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Friends of the Earth

Making the polluter pay for the transition to net zero

Should the fossil fuel industry fund the transition to zero carbon? In the UK they cause around £44 billion worth of damage each year.

Contents

Executive summary

The fact that greenhouses gases cause harm is not new. We see extreme weather events in the news virtually every day. Industry and policy makers have known that greenhouse gases cause harm for at least five decades.

The fossil fuels industry in its broadest sense i.e. those that extract, refine and sell fossil fuels have largely got away scot-free for this harm. In some cases they have even worked to undermine action to reduce greenhouse gases.

The social cost of carbon

This report calculates that the extraction and use of fossil fuels in the UK equates to at least £44 billion every year, based on the social cost of carbon (SCC) methodology that estimates the cost of the harm done by a tonne of fossil fuels.

Since 1990 the cost of harm caused is around £1.65 trillion: a vast cost borne by society at large, rather than by the polluter.

The SCC considers financial estimates of the harm being caused today. It also predicts the harm caused in the future by this long-lived and cumulative pollutant.

Recent estimates of the SCC range from £26 to £315 depending on

- whether they take account of possible tipping points in the climate system
- whether the impact on future generations is taken into account
- whether future economic impacts need to be considered.

For the above estimate of £44 billion we used an average SCC across recent studies of £120 per tonne: almost certainly conservative given the escalating risks of climate breakdown.

How much will it cost to transition to net zero?

This report also identifies an estimate of the additional public money that needs to be spent to deliver the UK's transition to net zero (i.e. the cost to government). We estimate the cost at around an additional £22 billion per year (see table below). Like any estimate for future spending this has significant uncertainties (e.g. in future costs of technology).

This figure excludes any estimates from the benefits of this investment which could be significant. For example: it has been estimated that for every £1 investing in energy efficiency £3.20 is returned through increased GDP plus £1.27 in increased tax revenues.

This report only focuses on the costs of UK decarbonisation and adaptation.

It does not consider any contributions the UK may need to make to help developing countries mitigate or adapt to climate change. Nor any compensation payments in recognition that the UK is historically a large polluter.

The polluter should pay

We argue that although the fossil fuel industry isn't the only polluter, it's time for the industry to pay for its fair share of the costs. After all, it's been free-riding for decades. This is in line with the Polluter Pays principle. The principal means for doing so should be through a new carbon tax or taxes levied at a rate that drives the necessary change across the economy and raises significant funds for the transition.

Designing the new carbon tax

A new carbon tax needs careful design. The burden must fall on major polluters and not on those least able to pay.

French President Macron's poorly designed fuel duty clearly demonstrated that a regressive carbon tax that penalises car drivers at the petrol pump, without sufficient investment in alternatives, can result in protest and disruption.

We suggest a number of ways in which a carbon tax can be levied fairly and used to fund accompanying measures e.g. a Green New Deal programme of government-backed home retrofits.

Or a 'carbon-tax-and-dividend' scheme that provides people with money for reducing their carbon impact.

We also examine other aspects of the design of effective carbon taxes. The price signal given by a carbon tax in one sector may need to be different in another sector, for example. For some sectors, approaches other than taxation may be better. Market mechanisms have their place but regulation is also a tried and tested approach that may be more effective for some sectors.

As much as possible the tax also needs to be easy to administer: for example, the Swedish carbon tax of $139 (£105) is only levied on fossil fuel importers, distributors and large energy consumers.

We aim to publish more on the design and rates during 2019.

The release of greenhouse gases is causing great harm now and will in the future. The transition to net zero greenhouse gases is urgent and necessary.

Transition will require public spending but in many cases it will bring very significant economic and other benefits (e.g. reduced NHS costs). The cost should be met at least in large part by the fossil fuel industry, primarily through a new carbon tax.

Summary expenditure table

What	**Estimate of *additional* annual expenditure**
Subsidy for electric cars and vans	£2 billion
Electric vehicle charging	£0.05 billion
Local authority electric bus subsidy	£0.25 billion
Cycle, walking and public transport	£6 billion
Renewable energy	£1 billion
Home insulation and low carbon heating	£10 billion
Afforestation	£0.5 billion
Habitat restoration for carbon storage	£1 billion
Promotion of healthy low meat diets	£0.01 billion
Extreme weather protection	£1 billion

The costs of climate change

Climate change warnings were ignored

Climate change is already happening. Significant sources of greenhouse gases include deforestation and agriculture but the extraction and use of fossil fuels is by far the major cause.

Scientists and policy makers have been concerned for many decades about the impact of greenhouse gases on global temperatures, well before the first Intergovernmental Panel on Climate Change (IPCC) report in 19901. The fossil fuel industry were also well aware, as we show below.

But despite all the warnings, the use of fossil fuels around the world has continued to grow. Total emissions of carbon dioxide have outstripped even those in the 1990 IPCC business as usual forecast.

Governments and those involved in the extraction, processing and sale of fossil fuels ignored the warnings of climate scientists. In some cases they even sought to mislead the public on this issue.

The impacts of ignoring these warnings are now being felt and will increasingly be felt over future decades.

Climate change impacts, now and in the future

Climate change is already leading to increasingly extreme weather. Floods, droughts and wildfires are sweeping the globe. And all of this is happening after the world has warmed by just 1 degree above pre-industrial levels.

Currently the world is on track for 3°C warming by 2100, with further warming beyond this date. The impact of this higher level of warming would be catastrophic, and the need for action is urgent.

The world's governments asked the IPCC to report on what it would mean to hold temperature increases to 1.5°C of global warming. In their October 2018 report, the IPCC spelt out the risks:

Tipping points. Above 1.5°C the risk of crossing irreversible 'climate tipping points' increases. For example, the melting of some of the West Antarctic ice sheet and/or irreversible loss of the Greenland ice sheet would result in a multi-metre rise in sea levels. The tipping point for this unstoppable process could be between 1.5°C to 2°C of global warming.

People at risk. Limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by several hundred million by 2050.

Spread of diseases. Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range.

Less food, more hunger. Reductions in projected food availability are larger at 2ºC than at 1.5°C of global warming in the Sahel, southern Africa, the Mediterranean, central Europe and the Amazon.

Heatwaves on the rise. At more than 1.5°C warming twice as many megacities as present are likely to become heat stressed. This potentially exposes 350 million people to deadly heat stress by 2050[2].

Nature in peril. Global warming of 2°C approximately doubles the proportion of plants and animals and triples the proportion of insects that are at risk compared to warming of 1.5 degrees. At 2°C 18% of insects, 16% of plants and 8% of vertebrates lose half of the area they are climatically adapted to.

Coral reefs on the brink. Coral reefs are projected to decline by a further 70–90% at 1.5°C with larger losses (>99%) at 2ºC. The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or more.

The IPCC urged governments to keep temperature rises below 1.5ºC. Doing so requires net zero global carbon dioxide emissions by 2050, with net zero greenhouse gas soon after.

Wealthy countries which industrialised first, like the UK, have a responsibility to reach net zero emissions faster and earlier than poorer nations who are still industrialising.

That's why Friends of the Earth is calling for the UK to set a new target to reach net zero by 2045 at the latest.

Putting a price on the harm caused by greenhouse gas emissions from fossil fuels

The idea of putting a price on the harm cause by a tonne of greenhouse gas emissions isn't new. There's a whole industry of researchers involved in trying to identify the social cost of carbon (SCC). But it's not straightforward, largely because there are big ethical choices involved.

On one end of the spectrum, Donald Trump's administration has in effect decided that harm to future generations doesn't count and nor does harm to other countries[3]. The US Government's official estimate of the social cost of carbon has been slashed from $50 per tonne under the Obama administration to under $10 dollars now. Trump's intervention will shape US policy for years to come[4].

Of course, this position is deeply unjust, given that the majority of climate impacts will be felt outside the US and by future generations. It will rightfully be challenged in the courts. But if it stands, it will favour fossil fuel companies by minimising financial estimates of the harm they're doing. It could enable the Trump administration to further roll back some of the more progressive climate policies undertaken by President Obama.

In addition to these ethical choices, it's just not possible to put an accurate price on everything that may be harmed by climate change.

The total value of nature - biodiversity and the ecosystem services they provide - are not easily priced. Nor are the physical, psychological and cultural harms of forced migration. At best these costs are poorly captured in the estimates calculated by economists.

There are still uncertainties as to how the planet will respond to different levels of greenhouse gases and warming in the atmosphere.

Whether particular tipping points might be passed such as the irreversible melting of the Greenland ice sheet

Whether warming leads to the release of further greenhouse gases such as releases of methane from permafrost, or soil carbon to turn from being a carbon sink to a carbon source.

In other words, calculations of the social cost of carbon can vary widely depending on how big a risk you consider climate change to be, and how much you value future generations and the rest of nature. However, notwithstanding these huge difficulties, there's still value in using estimates of the social cost of carbon to **illustrate** in financial terms the harm caused by fossil fuel extraction and use.

