on. We also

²Industry insiders indicate that most blended biodiesel comes from used cooking oils (UCOME), which receive double certificates. While the standard wholesale pricing formula offsets missing unleaded fuel certificates with these excess biodiesel certificates, the diesel formula relies on the price of FAME biodiesel, which earns only single certificates. This discrepancy was highlighted in the Competition and Markets Authority’s recent report on the retail fuel sector.

find evidence of “rocket and feather” effects: 50% of wholesale price increases are passed through within two weeks, while equivalent price drops take three weeks on average. As a result, volatile price increases are amplified relative to price declines. This volatility can make budgeting and planning difficult for consumers, a challenge exacerbated during periods of high inflation, such as in 2022, when real earnings were eroded.

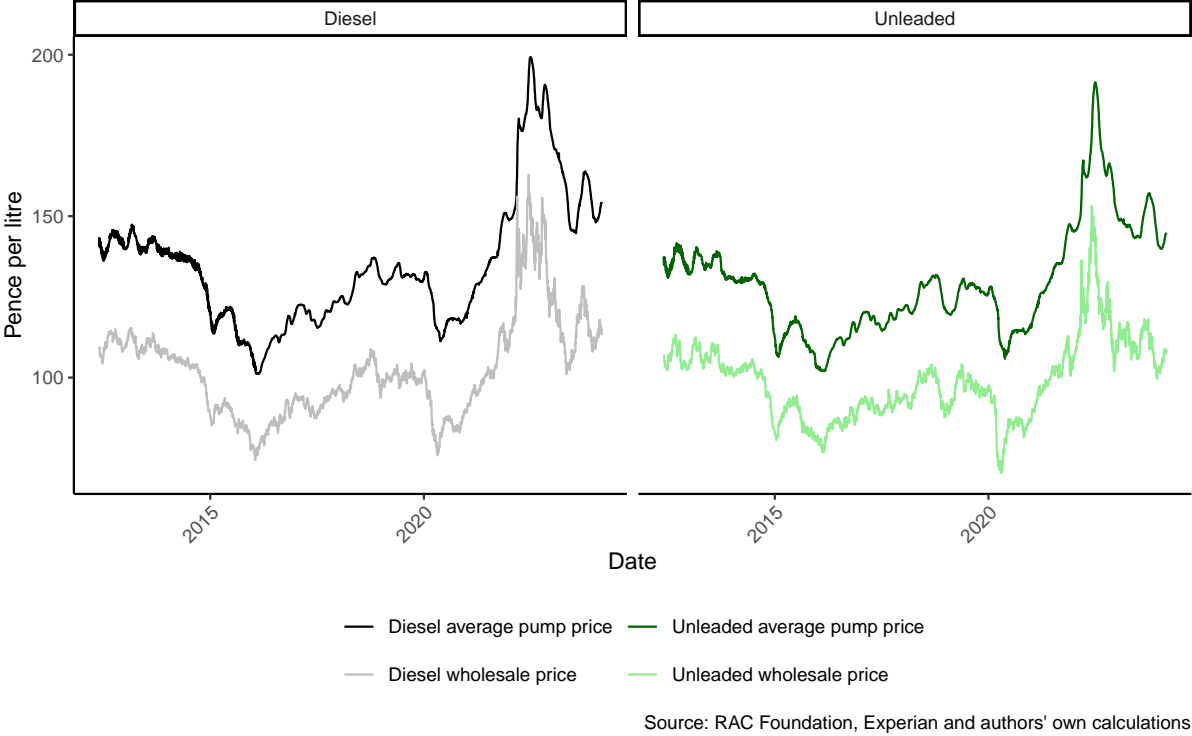


Figure 3: Wholesale prices for blended fuels and average prices at the pump

3 What drives the cost?

There are two main mechanisms which drive the cost of the RTFO to consumers: the level of the RTFO and the commodity prices of the biofuels which are being blended in. As seen by Figure 1, the RTFO has been increasing since its introduction in 2008, but has seen particularly larger and more rapid increases since 2018. For 5 years between April 2013 and April 2018 it stood completely unchanged.

Figure 4 shows the wholesale commodity prices for unblended fossil fuels (unleaded petrol and diesel) alongside the wholesale prices of the two main biofuels: ethanol and biodiesel. The figure highlights three key observations. First, fossil diesel and unleaded are very similar in levels and vary almost identically.

