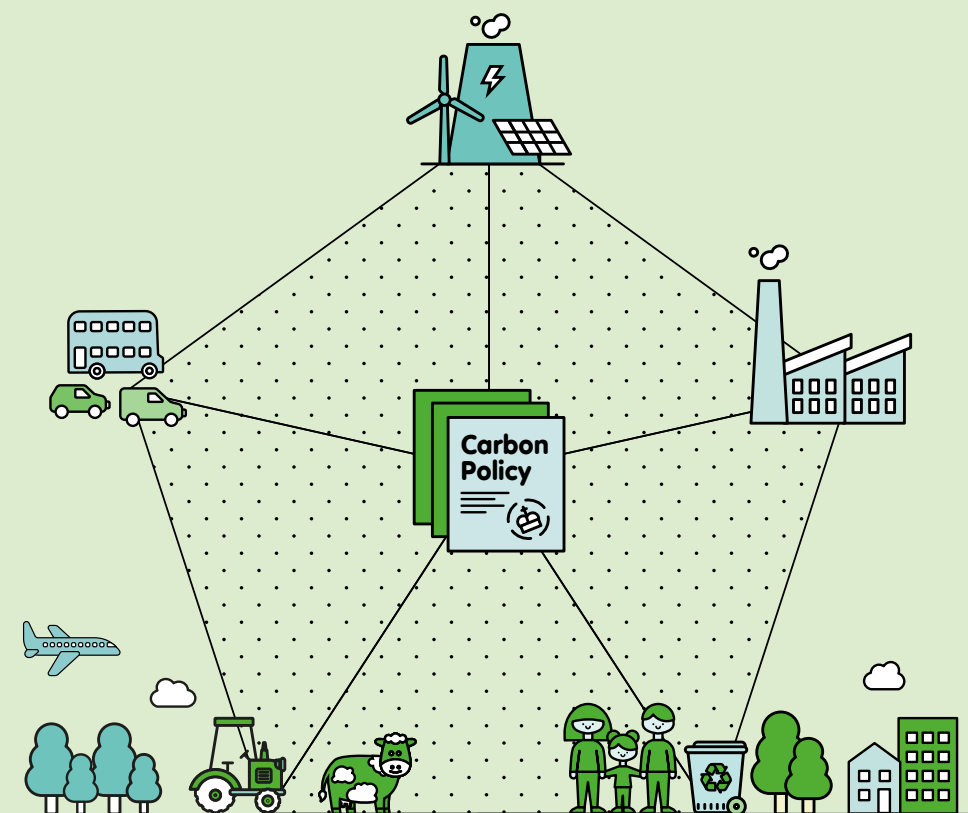




Rethinking Decarbonisation Incentives: Future Carbon Policy for Clean Growth

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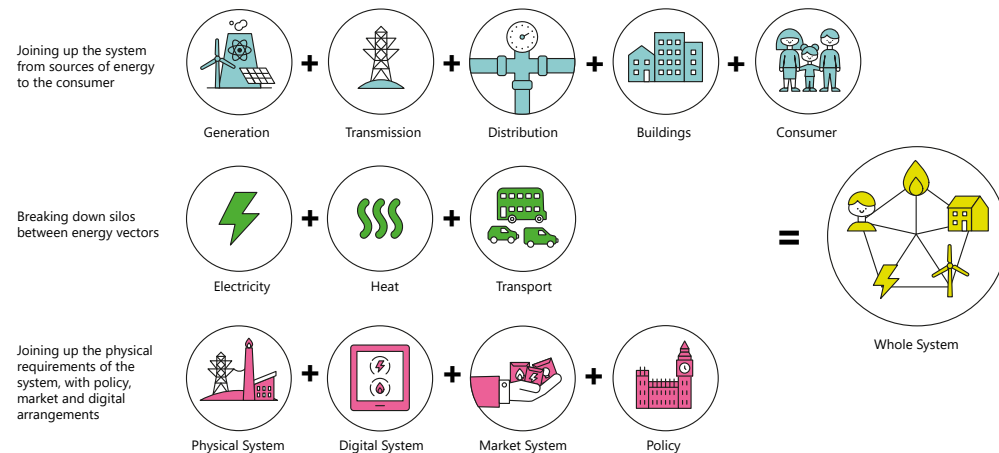
About Energy Systems Catapult

Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. The Catapult is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research. We take a whole systems view of the energy sector, helping us to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest cost.

We have more than 200 staff based in Birmingham and Derby with a variety of technical, commercial and policy backgrounds. We work with innovators from companies of all sizes to develop, test and scale their ideas. We also collaborate with industry, academia and Government to overcome the systemic barriers of the current energy market to help unleash the potential of new products, services and value chains required to achieve the UK's clean growth ambitions as set out in the Industrial Strategy.

Rethinking Decarbonisation Incentives is a major Energy Systems Catapult thought leadership project exploring how UK policies can promote clean growth by taking a whole systems perspective on carbon policy.

What is whole systems thinking?

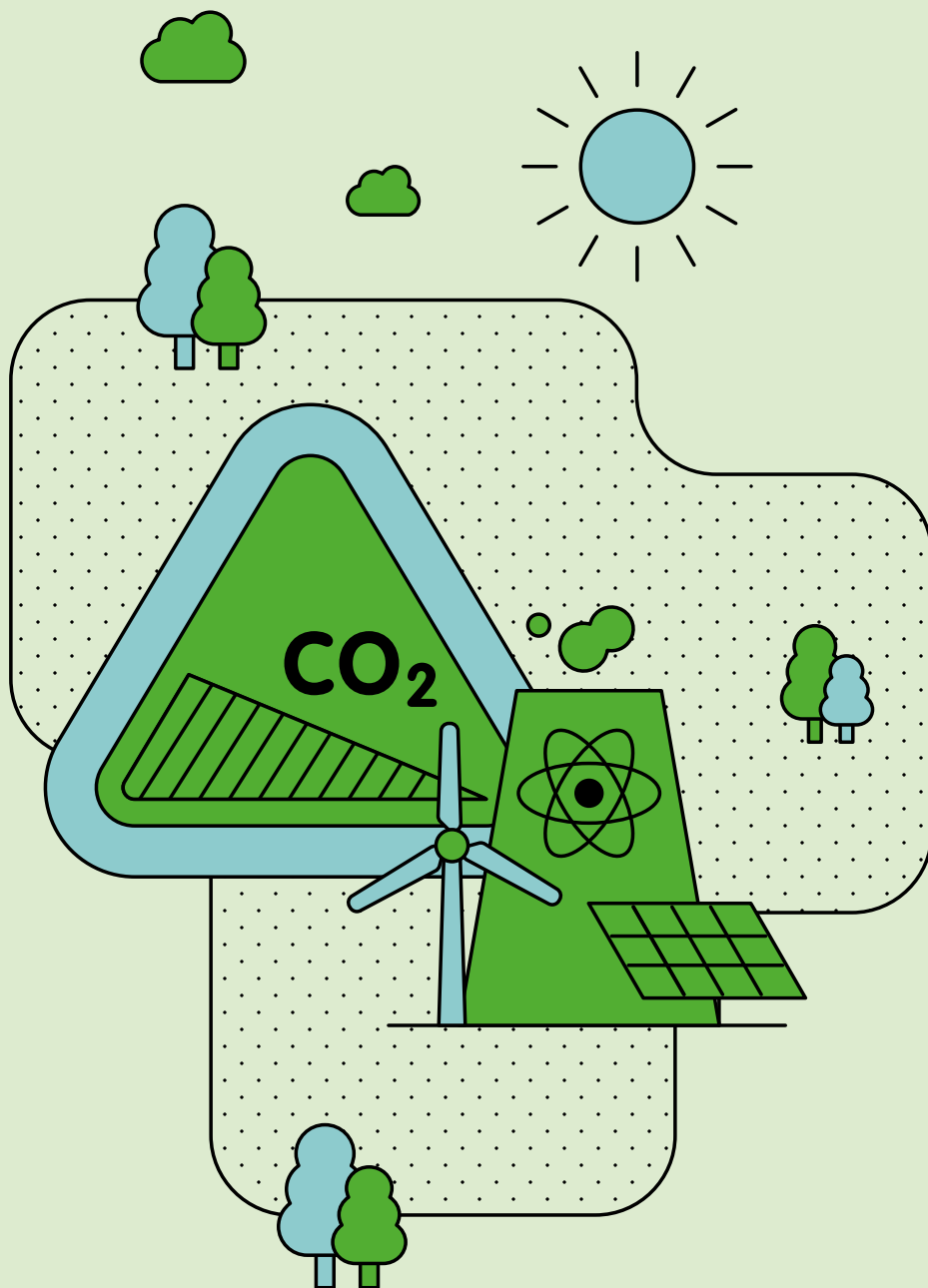


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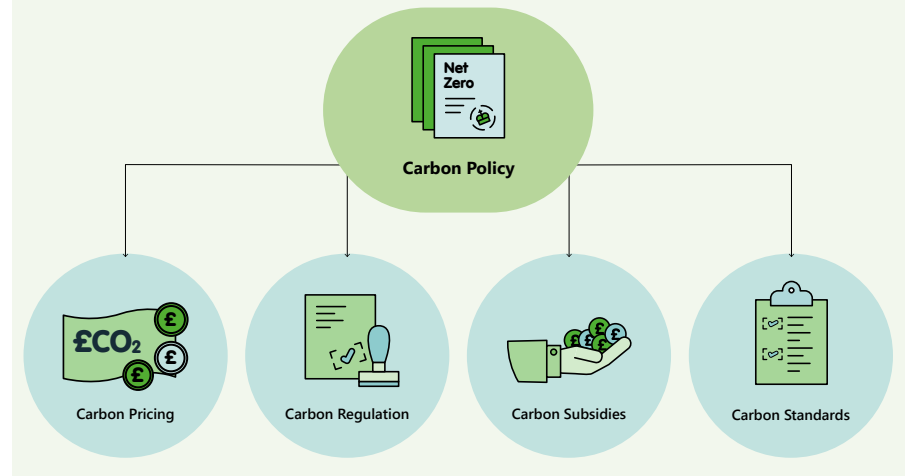




Executive Summary

Energy Systems Catapult's 'Rethinking Decarbonisation Incentives' (RDI) has explored how UK policies can promote clean growth by taking a whole systems perspective on carbon policy (see Figure 1).

Figure 1 Carbon policy is used as a shorthand for a wide set of policies that create economic incentives to reduce greenhouse gas emissions.



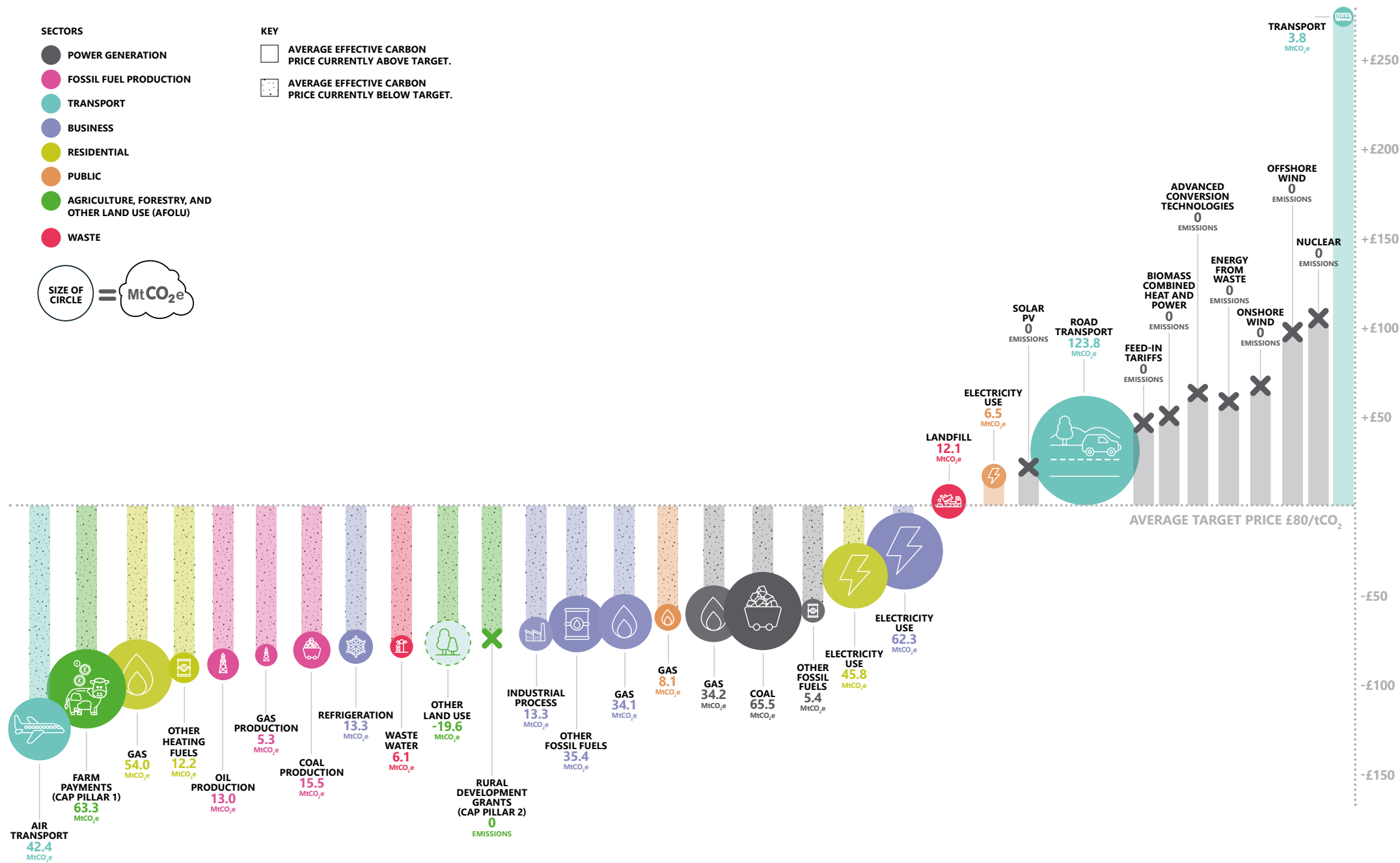
The UK's current economic framework for decarbonisation is uneven and incomplete

The UK has a complex mix of policies (including taxes, subsidies, standards, and regulations) which give rise to uneven and incomplete incentives to reduce greenhouse gas (GHG) emissions across the economy.

This is far removed from the textbook ideal of economy-wide carbon pricing and constrains low carbon innovation. However, it is clear that such an 'ideal' faces immense practical challenges. This report explores further options to improve the broader framework of economic incentives for decarbonisation ('carbon policy'), recognising those challenges.

'Effective carbon prices' are a measure of how much a firm or an individual is paid or rewarded per tonne of carbon (or CO₂e) saved when they make a choice that lowers emissions. The UK's current mix of policies creates 'effective carbon prices' across most of the economy that are too low to bring forward sufficient investment and innovation to reduce emissions (see full report for more detail). Effective carbon prices also vary widely across different sectors and activities (see Figure 2).¹

Figure 2 Effective carbon prices and emissions in the UK by sector.



Important sources of GHG emissions that currently have low effective carbon prices include:

- Residential gas use (circa 10-11% of emissions): Carbon emissions are not priced and VAT charged at only 5%.
- Agriculture (9% of emissions): No price signal is applied to emission-producing activities and the sector receives significant subsidies (of which only some target environmental outcomes).
- Air transport (7% of emissions): An air passenger duty is applied, but this is not related to the quantity of emissions and outweighed by the implicit subsidy from the zero VAT rating of air tickets. International flights make up the vast majority of UK aviation emissions. Flights within the EU are covered by the EU ETS, but the effective carbon price is low.