Table 1 below presents a range of recently published estimates of the social cost of carbon. The IPCC report on 1.5°degrees did not make an estimate of SCC but did note that estimates of over $100 per tonne are legitimate[5].

Table 1 – A range of estimates of the Social Cost of Carbon (SCC) with an estimate of the harm caused by the fossil fuel industry

Study into the Social Cost of Carbon	Estimate (per tonne)	Notes
Nordhaus, 2017[a], Revisiting the social cost of carbon	$35 (£26)	Based on a newer 2016 model i.e. updated after 2014 IPCC report but not updated with more recent research; also excludes consideration of tipping points.
Interagency working group on social cost of greenhouse gases, US Government, 2016[b]	$50 (£38)	In addition, the working group identified an estimate to include low-probability, high impact climate events which was $130 per tonne of carbon (see below).
Pindyck, 2016[c]	$90 (£68)	This estimate was developed through eliciting expert opinions from scientists and economists. We use $90 here as the mid-point of the $80-$100 he suggests.
Interagency working group on social cost of greenhouse gases, US Government, 2016[b]	$130 (£98)	Unlike their lower estimate (above) this incorporates understanding of low-probability, high impact climate events such as passing tipping points.
Nordhaus 2017[a], calculation using Stern Report discount rate	$225 (£170)	The Stern Report gave high value to intergenerational equity.
Ricke et al, 2018[d]	$417 (£315)	This study uses updated climate models. It also identified the social cost of carbon by country (which relates to vulnerability of countries) and included impacts on future economic growth.
Unweighted average across the above recent estimates	**$158 (£120)**	An alternative approach of discounting the highest and lowest estimate and averaging the rest would arrive at a price of $124 (£93)

Sources:
a Nordhaus, 2017, Revisiting the social cost of carbon, PNA, Vol 114, No 7, 1518-1523
b Interagency Working Group on Social Cost of Greenhouse Gases, 2016, Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866
c Pindyck, 2016, The Social Cost of Carbon Revisited, National Bureau of Economic Research,
d Ricke et al, 2018, Country-level social cost of carbon, Nature Climate Change, 8, 895-900

Multiplying the quantity in tonnes of greenhouse emissions released in the UK through the extraction and use of fossil fuels by the unweighted average SCC from the studies in table 1 above (£120) we can calculate that **the harm caused by emissions of carbon dioxide in the UK from the extraction and use of fossil fuels is £44 billion every year[6].** The cumulative cost from 1990 to 2017 is £1.65 trillion[7].

Note that this figure would be still higher if it included the UK's 'outsourced emissions (the emissions embedded in imported goods and services that the UK consumes) or historic emissions from before 1990.

These figures are important to remember during debates on the financial cost of the transition to net zero carbon emissions.

Politicians who argue that acting on climate change is too expensive blithely ignore the vast costs suffered by society because of decades of *inaction*.

The next section makes the case for the fossil fuel industry to pay a significant share of the costs of the transition to 'net zero', including through taxing carbon or putting a price on carbon But before this we describe the theory of carbon prices for internalising the cost of the damage they cause.

Carbon prices and internalising externalities

Economic theory suggests that if externalities - the social cost of carbon - are internalised into the price of a product, such as through taxes, then markets will respond. In general, more harmful (and therefore more costly) products will be replaced by less harmful products. In practice this theory is challenged by humans not always responding as economists' models predict. However Sir Nicholas Stern was correct in his report for HM Treasury when he identified climate change as the greatest market failure ever because externalities have not been internalised.

According to a recent study, 80-85% of global emissions are unpriced and the remaining two-thirds are priced at less than $10 per tonne[8]. In other words, it is common practice not to correct this market failure.

In the UK some emissions are priced, for example:

The **Carbon Price Floor** and **EU Emissions Trading Scheme**, both of which put a price on carbon emissions from industry and power generation, tax carbon dioxide at a combined rate of £36.60/tCO_2 (using ETS prices on 1 March 2019). This is well below most estimates of the social cost of carbon (see Table 1). The industries covered will also contribute to air pollution and other harms and therefore have additional externalities beyond climate change.

Fuel duty on petrol and diesel raises £28 billion annually for HM Treasury. However fuel duty is very far from being a pure tax on carbon. For example it's not differentiated by the differing carbon contents of petrol vs diesel. In fact the main justification for levying it has been to ease congestion and to raise revenues for spending on roads.

Road transport also has significant externalities besides climate change, including air pollution (recently estimated as $44 in addition to the harm caused for every tonne of carbon dioxide emitted by cars in developed countries[9]), noise, community severance, accidents and congestion. A recent peer-reviewed study showed that fuel duty in the UK and most other EU countries would need to be much higher to even cover the cost of these other harms, let alone the harm caused by CO_2[10].

Many commentators suggest that one of the most important mechanisms for driving decarbonisation is to price carbon[11] and to use at least some of the revenues for funding decarbonisation actions, such as insulation[12]. Friends of the Earth agrees, although we recognise that other approaches such as regulation will be the better policy tool in some areas. In section 4 we look in detail at how carbon might be priced within the UK in a way that makes the polluter pay and is not socially regressive.

In addition to pricing carbon, the government should eliminate the financial and political support it provides to the fossil fuel industry.

The government claims it doesn't provide subsidies to the fossil fuel industry, but it has very publicly reduced taxes on oil and gas exploration in recent years.

It has offered a variety of tax breaks to fracking firms and thrown a lifeline to old coal and new gas plants via the Capacity Market, under which the National Grid buys electricity in advance at a guaranteed price.

It also continues to finance oil and gas drilling overseas via UK Export Finance credits.

Free-riding by the UK fossil fuel industry

The fossil fuel industry is much wider than those that extract coal, oil and gas. It includes the companies that process the product and sell it.

Extraction companies such as Shell, refinery companies such as Petroineos, energy companies such as British Gas and EON and petrol retailers such as BP.

All these companies have profited from selling under-priced fossil fuels through the years.

As identified earlier, globally around 80-85% of emissions of greenhouse gases are not taxed to account for the harm they are causing (i.e. unpriced, free-riding) and 75% of those that are priced are priced at $10 dollars or less (i.e. largely free-riding). These companies therefore have a shared responsibility for funding a large proportion of the costs for the transition to net zero.

None of them can claim ignorance.

The fossil fuel industry has known about the huge risks of climate change for decades.

Scientific warnings on climate change were being issued to governments well before the IPCC produced their first report in 1990. In fact, the industry association the American Petroleum Industry had a report prepared on climate science as early as 196813. But instead of taking urgent action to change their business models and invest in cleaner energy, some fossil fuel companies decided to invest in sowing doubt about climate science. They vociferously lobbied against clean alternatives to coal, oil and gas14.

100 companies are responsible for more than half of greenhouse gases since industrialisation

A recent analysis by the Carbon Disclosure Project (CDP) identified the 100 fossil fuel extraction companies which have extracted fossil fuels leading to over half of total greenhouse gas emissions since 175115. They also name the biggest contributors since 1988. Some of these companies are UK based companies (listed on the UK stock exchange). See Table 2 for the UK companies listed by CDP.

Table 2 – The UK listed companies named in the top 50 for the greenhouse gases the have contributed (operational + product use) by the Climate Disclosure Project (CDP)

Company	Contribution of GHGs 1988-2015 (GtCO2)
Royal Dutch Shell Plc	15.0
BP Plc	13.8
Total SA	8.5
BHP Billiton Ltd	8.2
Rio Tinto Plc	6.7
AngloAmerican Plc	5.3
Glencore International Plc	3.4

Source: CDP, 2017, Carbon Majors

In addition, there are 6 fossil fuel refineries in the UK (Table 3).

Table 3 – Six major UK refineries

Company name	Location
Essar Stanlow Refinery	Elsemere Port, Merseyside
ExxonMobil Refinery	Fawley, Southampton
Petroineos Grangemouth Refinery	Grangemouth, Scotland
Phillips 66 Humber Refinery	South Kilinghome, Lincolnshire
Total Lindsey Oil Refinery	Humber Estuary, North Lincolnshire
Velero Pembroke Refinery	Pembroke coast, Wales

The Big 6 energy companies in the UK continue to primarily sell fossil fuels (Table 4).

Table 4 – Big 6 energy companies and the proportion of their energy mix which is fossil fuels

Company	Proportion of electricity energy mix which is fossil fuel
British Gas	44%
EON	64%
Npower	62%
EDF Energy	17%
SSE	72%
Scottish Power	64%
These companies are also the main providers of gas, with British Gas dominating the market with 30 per cent of customers.	

The ownership of petrol stations once dominated by the big oil companies is now much more fragmented. Supermarkets and smaller companies now responsible for much of the sales.

The internationally recognised Polluter Pays principle suggests that fossil fuel companies must take a large share of responsibility for the spending now needed to avert dangerous climate change and to adapt to the changes already baked in.

To date, these companies have almost entirely evaded responsibility for the climate damages caused by the fossil fuels they have extracted, processed, sold and profited from.