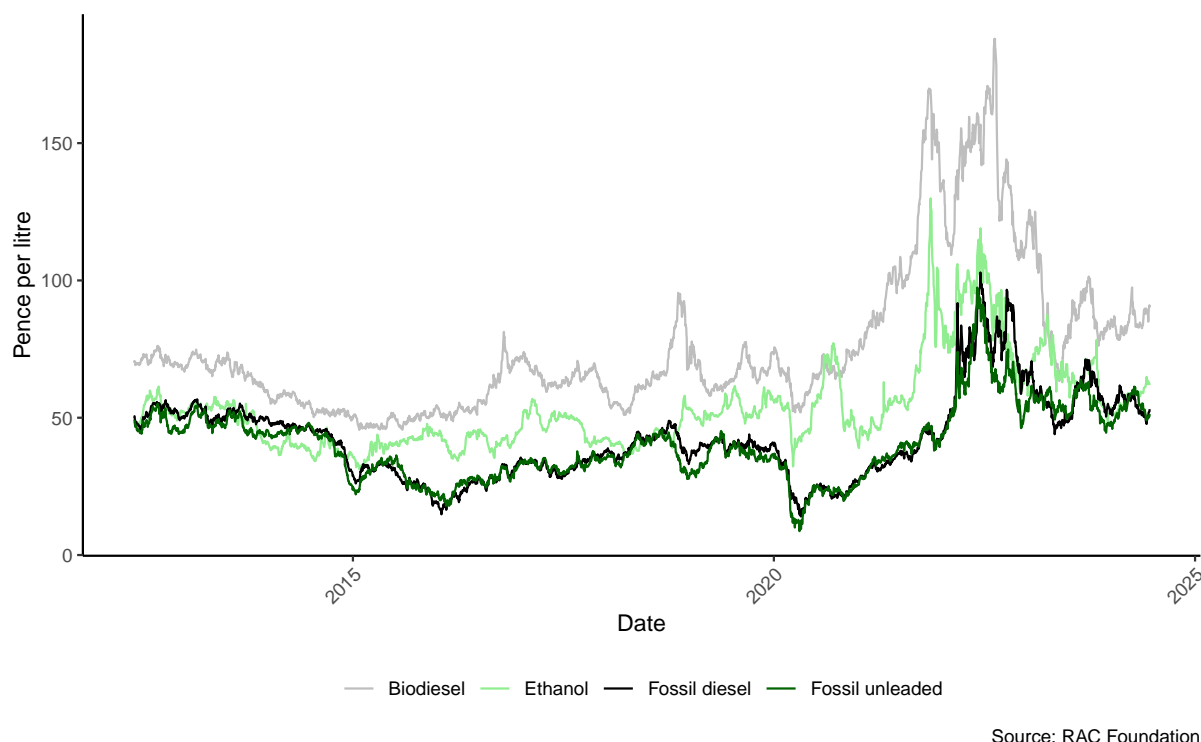


Figure 4: *Commodity prices over time*

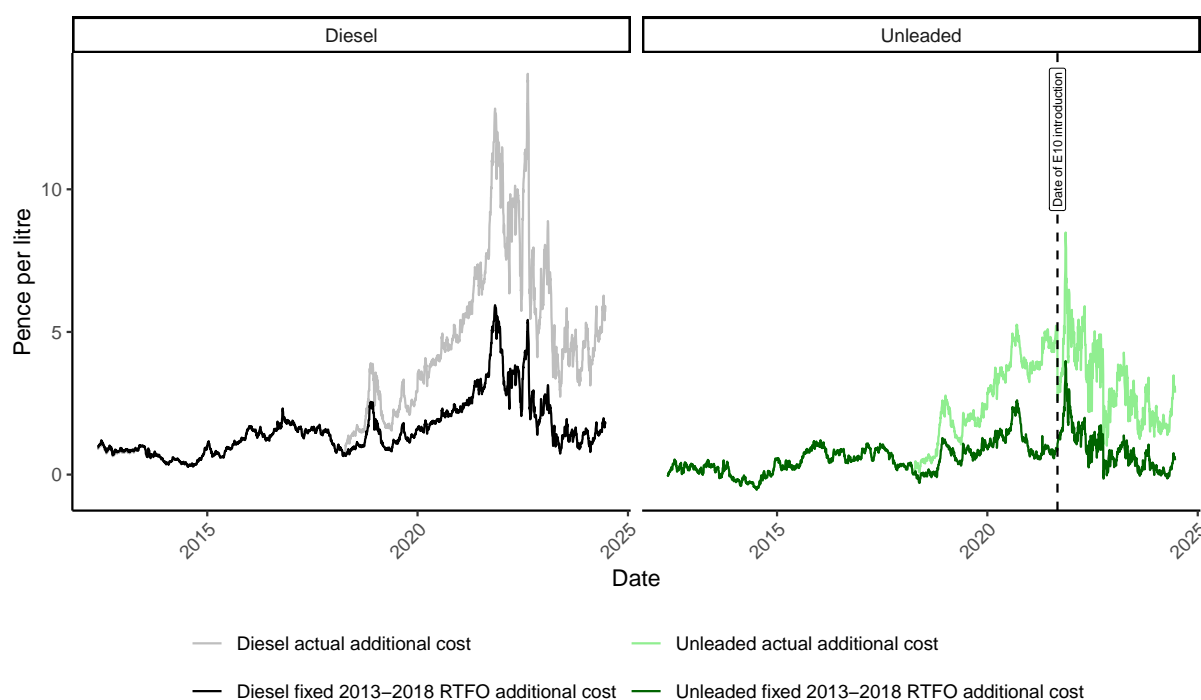
Second, ethanol was at a similar price to fossil unleaded (the product it is blended with) until 2015. Since then, the wholesale price for ethanol has been almost consistently higher, and by a considerable amount. In 2020 it reached 77 ppl, 3.5 times higher than its pure fossil counterpart, and in late 2021 it peaked at 130 ppl, while fossil unleaded stood at 46 ppl.

Third, and most striking, biodiesel is considerably more expensive per litre than all other products over the entire time period studied, and also more volatile. In 2012 it was around 20 ppl more expensive than fossil diesel, and this gap has generally increased over time, peaking in 2021 at 125 ppl, standing close to 4 times more expensive than fossil diesel. More generally, the figure suggests that diesel at the pump would be a far more similar price to unleaded in the absence of the RTFO.

The RTFO requirements currently exceed the 10% ethanol blend limit. To manage this, suppliers often compensate by over blending biodiesel beyond the RTFO's obligations. The most commonly used biodiesel in UK diesel blends is produced from used cooking oil, which qualifies for double counting under the RTFO. Suppliers use the surplus certificates generated from these biodiesel blends to fulfil their certificate obligations for unleaded petrol. Consequently, the high commodity price of biodiesel indirectly also impacts unleaded petrol prices at the pump.

Figure 5 and Figure 6 demonstrate the respective contributions of RTFO changes and biofuel price changes to the overall impact on consumer prices. Figure 5 shows both the actual impact on prices