The current pattern of effective carbon prices also reflects policy choices shaped by other fiscal and societal objectives, for example:

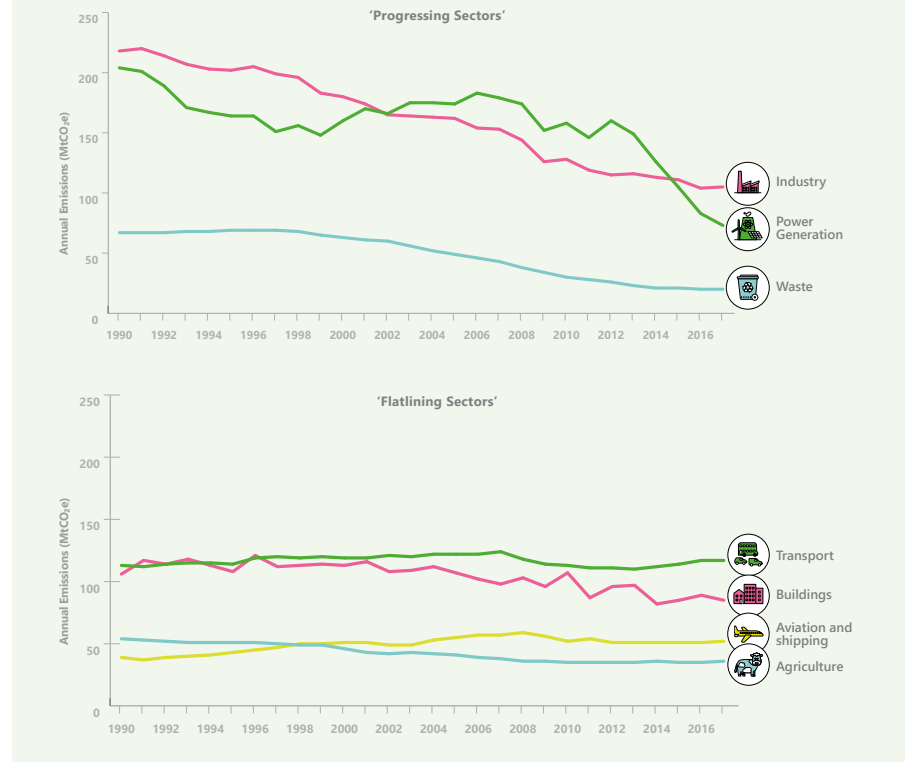
- Motoring is heavily taxed, but this only loosely aligns with incentivising choices that are less socially costly (i.e. less polluting and congestion causing). As more cars and vans are electrified, the significant fuel duty revenue will shrink and policy makers will need to reconsider alternative motoring taxation.
- Low carbon policy costs are recovered largely through electricity bills. This currently reduces incentives to cut emissions by electrifying heat and transport demand.
- The taxation of aviation emissions is constrained by international agreements, reducing incentives to make lower carbon travel choices.
- Public expenditure on agricultural policy support has been shaped by the Common Agricultural Policy (CAP) and is currently almost entirely disassociated from carbon impacts.

Reaching net zero will require strong and coherent economic incentives to reduce emissions and spur innovation across all sectors of the economy

The Committee on Climate Change's (CCC) recommendation of a net zero target for emissions by 2050 would widen the 'policy gap' that it has already identified in relation to the existing 80% reduction target.² The inadequacy of the current uneven and incomplete set of incentives to bring forward investment and innovation will become increasingly apparent (see Figure 3).

A net zero target means that, unlike the 80% target, no part of the economy can be exempt from investing in fundamental change and innovation to fully eliminate or offset emissions. Applying a polluter pays principle would imply that any sectors or activities with residual emissions in 2050 should bear the cost of offsetting greenhouse gas removals (GGRs) (i.e. negative emissions technologies). For example, if aviation proves impossible to fully decarbonise by 2050, then the cost of flying (or frequent flying) could include the costs of offsetting GGRs.

Figure 3 Progress in reducing emissions in the UK has been imbalanced.³



Achieving net zero will require all emitting sectors to work with governments to develop, implement, and sustain ambitious carbon policy reforms. Full decarbonisation of the energy system will be necessary, but no longer sufficient. The UK will need to decarbonise energy at a greater pace, address difficult to abate sectors in the near future, and develop options to remove greenhouse gases to offset any residual emissions during the 2030s. A whole systems approach with robust carbon policy design, implementation, monitoring, and evaluation will be essential.

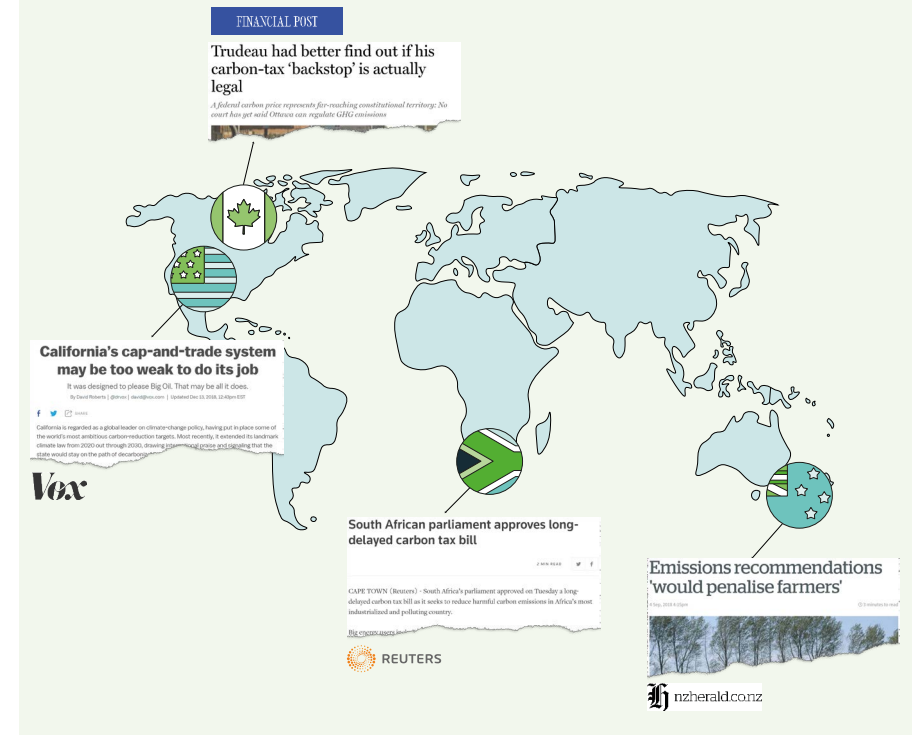
This does not necessarily mean that a single explicit carbon pricing policy (e.g. a carbon tax or emissions trading system) must be implemented economy wide. International experience to date supports using a mix of complementary policies within a strong overarching framework, although it is important to remember that no major market economy has yet achieved deep decarbonisation.⁴ Building a more coherent and enduring framework of economic incentives and market signals, including for GGRs, will be vital in delivering the scale of investment and innovation needed for deep decarbonisation.

A broad economy-wide carbon policy framework (comprising a mix of market, pricing, and regulatory interventions) can bring forward investment and innovation to deliver a cost-effective balance of emissions reduction. This will be vital for maintaining or enhancing UK economic competitiveness in a decarbonising world economy. The evidence suggests that a step-change in the economy-wide coherence and strength of incentives would also induce productivity enhancing investment in infrastructure and innovation (see full report for more detail).⁵ Traditional productivity measurement does not account for the positive value of output produced with lower emissions. In effect a cleaner economy is also a more productive one. It is worth stressing that the absence of prices that reflect the cost of pollution is economically inefficient, as it encourages more polluting activity than is desirable.

Explicit economy-wide carbon pricing is extremely challenging to implement

International experience suggests that it is very difficult to introduce ambitious economy-wide policies that focus explicitly on introducing a carbon price (i.e. carbon taxes or widely-applied cap and trade schemes). No major economy has yet succeeded in applying explicit carbon pricing policies at a sufficiently stringent level to deliver economy-wide progress in line with Paris Agreement objectives. In practice, sectoral concerns around competitiveness impacts and/or carbon leakage in key industries (e.g. iron and steel in South Africa⁶ or agriculture in New Zealand⁷) have limited stringency or required significant dilution of incentives through sectoral exemptions. The most ambitious jurisdictions have tended to apply a mix of sectoral and more generic carbon pricing policies, for example, California, USA⁸ and Canada⁹, but even these have proved politically challenging (see Figure 4).

Figure 4 International experience highlights the challenges associated with ambitious attempts to implement economy-wide carbon policy.¹⁰



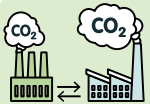
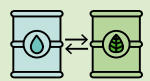
The UK's experience in implementing carbon pricing policies suggests that similar sectoral and distributional challenges apply, despite the economy-wide legal framework for emissions reduction created through the Climate Change Act 2008.

Key challenges for the UK remain in addressing the lack of incentives to reduce emissions from residential heating, given its potential impact on household energy bills and the difficulties of low carbon alternatives in a thermally-inefficient housing stock. Agriculture will also become an increasingly important source of emissions, but there are key behavioural and technical barriers that need addressing first (e.g. consuming less high carbon foods and improving measuring, monitoring, and verification techniques). The land-use sector will also be crucial for developing the biomass supply chain, a key component of achieving a net zero target.¹¹

There are a broad range of options to improve UK carbon policy and address anomalies and distortions, but there are no easy wins

We assessed five stylised options to reform UK carbon policy, in the context of the UK's current mix of policies and learnings from international experience.¹² The options we assessed are summarised in Table 1 below and represent a range of ambition and instruments (our full report contains a more detailed description of each). Our assessment aimed to build understanding of the likely challenges associated with each broad approach, as part of a process to identify promising policy options for more detailed analysis.

Table 1 Five stylised options to reform UK carbon policy.

	1. Aligning Sectoral Carbon Policies Adjusting existing sectoral policies to ensure that 'effective carbon prices' are broadly consistent across the economy and closer to the level required to meet carbon targets.
	2. Taxing Carbon Upstream Replacing current policies with a near economy-wide carbon tax at an upstream level on all fuels (at point of production or import), and direct sources of emissions from industry, waste, and agriculture. Complemented by measures to stimulate efficiency and innovation.
	3. Introducing a UK Emissions Trading System Replacing existing policies and membership of the EU ETS with a wider span UK emissions trading system, covering all fossil fuel use, industrial emitters, and power generators. Alongside complementary measures on efficiency and innovation.
	4. Setting Carbon Standards Setting tightening carbon standards (e.g. emissions per unit of energy) covering all forms of energy including electricity generation, and fuels used in transport and heating. Firms that outperform the carbon standard generate credits that can be sold to those who are unable to meet the standard directly.
	5. Taxing Carbon at Point of Consumption Applying a carbon tax on goods and services at the point of consumption, maximising consumer-visibility (through carbon labelling), and taking account of full lifecycle emissions for both imported and domestic production.

In the light of international experience, we concluded that the two economy-wide carbon tax options (Options 2 and 5) would be highly challenging to progress at the present time. Option 2 would have immediate economy-wide cost implications and present trade policy challenges. Option 5 would also raise major measuring, monitoring, and verification challenges.

Our assessment is that the remaining three reform options contain elements that provide more promising opportunities to improve UK carbon policy. But intervening to strengthen carbon incentives affects all parts of society and often interacts with other existing policies (e.g. fuel duty, lower rate VAT, etc.), so there are no obvious 'easy wins' for policymakers.

We recognise too that there are choices for policy makers about the extent to which they choose to focus primarily on one main option (e.g. creation of a UK ETS, or creation of carbon standards), or to adopt different elements in combination and/or sequence.

- Improving sectoral policies and addressing carbon policy gaps (see Table 2). This draws upon elements of Option 1 combining changes to improve the alignment of existing sectoral policies and introducing new policies to address clear omissions in current UK carbon policy incentives (e.g. for residential heating and agriculture). This could include some combination of the following measures:
 - Phasing in a levy on residential gas usage to fund targeted early heat decarbonisation investments. In effect, this would create an (initially low) carbon price on gas usage while reducing the current price distortion affecting choices between residential gas and electricity usage. A levy could also be used as a stepping stone to a more ambitious enduring carbon standard regime for residential heat (see below).
 - A move to make the carbon-related component of fuel duty explicit, aligning it on a medium-term basis with a target level, as part of a broader reform to motoring taxation to incentivise cleaner journey choices that cause less pollution and congestion.
 - Reforming air passenger duty to align aviation taxation with a target level, and make it more reflective of the actual emission impacts of journey/flight choices.

Table 2 Current carbon policies for each sector and policy gaps.¹³

Sector		Current Carbon Policy	Gaps
	Power Generation	EU Emissions Trading System Carbon Price Support Low Carbon Subsidies (e.g. CfD, FiTs, ROCs)	-
	Road	Fuel Duty Vehicle Excise Duty	Carbon component of fuel duty is not explicitly set.
	Air	EU Emissions Trading System Air Passenger Duty	No VAT on fuel or tickets.
	Rail	Fuel Duty	Carbon component of fuel duty is not explicitly set (for non-electrified rail).
	Industry	EU Emissions Trading System Climate Change Levy Climate Change Agreements Low Carbon Policy Costs (Electricity)	Currently receives significant compensation.
	Business & Public	Climate Change Levy Climate Change Agreements Low Carbon Policy Costs (Electricity)	Climate Change Levy rates for gas are currently low.
	Residential	Low Carbon Policy Costs (Electricity) Low Carbon Subsidies (e.g. RHI)	No existing carbon price for gas and a reduced VAT rate for both gas and electricity.
	AFOLU	-	No existing carbon price and fuel duty is very low on red diesel.
	Waste	Landfill Tax	-

- Introducing a UK Emissions Trading System (ETS). This is based on Option 3 and is also consistent with the Government's favoured post-Brexit approach to carbon pricing. A UK ETS could potentially be extended to broaden the scope of sectors covered by explicit carbon pricing (although the current consultation document does not suggest extending coverage of a UK ETS to residential gas usage¹⁴). The UK could also gain greater control over cap setting.
- Developing and introducing new long-term carbon standards. This would draw upon Option 4 and entails introducing carefully designed carbon standards (or mandatory carbon reduction obligations) applied to specified emitting sectors or firms. Such standards should be technology-neutral in design and aligned with longer-term carbon budgets. Flexibility in compliance and longer-term cost efficiency could be increased by allowing firms to trade verified carbon credits to comply with the standard. The framework would need clear definitions for its coverage, metrics, the obligated party, as well as regulatory arrangements for monitoring and compliance. In the medium-term, the market for traded carbon credit instruments could be linked with broader carbon markets/emissions trading.

The UK needs to develop a pathway towards more coherent incentives for emissions reduction across the economy based on a complementary mix of policies

A net zero emissions target brings into focus:

- The economy-wide challenge of decarbonisation.
- The importance of policies that are acceptable, but also salient and impactful on choices by consumers and investors.
- Our potential reliance on sustainable and socially acceptable methods of greenhouse gas removal.
- The potential advantages of moving towards a more coherent economy-wide policy framework.

A balanced economy-wide approach is likely to be best placed to promote an efficient - but inherently unpredictable - mix of low, zero, and negative carbon technologies across different emitting sectors. However, this does not necessarily require relying on a single ambitious economy-wide instrument, such as a carbon tax or economy-wide trading system.

Our assessment has identified a range of candidate reform options for policy makers to consider, as part of a process of moving towards a more coherent set of incentives. Work by other analysts also highlights additional options.¹⁵

Both UK and international experience suggests that detailed design of individual policies will be important from both an efficiency and distributional perspective. The need for a 'just transition' in relation to the costs and benefits of transition was also emphasised by the CCC in their net zero report.¹⁶ These considerations also inform the Energy Systems Catapult's Fair Futures work.¹⁷ Policy reform can and should be designed to align and interlock more coherently to create a balanced and broadly technology-neutral set of incentives for decarbonisation across the economy.

This suggests that all reforms to improve carbon policy should be considered as part of a longer-term pathway to a coherent economy-wide framework of carbon policy. A combination of reforms and simplifications of existing policies, along with carefully designed and targeted new policies, should be used to initiate the pathway.

A broad pathway can also be course-corrected and informed by large-scale trials, not only low carbon technologies, but also the performance of market structures and policy incentives.¹⁸

There are a series of considerations that should inform the development of the carbon policy reform pathway, which are summarised in Table 3.

Table 3 Key considerations to a pathway for carbon policy reform.