Fossil fuel company responsibility versus user responsibility

The fossil fuel industry will claim that it has simply provided society with the products we want - oil, coal, gas. Its responsibility for climate change should be limited to the emissions from its operations only, such as flaring.

It is true that consumers need to take a proportion of the responsibility for fuelling climate change. They will therefore necessarily need to take a proportion of the responsibility for funding the transition. This is particularly true of those who have used fossil fuels profligately (e.g. frequent fliers).

But individuals often had no choice because fossil fuels have been the only energy available until relatively recently to power homes and cars.

On the whole the British public have not lobbied against measures to increase renewable energy, insulate homes or electrify transport. Yet the fossil fuel industry has.

The fossil fuel industry fuelled climate denial

The fossil fuel industry cannot claim to have been an innocent bystander whilst the tragedy of climate change has unfolded. The industry's activities to seed doubt about climate change science or hold back regulations have directly prevented policies that would have hastened the decline of fossil fuels. Through these activities the quantity of carbon dioxide in the atmosphere is undoubtedly greater than it would be otherwise, potentially significantly greater. For example:

The Los Angeles Times exposed how from 1990 ExxonMobil poured millions into a campaign that questioned climate change. Over the following 15 years it placed prominent advertisements in the Washington Post, the Wall Street Journal and the New York Times, contending that climate change science was murky and uncertain. Exxon Mobil argued that regulations aimed at curbing global warming were ill-considered and premature16.

In 2015 The Guardian exposed how Shell attempted to weaken EU moves to set strong renewables energy targets, arguing that natural gas should have a bigger role. It also pointed out that Shell was the sixth biggest lobbyist in Brussels, spending between €4.25-4.5m a year lobbying the EU institutions17.

Energy UK, the trade body for the big energy companies, championed the UK government's opposition to new binding EU rules on energy efficiency18.

The polluters should pay for transition and adaption costs

The fossil fuel industry has had and continues to have the resources, expertise and money necessary to re-wire the global energy system, should it decide to do so.

For a while, it seemed plausible that the oil majors might be willing participants in the energy transition. During the early years of the 21st century, Shell and BP started investing tentatively in solar and wind power, with BP famously rebranding as Beyond Petroleum. But these investments were soon side-lined.

Friends of the Earth argues that the fossil fuel industry must be made to take significant responsibility for the past, current and future harm from the uses of its products. This should include taxing the industry to raise funds for the transition costs to net zero and to fund adaptation costs.

These revenues - alongside government investment and switching money from high carbon infrastructure such as roads to low carbon infrastructure such as cycle ways – will be vital to achieving net zero emissions and safeguarding the future for the generations to come.

Later we look at how this might work in practice.

In the following section, we provide illustrations of the public costs involved in the transition to net zero in the UK and the public costs of adaptation. In doing so we show that the costs are significant, albeit much smaller than estimates of the harm caused by carbon dioxide emissions.

A pathway to net zero in the UK

The recent IPCC report suggested that average annual investments in low-carbon energy technologies and energy efficiency need to be up-scaled by roughly a factor of five by 2050 compared to 2015.

In this section we identify that the additional public expenditure needed for the UK to achieve net zero is around £22 billion a year (roughly 2.5% of the national budget), in order to leverage the still greater sums of private finance also required.

However, the cost could be much lower if technology costs fall and efficiencies are achieved. In addition this investment would spur economic growth, lead to additional tax returns to the Treasury and reduce some costs (e.g. for NHS as a result of reduced air pollution).

A recent peer-reviewed paper by Dietz et al[19] suggests that while the cost of reaching global net zero is more expensive than previous goals, the huge environmental, economic and social costs of allowing temperatures to increase beyond 1.5 degrees should be taken into account. The authors say that the financial costs will escalate the slower countries to decarbonise their economies.

When should the UK achieve net zero emissions?

This depends on a range of factors, including:

Assessment of the UK's fair share of the remaining global carbon budget (the amount of emissions that can be released to deliver on the Paris Agreement) given that we are one of the wealthiest countries in the world. We are also a country with a long history of releasing large amounts of greenhouse gases

With what degree of certainty the UK wants to avoid certain global temperature increases

The Committee on Climate Change has been asked to provide advice to the government on when the UK should aim to be net zero and a pathway for doing so.

Mainstream UK environmental NGOs have an agreed campaigning position that the UK should achieve net zero by 2045. Friends of the Earth has developed a pathway that would lead to the UK achieving net zero earlier than 2045.

Given that the world is already experiencing extremely negative impacts after global warming of just 1 degree, the emphasis should be on reducing emissions as fast as possible.

The IPCC has said globally emissions of carbon dioxide should be net zero by 2050 and net zero for all greenhouse gases should be achieved soon after. The UK, as the country that began the fossil fuel age, has a huge historical responsibility for past emissions. We are rich enough to cut emissions faster and sooner which is why Friends of the Earth believes its right that the UK moves to net zero earlier.

Below is a very brief summary of Friends of the Earth's pathway for some key sectors of the UK economy, with estimates of the additional public finance needed to achieve some of the major changes proposed. These are provided as an illustration of the types and scale of costs that we argue

the fossil fuel industry should fund in part. They are not intended to be precise or comprehensive. A longer version of our net zero pathway is available here

As in earlier sections, the figures presented below are for illustrative purposes only. Note that costs are dynamic. Any delay in moving to meet the net zero goal is likely to lead to increased costs.

Investing in surface transport

The following excludes aviation & shipping.

Estimate of annual government investment needed: approx. £8.3 bn

Pathway

The Committee on Climate Change's max scenario for transport reaches 97% emissions reductions by 2050 with surface transport at 5 MtCO2e at 2050 compared to 120 MtCO2e today (excluding domestic aviation and shipping). The residual emissions at this date are largely some heavy goods vehicles (HGVs) and buses not yet electric or hydrogen. The CCC also states that near zero could be achieved by 2055-206020. Ongoing innovation and R&D into electric and hydrogen vehicles, particularly HGVs, could potentially mean surface transport reaching zero carbon by 2050.

Main actions and costs

Bring forward the deadline for all new cars, vans, buses and lorries to be zero carbon to 2030

Cars

The CCC scenarios identify that the vast bulk in reductions from transport will be through cleaner vehicles (70% of reductions to 2030).

The lifetime cost of owning and running an electric car is already comparable with that of a fossil fuel-driven car, aided by the rapid reductions in battery costs which have been much greater than forecast 21, and are forecast to fall by another 50% by 203022. The lifetime costs for fossil fuel-driven cars also includes fuel duty costs, which EVs do not pay. The £28bn this raises for the Treasury will need to be raised in other ways23, one of which may be additional taxes on the fossil fuel industry.

However, the upfront costs of EVs are greater than fossil fuel-driven cars, which creates a barrier to vehicle uptake. The government currently provides a £3,500 grant to overcome this24. Instead, a larger grant scheme would likely incentivise more rapid uptake. Extending the scheme until at least the first million EV cars and vans are sold would cost approximate **£2 billion per year until the goal is reached.**

There are also other barriers to the uptake of EVs, such as drivers' confidence in being able to re-charge their cars quickly and reliably at a network of kerbside charging points. This will require additional infrastructure spending, although the amount will depend on how it is done. For example, if lamp posts are converted into also being EV charging points, the cost will be much less25.

Already EV charging points are rolling out across the country as commercial propositions, recouping the costs via electricity sales. However the National Infrastructure Commission says more government support is needed in rural areas and smaller towns. The extra public expenditure needed in this area is likely to be small, in the low **£10s of millions** (e.g. £50 million per year).

Much of the charging of EVs will be done at home, with the costs of chargers quoted at around £800. Currently a £500 government grant is available. In addition, home-charging of electric cars will require electricity grid upgrades (as will the shift to electric home heating – see section on homes below). The

cost of this upgrade will depend on how charging occurs. The National Grid says that flexible time charging using a smart grid will reduce costs considerably[26].

Shifting from fossil fuel-driven cars to electric cars will also require additional power plants, although the costs of extracting, refining and distributing petrol and diesel will diminish.

The National Grid estimate the extra electricity demand will be around 60TWhr of electricity and around 8GW of power plant (around 15% additional GW of power plant)[27]. The capital cost of investing in this plant will be funded through the cost of electricity to electric vehicle consumers and facilitated by Contracts for Difference (see power sector below).

Buses

The current lifetime cost of electric buses is higher than for fossil-fuel-driven buses due to much higher upfront costs, even though the running costs are lower. Leeds City Council has estimated that the cost of switching the 1,000 buses it contracts to electric would cost in the order of £7 million per year[28]. The benefits of doing so, which don't accrue to the council directly, are reductions in the costs of air pollution and climate change.

Local authorities need the regulatory powers and the financial support to enable a swift replacement of diesel buses to electric. With approximately 35,000 buses in England alone[29] and an annual cost difference of £7000 between diesel and electric, the quantity of public support needed for switching to electric buses is around **£245 million per year,** plus the support needed in devolved nations. This cost will decline over time as the price of electric buses declines.