for unleaded and diesel, as shown on Figure 2, as well as what the impact on prices would have been had the RTFO main obligation stayed at the rate for which it was stable between April 2013 and April 2018 (4.75% of total volume). Both lines show prices relative to a world in which the RTFO had never been introduced. The difference between the two lines tells us about the contribution of the increases in the RTFO rate and introduction of the Development Obligation. As the figure shows, under lower RTFO requirements prices for both unleaded and diesel would have been lower. However, they still would have been higher than in a pure-fossil scenario without the RTFO, peaking at 4 ppl more for unleaded and 6 ppl more for diesel.



Source: RAC Foundation and authors' own calculations

Figure 5: Additional cost per litre with RTFO fixed at the 2013-2018 level

Figure 6 compares the actual impact of the RTFO on prices to a hypothetical scenario where biofuel prices tracked the same trajectory as fossil fuel prices. The gap between the two lines highlights the extent to which biofuel price changes have influenced final prices for blended fuels. The figure reveals that, had biofuel prices developed the same as fossil prices, the increase in final prices for blended unleaded petrol and diesel would have been significantly lower. This is most pronounced in late 2021 where the gaps between the lines are 7.8 and 10.5 ppl for unleaded and diesel respectively. It is worth noting, however, that since biofuel prices, especially the price of biodiesel, have decreased, this effect is much less pronounced recently. The figure also demonstrates how the rollout of E10 (a 10% maximum limit of ethanol at the pump, rather than the previous 5%) did temporarily ease the impact of the RTFO on the price for blended unleaded. With E10, more ethanol could be used in the

wholesale calculation to fulfill the requirements in certificates, rather than using excess certificates obtained from overblending biodiesel in diesel.