Key Consideration	Rationale
Focus on filling gaps in current carbon policy	• All sources of emissions need to be addressed, including difficult to abate industries, aviation, and agriculture and land use. • A number of key sources of emissions currently face effective carbon prices which are much too low, including residential gas usage, agriculture, and aviation. • Greenhouse gas removal options will require long-term investment, and there are currently no incentives to bring this forward.
Building long-term policy credibility	• The Climate Change Act 2008 provides a strong governance framework for target setting, but individual policies are generally not subject to the same statutory framework. • Governance is key, policy credibility to drive markets and investment depends significantly on its legislative and/or governance framework.¹⁹ Investor confidence in policy stability and longevity is crucial for its success. • Many reform options will require improvements in current measuring, monitoring, and verification capabilities (especially in agriculture) across the economy to ensure compliance and accurate reporting.
Integrating carbon policy across sectors	• Integrating policies across sectors by developing tradability or other linkages could provide more flexibility and greater scope for markets to reveal 'least-cost' combinations. Linking carbon credit markets could also open up future scope for linking to wider carbon markets. • Linkages across sectoral policies could prevent misalignments emerging and optimise the longer-term contribution of greenhouse gas removal technologies.
Creating incentives for greenhouse gas removals	• In the near-term, policy development is likely to require a combination of sectoral policies (e.g. specific agricultural support payments targeted to incentivise the adoption of emissions-friendly farming practices), specific support mechanisms for industrial clusters, etc. • In the medium-term there may be scope to move to a more generic market-based approach, where action to capture carbon is rewarded by tradeable carbon credits that reflect the emissions rating of processes (whether nature-based or industrial in character). • Such a market-based approach would require the creation of a more advanced carbon rating, verification, and regulation process.
Integrating carbon policy with wider policy objectives	• Through the Industrial Strategy²⁰ and the Clean Growth Strategy²¹ the UK Government has acknowledged the relationship between economic performance and carbon policy (e.g. the introduction of the Emissions Intensity Ratio). • Evidence suggests that good carbon policy can drive innovation and help to improve productivity.²² Given the scale of decarbonisation, the efficiency with which it is delivered is likely to be a significant influence of broader productivity growth. • Carbon policy choices have potentially large economic or fiscal impacts. For example, a carbon tax at the target carbon price (as determined by the Department for Business, Energy & Industrial Strategy in 2030²³) of £80/tCO₂ across the whole economy, would yield up to £27bn/year²⁴ (equivalent to a 4% reduction in VAT or a 6% reduction in the basic rate of income tax).²⁵ • Energy Systems Catapult's work on Local Area Energy Planning also points to the importance of local planning and investment co-ordination, particularly for heat decarbonisation.²⁶ There is a strong case to integrate carbon policy with other local planning and development objectives.

Carbon standards could play a key role in a pathway to a more coherent economy-wide framework of incentives

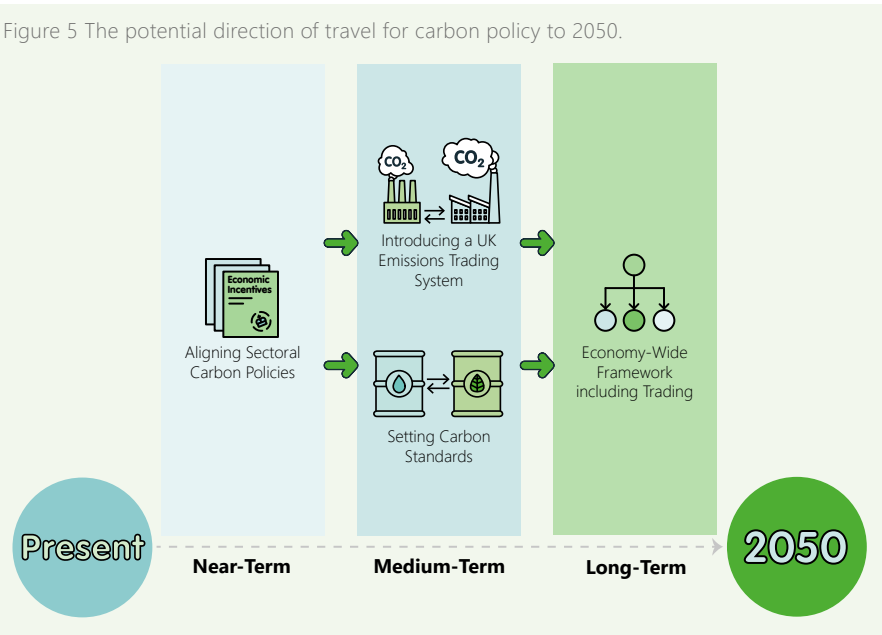
Approaches based on sectoral carbon standards and mandates have been used effectively in several jurisdictions to drive emissions reductions.²⁷ They can also be combined with a system of tradeable credits, allowing firms greater flexibility in compliance strategies. This design is similar to an emissions trading instrument in some important respects, but does not require allocation of allowances and may therefore have a lower impact on energy prices.



California Low Carbon Fuel Standard (LCFS)

The LCFS provides an example of a technology-neutral carbon standard, which aims to reduce road fuel GHG emissions by at least 10% by 2020. It also provides experience of developing processes for carbon rating, trading of credits, measurement, monitoring, and verification.

Our work suggests that carbon standards could play a key role as part of a pathway to an economy-wide carbon policy framework (see Figure 5). Standards can be used to shape markets so that they deliver coherent and balanced incentives for decarbonisation.



In the UK context, our analysis of current effective carbon prices shows that there is a key gap in carbon policy relating to emissions from the dominant fuel for residential heat (gas). Our work on cost-reflective pricing also shows that the current policy approach to low carbon cost recovery introduces a significant distortion around choices between domestic gas and electricity usage.²⁸

Sufficiently stringent direct carbon pricing is likely to be challenging to introduce for the residential heat sector, therefore, suitably designed carbon standards may provide a step towards an enduring market framework. The case for applying a similar carbon standards approach to drive down emissions from road transport could also be considered.

Our work on the Smart Systems Heat Programme for the Department for Business, Energy & Industrial Strategy has also pointed to the potential for an 'outcome-based decarbonisation obligation' on energy or energy service providers.²⁹ The importance of framing this in terms of 'outcomes' reflects the likelihood that technology solutions and systems integration challenges for low carbon heat solutions are likely to vary across different locations. This work concluded that such a policy instrument could help drive the creation of new business models and consumer-friendly low carbon heating offerings.

Design Considerations

However, it is critically important to get the design of standards right to avoid unintended consequences. Therefore, we commissioned Frontier Economics to analyse considerations around the design of a carbon intensity standard.³⁰ This work highlighted several key learnings (summarised in Table 4) which should inform the next phase of work to design a low carbon heat standard.

Table 4 Key learnings for designing a carbon intensity standard.

Key Learning	Rationale
Carbon standards trade-off pure economic efficiency and implementation practicality	A carbon intensity standard approach is second best in pure economic efficiency compared to direct carbon pricing through tax or an emissions trading system.³¹ Practical advantages centre around a lower direct impact on energy prices in price-sensitive market contexts (e.g. residential energy), since the cost incurred by suppliers of high carbon energy is offset by the revenue gained by low carbon suppliers. Current institutions and monitoring mechanisms would provide a good basis for monitoring compliance. Standard based approaches directly internalise costs, while avoiding new taxes or auction mechanisms, for emissions outside the scope of existing carbon pricing instruments.
The choice of metric and the obligated party for a standard is critical to deliver appropriate market incentives	Frontier's analysis highlighted that: • Intensity-based standards could over-incentivise consumption of energy with a carbon intensity below the standard. • This effect could be mitigated through complementary demand side measures or through a buyout price. • There are important practical considerations in choosing the point in the value chain at which a standard should be applied. Our analysis has also considered other potential metrics, such as a per-household emissions standard.
An economy-wide intensity standard is unlikely to be workable, but standards can be set on a sectoral basis	Frontier's analysis showed that setting an economy-wide energy carbon intensity standard will almost certainly over-incentivise consumption in one or more sectors (i.e. those with a starting carbon intensity below the standard). It is, however, possible to calibrate standards on a sectoral basis, according to the sector's starting position for emissions and the relevant lower carbon options. Sector-specific standards can be set and combined with a system of cross-sectoral carbon credit trading. This means that future carbon standards could be extended to other sectors (e.g. Frontier Economics examined the case for an intensity-standard in road transport fuel, including electricity).
Complementary policies are likely to be important	Technology-specific policies to incentivise innovation are still likely to be required to address market failures around innovation. Carbon standards may well need to be accompanied by a step up in policies to tackle fuel poverty. Demand side policies are still likely to be needed to correct market failures and to guard against incentives to over-consume energy. Other gaps in carbon policy may still need to be filled (e.g. top up of EU ETS prices).

Tradeable credits open up longer-term options to extend sectoral coverage and link with incentives for agriculture and greenhouse gas removals	Carbon standards can be combined with tradeable credits to provide an important means of flexibility in compliance with standards. Tradeable credits can also enable optimisation of emissions reductions effort across sectors, even with sector specific standards. This opens up the potential to create an interlocking set of sectoral carbon standards over time. In the longer-term, tradeable instruments could be part of a pathway towards a near economy-wide carbon price. There is potential to align sectoral credits with those generated by agricultural greenhouse gas removal policies, enhancing the scope for economy-wide optimisation.³² Approaches to carbon crediting could potentially take account of overlapping policies (e.g. upstream coverage of electricity in the EU ETS), or future decisions about a UK ETS.
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Overall, our assessment is that carbon standards could be used in the UK as part of a more gradual policy pathway towards a more coherent framework of incentives. Designing and introducing standards at a sectoral level may provide a way to circumvent the policy risk and complexity entailed in implementing economy-wide carbon pricing.

The stringency of carbon standards could also be transparently linked with carbon budget projections. This could provide a clear objective justification for policy, potentially enhancing its credibility with investors. The design of new standards can also be combined with complementary policies for energy efficiency, to address risks around over-incentivising use of low or zero carbon (i.e. credit generating) energy, or alleviate distributional impacts for those in difficult to decarbonise properties.

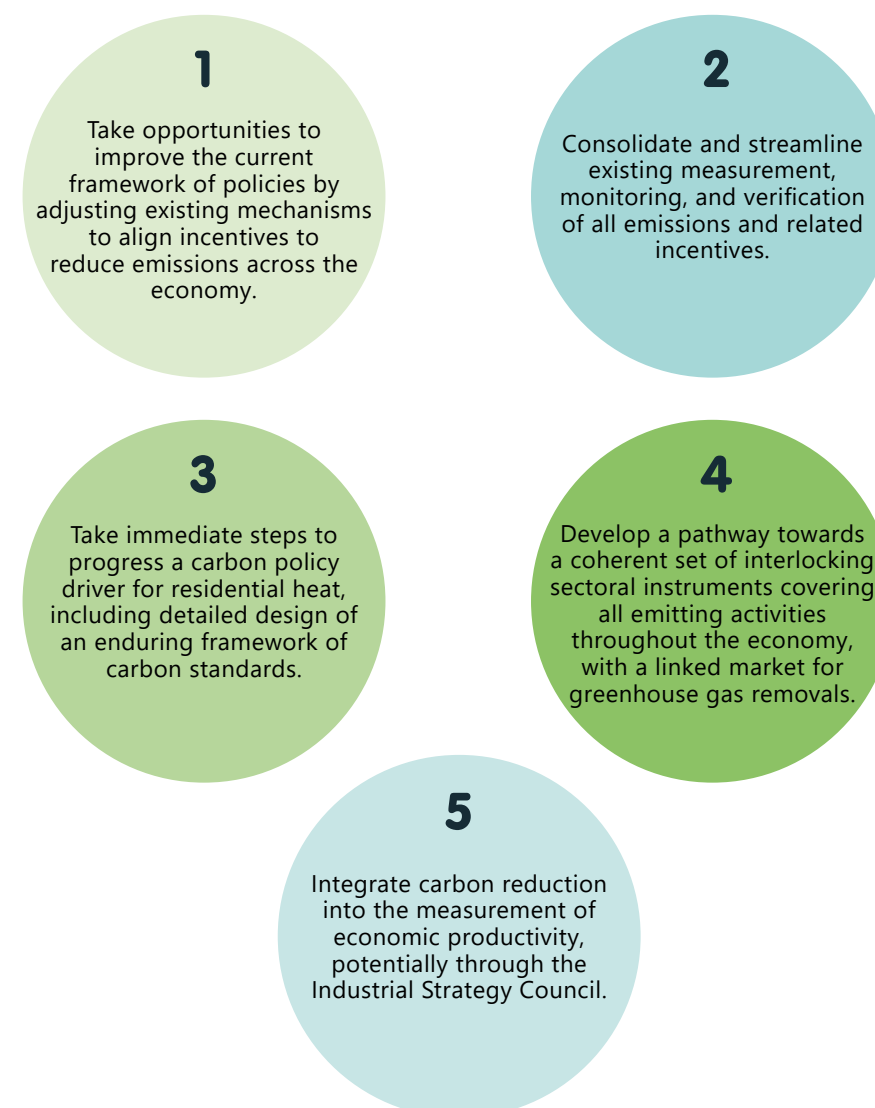
Our analysis also found that road transport fuels (i.e. biofuel, petroleum, diesel, and electricity) could potentially be covered by a carbon standard. In doing so, carbon standards would be set individually for sectors. The introduction of a tradability component between sectors (i.e. residential heat and road transport) would place the UK on a path to an economy-wide set of coherent carbon policies with credits also generated by negative emission technologies.

These factors suggest a strong case for considering carbon standards to strengthen incentives for decarbonising residential heat, and potentially road transport.

Recommendations

The Rethinking Decarbonisation Incentives project has shown that the UK can achieve a balanced economy-wide carbon policy framework to boost innovation and deliver clean growth, consistent with a net zero target in 2050. This does not necessarily require relying on a single ambitious economy-wide instrument, such as a carbon tax or economy-wide trading system. Rather it is possible for the UK to develop a pathway towards more coherent incentives for emissions reduction across the energy system and the wider economy by developing a complementary mix of policies. Carbon standards offer potential to play a key role in this pathway.

Acting on the following set of recommendations for policy makers will help put the UK on course for meeting its legally binding targets to reduce emissions in a cost-effective way.



Working towards better carbon policies

What next?

The Rethinking Decarbonisation Incentives project has helped us to better understand the nature and scale of challenges in improving carbon policies.