Heavy Goods Vehicles (HGVs)

Technology for HGVs is also developing fast. Earlier assumptions that these vehicles can't be switched to electric are looking misplaced. In a 2018 report, Hitachi Capital stated that "if every van and HGV was powered by electricity, approximately £14 billion could be saved on fuel costs"[30].

The innovative British HGV company Tevva claims its lifetime costs are already lower than diesel. The shift in HGVs and vans to electric may be better achieved through regulatory action together with research and development financial support rather than subsidies for the vehicles, at least if Tevva is correct that lifetime costs are lower. The shift will also take time, as more innovation is needed to develop pure electric HGVs with a range in excess of 100 miles (though the average HGV journey length is only around 90 km/55 miles[31]).

Invest in urban transport: cycling, walking and public transport

The National Infrastructure Commission (NIC) has said urban transport must be a priority for infrastructure investment for productivity and quality of life reasons (air pollution, noise, etc.)[32].

They say that transport networks are close to capacity in many cities, and that "better cars can't solve the problems because there isn't enough space". They suggest that at least £43 billion additional spending on urban transport is needed between now and 2040, *excluding* the cost of electric vehicles, with a strong focus on public transport, walking and cycling.

The NIC states that infrastructure to support public transport in growing and congested cities offers some of the highest returns for transport investment. Indeed public transport in the UK nowadays is by some measures very much worse than it was in the past. In 1927, there were 14,000 trams in operation across the country[33]; today very few UK cities benefit from trams.

While the NIC does not quantify the emissions benefits from a modal shift from cars to other forms of transport, it's clear that more cycling, walking and public transport will undoubtedly produce some emissions savings, as even EVs are low carbon not zero carbon.

Modal shift to cut emissions

The UK's Committee on Climate Change (CCC) in their 2016 Progress Report estimated that modal shift can reduce the distance travelled in cars by 5-10% by 2030. They called on the Department for Transport to better model the emissions savings from switching to cycling and walking[34].

£43 billion by 2040, or roughly £2 billion per year, is likely to be at the low end of what is needed if UK cities are to become more like Copenhagen or Amsterdam, with their much higher levels of cycling and tram systems.

Levels of investment

Transport for Quality of Life have called for a £2 billion a year investment in cycling infrastructure. They have also reported that some towns and cities across the world are now making buses free to use to encourage people out of cars, reduce congestion and reduce air pollution.

It's been estimated that making buses free in the UK could cost an additional **£3 billion per year**. Friends of the Earth is arguing that to start with bus travel should be made free to the under 30s.

For the purpose of this report we have used an estimate of **£6 billion a year** extra funding for walking, cycling, buses and trams. Some of this money could be reallocated from high-carbon road projects or through switching funding from the expensive HS2 project to cheaper rail improvements.

Friends of the Earth has commissioned research to identify the changes and costs of developing an urban transport system compatible with net zero. We will update this estimate when it is completed.

We have not looked at inter-urban travel beyond cars but have commissioned separate research into the expenditure needs for railways. We will publish this shortly.

Investing in the power sector

Estimate of annual government investment needed: approx. an additional £1bn above planned to 2030, with subsidy free auctions and market mechanisms becoming increasing important.

Pathway

The emissions reductions from the power sector are a success story for the UK. But there's much more to do to build on the 65% reduction in emissions from electricity supply since 1990.

The CCC max scenario has this almost totally decarbonised by 2050: a 99% reduction from 1990 levels. It may be possible to fully decarbonise this sector earlier, even though it will need to expand considerably to provide all the energy needs for heating, transportation and much of industry. This will require significant action on energy storage.

Main actions and costs

Maintain the shift to renewable electricity while simultaneously electrifying transport and heating

Renewable energy is currently supported in the UK through the Renewables Obligation, Feed-in tariff and more recently through Contracts for Difference (CfD), which guarantee a set price of electricity. Together, these support mechanisms currently cost around £7 billion a year[35].

These policies have helped develop renewable energy technology and drive cost reductions. The UK is now a world leader in offshore wind[36]. Onshore wind is now the lowest cost source of new electricity, and solar power is also increasingly capable of delivering low prices. An analysis by the Green Alliance has shown that even with a low carbon price offshore wind will be cheaper than new gas plants by 2023. On-shore and solar farms already are[37]. Ensuring the growth of offshore wind is the best option for consumers.

However, until the electricity produced by coal or electricity factors in the full cost of climate damages renewable energy will still need a strong route to market into the future. The UK's Carbon Price Floor mechanism, currently frozen at £18/tCO_2, could be increased to better reflect the harm caused by coal and gas and to reduce or eliminate the support renewable energy needs.

Heating and transport

The quantity of renewably-powered electricity will need to rise substantially to also provide additional electricity for heating and transport. Eventually the UK will need something like 800 TWhr of renewable electricity (eight times the current amount of renewable electricity), with around 320 TWhr to decarbonise the grid to 50g/CO2/kWh by 2030. Current government ambitions for offshore wind is 30GW by 2030 which is around half of what is needed by that date.

Storage

In addition investment in energy storage is also required. Short-term energy storage in batteries is already being tested at some solar farm and a number of onshore and offshore windfarm sites. But investment in multi-day storage and seasonal storage is also necessary, particularly as heating is electrified (see below).

Financial mechanisms

Identifying the financial mechanisms needed to speed up and scale up renewable energy for faster decarbonisation and faster electrification of transport and heating is not straightforward with rapid price falls in the technologies and fluctuations of wholesale prices. A higher Carbon Price Floor would reduce the level of support the industry needs, by helping to level the playing field.

The government has announced £577 million in 2019 for a CfD tender with a promise of biannual auctions thereafter. It's estimated that this could deliver 1-2 GW of offshore wind each year in the 2020s. Thanks to the tumbling costs of offshore wind, the £557 million announced for further auctions until 2025 could potentially build sufficient renewables for roughly another 100 TWhr.

This would still leave a gap of around 65TWh by 2030 to reach the lower decarbonisation goals. It also assumes that the current low bid prices for offshore wind and increasing market reference prices can be maintained, and that all planned projects get built. None of this is certain.

Depending on a range of factors, an additional £500million-£1.5billion per year in CfDs should be made available over the period to 2025 to ensure sufficient renewables are built by 2030.

In order to secure deep decarbonisation we will also need to greatly increase renewable energy deployment in the 2030s and 2040s. This suggests we need to consider CfD auctions sufficient to ensure this. Alternatively, a mix of increased Carbon Price Floor and reduced expenditure on CfD.

Given the cost trajectory of renewable energy generation however, the actual subsidy element of these is likely to be minimal. The focus after 2030 is likely to be on ensuring that the market is able to deliver rapidly increasing amounts of renewable electricity.

Development of a renewables-to-hydrogen pathway for energy storage and use

Seasonal and multi-day energy storage will be critical for a 100% renewable energy future – particularly for heating. Day to day electricity storage can be supported through batteries in electric cars, battery storage at wind and solar farms, and pumped storage.

Hydrogen is a promising form of energy storage.

The hydrogen can be produced through electrolysis (splitting water into hydrogen and oxygen) using dedicated renewable energy and excess electricity at times of high wind and solar generation.

The existing gas grid can operate as an energy store for hydrogen, especially if a large proportion of demand for heating is provided by electricity. (The gas grid is already being upgraded to reduce methane leakages and the upgraded grid should be compatible with hydrogen).

The costs of this are very uncertain and are strongly influenced by how the hydrogen is produced and the quantity needed. Right now what is needed is money to explore the options and costs, with an aim to reduce this cost considerably. The government recently announced £20 million of research money to do this[38].

Until there is greater clarity on the costs we are unable to make an assessment of public money needed for this area. Policy Exchange has recommended that "the Government should consider targeted investment to reduce the cost of electrolysers, at the same time giving due regard to export

opportunities for the technology.39”

Investing in buildings

Estimate of annual government investment needed: approx. £10 bn

Pathway

Nearly all the emissions in this sector are from the use of natural gas in heating. (Note: electricity use is captured in the section on the power sector). The CCC max scenario has this sector reducing to 4 MtCO2e by 2050, a cut of 95% from current levels and zero at 2055-70. This sector is particularly expensive to decarbonise fully.

There has been some limited progress in cutting emissions from this sector, for example through regulations leading to more efficient boilers. But only 22% reductions compared to 57% across all sectors. An earlier net zero date is practically possible but will require a huge step-change in government action.

Main actions and costs

Roll out an area-by-area heating transformation programme

Most home heating currently comes from burning gas.

To decarbonise heat, we firstly need better-insulated homes.

Secondly over at least the next 10-15 years the electrification of heating needs to be the priority, powered by a decarbonised grid.

Need for grants

To drive this forward, the government needs to provide householders with capital grants for heat pumps and other forms of electric heating, as well as funding a massive programme of home insulation.