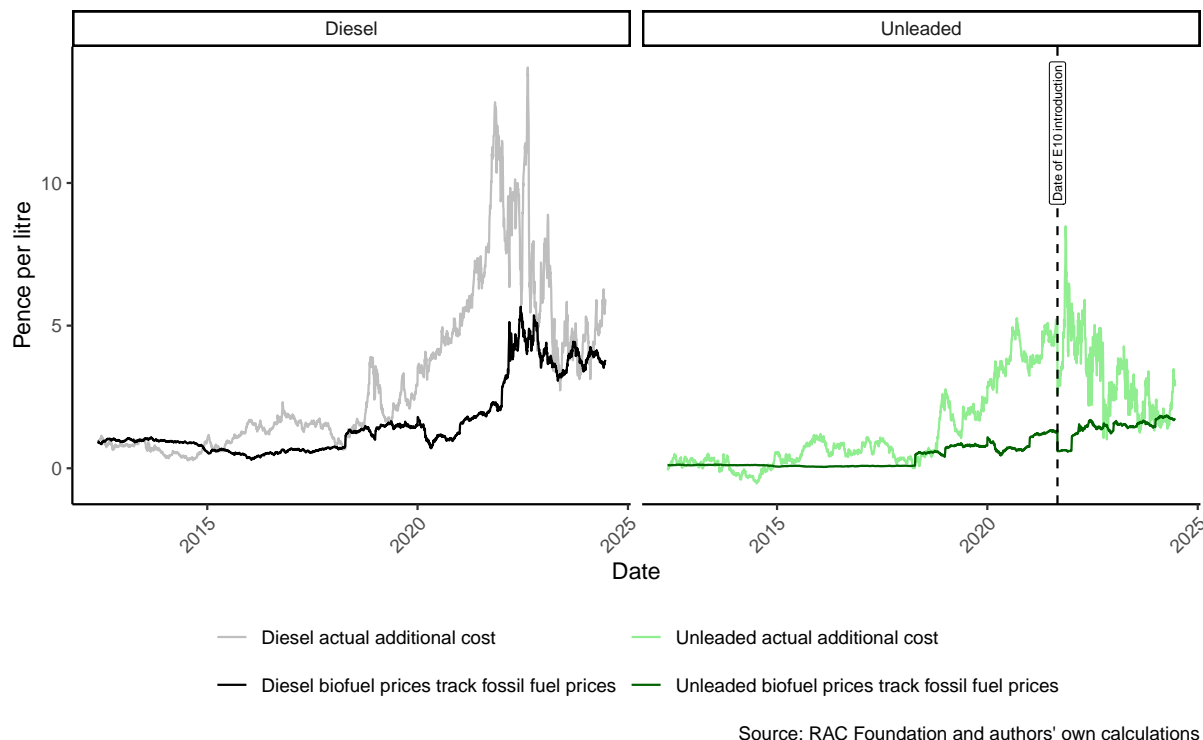


Figure 6: *Additional cost per litre with biofuels tracking fossil fuels*

The evidence from Figure 5 and Figure 6 point to the combined role of both the level of the RTFO and the cost of biofuels in increasing prices for blended fuels. The interaction of these two mechanisms have the potential to have the largest impacts to consumers. Commodity prices for biofuels are complex and driven by global supply and demand, and as such out of the control of domestic policymakers. Global demand factors include regulations on biofuel mandates in other countries, which has the added complexity of reducing demand for fossil fuels, decreasing their price, and thus exacerbating the gap between pure fossil and blended fuel. Global supply factors include major geopolitical events such as the Russian invasion of Ukraine³ and the interconnectedness of food and biofuel markets⁴.