We plan to continue working on these themes, focusing on practical steps to promote clean growth, innovation, and investment across the whole energy system and economy. Potential themes include:

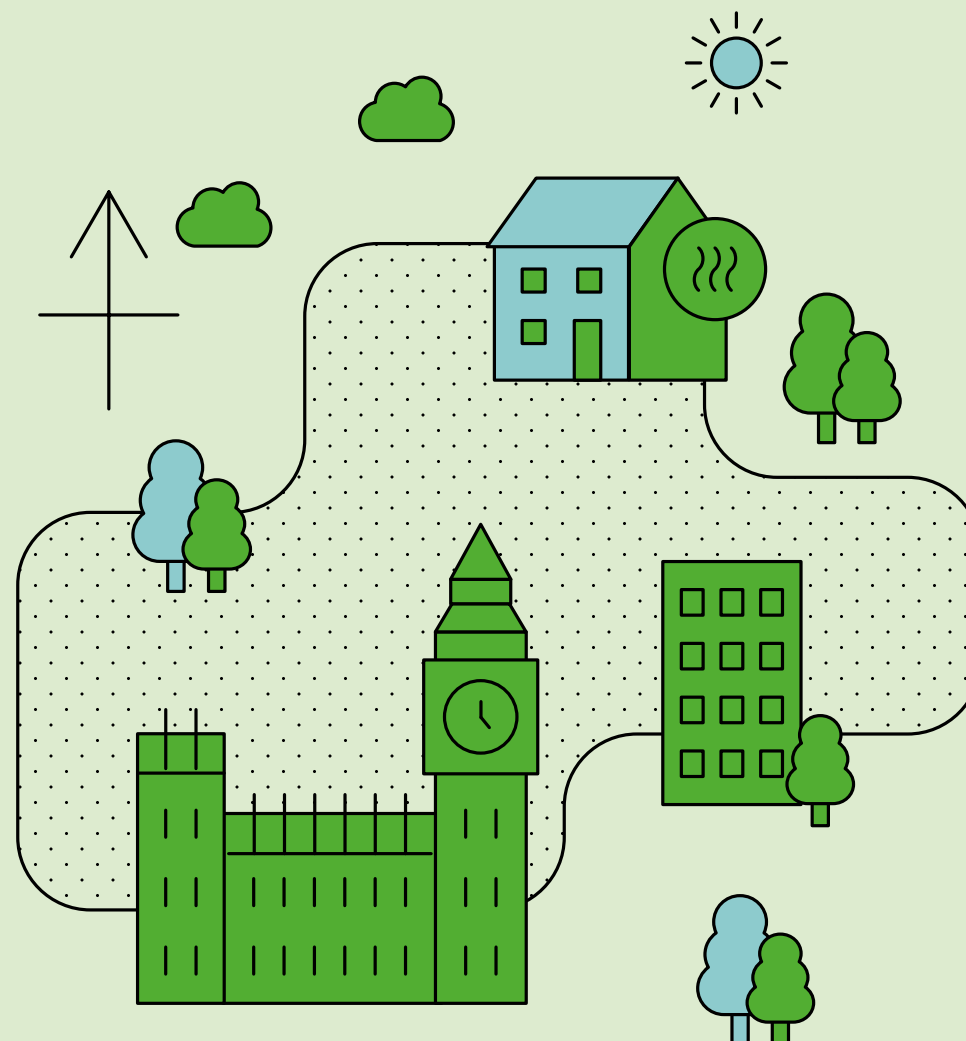
- Further developing carbon standards for low/zero carbon residential heat.
- Understanding the features of carbon policy that work best for industry and innovation.
- Examining strategic interactions with wider policy challenges (e.g. vehicle electrification, air quality, congestion, and motoring taxation).
- Improving the empirical basis for policy and incentives through more integrated greenhouse gas emission measuring, monitoring, and verification.
- Long-term policy to promote investment in options for greenhouse gas removals.

If you would like to work or collaborate with us in any of these areas, please contact Danial Sturge.

Further reading

All of the work carried out under the Rethinking Decarbonisation Incentives project can be found on Energy Systems Catapult's website, these include:

- Current Economic Signals for Decarbonisation in the UK, which summarised the current pattern of effective carbon prices for reducing emissions in different UK sectors and activities.
- Eleven International Case Studies analysed experience with decarbonisation policies in the USA, Canada, South Africa, New Zealand, and the EU.
- Synthesis of Key Findings from Case Studies drew together the relevant findings for UK carbon policy from the international case studies.
- Reform Options: Initial Thinking aimed to build understanding of the likely challenges associated with each broad approach, as part of a process to identify more promising policy options for more detailed analysis.
- Sectoral Assessment for Agriculture, Forestry and Other Land Use (AFOLU) highlighted the issues and challenges associated with policy mechanisms to deliver climate mitigation in the AFOLU sectors.
- Carbon Policy and Economy-Wide Productivity explored the links between carbon policy and economy-wide productivity.
- Near-Term Options to Address Low-Priced Emissions presented available opportunities to increase and align effective carbon prices through adjusting existing measures.
- Setting Standards for Carbon Intensity considered designing carbon standards for domestic heating and the road transport sectors.



Introduction

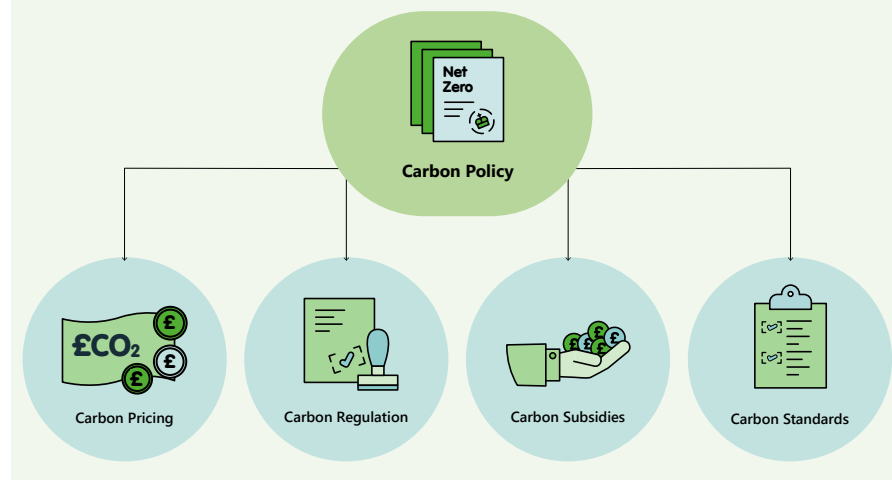
The UK has clear, legally binding long-term targets to reduce greenhouse gas emissions (GHG) to net zero by 2050, but the economic incentives to do so are complex and changeable. A combination of taxes, subsidies, standards, and regulations create rewards for cutting emissions that are mostly much lower than they need to be and vary widely across different sectors. This is inefficient, pushing up the cost of meeting carbon budgets and making it more difficult to promote long-term investment and innovation in low carbon solutions.

The Government has published a Clean Growth Strategy³³, but unlike other jurisdictions around the world (e.g. California and Canada) there is relatively little strategic debate about:

- The broad pattern of economic drivers for decarbonisation,
- How to create an enduring framework for carbon reduction across the whole economy.

The 'Rethinking Decarbonisation Incentives' (RDI) project has explored filling this gap and how UK policies can promote clean growth by taking a whole systems perspective on carbon policy.

Figure 1.1 Carbon policy is used as a shorthand for a wide set of policies that create economic incentives to reduce greenhouse gas emissions.

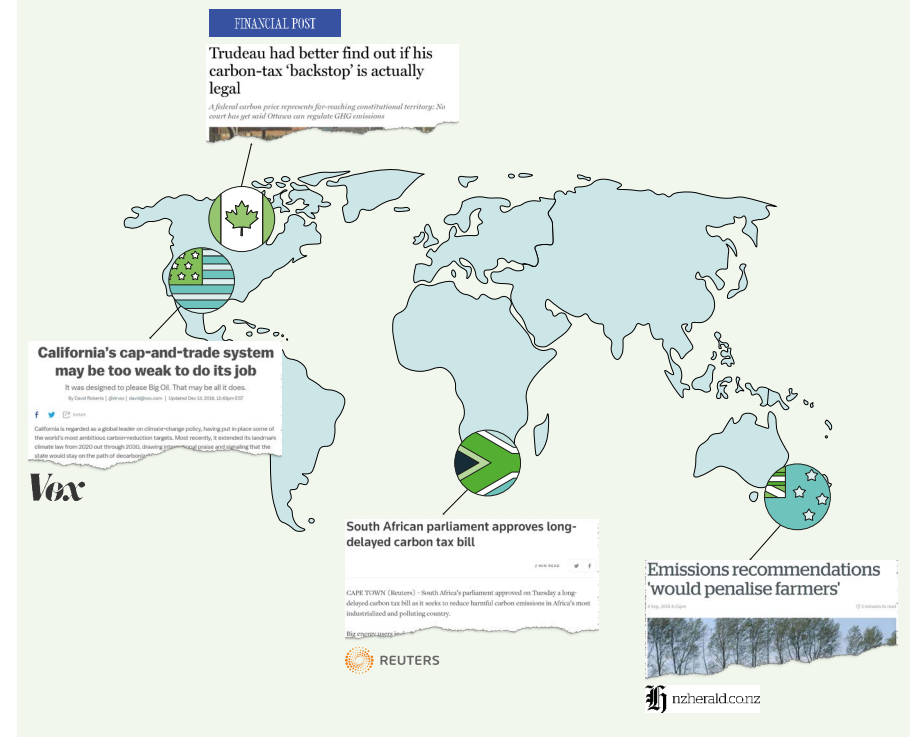


1.1 Current Carbon Policy Framework

The current policy framework is made up of many, often overlapping, policies that target GHG emissions in the UK. The result of which is a complex interaction where incentives for emissions reduction differ depending on economic activity even though their environmental impact is the same.

In a 'first-best' policy world, an economy-wide carbon price would in principle be more efficient than the current patchwork approach to reducing emissions.³⁴ However, practical experience around the world suggests that introducing 'first-best' carbon pricing policies remain extremely challenging for governments (see Figure 1.2).

Figure 1.2 International experience highlights the challenges associated with ambitious attempts to implement economy-wide carbon policy.³⁵



In addition, policies that affect the incentives for decarbonisation are often mixed with other policy objectives such as:

- Raising revenue,
- Supporting particular technologies,
- Protecting industrial competitiveness, and
- Addressing other externalities, for example, fuel poverty and other (related) environmental impacts such as air pollution.

In addition, some sectors may be less responsive than others to carbon pricing; for example, if there are relatively few affordable decarbonisation options, or where carbon pricing is less salient to decision-making due to non-price barriers. These factors can reduce the effectiveness of pure price signals, particularly over shorter time periods, and point to the need for other types of policy intervention. It is, therefore, understandable that variations in economic signals have often arisen for policy reasons.

Table 1.1 How current effective carbon prices apply to emitting activities and low carbon alternatives.

Sectors where current effective carbon prices are broadly aligned with expected target prices for 2030 include:

- Solar PV and the most recent offshore wind bids of Contracts for Difference (CfD) auctions.
- Possibly road transport (if the value of congestion and other externalities is offset against tax receipts).



1.2 Whole System Carbon Policy

The variation and mix of incentives currently in place in the UK suggest that, to date, policy-making has been formulated largely on a sector-specific basis. This reflects the different policy objectives and practical challenges that arise in each sector. In practice this means that policies affecting emissions vary in operation, design, and strength across sectors (see Table 1.2). International case studies show a similar variation across sectors in many other countries.³⁹

Table 1.2 Carbon policy considerations and impact on sectors.

Policy Consideration	Impact on Sectors
Efficiency	Sectors vary in their ability to incentivise emissions reduction, encourage innovation, and often come up against barriers for sending a strong price signal.
Practicality	Ease of administering carbon policies varies widely between sectors, for example, accurately measuring, monitoring, and verification of emissions is relatively straight forward in the power sector, but extremely difficult in the agriculture sector.
Impact on consumers and competitiveness	Considerations of the impact on vulnerable customers (e.g. fuel poverty) and heavy industry (e.g. carbon leakage) often determine the level of ambition of carbon policies and the resulting strength of the economic incentive.
Transition	With existing policies in place, which sectors have often invested heavily in order to comply with, transitioning to new policies must be carefully considered.
Related policy objectives in the wider economy	Co-benefits of policies must also be considered, for example, job creation, tackling air pollution, raising revenue, and protecting industries. All of these have a direct impact on the design and implementation of carbon policy.

A whole systems perspective on carbon policy involves treating decarbonisation explicitly as a challenge for the whole energy system, and in turn for the whole economy. There are a number of potential reasons for doing this:

- All economic sectors and parts of our energy system produce GHG emissions.
- The energy system underpins all economic sectors to some degree, and is responsible for a majority of total GHG emissions.
- Reductions in emissions are equally valuable across the whole economy, but current policies only reward emissions reductions in some areas and not others.
- A whole systems approach to policy could help to get the right balance of investment to reduce emissions across the whole economy.
- This could enable a more efficient overall transition to a net zero economy, with incentives to deliver the biggest emissions reductions per £ of investment.

From a whole systems viewpoint, carbon policy is taken from its current siloed approach to one that results in the following features:

- A set of balanced incentives for decarbonisation across all emitting activities throughout the economy.
- Rewards emissions reduction where it is most economically efficient to do so.
- Broadly technology and sector neutral, allowing for unexpected innovation to occur.
- Transparent in terms of governance.
- Politically enduring and stable over time.
- Based on achieving a set of objectives, akin to the Climate Change Act 2008.
- Provides interaction and flexibility between sectors (e.g. through trading) to encompass a coherent, whole systems framework.

A whole systems approach to carbon policy does not necessarily reduce to a particular ‘first-best’ design of a single or main policy instrument, for example, through explicit carbon pricing such as a carbon tax or emissions trading system. Rather, it describes an approach that takes full account of the interaction between emitting activities and the policies and regulations applied in those markets. The aim should be to create a broadly balanced framework of incentives to reduce emissions while remaining politically salient and accepted by the public.

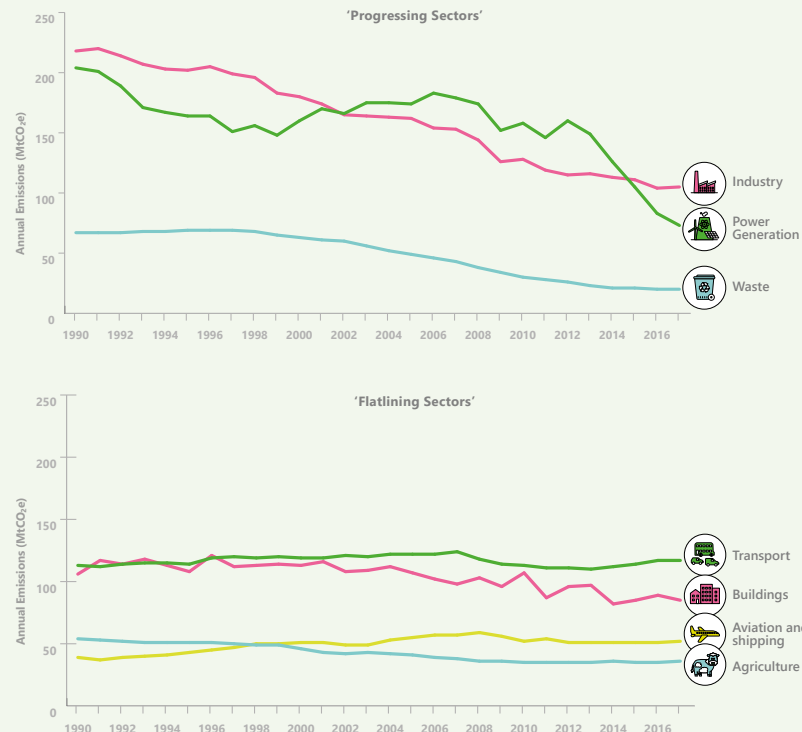
Developing tradability across sectors can provide more flexibility and greater scope for markets to reveal ‘least-cost’ combinations of measures to reduce emissions; and to incentivise innovation in crucial greenhouse gas removal (GGRs) technologies. This requires improvements in current measuring, monitoring, and verification capabilities (especially in agriculture) across the economy to ensure compliance and accurate reporting.

1.3 Achieving Net Zero

Following publication of the Intergovernmental Panel on Climate Change’s (IPCC) Special Report on the impacts of global warming of 1.5 degrees⁴⁰, the government requested⁴¹ the Committee on Climate Change’s (CCC) advice on setting the UK’s long-term emissions target in the context of achieving net zero⁴². In May 2019, the CCC recommended to Government that “the UK should set and vigorously pursue an ambitious target to reduce greenhouse gas emissions to ‘net-zero’ by 2050, ending the UK’s contribution to global warming within 30 years”.⁴³

The UK’s previous target of an 80% reduction by 2050 has now been substantially amplified by this commitment. By doing so, the shift in agenda no longer exempts any part of the economy from emissions reduction, even if they are perceived as being ‘too difficult to abate’. The inadequacy of the current uneven and incomplete set of incentives to bring forward investment and innovation will become increasingly apparent (see Figure 1.4). Therefore, achieving net zero will require governmental departments to work together on a whole systems approach to carbon policy. In addition successive governments will have to continue to develop, implement, and sustain ambitious policy reforms across all sectors of the UK economy.

Figure 1.4 Progress in reducing emissions in the UK has been imbalanced.⁴⁴



In the near-term, there is substantial potential to improve the coherence of economic drivers across the whole economy; either by aligning the existing sectoral policies and addressing clear omissions (e.g. for residential heating and agriculture), or by introducing and broadening the scope of more widely applied policy instruments (e.g. emissions trading and/or carbon standards). Crucially, in the attempt to achieve net zero, there is an opportunity to implement policies that places the costs of eliminating emissions on those who emit and reward those who yield negative emissions (i.e. greenhouse gas removal technologies).