Yet currently, for most householders, there is no public funding available for energy efficiency measures. The failure of the government's Green Deal scheme has caused the roll-out of domestic insulation to collapse. Capital grants will also need to supplemented with regulations to force change at certain trigger points (e.g. boiler replacement, re-letting of homes or home sales) and to ensure standards are met.

Home insulation

The National Infrastructure Commission (NIC) has recommended that £3.8 billion is allocated by government for home insulation in social housing over 10 years40. Research for environmental group E3G suggested that the cheapest way to deliver energy efficiency for all homes would be around £50bn over a twenty year period41. This would include 0% interest loans for those householders able to pay for insulation.

The research also identified the very significant economic and social benefits from this investment. For every £1 invested by government in energy efficiency, £3.20 is returned through increased GDP, plus extra tax revenues of £1.27.

Heat pumps

Heat pumps, which on average provide three units of heat for one unit of electricity are the second vital part of decarbonising heat. The rollout of heat pumps will not be cheap because they are expensive to buy and fit.

Currently the government provides some support for heat pumps under the Renewable Heat Incentive. These are not upfront capital grants and instead are funded by income paid by the government over 7 years.

The cost per household for installing heat pumps has been estimated in government-commissioned research at around £9,000 per household. Not all homes will be suitable for fitting heat pumps, although if hybrid pumps are used then the vast majority should be.

There are 25 million homes in the UK. Upgrading these with a heat pump could cost around £5,000 to £10,000. This comes out as around £125 billion to £250 billion over the next 20 years. Some of this cost could be met by householders through contributing the cost of their boiler upgrade, but in practice it may be better to make this a government-led funded programme.

In addition, some upgrades of the electricity grid would be required to cope with the extra demand, estimated as around £20 billion by Element Energy42.

Transformation area by area

The costs for insulation and installing heat pumps could potentially be significantly reduced. A coordinated deployment of an area-by-area transformation programme would bring the added benefit of less overall disruption for householders.

Research based on a practical area-wide solid wall insulation programme in Bristol found that costs were 45% cheaper than piecemeal deployment.

This suggests that forecasts for a combined comprehensive energy efficiency and low carbon heating programme of around £195-320 billion are likely to be too high. A £10 billion annual programme over 20 years – a total of £200bn – may be sufficient. This lower cost estimate is within the range of cost estimates provided for the NIC by consultancy Element Energy43.

Ensure that all new homes and buildings are zero carbon and contain integrated renewable technologies

The UK will need to build millions more affordable homes over coming decades to address the current housing shortage and to accommodate a rising population44.

New homes and commercial properties should be

- Built to highest energy efficiency standards (e.g. Passivhaus standards),
- fitted with heat pumps or connected to low carbon heat networks
- with in-built renewable energy generation where possible (such as solar PV or solar hot water panels).

This isn’t currently government policy. Houses are being built to low standards and still being connected to the gas grid (although the Government has at last set a date for this to cease).

The Prime Minister did at least announce in May 2018 that “we will use new technologies and modern construction practices to at least halve the energy usage of new buildings by 2030”. But more is needed.

The additional cost of building homes to high energy efficiency standards, with integrated renewable power (the old Zero Carbon Homes target, scrapped by the government) is actually very low. An analysis by the Green Alliance suggests the cost is around 1.4 per cent more than current building regulations, and the savings in energy bills will mean this will be recouped in around 6 years[45]. The price of installing a heat pump in new builds in also going to be much cheaper than retrofitting, although will still cost around £5,000.

Government choices

The government should regulate for all new build homes to be zero carbon and fitted with heat pumps or plugged into heat networks. They should not need to subsidise the cost of building new homes. Instead of saving developers money by slashing energy efficiency standards, they should look to other measures to make housing more affordable, such as by reducing land values and speculation.

Investing in agriculture and land-use

Estimate of annual government investment needed: Approx. £1.5 billion

Pathway

Agricultural emissions have reduced slightly but have scope to reduce further and to be more than offset through negative emissions. The Committee on Climate Change (CCC) has suggested emissions from agriculture could be slightly reduced to 45.3 MtCO2e by 2030 with scope for further unquantified emissions reductions later.

An analysis for Friends of the Earth has estimated that around 80 MtCO2e could be removed through land-use change. This is roughly the same as the CCC max scenario which includes a total of 67 MtCO2e reductions.

Main actions and costs

Double the area of UK land forested and increasing carbon in soils, peatlands and salt marshes to sequester carbon

Forests – planting more trees

The Woodland Trust together with the community forests in northern England are promoting the concept of a northern forest. This would stretch from Liverpool and Chester on the west coast to Hull and Whitby on the east coast, with 50 million trees planted over the next 25 years. The Trust estimates the costs as £500 million (£20 million per year) and the benefits add up to £2.5 billion46.

In 2015 the Natural Capital Committee (NIC) recommended the planting of 625 million trees across 250,000 hectares.

The Royal Society and Royal Academy of Engineering have said in their joint report on negative emissions that 1.2 million hectares of land should be planted with trees.

The Centre for Alternative Technology and Friends of the Earth both argue that the UK should aim to double the amount of tree cover in the UK from 3 million hectares to 6 million hectares. This would include freeing up some land from agriculture by changing diets. See below.

The forestry industry estimates that up to 7.3 tonnes of carbon can be captured each year by each hectare of productive woodland, including through substitution of building materials47.

The cost of forest expansion

The costs of this expansion of forestry can, in part, be met through annual payments to landowners and farmers to establish and manage forests. This would be partly through a reformed farm payments system and partly through additional grants.

Costs of tree-planting varies depending on the quality of land. In England, as in Scotland, grants are available for capital and maintenance costs48. The average payment under Scotland's Forest Grant Scheme is around £4,000 per hectare of trees planted (which includes an initial planting payment, a capital grant, and annual maintenance payments for 5 years)49.

Making allowances for potentially higher land costs in England, we estimate funding of £5000 needed per hectare, with the 3 million hectares planted over the next 30 years starting in 2020 (i.e. 100,000 hectares per year).

This therefore requires £500 million per annum for afforestation. The NIC has suggested that planting woodland around towns and cities would yield a very high benefit cost ratio of between 5:1 and 6:150.

Soil and habitat restoration

The Royal Society and Royal Academy of Engineering's recent report on negative emissions identified significant potential to sequester carbon through

- better soil management in agriculture
- the restoration of peatlands.

They suggest better soil management could drawdown 10MtCO2 per year by 2050 and that habitat restoration, principally salt marshes and peatlands, could sequester an additional 5MtCO2 per year.

The government is promising changing farm subsidies to ensure that public goods result from public money. This must include better soil management. We have not included an extra cost for improving soil carbon as it appears from government statements that it is already planned and will be cost neutral.

The cost of restoration

The cost of habitat restorations is estimated by the Royal Society and Royal Academy of Engineering to be around $10 (£7.60) to $100 (£76.00) per tonne of carbon. They point out that these ecosystems provide services such as flood alleviation worth thousands of pounds per hectare.

A recent assessment of costs in Scotland found the costs of peatland restoration varied enormously, from £300-£5000 per hectare, with on-going costs of £25-400 per hectare51. That makes it difficult to provide an estimate of the funds needed.

The UK has nearly 3 million hectares of peatland and 80% is considered to be in poor condition. The Royal Society and Royal Academy of Engineering suggest restoring 1 million hectares of peatlands and 1.25 million hectares of wetlands and saltmarshes. Using the mid-point of the assessment of costs in Scotland suggests an investment of around £2650 per hectare plus approximately £200 per hectare on-going costs.

This suggests a cost of approximately £1 billion per annum for habitat restoration over a 10 year period. Governments across the UK have provided less than £30 million.

Reduce methane emissions by reducing consumption and production of meat and dairy to healthy sustainable levels

Consumption

Methane is a much more powerful greenhouse gas than carbon dioxide. In the UK livestock production is responsible for more than half of methane emissions. (Waste management and leaks from gas pipelines are responsible for the majority of remainder).

There are experiments underway to test whether feeding a particular type of seaweed to cows can reduce the amount of methane produced. But it is early days and to date the impact on the taste of meat and milk has yet to be tested[52].

Healthy diets

Even if this and other feed technology can work – and it's a big if – the UK average diet already contains unhealthy levels of meat. This is damaging to health and costing the NHS.

6 out of 10 men and 4 out of 10 women exceed recommended levels of meat consumption.

Shifting to healthy diets will not only reduce methane emissions directly, but also free up land for forests and wildlife. It is also necessary for meeting greenhouse reduction targets because technological actions, efficiency improvements and reducing food waste is not enough on their own[53].

Freeing up land for forests and wildlife

A more sustainable diet in the UK could free up more than 3 million hectares of land in the UK. We recommend using this in part to plant new forests[54].

It would also reduce the impact of livestock feed production overseas. For example, preventing deforestation for soya production in the Brazilian Amazon. The UK imports 1.1 million tonnes of soya products for animal feed[55].