Lastly, there is the impact of the method of pricing in the wholesale market. The current industry-standard wholesale pricing equation assumes that blends are utilising single certificate biofuels. Statistics from 2023 suggest that 84% of issued RTFCs were double-counted RTFCs⁵, and given the current limits (E10 and B7) it would be impossible to meet the requirements using single counted

³<https://www.sciencedirect.com/science/article/pii/S2405844023086917#:~:text=3.6.,exported%20by%20Ukraine%20%5B45%5D.&text=1.,-Maize&text=2.&text=3.>

⁴<https://www.sciencedirect.com/science/article/pii/S240585132400059X>

⁵<https://www.gov.uk/government/statistics/renewable-fuel-statistics-2023-final-report/renewable-fuel-statistics-2023-final-report>

certificates without using buyouts. The Competition and Markets Authority estimate⁶ that using the proportions and price of single certificated counted biofuel in the wholesale pricing equation, and not the price of the double-counted biofuel at half the relative share that's actually used, has increased diesel prices by approximately 3.5 ppl, and unleaded by 0.5 ppl over 2021 and 2022.

4 What is the implied cost of carbon?

The RTFO appears to be highly successful in achieving its specific aim of reducing carbon emissions from the road transport sector. Using the estimates on the impact on prices, publicly available statistics on fuel consumption and emissions from road transport and carbon savings of the policy from the Department for Transport⁷ we can determine an implied cost for the greenhouse gas emissions saved by the policy.

Figure 7 presents this implied cost per tonne of CO₂ saved due to the RTFO regulations over time (in 2024 prices). Probably the most striking result from the figure is how the RTFO results in a highly volatile cost of carbon saving, peaking at £228 per tonne in 2021, and seeing huge swings within relatively short time frames. For example, in 2018 the cost of saving a tonne of carbon dioxide ranged from £13 in March to over 10 times that amount just 9 months later. A comparison between Figure 7 and Figure 4 demonstrates that this cost is largely determined by biofuel prices. As already discussed, these are subject to fluctuations from global demand and supply pressures, which can be transmitted from interconnected food markets.

5 Are the costs outweighed by the benefits?

The estimated cost of overall damage to society for emitting an additional tonne of CO₂ (“carbon values”) in the UK currently stands at £312 per tonne⁸. Estimates of carbon values are produced using models which account for how carbon emissions affect a wide range of factors including human health, agricultural production and property values. This number suggests that the societal benefits of reduced carbon emissions under the policy have significantly outweighed the costs of the RTFO to consumers over time. Figure 8⁹ presents the ratio of the benefits relative to the costs from the policy, based on the £312 carbon value. It suggests that for every £1 cost to consumers, the policy has saved between £1.37 to nearly £25 of carbon damage over time. The average over the time period is 5.7,

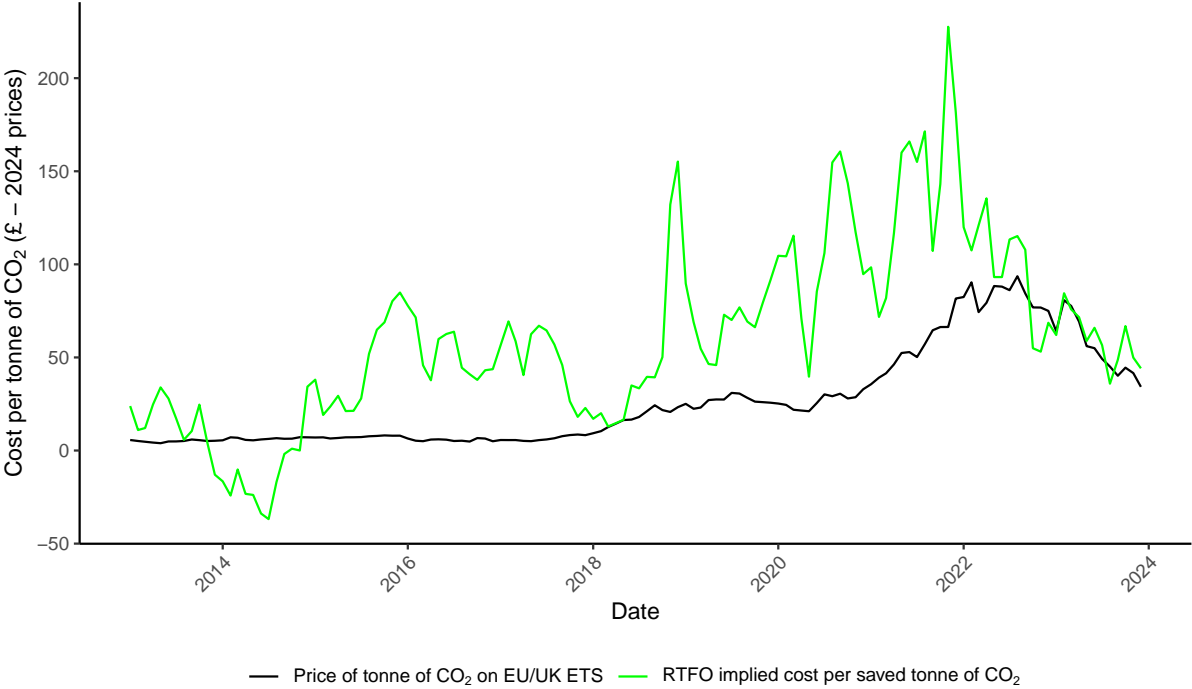
⁶https://assets.publishing.service.gov.uk/media/64a280e845b6a200123d46e7/Supply_of_road_fuel_in_the_United_Kingdom_market_study_Final_Report.pdf