Introducing policies to require or reward action to capture carbon from the atmosphere. Net zero will require action on all sources of emissions, including difficult to abate industries, aviation, and agriculture and land use. A more coherent set of incentives for decarbonisation will therefore need to apply to these areas:

- In the near-term, policy development is likely to require a combination of sectoral policies (e.g. specific agricultural support payments targeted to incentivise the adoption of emissions-friendly farming practices); specific support mechanisms for industrial clusters, etc.
- In the medium-term there may be scope to move to a more generic market-based approach, where action to capture carbon is rewarded by tradeable carbon credits that reflect the emissions rating of processes (whether nature-based or industrial in character).
- Such a market-based approach would require the creation of a more advanced carbon rating, verification, and regulation process.

Governance is key. The impact of decarbonisation policies on markets and investment depends significantly on its legislative and/or governance framework. Investor confidence in the stability and longevity of the policies is important for success. Complementary policies may be required to address other barriers to abatement, which carbon pricing or regulation would not address, for example, job creation, distributional impacts, and energy security.

Fundamentally, the UK is going to have to implement the available technologies to decarbonise sooner, actively reduce emissions in the difficult to abate sectors, and develop the techniques and technologies to realise negative emissions to offset any residual emissions. In this context, taking a whole systems approach to carbon policy as well as ensuring good design and implementation becomes even more important.

In the next section, the report begins by drawing links between carbon policy and economy-wide productivity by asking the question of: how important, in productivity terms, is it to get carbon policy right?

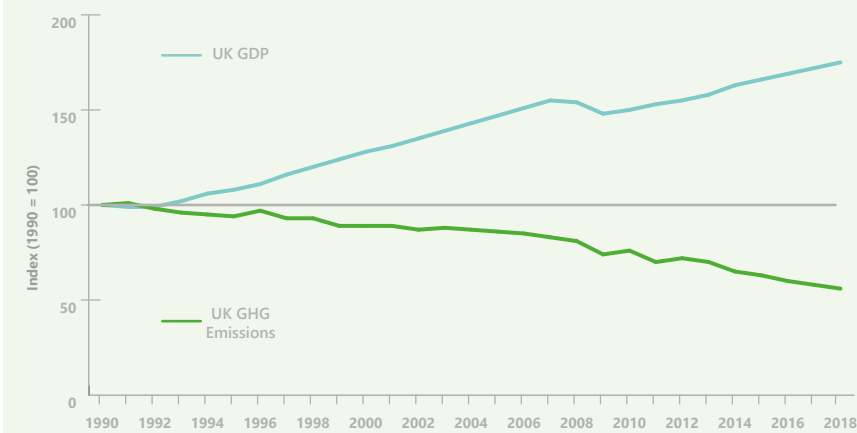
The third section describes five stylised reform options for future carbon policy, drawing on experiences from international case studies and discussing the relevant sectoral impacts.

Finally, the fourth section takes a near- and medium-term view of carbon policy; first by addressing what the near-term options are, then looking towards 2030 and beyond at what a future mechanism might look like for the UK.

Getting Carbon Policy Right

Carbon policy is more than just a tool for reducing emissions, the UK can seize this opportunity to improve living standards through improved productivity. The UK has reduced emissions by 42% since 1990⁴⁵ while the economy has continued to grow (see Figure 2.1), but productivity growth has stalled. Through the Industrial Strategy⁴⁶ and the Clean Growth Strategy⁴⁷, the UK Government has clearly acknowledged the relationship between economic performance and carbon policy (e.g. the introduction of the Emissions Intensity Ratio). This indicates that policy makers are beginning to consider how to make growth 'clean' and how to increase productivity. However, much of the progress to date has been through industrial change (e.g. offshoring manufacturing emissions). As such, significant challenges remain for the UK economy, including persistent poor productivity performance. Therefore, if the UK's aims are to continue to grow GDP and reduce emissions, then going forward the UK must put carbon policy at the centre of economic policy considerations. At the moment, clear articulation of how carbon policy is linked to productivity is missing, but such a framework would help guide policy decisions.

Figure 2.1 Trends in UK economic growth and greenhouse gas emissions.⁴⁸



2.1 Carbon Policy and Economy-Wide Productivity

Greenhouse gas emissions are currently largely unpriced/underpriced in productivity measurements, which focuses on GDP per capita or per hour worked. Therefore, the benefit of emissions reduction (i.e. less damaging, higher quality goods and services) is not fully reflected in official statistics. A more complete measurement of productivity would provide more accurate signals to help improve future productivity by directing money, jobs, and efforts into sectors most likely to grow.

Box 1: Does the failure to account for carbon externalities have a material effect on how we might account for recent productivity trends in the UK?

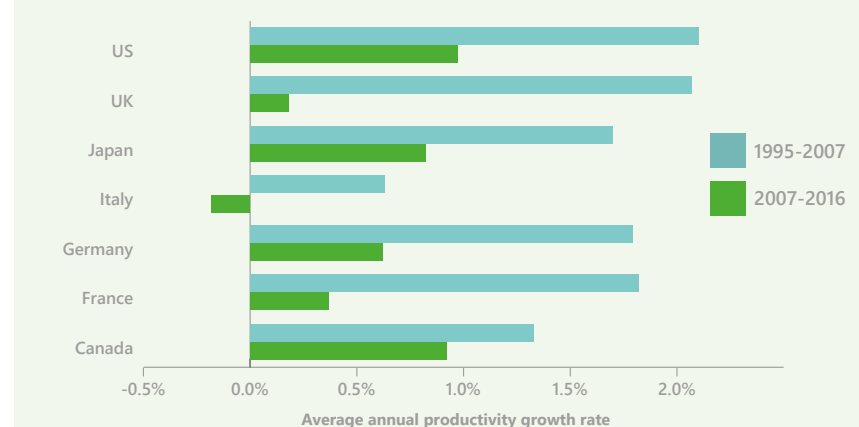
The amount of emissions that are avoided in the UK each year through actions to date can be multiplied by a carbon price to understand their value. The precise magnitude of the estimate depends on the carbon price used. Absent of any abatement since 1990, the UK would have emitted an additional 215.6 MtCO₂ by 2016. If this is multiplied by the carbon price used in government appraisals (£4.20 for traded and £66 for non-traded)⁴⁹ then the total value of avoided emissions is approximately £7.5bn or 0.4% of GDP (assuming half of the reduction came from the traded sector).

Higher carbon prices are expected in the future and if the predicted carbon prices (even holding emissions reductions constant at 2016 levels) for 2025 are used, then there is a more significant effect on GDP at nearly 0.6%. As carbon prices continue to rise further, then by 2030 the impact on GDP could increase to 1%.

Appropriately accounting for the value of avoided greenhouse gas emissions could increase productivity by a small but not insignificant amount. Furthermore, this captures only one aspect of how carbon policy affects productivity (i.e. the direct impact of reduced emissions). Other, larger, drivers of productivity growth (e.g. skills) would also be affected by comprehensive carbon policies.

Productivity, as it's currently measured (GDP per hour worked) grew between 2-3% per year from the 1970s until the early 2000s in the UK and comparable countries such as Germany, France, and the USA. However, since the global financial crisis, productivity in the UK has been largely stagnant while other countries have continued to see modest increases (e.g. ~1% per year in the USA and Canada), as shown in Figure 2.2. Had the UK seen this kind of productivity growth then it would be approximately 20% higher than it is today.

Figure 2.2 UK/G7 productivity growth before and after financial crisis.⁵⁰



The following explores the links between carbon policy and economy-wide productivity and what the evidence suggests for policy.

What does the literature say?

Table 2.1 is a summary of evidence from a literature review in relation to four research questions.⁵¹

Table 2.1 Summary of evidence from a literature review addressing four research questions.

Research Questions	Summary of Evidence
Through what mechanisms do carbon policies influence productivity?	• Theoretical effect is ambiguous. • Compliance costs reduce productivity as resources are diverted away from production. However, regulations may improve productivity if firms are not already optimising. • If innovation is induced, productivity could improve.
Does the choice and design of carbon policies affect the capacity of the economy to innovate?	• Strong evidence that market-based policies are associated with increases in innovation ('narrow' Porter Hypothesis). • Good evidence that strategic investment by government is associated with more innovation. • More ambiguous on the impacts of standards and engagement.
Does the choice and combination of carbon policies have any particular implications for productivity over time?	• Substantial literature demonstrating that increases in innovation are associated with improved productivity. • Literature linking carbon policy and productivity directly is less available and very context-specific. • Literature generally finds small positive effects of market-based policies and less clear results of other types of carbon policy.
How important, in productivity terms, is it to have a coherent set of economic carbon abatement drivers and how could this be measured or quantified?	• Most of the literature uses micro-data linking very specific policies to firm-level outcomes. • Very difficult to extrapolate to the macroeconomic effects from this, but the few studies that exist suggest a small positive effect of up to 5% of productivity growth.

Conclusions

The findings of the literature review lend themselves to three conclusions for policy:

1. **Policy needs to be informed by a more complete measurement of productivity.** Traditional productivity measurement does not account for the positive value of outputs produced with lower emissions. In effect a cleaner economy is also a more productive economy. The importance of clean growth within the overall Industrial Strategy suggests that the Industrial Strategy Council should consider how its interpretation of productivity and future productivity growth is affected by complete measurement and valuation of carbon abatement
2. **Carbon pricing and environmental standards help drive innovation in the production of less damaging outputs.** The appropriate policy and length of time to deliver new innovation will vary from sector-to-sector, but the existing evidence suggests a strong link between the two. This economic 'free lunch' (i.e. an increase in output that is not commensurate with the increase in effort/cost necessary to bring it about) means the UK should implement ambitious long-term, pro-innovation policies.
3. **Carbon policies need to adapt to the specific context to improve aggregate productivity.** The evidence suggests that how a policy is designed and implemented matter more for its success as the initial choice of policy instrument. Factors such as the credibility and stability of a policy are likely to be as important as the type of policy.

These conclusions bring policy design and productivity measurement to the forefront of the debate about how to ensure carbon policy supports and enhances productivity growth.

The next section of the report explores economy-wide carbon policy options, drawing learning from international case studies with consideration of potential impacts to key sectors.

Future Carbon Policy Options

In the UK, the debate surrounding economy-wide carbon policy, and especially carbon pricing, tends to be focused on Emission Trading Systems (ETS)⁵² (in particular cap and trade) and Carbon Taxes⁵³. Indeed, 45% of emissions are currently covered by the EU ETS, with electricity generation paying an additional carbon tax through the Carbon Price Support. This section of the report explores five stylised policy options to improve decarbonisation incentives across the UK economy, recognising both uncertainty about future UK participation in the EU ETS, and the wider context of the Clean Growth Strategy.

Box 2: International case studies

A set of eleven international case were carried out to explore the policy approaches to decarbonisation (or related objectives) in jurisdictions around the world. The ones chosen represent a wide range of relevant policy examples that amongst them:

- Have jurisdictions with a similar economy to the UK,
- Cover the broad economy or multiple related policies,
- Are long-standing,
- Have trading systems,
- Attempt to address competitiveness issues,
- Cover all sectors of the economy,
- Cover a diverse range of types of policies,
- Are implemented upstream or downstream.

Below is the list of case studies, which include examples of standards, subsidies, tradable certificates, and interacting suites of policies, as well as carbon pricing instruments such as carbon taxes and cap and trade schemes:

- Interaction of Climate Policies in California⁵⁴
- California Low Carbon Fuel Standard⁵⁵
- EU Automotive Emissions Standards⁵⁶
- EU Emissions Trading System⁵⁷
- Italy Energy Efficiency White Certificates Scheme⁵⁸
- Netherlands Renewable Energy Support Schemes⁵⁹
- New Zealand Emissions Trading Scheme⁶⁰
- Pan Canadian Carbon Pricing⁶¹
- South African Carbon Tax⁶²
- Sweden Energy and Carbon Tax Policy⁶³
- US SO₂ Emissions Trading⁶⁴

Box 3: Carbon policy design considerations⁶⁵

Drawing on the key findings from the eleven international case studies found in Box 2, a set of design considerations for carbon policy were developed:

Coverage and Point of Regulation: the coverage of a carbon policy determines which greenhouse gases and sectors will be subject to any resulting price signal. Considerations include:

- Sector selection and the reasons why (e.g. availability and costs of abatement options, difficulty of measuring emissions).
- The point at which the policy is placed relative to the point of emission (e.g. an upstream approach can ensure comprehensive coverage and lower costs).

Price Signal and Policy Certainty: carbon policies generally require a target to be set to underpin the economic incentive. The robustness of this target and its surrounding governance framework will strongly affect the credibility of the policy and the emission reduction outcomes that are achieved. Considerations include:

- Type of target (e.g. cap on volume of emissions, emission intensity per unit of activity, or implicit target used to set a carbon tax rate).
- Protecting competitiveness of industries.
- Trade off and balance between economic circumstances and the need for policy certainty.

Governance: the impact of carbon policies on markets and investment depends significantly on its legislative and/or governance framework. Investor confidence in the stability and longevity of the policies is important for success. Considerations include:

- Roadmap for governance:
 - An independent and legally enshrined policy framework.
 - Substantial political will at a centralised level.
 - Robust stakeholder engagement process.
- Stakeholder acceptance to build investor confidence.

Policy Interactions and Harmonisation: complementary policies may be required to address other barriers to abatement, which carbon pricing or regulation would not address. Considerations include:

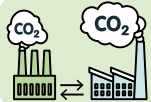
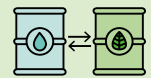
- Complementary policies used to address market barriers and additional objectives (e.g. job creation, energy security, etc.).
- Managing overlaps between carbon pricing and other policies (e.g. target setting in one mechanism will need to account for the impact of another), so that distinct objectives are achieved.

International harmonisation can provide abatement options not available in a standalone system (e.g. EU ETS).

3.1 The Reform Options

Using the design considerations for carbon policy described above, five stylised reform options were developed in order to identify options and build understanding of likely challenges. The carbon policy options are intended to illustrate the range of potential approaches open to the UK and were selected so that they represent a combination of quantity and price mechanisms, applied upstream or downstream, and cover a broad range of entities and general policy approaches.⁶⁶ The options listed below in Table 3.1 are ambitious, and range in feasibility.

Table 3.1 Five stylised options to reform UK carbon policy.

	1. Aligning Sectoral Carbon Policies Adjusting existing sectoral policies to ensure that 'effective carbon prices' are broadly consistent across the economy and closer to the level required to meet carbon targets.
	2. Taxing Carbon Upstream Replacing current policies with a near economy-wide carbon tax at an upstream level on all fuels (at point of production or import), and direct sources of emissions from industry, waste, and agriculture. Complemented by measures to stimulate efficiency and innovation.
	3. Introducing a UK Emissions Trading System Replacing existing policies and membership of the EU ETS with a wider span UK emissions trading system, covering all fossil fuel use, industrial emitters, and power generators. Alongside complementary measures on efficiency and innovation.
	4. Setting Carbon Standards Setting tightening carbon standards (e.g. emissions per unit of energy) covering all forms of energy including electricity generation, and fuels used in transport and heating. Firms that outperform the carbon standard generate credits that can be sold to those who are unable to meet the standard directly.
	5. Taxing Carbon at Point of Consumption Applying a carbon tax on goods and services at the point of consumption, maximising consumer-visibility (through carbon labelling), and taking account of full lifecycle emissions for both imported and domestic production.

In addition to the brief descriptions above, each of the policy options are described in further detail in the following pages and contain the following:

- A list of the policy instruments used to set economic incentives to reduce emissions, and
- Additional details relevant to the policy.

There are also boxes containing brief descriptions of international case studies relevant to each reform option as well as a discussion of the sectoral impacts it might have for road transport and residential heating. These sectors were chosen for analysis because they both rank high in terms of overall emissions, and the choices surrounding them also significantly impact government revenue (e.g. fuel duty), non-carbon policy objectives (e.g. air pollution, fuel poverty), infrastructure investment (e.g. EV charging network, hydrogen heating), behavioural change (e.g. use of EVs or heat pumps), and increased costs for households with potentially high distributional impacts (e.g. increased heating bills).