Public health campaigns for a low-meat diet

Evidence from anti-smoking campaigns suggests that public health campaigns can work to change public behaviours[56]. In 2018/19 the government intends to run 140 communications campaigns[57]. It obviously has faith that public information campaigns work.

According to obesity charities the government spent £5.2 million on its Change4life food campaign. But it's up against the junk food industry which spent £143 million in the same year[58].

Eating meat no more than three times a week has been estimated to prevent 45,000 early deaths a year in the UK and save the NHS 1.2bn a year.

Given the health benefits and the consequent saving to the NHS, public health campaigns to communicate the benefit of low meat diet should be funded at least in the scale of the Change4life campaign cited above. We suggest £10 million per annum.

To do this the UK national dietary guidance – the Eatwell Guide – should be reviewed to ensure that sustainability is fully integrated. It should then underpin all healthy eating advice to the public, as well as government and local authority procurement. It should introduce mandatory standards for caterers to ensure that meals paid for by taxpayers in schools, hospitals, prisons, care homes and all government departments are healthy and sustainable.

Fiscal measures to encourage dietary shift

The government should explore fiscal measures such as introducing VAT or other tax on some types of livestock products. These could be ring-fenced for implementing healthy, sustainable eating strategies. The sugar tax is a good example. This is expected to raise around £275 million a year which will fund improvements in school sports. And there could be financial incentives for growing vegetables and plant-based proteins.

Livestock production

The government should aim for sustainable levels of livestock production in line with:

- the carrying capacity of land
- climate change goals and environmental limits
- the principles of sustainable diets
- public expectations for high quality, high welfare, and sustainably produced UK livestock products.

This should also include the UK's impact on emissions in other countries including deforestation and other land use change from soy production for animal feed.

Managing the transition

Further research is needed to determine which production systems provide greatest benefits. What would be a more appropriately sized and structured livestock sector taking into account the UK's geography and climate.

This could also free up land for alternative use, contributing to a range of policy goals, such as flood alleviation or nature conservation.

Farmers, land managers and communities who live and work in these areas should be supported to enable a managed transition to reduced stocking densities and alternative land use.

There should be protection for high quality permanent grassland and carbon-rich soils. This could be delivered by maintaining inventories and ensuring appropriate site-specific livestock stocking densities to avoid overgrazing. Along with greater support for agroforestry - integrating trees and shrubs onto agricultural land.

Labelling to help the consumer

Clear and honest labelling including a mandatory method of production labelling should be introduced for all livestock products to empower the public, level the playing field and reward farmers who shift from volume to quality production.

Investing in extreme weather protection

Estimate of annual government investment needed: Approx. £1bn

Protect people from extreme weather

In the UK the wildfires during the heatwave of 2018 were a foretaste of what's to come in a hotter world.

UK rainfall levels have got heavier since the 1980s and recent severe floods bear the imprint of human-made global warming. Meanwhile, sea levels around the British coast have risen by 10cm already over the past century. The time-lag in the climate system means we're already committed to more warming, even if we stopped all emissions tomorrow.

Whilst the UK, as a rich nation, is much better placed to cope with the impacts of climate change than many developing countries, there's still a cost to be borne.

We need to urgently adapt our homes, communities and landscapes to the increasing risk of floods, wildfires and heatwaves.

Politicians tend to respond to disasters like floods and wildfires by focusing on the emergency response – whether that's sending in the army or piling up sandbags. But that's a very near-sighted approach when faced with an inexorably changing climate.

Smarter adaptation

The National Infrastructure Assessment (2018) estimates that relying on emergency measures alone to combat increased flooding and droughts would cost the country £40 billion over the next 30 years.

But it calculates that taking a smarter approach to adaptation, by building up our resilience, would cost 'just' £30.5bn over that same period - around £1bn/year.

This includes building flood defences (drawing upon the Environment Agency's latest Long Term Investment Scenarios from 2014), natural flood management measures like tree-planting, and safeguarding against drought by wasting less water.

A previous assessment of future flood defence spending needs by the Environment Agency in 2009 stated that its 'most favourable scenario' was to invest £20 billion between 2010 and 2035. The National Infrastructure Commission (NIC) and Environment Agency climate change scenarios, however, are predicated on a 1.5-2C world. Under business-as-usual levels of warming, the costs of adaptation become much, much higher.

While governments must aim for a future that keeps temperature rises below 1.5C it is prudent to start preparing for a world of climate change failure in which the world warms by 3C or more.

Flood risk

The Committee on Climate Change, as part of its background work for the second Climate Change Risk Assessment (2017), commissioned a study that looked at UK flood risk and sea level rise under a 4C rise in global temperatures.

This showed that the area of low-lying land at risk of inundation from sea level rise would double under a 4C as against a 2C scenario[59].

The NIC agreed that the costs of adapting to 4C would be “much higher”. Figures in its technical annex on flood modelling show that protecting households to its recommended standard of resilience under a 4C scenario costs an average of £1.8bn per year between 2020-2050[60].

These do not take into account adaptation costs that result from global food shortages, conflict or high levels of forced migration. So this 4^{o}C adaptation cost could be orders of magnitude too low.

Investing in flood protection and building resilience

Based on the NIC’s 2018 assessment, the government needs to invest £30.5bn between 2020-2050, i.e. £1bn/year, on constructing flood defences, installing property-level flood protection, supporting natural flood measures and building resilience against droughts, heatwaves and wildfires.

How to make the polluter pay

In this section we make the case for the introduction of a new carbon tax in the UK to both drive change in the sectors affected and to raise money.

We have identified that around £22bn of additional public money is needed annually to fund the low-carbon transition and leverage in the necessary additional private finance.

A new carbon tax would not fund this entire transition. It would be a valuable source of revenue for addressing sectors where public finance is most needed e.g. home heating and urban transport.

It would also help drive decarbonisation directly, by penalising high-carbon activities and incentivising investment in clean alternatives.

A new carbon tax

There is a moral case for the fossil fuel industry – the oil and gas majors, refineries, and Big Six energy companies – to substantially contribute to the cost of transition to net zero.

These companies have profited over the years from fossil fuels. They have not had to pay the full price for externalised harms over the years, principally climate change but also air pollution and other impacts.

The carbon tax we envisage is not set at the estimated cost of the harm arising from one tonne of CO2. Instead we take the approach of the High Level Commission on Carbon Prices, chaired by Sir Nicholas Stern and Joseph Stiglitz. This recommended setting the carbon price at the level necessary to achieve the desired outcome[61]. They suggested a rate of around $40-80 (£30-60), as long as “a supportive policy framework is in place”. This is much lower than most estimates of harm. Higher rates could be justified if seeking to force polluters to pay the full costs of the climate damages they have caused.

A Carbon tax is a tool among many

Like Stern and Stiglitz, Friends of the Earth does not see a carbon tax as a silver bullet. Some economists and policy advocates tend to portray a carbon tax as the only policy intervention needed to fix climate change. They use this to justify sweeping away all other climate policies and regulations.

Instead a carbon tax should be viewed as one tool in the climate policy toolbox, suitable for some sectors but not for others.

Even a well-designed carbon tax has the potential to be socially regressive unless it is complemented by mitigation measures. For example, significant investment in energy efficiency or better public transport.

Nevertheless, a carbon tax is now urgently needed in the UK. There is looming uncertainty about what happens to the existing Carbon Floor Price after 2021 (see below). Such uncertainty is only magnified by what may or may not happen with Brexit.

Like many others, Friends of the Earth believes it is now time to put in place a high and rising carbon tax. This tax should be levied upstream on the fossil fuel industry. It adheres to the polluter pays principle. Pragmatically it's easier to levy a tax on a small number of companies rather than lots of end-users.

A carbon tax must be progressive

Fundamentally, a carbon tax should not fall on the shoulders of the poorest in society. It should be accompanied either by a massive public investment programme (like the Green New Deal proposals currently being discussed by Democrats in the US) or by a tax-and-dividend scheme that would put money into people's pockets for reducing their own carbon footprint.

We also believe that any carbon tax has to be set at the appropriate level for different sectors. Friends of the Earth will be drawing on forthcoming research from the highly respected Grantham Institute for Climate Change Research into what the different tax levels should be and how it should be levied.

What are carbon taxes?

Carbon taxes are a tool to

- discourage high-carbon activities
- encourage investment in low-carbon infrastructure and
- raise revenues for governments to spend – ideally on decarbonising the economy.

Like any tax, they can simultaneously change behaviours (in this case, away from high-carbon and towards low-carbon activities) and raise money for the state.

Carbon tax v emissions trading schemes

Many countries around the world now levy carbon taxes. They are an alternative and arguably more direct way of putting a price on carbon than the other main climate policy favoured by some governments in recent decades – emissions trading schemes (such as the EU ETS).

Under an ETS, a market-wide cap on emissions is agreed and permits issued or auctioned to companies, who trade them in order to buy permission to pollute. Over time, in order to reduce emissions, the cap is reduced and fewer permits are issued.