⁷<https://www.gov.uk/government/statistics/renewable-fuel-statistics-2023-final-report/renewable-fuel-statistics-2023-final-report>

⁸<https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation>

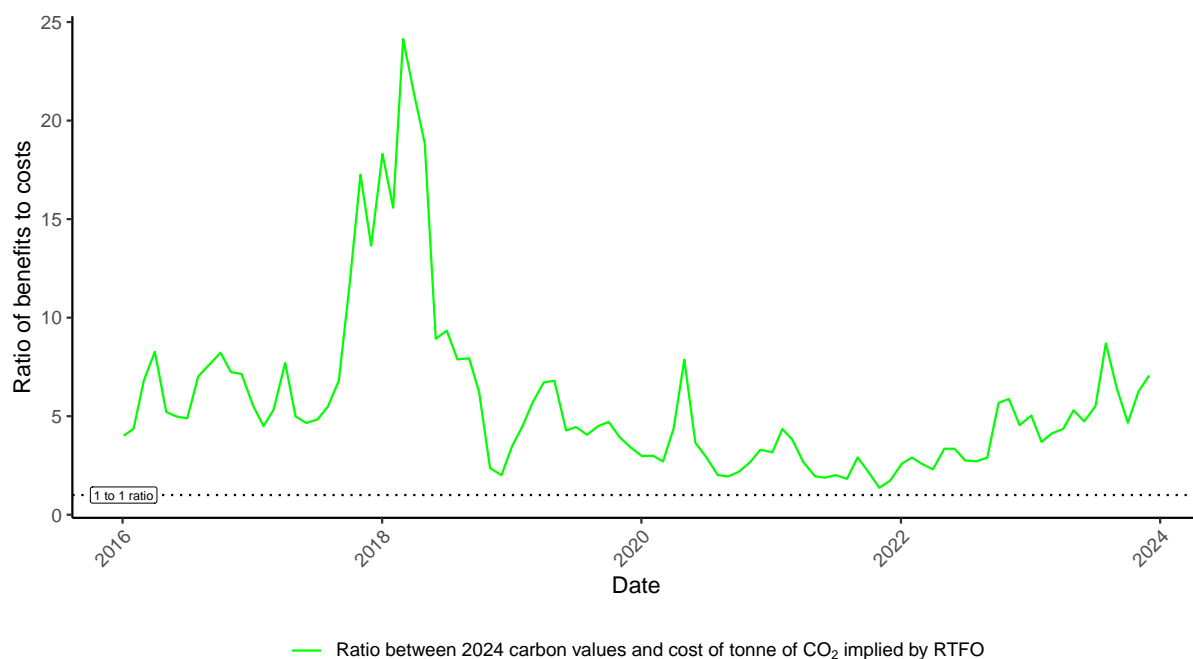
⁹Figure 8 starts in 2016, approximately 3 years later than the other figures. This is because the implied cost of carbon is negative at certain points prior to this (as the price of ethanol dipped below that of fossil unleaded, as seen in Figure 4), which in turn would make the benefit-to-cost ratio undefined.

implying that every £1 cost to consumers saved £5.70 worth of carbon damage. One important factor to note which determines this benefit-cost ratio is the carbon value. A higher carbon value increases the implied benefits of reducing carbon emissions. While recent appraisals put the number at £312 per tonne, the 2018 appraisal would have put it considerably lower at £51.81, which at the average over the time period, would suggest the costs outweigh the benefits by approximately 5%.