Agriculture, forestry, and other land use sectors are covered separately in Section 3.2.

Aligning Sectoral Carbon Policies

Policy Instruments: EU (or UK) Emissions Trading System (ETS), Climate Change Levy (CCL), Climate Change Agreements (CCAs), Climate Change Support (CPS), and Fuel Duty.

Policy Details:

- The UK remains in the EU ETS or an ETS continues in the UK under the same basis as the current EU ETS in terms of coverage.
- Existing policies are adjusted to increase the coverage and coherence of decarbonisation incentives, for example, normalising VAT for residential gas consumption and sales of transport fuels are covered by a reformed fuel duty (denominated by carbon content and aligned with the required carbon price).
- Carbon leakage risks are contained through free allowance allocations and CCAs, which are available only to qualifying trade-exposed emission-intensive activities.



Aligning Sectoral Carbon Policies: Relevant international case studies⁶⁷



California uses a cap and trade scheme as a backstop policy to manage any shortfall in emissions reductions from complementary measures. This combination of a cap and trade scheme and a range of other sector-specific policies for transportation (e.g. fuel portfolio and vehicle emissions standards) and electricity generation (e.g. renewable energy trading system and energy efficiency standards) covers 85% of the state's emissions. California's Air Resources Board (CARB) chose this combination of policies because a cap and trade scheme was considered insufficient on its own to meet targets, as it would not address non-price barriers such as incentivising innovation.



The Canadian federal government is seeking to establish a consistent set of carbon pricing systems across Canada through the Pan-Canadian Framework on Clean Growth and Climate Change (PCF). Through this, provinces have the autonomy to design their own carbon pricing mechanism (e.g. taxes, emission trading systems, offsetting mechanisms, and hybrids). A back-stop made up of a carbon tax on all fossil fuels and an output-based pricing system for large industrial facilities (designed to protect competitiveness), will be applied to jurisdictions whose own policy fail to meet the minimum stringency standards or who choose it. However, the federal government is facing significant political challenges from province governments who oppose the policy.

Aligning Sectoral Carbon Policies: Potential sectoral impacts for road transport and heating⁶⁸



If fuel duty was reformed to account for the specific carbon content of different road transport fuels and aligned with the social cost of carbon, then it could significantly lower the tax rate for all fuels (in particular petrol and biofuels); depending on the percentage of fuel duty that is assumed to be linked to emissions reduction. This would reduce the overall decarbonisation incentive, which risks increased emissions from the sector, as well as worsening air pollution and congestion. Government revenue would also be affected by a lower tax rate; however, this is an issue that will eventually need addressing as the uptake of EVs increases.



85% of UK households are currently connected to the gas grid and use a gas boiler for heating, therefore, a modified CCL or carbon tax essentially focuses on natural gas. Pricing natural gas to reflect the social cost of carbon will significantly increase bills (by 23% for the average household⁶⁹) and result in an increase in the fuel poverty gap. This increases further for residential users who are off the gas grid and rely on other heating fuels, which have an even higher carbon content. It is also unlikely that a tax alone will incentivise the residential sector to decarbonise heat, therefore, complementary policies would be required to stimulate behaviour change and yield the required infrastructure investment.

Taxing Carbon Upstream

Policy Instruments: Carbon Tax and Reformed Fuel Duty.

Policy Details:

- UK opts out of the EU ETS and removes existing carbon/climate change taxes.
- An upstream carbon tax is introduced to cover all fuels for energy related purposes (including transport, heat, and electricity generation).
- The carbon tax is also applied to direct emissions from industry and waste.
- Transport fuel duty is reformed to focus on revenue raising and other externalities, such as congestion and air pollution.
- Border tax adjustments are introduced for trade-exposed activities/products.
- Complementary measures are introduced to encourage investment in behavioural measures, innovation or infrastructure to address barriers that carbon pricing alone cannot.



Taxing Carbon Upstream: Relevant international case studies⁷⁰



South Africa is on a decade long journey to implement an ambitious carbon tax to reduce economy-wide GHG emissions. The carbon tax, which aims to cover 90% of emissions, highlights the challenges of designing a carbon policy that aims to introduce a uniform carbon price throughout the economy. The tax design has evolved significantly, incorporating a number of exemptions, phasing, offsetting, and revenue recycling, which will result in a very low carbon price for some sectors such as industry. The agriculture, forestry and other land use (AFOLU), and waste sectors are not included in the first phase, citing difficulties in measuring, monitoring, and verification of emissions.



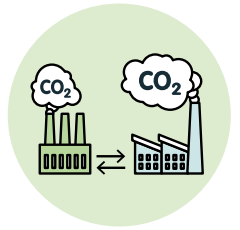
Sweden introduced an upstream carbon tax in 1991, which builds on the energy tax that dates back to the 1930s. The taxes are applied to the supply of fossil fuels and electricity, covering 77% of emissions. The carbon tax has been designed to protect industrial competitiveness and social equity concerns (e.g. cost of heating based on geographical location). Despite having the highest carbon tax rates in the world (~£111/tCO₂e), political support has remained high, partly because it has had no negative impact on Sweden's economy.

Introducing a UK Emissions Trading System

Policy Instruments: UK ETS and Reformed Fuel Duty

Policy Details:

- The UK opts out of the EU ETS and introduces its own ETS covering emissions from all fuels and industries.
- The CCL, CCAs, and CPS are all replaced by the UK ETS.
- Fuel duty is modified to limit the impacts on transport fuel prices.
- Direct emissions from waste and agriculture are not covered.
- Complementary measures are introduced to encourage investment in behavioural measures, innovation or infrastructure to address barriers that carbon pricing alone cannot



Introducing a UK Emissions Trading System: Relevant international case studies⁷¹



The EU ETS has been a core part of EU climate policy since it was established in 2005. It covers more than 11,000 installations in 31 countries (including all 28 EU member states), and covers 45% of emissions. Policy makers have faced a number of challenges however, not least in how to maintain a strong decarbonisation incentive given the turbulent economic conditions of the last decade. In addition, protecting industries have been a major factor in the systems design. The EU ETS remains a strong model for decarbonisation policy and is looking to be further linked to other similar systems in the future.



During the 1990s, the US established the world's first ETS to reduce Sulphur Dioxide (SO₂) emissions. The scheme, called the Acid Rain Programme (ARP), shows the importance of providing policy certainty to regulated entities to facilitate planning. ARP was enshrined in legislation, and its statutory nature meant it was predictable and transparent, reducing the risk of legal challenge. An important design feature was that it largely avoided imposing additional regulations, which maximised the cost effectiveness of the scheme because obliged entities were free to choose their best response strategy.



The New Zealand ETS was implemented in 2008 as the government's principle policy response to climate change. It is one of the few countries that has seriously considered including agriculture, but ultimately decided not to do so; citing reasons such as potential negative impacts on the dairy industry, complex measuring, monitoring, and verification of emissions, and a perceived lack of abatement options. An independent committee was established with the responsibility to manage the supply of allowances to ensure a strong price signal. The government is required to determine the supply of allowances every five years, providing an element of policy certainty while maintaining stability.

Introducing a UK Emissions Trading System: Potential sectoral impacts for road transport and residential heating



The strength of the incentive would ultimately depend on the ETS price, which is a result of key design features such as the level of the cap, greenhouse gases covered, allowance distribution method, etc. Therefore, it is unclear what the effects will be on fuel prices, but given current EU ETS rates, it would be a small amount compared to current tax rates. Integration of road transport fuels via supplier obligations into an ETS can be expected to lead to monetary flows from the transport sector to other covered sectors. This would result in less emissions reduction within the transport sector in the near-term.



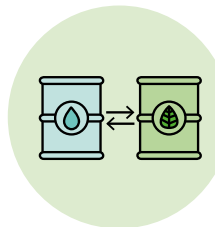
Bringing residential heating fuels into an ETS would result in the same carbon price being applied to both electricity and gas. From the perspective of consumers, the inclusion of upstream fuel suppliers into the system is similar to a carbon tax, i.e. the carbon price will be reflected in energy bills. An ETS alone is unlikely to drive significant emissions reduction from heating because of existing mismatches of incentives and benefits between developers and owners. Therefore, incentivising the installation of energy efficiency measures and low carbon heating technologies will still be required. Revenue raised from emission allowance auctioning could be used to subsidise programmes promoting uptake of low carbon heating systems and address fuel poverty impacts.

Setting Carbon Standards

Policy Instruments: Carbon Standard(s) and Modified Fuel Duty.

Policy Details:

- The UK opts out of the EU ETS and removes CCL, CCAs, and CPS, as well as specific support for renewables (e.g. CfDs, RHI).
- A single standard could be set to cover transport, heat, and electricity (e.g. expressed in CO₂ per unit of primary energy) or a number of sector specific standards.
- The carbon standard is applied to suppliers of electricity, and fuels for transport and heating. The standard is set to tighten progressively in line with carbon budgets.
- In either case, credits would be tradeable across sectors. This would establish a near economy-wide carbon market.
- A variation of this option is discussed in more detail in Section 4.2.1.



Setting Carbon Standards: Relevant international case studies⁷²



California implemented the Low Carbon Fuel Standard (LCFS), which is a market-based mechanism to incentivise the use of low carbon fuels in transport. A carbon intensity target for fuel is set annually, and obligated fuel suppliers can comply by either acquiring certificates on a traded market or by supplying low carbon fuels. A legal challenge questioning the robustness of the lifecycle analysis (LCA) when used to measure emissions from indirect land use change from the production of biofuels led to revisions of the methodologies used. Complimentary policies, such as tax rebates, have been used to address the demand side (i.e. by increasing the uptake of electric vehicles).



EU Automotive Emissions Standards set CO₂ emission intensity limits that must be achieved on average across all new cars and vans sold across EU markets each year by a manufacturer. The performance standard allows variations between each vehicle type, but the overall targets treat manufacturers consistently. The standard has led to significant improvements in emissions performance of new vehicles sold, but they do not directly target reduced use of the vehicles themselves.

Setting Carbon Standards: Potential sectoral impacts for road transport and residential heating



Petroleum currently has the lowest emissions intensity (MtCO₂e/Mtoe) of the main fuels used in the UK (i.e. natural gas, electricity, and petroleum). Therefore, an economy-wide intensity target would be unlikely to incentivise further change in the transport sector in the near-term. In order to overcome this, a sector specific target could be used. Special attention to the non-carbon effects of biofuels should be given, especially indirect land use changes and air pollution. The loss of fuel duty would impact governmental revenue, for which this policy option would not be able to replace.



If the obligation to meet the standard is placed at the supplier level, then this instrument creates an incentive for residential energy suppliers to decarbonise their fuel portfolio. The incentive will be strongest for gas suppliers and in the near-term it has the potential to address demand-side efficiency given that fuel switching is the main alternative. In the long-term these options include expanding district heating, promoting the installation of heat pumps, and exploring the use of hydrogen; given these have infrastructure requirements, complementary measures will be needed. Further support for fuel poor homes will be required, but without revenue being raised centrally, it may add further challenges.

Taxing Carbon at Point of Consumption

Policy Instruments: End-User Carbon Tax.

Policy Details:

- The UK opts out of the EU ETS and removes CCL, CCAs, CPS, Fuel Duty, as well as specific support for renewables (e.g. CfDs or RHI).
- The consumption-based carbon tax can either be applied as a:
 - Levy by retailers at point of end use, based on a certified assessment of a service or a product's full lifecycle emissions
 - 'Carbon Added Tax' (similar to VAT) on the amount of carbon added at each stage of production and distribution of goods and services.
- Carbon labelling and lifecycle carbon accounting is developed in all sectors.



Taxing Carbon at Point of Consumption: Potential sectoral impacts for road transport and residential heating



A Carbon Added Tax (CAT) would require real-time carbon footprint monitoring to ensure accurate costs are passed along the supply chain. A Carbon Levy would require similar measuring, monitoring, and verification systems, but would also be able to account for emissions from the use of fuel in the consumer's vehicle. Both will continue to raise revenue for the government, and could also accelerate the transition to EVs through the use of carbon labelling as consumers become aware of the price impact carbon has on their vehicle and fuel choice.



In the near-term, this approach could increase gas prices significantly as it not only accounts for the carbon released from burning the fuel, but also the emissions associated with extracting, processing, and distributing the fuel itself. This will significantly impact fuel poor homes, but the revenue raised could be used for benefits and grants such as the current Winter Fuel Payments and Cold Weather Payments. Ensuring measuring, monitoring, and verification of emissions is comparable between suppliers and fuel types will be key to sending accurate price signals through to consumers.

3.2 Policy Options for Agriculture

The five stylised policy options described above do not account for emissions from the agriculture, forestry and other land use (AFOLU) sectors. Indeed, these sectors are seldom covered by policies to incentivise lower emissions.

The AFOLU category is the combination of two distinct sectors, Agriculture and Land Use, Land Use Change and Forestry, as reported in UK GHG statistics:⁷³

- Agriculture accounts for 9% of the UK's emissions (45.6 MtCO₂e)
- Land Use, Land Use Change and Forestry are a net sink for UK emissions (-9.9 MtCO₂e)

Emissions reduction in the AFOLU sectors are both different from, and in many ways more challenging than, emissions reduction in other sectors of the economy. The international case studies highlight the policy challenges, including a perceived lack of abatement options, complex measuring, monitoring, and verification requirements, and the inherent risk of carbon leakage.⁷⁴ To date, mitigation has been slow, with even cost-effective reductions not being delivered. A lack of action on forestry has led to a flatlining of carbon sequestration. Progress is essential in order to generate learning on emissions reduction techniques and policy options, leading to improved cost effectiveness. As emissions reduce in other sectors such as power and transport, then agriculture and land use related emissions will account for an increased proportion of the remaining total. Therefore, changes in these sectors are an essential part of the UK's transition to a net zero future.

These issues and challenges were explored separately, Table 3.2 summarises the main characteristics of each policy option, including the implications for other sectors.⁷⁵

A balanced economy-wide approach is likely to be best placed to promote an efficient - but inherently unpredictable - mix of low, zero, and negative carbon technologies across different emitting sectors. However, this does not necessarily require relying on a single ambitious economy-wide instrument, such as a carbon tax or economy-wide trading system.

The above assessment has identified a range of candidate reform options for policy makers to consider, as part of a process of moving towards a more coherent set of incentives. In the next section the near- and medium-term options for addressing emissions are discussed as part of the pathway to an economy-wide carbon policy framework.

Table 3.2 Summary of AFOLU policy options.

Policy Option	Strength of Incentive Signal	Feasibility	Impact on Other Sectoral Policies
Tradeable Credits: Generated by Emissions Reduction in the AFOLU Sectors	↑ High – but with risk of poor targeting, and unwanted secondary impacts, e.g. on biodiversity.	→ Medium – mechanisms to address risks of poor targeting would add to complexity.	Caps would need to be tightened to reflect the availability of credits.
Emissions Trading	↑ High (in principle) – but measures to tackle feasibility (e.g. reduced coverage) may reduce effectiveness.	↓ Low – measuring, monitoring, and verification challenges are a significant barrier.	↓ Low.
Public Expenditure Support: Farming	↑ High (potentially) – depending on level of support available.	↑ High – but better targeting would raise administration costs on all sides.	Depends on tax receipts from other sectors.
Public Expenditure Support: Forestry	↑ High (potentially) – but risk of deadweight cost.	↑ High.	Potentially greater availability of harvested wood, either as fuel or as a material substitute.
Tax: Production of Emissions from Agriculture	↕ Varies – depends on level of tax.	↓ Low – challenging and design would need to address risk of carbon leakage.	↓ Low.
Tax: Consumption of Carbon Intensive Foods	↕ Varies – depends on level of tax and sectoral coverage.	↑ High – but with significant political risk.	Potential impacts on retail and food processing sectors.
Voluntary Measures: Emissions Reduction in Agriculture	↓ Low (negligible).	↑ High – to establish system, but making it effective is challenging.	Due to negligible strength of incentive other sectors will need to compensate in terms of mitigation.
Regulation	↕ Varies – depends on scope and strength of regulation.	↑ High – but becoming more complex as mitigation ambition increases.	↓ Low.