The price of carbon is influenced by the numbers of permits issued and the ease by which the companies can reduce their emissions. In the EU ETS far too many permits were issued. The price of permits has been low almost its entire life since 2005, although recent changes have reduced the supply of permits and the price has increased.

Carbon tax benefits

A carbon tax has several benefits over an ETS.

1. It's conceptually easier to understand and put in place.

2. The revenues that flow from a carbon tax are more predictable than the price of auctioned emissions permits, which fluctuate over time.
3. Emissions trading schemes invariably start by granting large polluters free permission to pollute (the process known as grandfathering).

Until recently, most ETS permits were handed free of charge to companies so revenues were very low. Now around £5 billion is raised across the EU, of which £1.5 billion is raised in the UK[62].

A Carbon Tax would give no such free ride to polluters.

What about Brexit?

If – as seems plausible – Brexit results in the UK leaving the EU ETS, it would be far more efficient to replace it with a carbon tax. The government's current proposal is to set up a UK-only ETS, with its far smaller pool of participants and lower market liquidity.

There are pros and cons to either system

The most important thing is whether the price signal produced by a tax or trading scheme is high enough to trigger a shift in investment from high-carbon to zero-carbon.

In the UK, and indeed in most countries around the world, carbon prices are nowhere near high enough currently to decarbonise the economy in line with the Paris Agreement.

A high and rising carbon tax would help resolve some of the problems that currently bedevil UK climate policy. A need to drive deeper decarbonisation. A need for extra revenues for government to spend on low-carbon infrastructure, particularly in areas which have struggled to leverage in private finance e.g. energy efficiency, urban transport, electrification of heating, and reforestation. But as mentioned earlier, there isn't a catch-all solution.

The policy toolbox

Other tools in the policy toolbox would also need to be used, such as:

Direct regulation – for example, bans on especially high-carbon or inefficient products (like the EU's ban on incandescent lightbulbs)

Product design regulations - to encourage greater efficiency

Bans on new fossil fuel extraction – such as halting fracking and ending opencast coal mining

Subsidies - for example to support afforestation

Stopping perverse subsidies - for example, Government financing fossil fuel projects internationally, as it currently does through UK Export Finance loans and other forms of finance

Public information campaigns - for example on diets or green heating option.

In addition, there is likely to be a need for additional taxes for sectors or activities not caught by the carbon tax (for example, on oil and gas extraction itself or a Frequent Flyer Levy to discourage excessive use of aviation).

Putting a price on carbon: policies around the world

Many countries now put a price on carbon whether via carbon taxes or emissions trading schemes.

A review by the World Bank in 2018 found that 45 nations and 25 subnational jurisdictions now put a price on carbon, covering about 20% of global greenhouse gas emissions. Governments raised $33bn in carbon pricing revenues in 2017. Carbon prices vary greatly across the world, from as low as $1/tCO2 in some of China's pilot emissions trading schemes, to as high as $139/tCO2 under Sweden's carbon tax[63].

Sweden has had a tax since 1991, which has gradually risen in price. According to the government it is an expression of the polluter pays principle, is easy to administer, raises important revenues and is effective[64]. It's levied on importers, distributors and large energy consumers, of which there are around 300 in Sweden[65].

The UK, despite billing itself as a global leader on climate change, has a comparatively weak carbon price in place. The World Bank states that France, Denmark, Norway, Finland, Switzerland and the Canadian province of British Columbia all have policies in place where the per-tonne carbon price is higher than in the UK[66].

The coverage of carbon pricing also varies from country to country. For countries in the EU, about 40% of European carbon emissions are covered by the EU Emissions Trading Scheme. In some other countries, coverage is wider. For example, Japan's carbon tax covers 65% of the country's total greenhouse gases (GHGs) – though it's levied at a very low rate (around $3/tCO2e). South Korea's emissions trading scheme covers 68% of the country's GHGs, with a carbon price similar to the UK's, at $21/tCO2e[67].

The UK's carbon pricing schemes are neither as widespread in their coverage, nor set at as high a level as is the case in some other countries.

Putting a price on carbon: existing UK policies

There have been efforts to put a price on carbon at different points in the UK economy since the early 1990s.

The introduction of the fuel duty escalator in 1993 by John Major's Conservative government was explicitly billed as a way to reduce carbon emissions from road transport. Unlike in Sweden it was never explicit what proportion of fuel duty was for climate reasons.

The major rationale for UK fuel duty has been to ease congestion, and the current rate does not capture the full cost of externalities from transport. The fuel duty escalator was abandoned in 2000 and rumours of its return remain a bete noir of the right-wing press.

Subsequent efforts by successive governments to price carbon have tended to shy away from taxes, particularly ones paid at point of sale by consumers. Instead they have favoured market-based mechanisms like emissions trading schemes.

In fact multiple policy interventions means that there are a wide range of different carbon prices, or effective carbon prices, in place across the UK economy.

The failure of current carbon pricing to drive serious change

The government-funded Energy Systems Catapult, in a report looking at effective carbon pricing across the UK economy, argues that “some big sources of carbon emissions, including natural gas usage and agriculture, have effective carbon prices which are too low.[68]” They argue that there are currently a wide range of carbon prices in place across different sectors. But nearly all of them too low to drive serious change.

Some sectors operate with no carbon price. Jet fuel, for example, isn’t taxed - and isn’t anywhere in the world, because of an international convention.

A single carbon price. Or multiple policy interventions

There are pros and cons to having multiple policy interventions, all designed to create a carbon price signal.

Classical economists tend to aspire towards a single carbon price, levied at one level across the entire economy. Policy Exchange, in their 2018 report advocating for a carbon tax, see one as supplanting other climate policies and rationalising a cluttered policy landscape[69]. There’s some merit to this.

But there can be good reasons for having multiple policy interventions, especially when dealing with a problem as complex and deeply embedded as fossil fuels.

Friends of the Earth is of the view that having differential carbon taxes or price signals in place for different sectors is likely to be more effective and probably more politically acceptable. A differential tax also acknowledges that decarbonisation can be achieved in some sectors with a lower carbon price signal than in others, because of elasticity of demand and the availability of alternatives.

The main way in which the UK currently puts a price on carbon is via two interconnected policies – participation in the EU Emissions Trading Scheme (EU ETS) with the ‘top-up’ of the Carbon Floor Price.

The EU ETS and Carbon Floor Price

There are around 1,000 installations in the UK which participate in the EU ETS, including power stations, oil refineries and factories for manufacturing things like steel, ceramics and chemicals – covering around 40% of all UK greenhouse gas emissions[70].

Therefore around 60% of UK emissions fall outside of the scope of the ETS and its concomitant carbon price. This includes most of the transport sector, domestic and commercial buildings, agriculture, and waste management[71].

The price of carbon traded within the EU ETS has also been very low for a long time, bumping along at around €5/tCO2 for years - thanks to an initial oversupply of permits handed out to companies. Recent reforms to tighten up the ETS have caused the carbon price to rise rapidly in 2018 to over €20/tCO2, the first time it’s reached this level since 2008[72].

Introduction of the Carbon Floor Price

To its credit, the UK government recognised some years ago that the EU ETS carbon price was far too low to drive effective climate policy. In 2013 it introduced a top-up carbon pricing policy: the Carbon Price Floor (CPF). It sets a total carbon price in advance. Then depending on the EU ETS carbon price that year, it levies a charge on top of it to bring carbon pricing levels up to the CPF.

The initial idea behind the CPF was that it would rise every year to reflect the need to progressively decarbonise the economy and drive low-carbon investment. From a starting price of £9/tCO2, the CPF was to rise to £30/t by 2020, and £70/t by 203073. However, only a year after its introduction, the then Chancellor George Osborne froze the level of the Carbon Price Floor at £18/t. It has remained at this level ever since and will do so until 2021.

Industry exemptions – who picks up the tab?

The government has also granted heavy industry generous exemptions from the Carbon Floor Price and from paying the costs of some other UK climate change policies.While there are some good reasons for this, such as guarding against carbon

leakage – industry simply leaving the country and taking its pollution overseas – it's important to understand that wider society is essentially having to pick up the tab for heavy industry's ongoing pollution.

It's vital that industry invests in up-to-date, low carbon technologies to reduce carbon emissions.

The Carbon Price Floor though it's had its critics, has already been more successful than most observers ever expected in driving a dramatic reduction in coal use in UK power stations. It's also raised considerable revenues: £1billion in 2014/15, £1.2billion in 2015/16 and £1billion in 2016/17. This is set to fall partly due to the level being frozen74.

Uncertainty about CPF's future

By freezing it at a relatively low level rather than sticking with the original 'escalator', the CPF isn't generating the rising carbon price signal that is needed to decarbonise the economy. The uncertainty around the long-term future of the CPF has grown as successive Budgets have failed to significantly extend its lifespan or raise its level. Uncertainty discourages low-carbon investment decisions.