Source: Renewable fuel statistics 2023: Final report, European Energy Exchange, ICE UK ETS auction, authors' own calculations

Figure 7: Cost of saving one tonne of CO₂ implied by RTFO regulation and price of a tonne of CO₂



Source: Renewable fuel statistics 2023: Final report, Department for Energy Security & Net Zero and the Department for Business, Energy & Industrial Strategy's central series for carbon values, authors' own calculations

Figure 8: Ratio of carbon values (as of 2024) to cost of saving one tonne of CO₂ implied by RTFO regulation

6 How does it compare to other policies?

The three main instruments used for pricing carbon dioxide emissions are fuel excise taxes, explicit carbon taxes and Emissions Trading Systems (ETS). The first two of these generally fix prices for a period (e.g. a year), while the latter is subject to market clearing prices at auction and so can also feature a degree of volatility. Costs of carbon in these markets are partly driven by the emissions supply cap. In Figure 7 we compare the RTFO-implied cost for saving a tonne of carbon dioxide to the price for a tonne of carbon imposed on industries subject to the UK Emissions Trading Systems¹⁰. This comparison shows that in recent years, as the caps on the ETS have reduced, and the cost of biofuels have reduced, the RTFO saves carbon emission at a similar price to the UK ETS. Up until 2022, however, the cost of saving a tonne of carbon imposed by the RTFO was almost always higher than the price for emitting a tonne of carbon for a firm subject to the ETS. These price differences suggest an economic inefficiency.

7 What isn't accounted for?

The estimated carbon savings for the RTFO only consider the difference in emissions between conventional fossil fuels and fuels blending bio- and fossil fuels and, thus, do not reflect the RTFO's total

¹⁰Energy-intensive industries, the power generation sector and the aviation sector are subject to the UK ETS. The figure shows auction prices for the EU ETS up until 1 January 2021, when the UK left the EU's ETS and created its own system.

reduction in emissions. In particular, as fuel prices increase, demand does go down¹¹. Calculations suggest that, over the last 5 years, decreases in fuel demand lead to an additional reduction in CO₂ emissions of more than 10% on top of the direct effect of blending lower-emission biofuels. However, this number does not take into account potential increases in emissions from alternative transport modes if people switch away from cars, *nor the costs of switching to alternative modes*. Furthermore, in recent years as electric vehicles have become more readily available with better public infrastructure, substitution patterns away from petrol operated personal cars will likely have become more sensitive. On the other hand, the study does not take into consideration efficiency losses from switching from pure fossil fuels, to using biofuel blends. The Department for Transport suggest a 1% loss of fuel economy from switching to E10 from E5¹². While these are important margins, they are beyond the scope of this analysis.

8 Acknowledgements

We are grateful for the support and expert industry knowledge from the RAC Foundation and James Hitchman at PetrolPrices.com.

9 Appendix

Define:

$RTFO_t$ = RTFO main obligation with respect to amount of unsustainable fuel

Dev_t = RTFO development obligation with respect to amount of unsustainable fuel

γ_t = maximum of biofuel allowed for blended fuel at time t

δ_t = maximum of biofuel allowed for blended diesel at time t

$\mu_t = \frac{RTFO_t}{1 + RTFO_t}$ = RTFO main obligation as share of total fuel at time t

τ_t = fuel duty at time t

b = buy-out price for development fuel certificate

t_0 = 2018-04-13: last day for which wholesale commodity prices are available before change in RTFO on 2018-04-15.