Carbon Policies in the Near- and Medium-Term

If the UK is to meet its climate targets and achieve net zero, then there must be credible near- and medium-term carbon policies. In the light of international experience, the two economy-wide carbon tax options (Options 2 and 5) would be highly challenging to progress at the present time. Option 2 would have immediate economy-wide cost implications and present trade policy challenges. Option 5 would also raise major measuring, monitoring, and verification challenges.

The opportunities to improve UK carbon policy draw upon elements of the three remaining reform options, and include:

- **Improving sectoral policies and addressing carbon policy gaps.** This draws upon elements of Option 1 and is discussed in the first half of this section (4.1) through describing the UK's near-term options for adjusting existing policies.
- **Introducing a UK Emissions Trading System (ETS).** This is based on Option 3 and is also consistent with the Government's favoured post-Brexit approach to carbon pricing and, therefore, not described in any further detail in this report.
- **Developing and introducing new long-term carbon standards.** This draws upon Option 4. The second half of this section (4.2) proposes policy options for residential heat and road transport in the medium-term as a means to tackle these particularly high emitting and difficult to abate sectors.

4.1 Near-Term Options

Current policies take a mixed approach to design and implementation in different sectors. This has the advantage of being able to tailor the policy approach to the needs of the sectors, but has the disadvantage of making it harder to create coherent price signals between them. An obvious short-term approach to carbon policy reform would be to take the opportunity to increase and align effective carbon prices through adjusting existing measures.

Previous analysis found that the major gaps in current carbon pricing are:⁷⁶

- **Residential gas use** (circa 10-11% of emissions): Carbon emissions are not priced and VAT charged at only 5%. In addition, heating oil for the residential sector (2% of emissions) pays a lower rate of fuel duty compared to road diesel and is further offset by a reduced rate of VAT.
- **Agriculture** (9% of emissions): No price signal is applied to emission-producing activities and the sector receives significant subsidies (of which only some target environmental outcomes).
- **Air transport** (7% of emissions): An air passenger duty is applied, but this is unrelated to the quantity of emissions and outweighed by the implicit subsidy from the zero VAT rating on air tickets. International flights make up the vast majority of UK aviation emissions. Flights within the EU are covered by the EU ETS, but the corresponding effective carbon price is low.

- **Business and industrial** (31% of UK emissions): Economic incentives are in place through the Climate Change Levy (CCL) and the feed-through of electricity carbon prices, but are highly differentiated by fuel, subsector, and the size of firms. Approximately 7% of firms' emissions from electricity benefit from up to 85% CCL discounts, whilst emissions from business gas consumption attract a tax rate typically less than a quarter that is levied on business electricity consumption.

Summarised below in Table 4.1 are the benefits of a more coherent carbon price, but also the reasons for the status quo and the barriers to change.

Table 4.1 Benefits of a more coherent carbon price and reasons for the status quo and barriers to change.

Sector	Benefits of increased and a more coherent carbon price	Reasons for status quo and barriers to change
Gas and Electricity: Residential Use	• More rational choices concerning behavioural and investment aspects of energy efficiency and renewable heat. • Rebalancing of gas and electricity costs improve choices on heating technologies and feeds through to long-term infrastructure development choices.	• Reduced VAT justified on basis that energy considered an essential good, and often linked to issues of fuel poverty (despite evidence that such subsidies are generally not well targeted to poverty alleviation). • Low quality housing stock (especially for poorer households) increases energy bills making price increases politically sensitive.
AFOLU	• More rational consumer choices over levels of consumption of different products. • Improved incentives for producers to choose and develop lower emission products and production methods.	• Major barriers to accurate emissions measuring, monitoring, and verification, and other administrative challenges. • Strong risk of carbon leakage (in the absence of a carbon border adjustment tax mechanism).
Air Transport	• Improve consumer choices over volume of air travel consumed and transport mode. • Improve signals to operators to reduce emissions from flights. • Improve long-term infrastructure development choices (e.g. air vs. rail).	• Air transport is governed by international treaties mandating zero VAT. • Lack of internationally agreed protocol for allocating national responsibility for international flight emissions.

This section continues by providing near-term policy options for all sectors across the economy to fill the policy gaps as described in Table 4.2.

Table 4.2 Current carbon policies for each sector and policy gaps.⁷⁷

	Sector	Current Carbon Policy	Gaps
	Power Generation	EU Emissions Trading System Carbon Price Support Low Carbon Subsidies (e.g. CfD, FiTs, ROCs)	-
	Road	Fuel Duty Vehicle Excise Duty	Carbon component of fuel duty is not explicitly set.
	Air	EU Emissions Trading System Air Passenger Duty	No VAT on fuel or tickets.
	Rail	Fuel Duty	Carbon component of fuel duty is not explicitly set (for non-electrified rail).
	Industry	EU Emissions Trading System Climate Change Levy Climate Change Agreements Low Carbon Policy Costs (Electricity)	Currently receives significant compensation.
	Business & Public	Climate Change Levy Climate Change Agreements Low Carbon Policy Costs (Electricity)	Climate Change Levy rates for gas are currently low.
	Residential	Low Carbon Policy Costs (Electricity) Low Carbon Subsidies (e.g. RHI)	No existing carbon price for gas and a reduced VAT rate for both gas and electricity.
	AFOLU	-	No existing carbon price and fuel duty is very low on red diesel.
	Waste	Landfill Tax	-

4.1.1 Aligning Sectoral Carbon Policies

The policy options listed below would begin to align the effective carbon prices seen by emitting activities across the UK. In some cases, 'do nothing' is a viable option given the current price signal seen by that sector. While in others, larger adjustments followed by the introduction of new policy is required going forward. AFOLU is treated separately given the inherent barriers the sector faces in reducing emissions in the near-term.

Table 4.3 Near-term carbon policy options.⁷⁸

Sector	Options	Comments
EU ETS Traded Sectors	1. Remain in EU ETS 2. Implement alternative UK systems	Near-term reform options depend on Brexit outcomes: 1. Remaining within the EU Emissions Trading System (ETS) would require little to no change in current policy, along with continued application of the Carbon Price Support mechanism to electricity generation. 2. Alternatives include setting up a linked or stand-alone ETS, taxing carbon, or setting carbon standards. All have the flexibility to increase coverage and form part of the long-term emissions reduction strategy.
Electricity: Business & Industrial Use	1. Do nothing 2. Improve Climate Change Levy (CCL) design 3. Rebalance pricing between electricity and gas	1. 'Do nothing' is a viable short-term option. Effective carbon prices for business electricity use are already broadly in line with target levels. 2. Smooth out cliff-edges on eligibility and payment levels for different size of firms to avoid competitive distortions (e.g. incremental changes to compensation mechanisms). 3. Carbon price signal for business could be rebalanced between electricity and gas to reduce distortion of fuel/energy choices.
Electricity: Residential Use	1. Do nothing 2. Normalise VAT rates	1. 'Do nothing' is a reasonable short-term option since households pay the carbon costs fed through by electricity generators who pay for EU ETS allowances and the CPS. 2. The carbon price signal is offset by the subsidy of a reduced rate of VAT. In the medium-term, normalisation of VAT rates should be considered. VAT reform could be phased in alongside the natural tapering of legacy policy charged to consumers (for historical low carbon investments), or if a decision were taken to recover these in part or full via a different route.
Gas: Business & Industrial Use	1. Do nothing 2. Include gas in upstream pricing mechanism	1. 'Do nothing' is a reasonable short-term option since small to medium business gas users are subject to the CCL, and large users are within the EU ETS. However, prices will need to rise over time to keep within expected target price range. 2. In the medium-term, replacing CCL with a common upstream policy instrument such as a UK ETS or carbon tax may have efficiency benefits by streamlining policy.

Sector	Options	Comments
Gas: Residential Use	1. New policy mechanism required 2. Phase in a levy	1. Gas for households does not currently face any carbon pricing. Policy mechanisms need to be implemented to create incentives to decarbonise this important source of emissions. 2. In the near-term, phasing a levy on residential gas usage should be considered. All or part of revenue raised could be used to fund assistance for vulnerable or lower income groups to transition to low carbon heat in their homes. In effect, this would create an (initially low) carbon price on gas usage while reducing the current price distortion affecting choices between residential gas and electricity usage. An alternative would be to increase the VAT rate, which is currently set at 5% (see Box 4).
Road Transport	1. Do nothing 2. Increase carbon component of road fuel duty 3. Increase incentives to buy lower carbon vehicles	1. 'Do nothing' is a reasonable short-term option since current taxation rates are high in the road transport sector. 2. When other externalities (e.g. congestion) are taken into account, there is still a case to increase the carbon component of fuel duty to align it with the target level. This could be part of broader reform to motoring taxation, with the carbon component made explicit. 3. The UK offers consumers comparatively few tax benefits for low carbon vehicle choices relative to other EU countries.⁷⁹ The case to increase these incentives over vehicle choice at point of purchase (e.g. by increasing tax differentials on vehicle choices) should be considered.
Air Transport	1. Increase air passenger duty and improve design 2. Work towards international pricing	1. There is no effective carbon price signal for air travel emissions. No VAT is charged on tickets, and this is not offset by the application of air passenger duty. In the short-term, air passenger duty could be increased to cover the gap. The duty could also be reformed to be more reflective of actual emissions. 2. In the longer-term, it will be important to work with the international community to work towards a common carbon pricing/ carbon policy approach for aviation emissions.

As an illustration of the scale of potential carbon incentives in the economy, for example, a carbon tax or an auction of allowances at the target carbon price (as determined by the Department for Business, Energy & Industrial Strategy in 2030⁸⁰) of £80/tCO₂ across the whole economy, would yield up to £27 bn/year.⁸¹ This is equivalent to:



Box 4: Residential Gas Use: Introducing a carbon price

In common with many other countries, the UK applies a low rate of VAT (5%) on residential energy usage (gas and electricity). The effect is equivalent to a subsidy, because VAT is charged at the standard rate (20%) for most other goods and services purchased by households.⁸²

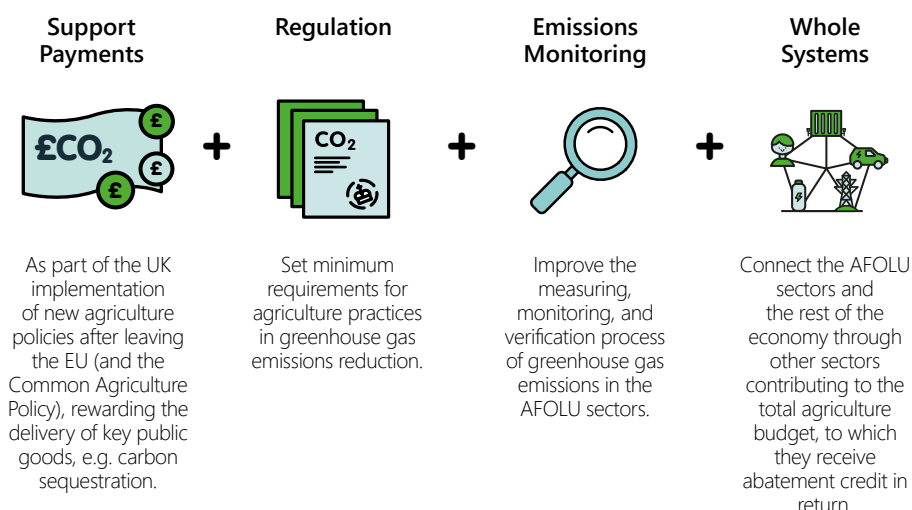
In the UK this implicit subsidy is largely counterbalanced for electricity by the recovery of low carbon policy costs through electricity bills. In addition, electricity is also subject to carbon pricing via application of the EU ETS and Carbon Price Support to upstream generation. In contrast, for gas usage there is no equivalent counterbalance. The result is that gas usage attracts a much lower effective carbon price than electricity.

Charging VAT at the standard rate on gas usage would correct much of this distortion, however, it would raise difficult implementation challenges. In general, VAT is currently charged at three rates (standard 20%, reduced rate 5%, and zero rate), suggesting that it would be difficult to phase in changes.

Therefore, introducing a levy on residential gas use would be a more flexible policy approach. This would enable a phased approach to introduce a carbon price gradually and reduce the distortion of choice between residential gas and electricity use. A levy could also fund early heat decarbonisation investments. Investments could be targeted to ensure both a positive impact on the market for low carbon heat, and a progressive distributional impact by focusing on assisting lower income and vulnerable groups to transition to low carbon heat solutions.

Agriculture, Forestry and Other Land Use

The issues and challenges associated with policy mechanisms to deliver climate mitigation in the AFOLU sectors has been explored in more detail.⁸³ Below (Table 4.4) is a set of recommended policy approaches that balance practicability, acceptability, and effectiveness in the short-term, and how it could be developed in the longer-term to form part of an economy-wide framework.



4.2 Medium-Term Options

The near-term options discussed above go some way to sending stronger, more coherent decarbonisation signals across the whole economy, however, more substantial policy change is required in the medium- to long-term if the UK is to achieve net zero. Section 1.1 highlighted the areas of the economy that are currently underpriced in terms of carbon and the reform options in Section 3.1 went further in highlighting the sectors that are difficult to introduce sweeping policies, such as a carbon tax. Therefore, the focus of the medium-term policy option is on the residential heating and road transport sectors for the following reasons:

- **Materiality:** Road transport accounts for 23% of emissions (including HGVs) while residential heat accounts for circa 15%.⁸⁴
- **Policy gaps and distortion:** Current effective carbon prices are relatively low in these sectors, particularly for non-electric residential heating. There are also significant distortions currently in place, with different price signals depending on fuel choice.
- **Sensitivity to energy prices:** Policies involving energy price increases have been particularly hard to introduce, for example, due to concerns about the impact on vulnerable customers.

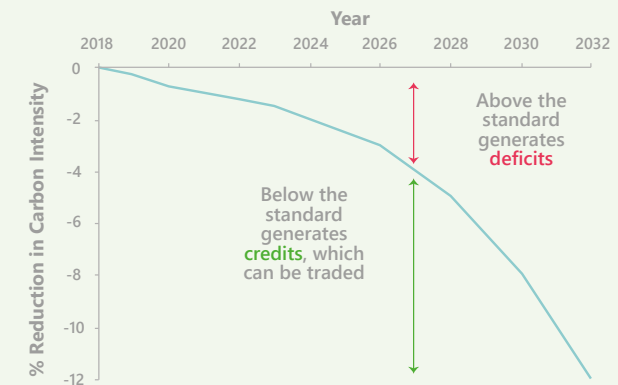
4.2.1 Setting Carbon Intensity Standards for Residential Heat and Road Transport

Frontier Economics were commissioned to analyse considerations around the design of carbon intensity standards.⁸⁵ This work highlighted several key learnings (described below), which should inform the next phase of work to design a low carbon heat standard.

Tradable carbon intensity standard

A carbon intensity standard would set an obligation on suppliers in the energy sector to reduce the carbon content of the energy they sell. Obligated parties could meet the standard either by reducing the emissions intensity of the energy they sell, or by buying credits from parties who are supplying energy with a carbon intensity below the standard (see Figure 4.1). Allowing credits to be traded in this way, within and across sectors, would help reduce the overall cost of mitigating emissions by providing an incentive for abatement to occur where it could be delivered at least-cost. Trading would also result in one credit price across all sectors covered, thereby setting an implicit carbon price. In addition, negative emission technologies (such as direct air capture) could receive credits for their 'negative emissions'.

Figure 4.1 An example of a tradeable carbon intensity standard.



Box 5: California Low Carbon Fuel Standard

Carbon intensity standards are by no means a new type of policy. An RDI case study describes the most notable of these, the California Low Carbon Fuel Standard (LCFS), which is a technology-neutral carbon standard applied to the road sector in California, with the aim of reducing GHG emissions by at least 10% by 2020.⁸⁶

The LCFS is placed on upstream fuel suppliers, for the sale and supply of all transport fuels. The scheme allows for trading of LCFS credits between fuel suppliers, with the price in the market set based on the supply and demand of these credits. The demand for credits is driven by fossil fuel suppliers (who earn deficits against the target), while the supply of credits is provided by sustainable fuel suppliers, for example, suppliers of biodiesel, biogas, and electricity for use in EVs (who earn credits against the target).