That uncertainty has been exacerbated by Brexit. Without a deal, the UK would automatically leave the EU ETS. Companies would no longer be subject to the now much strengthened carbon price signal coming from the trade in EU carbon allowances.

The impact of Brexit

The Government has stated that in a no deal scenario, the UK government will set the carbon price floor at £24 tonne75. NGO Sandbag argues that this would be considerably lower than current carbon price levels (£36/t). It is far too low to drive the UK's remaining coal power stations off the system. This could lead to a resurgence in coal, despite the Government's policy to phase it out by 202576.

Even if there is a Brexit deal, the currently uncertain nature of that deal casts doubt on future carbon prices. Some hard Brexiteers, such as Iain Duncan Smith, for example, have called for the Carbon Price Floor to be abolished after Brexit77. Soft Brexiteers on the other hand, want the UK to remain in the EU ETS. Climate Minister Claire Perry has said that dropping out of the ETS after Brexit is "in no-one's interest"78. Policy Exchange meanwhile points out that staying in the EU ETS means remaining subject to the jurisdiction of the European Court of Justice (ECJ), something rejected by Theresa May at an early stage of the negotiations. They speculate that the UK may therefore leave the ETS in 2021, after the end of the current Phase III79.

Whether we have a hard Brexit, soft Brexit, no deal Brexit or indeed remain in the EU, there is a cliff-edge approaching for carbon pricing policies in the UK.

The Carbon Floor Price is already too low. Even without the challenge of Brexit it needs to be overhauled to rise rapidly through the 2020s and extend its coverage across more sectors of the economy.

The Government urgently needs to raise more revenues to finance the low-carbon transition.

The case for a new Carbon Tax

There are growing calls for some form of new carbon tax post-Brexit.

For several years, the Grantham Institute – sometimes in collaboration with the Institute for Fiscal Studies – has published reports setting out the potential for a wide-reaching carbon tax to take the place of the CPF and ETS80.

The energy analyst Professor Dieter Helm has also made the case on a number of occasions for the UK to leave the EU ETS and put in place a high carbon price. As he said in an October 2016 briefing, "What matters is the carbon price, and the best way is to set it directly – a carbon tax"81.

In October 2018, the think tank Policy Exchange advocated a new carbon tax scheme for the UK in order to drive decarbonisation and low-carbon investment after Brexit82.

Economists of both right and left agree on the need for higher carbon taxes.

Even in the wake of the fuel duty riots in France, the left-wing French economist Thomas Piketty spearheaded a manifesto calling for carbon taxes to be levied across Europe at a rate of €30/tonne, alongside fresh taxes on wealth.

And in a possible sign of preparations for exiting the EU ETS, the UK Department for the Environment has recently commissioned research into the role a carbon tax could play in decarbonising the economy83.

Meanwhile, a wide range of environmental groups including Friends of the Earth are calling on the government to protect and raise the level of the existing Carbon Floor Price, as rumours swirl that it could be reduced in future84.

Friends of the Earth supports the case for a new carbon tax, regardless of how the Brexit negotiations play out. It's clear that one is needed to put a higher price on carbon pollution across the economy and raise public revenues towards the huge investments needed to decarbonise the economy.

A carbon tax is not a silver bullet and must not be used as an excuse to wipe away other climate policies, in the name of tidiness or free-market philosophy. The economy and human behaviour are more complicated than many economists like to pretend.

Designing a new carbon tax

To be effective, a new Carbon Tax would need to:

Avoid socially regressive impacts.

A poorly constructed carbon tax could create socially regressive outcomes. There are measures to avoid or mitigate these risks.

Some favour a carbon tax-and-dividend scheme where the proceeds of a carbon tax on big polluters are given as lump sums to all households.

An alternative approach is to use revenues to fund mitigation activities, for example each household receiving an energy efficiency voucher.

The carbon tax funds a huge public investment programme – a Green New Deal – that insulates fuel-poor homes, improves public transport and delivers a better society for all.

For people working in fossil fuel industries, such as North Sea oil and gas, a clear just transition programme is required, to re-train and redeploy workers to burgeoning new green industries, like offshore wind and electric car production.

Whichever approach is taken it is morally right that the poorest, who in general are the smallest polluters, must not be disproportionately impacted.

Put in place a high and rising carbon price signal.

This should be higher than the current total carbon price, as levied through the EU ETS and the frozen CPF.

Many other countries already have carbon prices in place far in excess of the UK's – Sweden's carbon tax, for example, is $139/tCO2 (£105). A new carbon tax must also rise over time, in order to send a clear and long-term signal to polluters and investors.

The current approach of chopping and changing policy every few years hinders long-term planning and undermines the certainty that investors need. The Swiss also have a law in place that requires the government to increase their tax should emissions not decline in line with targets. This would be worth exploring.

Expand over time

Over time a carbon tax would need to cover more sectors of the economy, levied at rates appropriate to drive changes within sectors. Currently 60% of UK emissions are not currently covered by the ETS or CFP.

Differentiated levels of carbon tax could be applied to different sectors, depending on how responsive they are to prices. The power sector has proven very responsive to even a relatively low carbon price signal, whereas domestic buildings and transport are much tougher to decarbonise. There are also some sources of emissions where, for reasons of social equity and political acceptability, other policies instead of a direct carbon tax would be more appropriate.

Raise large sums of money to fund the low-carbon transition.

A huge amount of investment is needed to decarbonise the economy, much of it likely to be public money – in the order of £22 billion per year. A carbon tax would not be expected to raise all of this, but it should make a significant contribution. Box 2 identifies other ways to raise the money for low carbon investment.

Avoid carbon leakage.

To avoid the risk of large polluters in heavy industry simply upping sticks and leaving the UK in response to a new carbon tax, there are options.

- They could be exempted from the tax, just as energy intensive industries are currently cushioned from the costs of decarbonisation policies.
- As advocated by Policy Exchange and Dieter Helm put in place carbon border tariffs that match the level of a carbon tax, thereby ensuring that domestic industries are not placed at a disadvantage relative to imports.
- A proportion of the revenues from a carbon tax could be channelled into funding low-carbon technologies for heavy industry to adopt, such as industrial carbon capture & storage, or renewably-powered electric arc furnaces for steel production.

Other policies to raise revenues for the low-carbon transition

While we see a new carbon tax as a central means for raising revenues to fund the low-carbon transition, it will not raise the sums needed on its own. Here are some other illustrative policies we think will be needed in addition to a carbon tax, to help raise the £22bn we need to fund decarbonisation each year:

Reallocate high carbon impact spending to low carbon

The government is investing record amounts on new roads, despite clear evidence that increasing road capacity increases traffic and therefore boosts carbon emissions.

In addition, the huge and growing cost of HS2 suggests that there are much better ways to reduce carbon at a much lower cost. That if the small carbon savings from HS2 in the distant future are even real, which is very unlikely (it is more likely HS2 will increase emissions).

Reverse tax cuts to the oil and gas industry.

The process of fossil fuel extraction doesn’t produce large quantities of direct emissions (apart from some flaring by oil rights), so this part of the fossil fuel supply chain will avoid paying much under the carbon tax. Recent years have seen the Government give generous tax breaks to the offshore oil and gas industry, to encourage more drilling. Taxes on North Sea oil and gas producers have fallen from

an effective rate of 62% to just 30%. This flies in the face of efforts to wean the economy off fossil fuels, as well as allowing extraction companies to profit from a common natural resource. The tax cuts should be reversed and extraction companies made to pay more towards fixing climate change.

Frequent Flyer Levy.

70% of all flights are taken by just 15% of people in the UK. A Frequent Flyer Levy, under which everyone would get one tax-free flight a year and then pay a rising tax thereafter, would incentivise frequent flyers to reduce the number of flights they take (for example, business travellers using videoconferencing more).

Reinstate differentiated Vehicle Excise Duty on luxury cars.

Former Chancellor George Osborne scrapped differentiated VED on cars. Over recent years sales of larger cars have increased significantly. If not captured by a carbon tax, a differentiated VED should be introduced which rewards the sale of smaller efficient cars and electric vehicles but penalises the sale of larger luxury cars.

Increase borrowing for investment.

The Conservatives and Labour both say they will borrow to invest in infrastructure at the level of around £500bn over 10 years. There is no law that prevents higher levels of borrowing, particularly for areas of high return[85]. Many investments needed for the low carbon transition have high returns on investments. When the social cost of carbon at £120/tonne is factored in, the return on investment for low carbon infrastructure is very high.

Conclusions

To conclude, carbon pricing is currently too low within the UK and a well-designed carbon tax is desperately needed. The primary purpose of a carbon tax is to drive change and provide investor confidence. But in addition it will also provide much needed finance for public spending and investment into the low carbon economy. The Grantham Institute for Climate Change will also be producing fresh research in 2019 on the different rates needed for different sectors, how to ensure that any tax complies with the polluter pays principle, and how to avoid socially regressive impacts. We look forward to drawing upon this.

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