¹¹<https://www.aeaweb.org/articles?id=10.1257/pol.20140093>

¹²<https://www.gov.uk/guidance/e10-petrol-explained#:~:text=Using%20E10%20petrol%20can%20slightly,economy%20than%20using%20E10%20petrol.>

Construct actual wholesale prices:

Case 1: RTFO mandated share is below maximum biofuel share allowed

$$Price_{i,t} = (1 - \mu_t) \cdot PriceFossil_{i,t} + \mu_t \cdot PriceBio_{i,t} + \tau_t$$

Case 2: RTFO mandated share is higher than maximum biofuel share allowed. The formula used for unleaded reflects overblending of double-certifiable biodiesel in blended diesel. The obtained excess certificates are used to make up for the lack of certificates for blended unleaded when the mandated share of biofuel exceeds the maximum share allowed for ethanol in the unleaded blend. The formula used for diesel reflects the use of single-counted biodiesel in the pricing formula at a share exceeding the requirements by the RTFO instead of the double-counted biodiesel which is actually used in the blend.

$$\begin{aligned} PriceBlendUnleaded_t &= (1 - \gamma_t) \cdot PriceUnleaded_t + \gamma_t \cdot PriceEthanol_t \\ &+ \max((1 - \gamma_t) \cdot RTFO_t - \gamma_t, 0) \cdot (PriceBiodiesel_t - PriceDiesel_t) \\ &+ (1 - \gamma_t) \cdot Dev_t \cdot b + \tau_t \end{aligned}$$

$$\begin{aligned} PriceBlendDiesel_t &= (1 - (1 - \delta_t) \cdot RTFO_t) \cdot PriceDiesel_t \\ &+ (1 - \delta_t) \cdot RTFO_t \cdot PriceBiodiesel_t \\ &+ (1 - \delta_t) \cdot Dev_t \cdot b + \tau_t \end{aligned}$$

Fossil only scenario:

$$PriceFossilOnly_{i,t} = PriceFossil_{i,t} + \tau_t$$

Scenario with RTFO at 2013-2018 level:

$$PriceRTFOFixed_{i,t} = (1 - \mu_{t_0}) \cdot PriceFossil_{i,t} + \mu_{t_0} \cdot PriceBio_{i,t} + \tau_t$$

Scenario with biofuel prices indexed with fossil fuel prices at time of 2018 RTFO change:

Define:

$$\widehat{Ethanol}_t = Ethanol_{t_0} \cdot \frac{Unleaded_t}{Unleaded_{t_0}}$$

$$\widehat{Biodiesel}_t = Biodiesel_{t_0} \cdot \frac{Diesel_t}{Diesel_{t_0}}$$

Equations used for constructing counterfactual prices are those used for constructing actual wholesale prices. Instead of actual commodity prices for biofuels, their indexed counterparts are used.

Calculate implied cost of saving one tonne of carbon dioxide:

$PriceDiffMonthly_{i,m,y}$ = average of difference between actual wholesale prices of fuel i and counterfactual price in the fossil-only scenario in month m and year y . Indexed at 2024 price levels.

$$CostCO_{2,m,y} = \frac{\sum_i PriceDiffMonthly_{i,m,y} \cdot FuelAmount_{i,m,y}}{CO_2Savings_y/12}$$

Calculate change in carbon dioxide emissions implied by reduction in fuel demand:

Compute effect of RTFO on pump prices in percent

$$PumpPriceChange_{i,m,y} = \frac{PriceDiffMonthly_{i,m,y}}{PumpPriceAvg_{i,m,y} - PriceDiffMonthly_{i,m,y}}$$

Compute difference to counterfactual demand using a demand elasticity¹³ of -0.3:

$$\Delta Demand_{i,m,y} = -0.3 \cdot PumpPriceChange_{i,m,y} \cdot FuelAmount_{i,m,y}$$

Compute implied reduction in carbon dioxide emissions. Emissions per litre of fuel are calculated assuming fuels cannot exceed maximum share of biofuels allowed. If RTFO requirements exceed these limits it is implicitly assumed that the difference will be met by double-certifiable fuels:

Define:

$\phi_{i,t}$ = maximum of biofuel allowed for fuel blend i (either unleaded or diesel) at time t

$$\Delta CO_{2,i,m,y} = \Delta Demand_{i,m,y} \cdot ((1 - \min(\phi_{i,t}, \mu_t)) \cdot FossilEmissions_{i,t} + \min(\phi_{i,t}, \mu_t) \cdot BiofuelEmissions_{i,t})$$

¹³<https://www.aeaweb.org/articles?id=10.1257/pol.20140093>