An intensity standard has some practical benefits over other carbon policy options such as a carbon tax or cap and trade scheme:

- **Energy Prices:** The impact on energy prices is lower, because while a carbon tax entails a transfer of revenue from energy consumers to the Treasury, under a carbon intensity standard, the cost of purchasing credits incurred by suppliers of a high carbon fuel is offset by the revenue gained by suppliers of the low carbon fuel. Therefore, it can give the same differential between the fuels as a carbon tax, but with less of an adverse impact on the price of the high carbon fuel. However, this means that less (or potentially no) revenue will be collected by the Treasury.
- **Stability:** An approach based on the intensity of standards, rather than an absolute amount, would result in a more stable incentive to investors compared to a system such as the EU ETS. In particular, the price of credits will not be as sensitive to economic shocks. This is because, while a large change in supply or demand for energy would drive a correspondingly large change in total emissions, the carbon intensity of energy would remain relatively stable under such a scenario. In addition, as a result of no revenue being collected by the Treasury, this may improve the stability of the policy, because it removes the ability to freeze prices as previously seen with fuel duty.

However, a carbon intensity standard does not necessarily result in decarbonising at least-cost when compared to a first-best policy option such as a carbon tax or cap and trade scheme.⁸⁷ This is because, while the standard acts as an implicit tax on fuels with an intensity above the standard, it also acts as an implicit subsidy for any fuels with a carbon intensity below the standard. This could over-incentivise consumption of lower carbon fuels, relative to other abatement options, such as energy efficiency measures. Complementary measures such as a buyout price and/or incentivising energy efficiency would go some way to mitigate this issue.

Obligated parties

Of the options in the value chain for where the standard could be applied, three were assessed in detail: primary energy, retailers/suppliers, and combustion/consumption. Retailers/suppliers is most practical for two main reasons:

- It would not be possible to target a carbon intensity standard applied to primary energy on individual sectors, as the intensity target would apply to each type of energy no matter where it was used in the economy.
- Applying the standard to combustion/consumption would likely entail very high administrative costs associated with trading, monitoring, and compliance, due to the very large number of end users, and the degree of diversity between them.

Table 4.5 describes the obligated parties for each fuel.

Table 4.5 Overview of obligated parties under a sectoral carbon intensity standard.

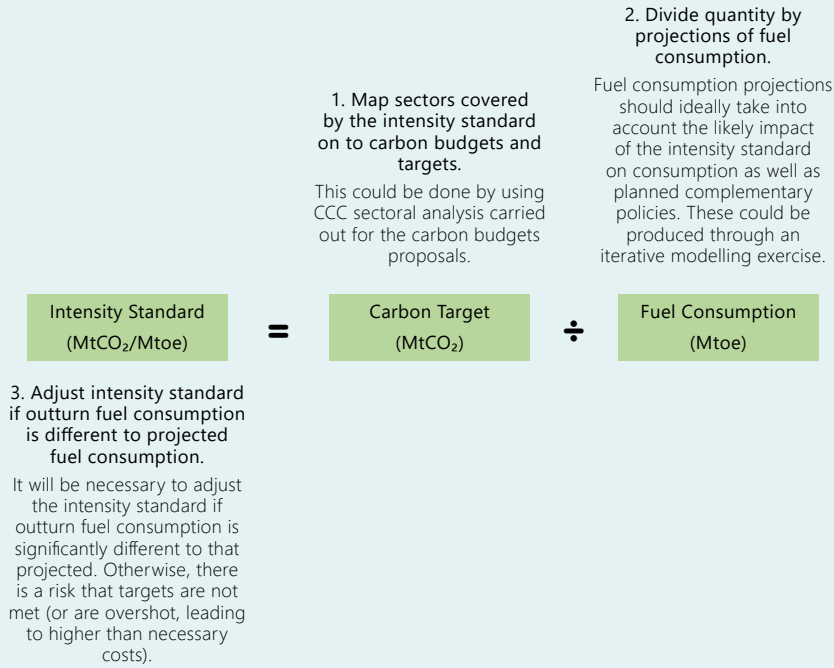
	Fuels used to heat buildings				Road transport fuels
	Gas	Heating oil	Biomass	Electricity	
Fuels	All natural gas supplies, both imported and domestic.	All forms of heating oil.	All biomass sources, including wood pellets, wood chips, and crop biomass.	All electricity supplies, from both fossil fuel and renewable sources.	Biofuels, petroleum, and diesel (in line with current RTFO fuels).
Suppliers	~75 residential gas suppliers. ⁸⁸	Large number of suppliers, both large global suppliers, and smaller residential suppliers.	Small number of importers. Large number of smaller biomass suppliers (domestic and imported).	~65 residential electricity suppliers.	Small number of petroleum/diesel suppliers by large global companies. Large number of liquid biofuel suppliers.

Setting the standard

Choices need to be made on the level of the standard, any differences by sector, and adjustments to the standard over time:

- **Aligning standards to carbon budgets:** Ideally, the standard could be set at a level that would allow the UK's carbon budgets and targets to be met (see Box 6). Carbon budgets become more stringent overtime, and a trajectory for the level of the intensity standard should be set out in line with the trajectory for overall carbon budgets. Targeting a set level of emissions would require some form of iterative approach.
- **Filling policy gaps in the interim:** While ideally the target would be set to ensure carbon budgets are met, a pragmatic interim step would be to use the intensity standard to fill existing policy gaps.
- **Aligning with existing policies:** After the application of a sectoral carbon intensity standard, key policy instruments will vary by sector of the economy. For example, electricity would be covered by the EU ETS and the standard, whereas gas would be covered by the standard only. This is also important when considering interactions with policies such as the CCL and fuel duty.
- **Setting different standards by sector:** As discussed below, modelling suggests that separate standards for different sectors should be applied, but with trading of credits between sectors allowed.
- **Adjustments to the standard over time to ensure targets are met:** Minimising policy risk will be important to investors and consumers. Therefore, acknowledging that the carbon intensity standard will need to be adjusted over time is important.

Box 6: Process for setting an intensity standard



Monitoring and compliance

The application of a carbon intensity standard in the residential heat and road transport sectors would require monitoring of fuel intensity data on a periodic basis, to ensure that obligated parties are meeting targets. This in turn will require that an appropriate institutional framework is in place to carry out these duties.

Current institutions and monitoring mechanisms would provide a good basis for monitoring compliance with an intensity standard, with limited changes needed to the duties and processes of data collection and verification that are already in place:

- **Administrative bodies:** For residential heat, this could be administered by the regulator, Ofgem. For road transport, as with the current Renewable Transport Fuel Obligation (RTFO), this could be administered by the Department for Transport.
- **Administrative burden:** Given that the number of obligated parties in each sector assessed is relatively limited, periodic reporting and verification of data would be feasible with limited additional administration.
- **Need for data verification:** A verification process for the provision of fuel intensity information by obligated parties would need to be put in place. This would be particularly important for biomass fuels given the uncertainty of land use impacts when calculating lifecycle emissions. A list of accredited verifiers would need to be developed as part of this process.

How would obligated parties meet the standard?

Obligated parties in each sector would face three choices in meeting the intensity standard: reduce credit requirements, purchase credits, or diversify into other options of low carbon energy. Table 4.6 describes how obligated parties could meet a standard if set above the emissions intensity of electricity and biomass, but below the emissions intensity of all other fuels.

Table 4.6 How obligated parties could meet the standard.

	Gas suppliers	Heating oil suppliers	Biomass suppliers	Electricity suppliers	Road fuel suppliers
Reduce credit requirements	Increasing proportion of low carbon gas in gas supply.			Increase proportion of renewables and nuclear in the mix.	Increase proportion of biofuels in the mix.
Purchase credits	Purchase credits from road fuel, biomass or electricity sectors.	Purchase credits from road fuel, biomass or electricity sectors.	Sell credits.	Sell credits.	Purchase credits from heat sector.
Sell other fuels	Sell customers other fuels (e.g. electricity, biomass).	Diversify (e.g. into biomass).			Sell customers other fuels (e.g. electricity for EVs).

Complementary policies and the transition

The policy landscape in residential heat and road transport is complex. Therefore, key actions on complementary policies are likely to be required in the transition to a carbon intensity standard to ensure that the policy effectively fills the gap, without resulting in double counting, and aligns as much as possible to policies in other sectors.

- **Innovation/technology policy:** A carbon intensity standard alone may not be enough for delivering the innovation required to reduce emissions. Technology-specific policies that aim to incentivise innovation in the development of carbon-abating technologies should be maintained.
- **Policies to tackle fuel poverty:** Any carbon price signal will adversely impact vulnerable customers by increasing the price of energy. Therefore, there should be policies in place to tackle fuel poverty.
- **Policies to address energy efficiency:** Previous research has shown that customers may not invest in energy efficiency measures in response to price signals, even where there are financial benefits.⁸⁹
- **Double counting:** Aspects of certain policies might need to be amended to ensure that carbon is not double-counted. For example, the part of fuel duty that can be attributed to carbon may need to be adjusted downwards.

Modelling

Modelling carried out by Frontier Economics as part of the analysis suggests that the following design features will be important:

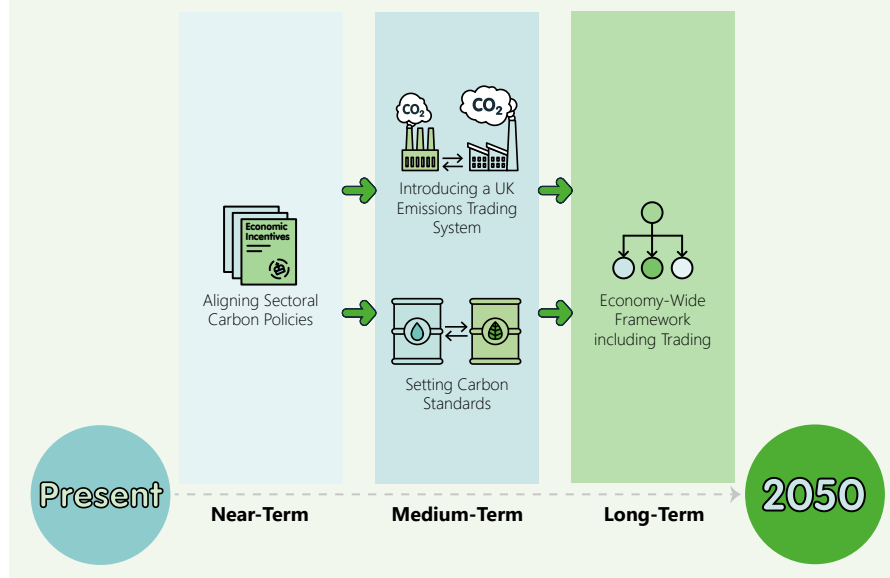
- **Apply separate standards for separate sectors:** This reduces the risk of incentivising overconsumption in sectors that are starting from a lower average emissions intensity. The distortions are generally higher for a single standard, which applies across sectors, rather than separate sector-specific standards. For example, owing to the high emissions intensity of petrol, an average standard across residential heat and road transport will be above the emissions intensity of gas. This would result in owners of gas boilers receiving an effective subsidy.
- **Cover all choices faced by consumers in a sector:** Omitting a major fuel from the policy risks exacerbating consumers' choices between different abatement options. For example, if electric heating is removed from the standard on the grounds that it already covered by the EU ETS and Carbon Price Support, there is a resulting disincentive for customers to choose electric heating.
- **Use tighter standards plus a buyout, where possible:** Tighter standards plus a buyout allows the policy to be as economically efficient as possible while maintaining the benefits described above. It would also provide a source of revenue for the Treasury.

These factors suggest a strong case for considering carbon standards to strengthen incentives for decarbonising residential heat, and potentially road transport.

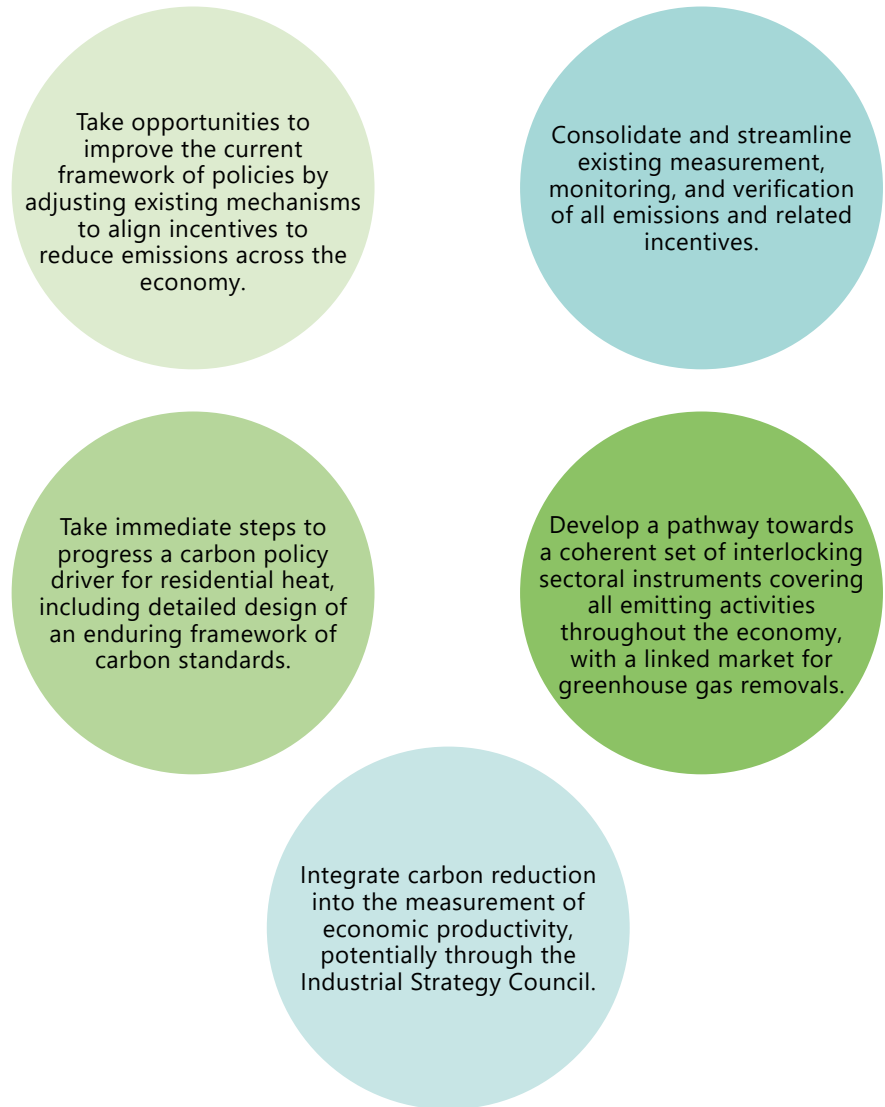
Recommendations

The Rethinking Decarbonisation Incentives project has shown that the UK can achieve a balanced economy-wide carbon policy framework to boost innovation and deliver clean growth, consistent with a net zero target in 2050. This does not necessarily require relying on a single ambitious economy-wide instrument, such as a carbon tax or economy-wide trading system. Rather it is possible for the UK to develop a pathway towards more coherent incentives for emissions reduction across the energy system and the wider economy by developing a complementary mix of policies (see Figure 5.1). Carbon standards offer potential to play a key role in this pathway.

Figure 5.1 The potential direction of travel for carbon policy to 2050.



Acting on the following set of recommendations for policy makers will help put the UK on course for meeting its legally binding targets to reduce emissions in a cost-effective way.



Endnotes

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- Road transport – Fuel duty is adjusted to align with the social cost of carbon.
- Residential heating – The Climate Change Levy (CCL) is modified to include the residential sector.

⁶⁹ Calculated based on current price of natural gas, the average annual household consumption and bill, and then aligned with a carbon tax rate.

⁷⁰ Ibid. see 6 & 63.

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