THE INFRASTRUCTURE FORUM

Carbon Pricing and Infrastructure Investment

A Virtuous Double Act?

A paper for The Infrastructure Forum on the need for the introduction of carbon pricing through a UK Emissions Trading System (ETS) and carbon tax, the critical role of Government and the infrastructure industry, and the link to Government's ambitious 10 Point Plan for Green Infrastructure Investment

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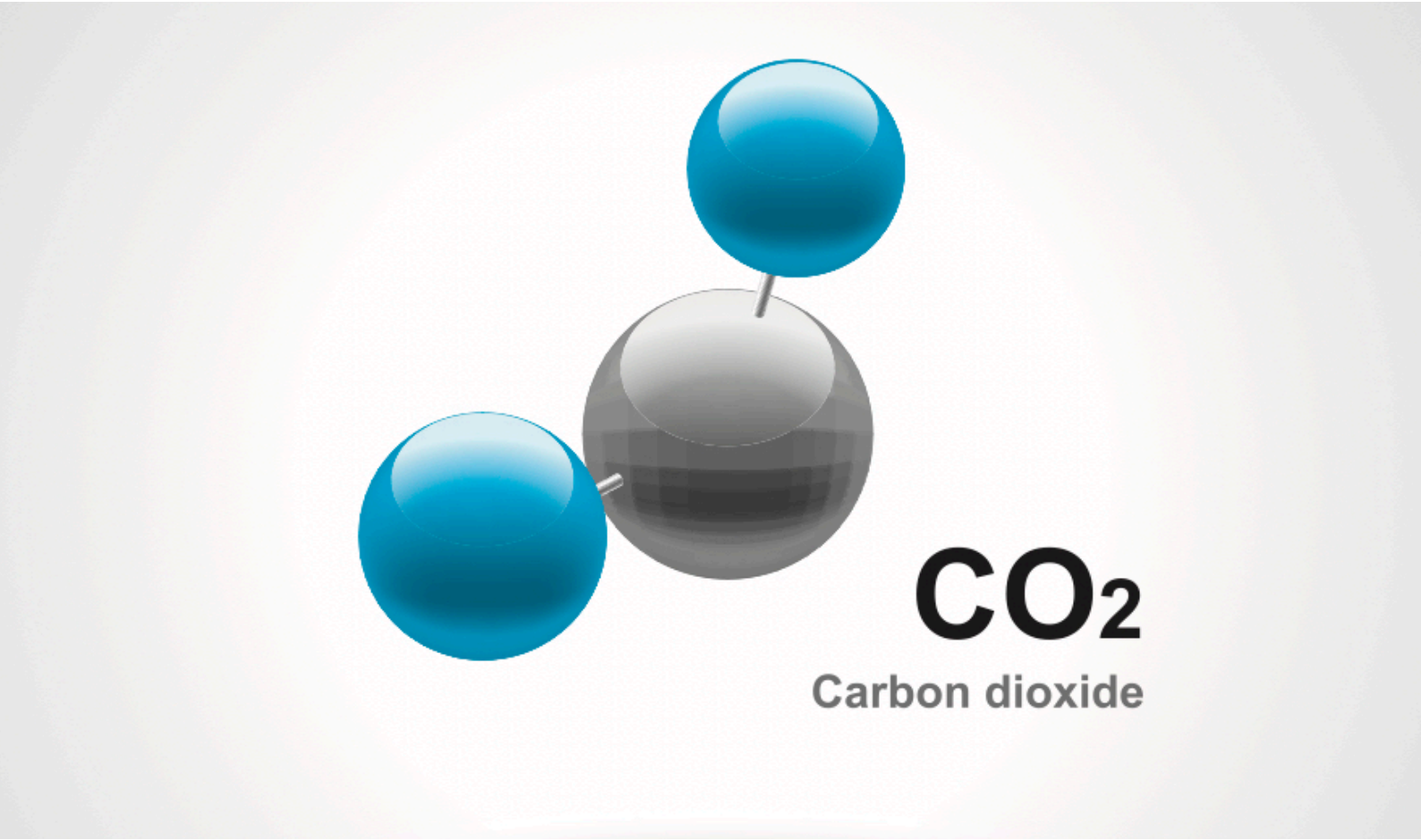


December 2020

OVERVIEW

The Government has just announced an ambitious Ten Point Plan - The Ten Point Plan for a Green Industrial Revolution - for investment into green infrastructure. This is a comprehensive plan across a number of sectors, with clear integrated policy and commitments that will in turn bring in large amounts of private sector investment across the economy. It comes together with the Government's Energy White paper - Energy White Paper 2020 – and the Climate Change Committee's (CCC) 6th Annual Budget - CCC - The UK's Path to Net Zero that sets out a comprehensive plan and alternative strategies to deliver Net Zero by 2050.

In light of these most welcome policies and publications, it might seem strange to write a paper focusing on carbon pricing, which is not referenced in the 10 Point Plan nor majored on by the CCC in its report. Government's commitment to green investment, jobs and leading the reduction in emissions surely goes to the heart of the problems that need addressing, so why do we need carbon pricing?

Nonetheless, the introduction of explicit carbon pricing is the recommended policy of the Climate Change Committee, the UN Intergovernmental Panel on Climate Change, and is the stated long-term UK Government policy, who have already committed to introducing a UK Emissions Trading Scheme (UK ETS), which will put a decreasing cap on allowable CO_2 emissions, leading to a 'carbon price' for available allowances.

This paper therefore reviews the arguments for carbon pricing, but then sets it alongside the need for infrastructure investment and Government policy, which the 10 Point Plan has gone a long way to initiate and address. It describes how a carbon tax can help deliver and fund infrastructure and in turn how infrastructure investment can lower the need for, and size of, carbon tax.

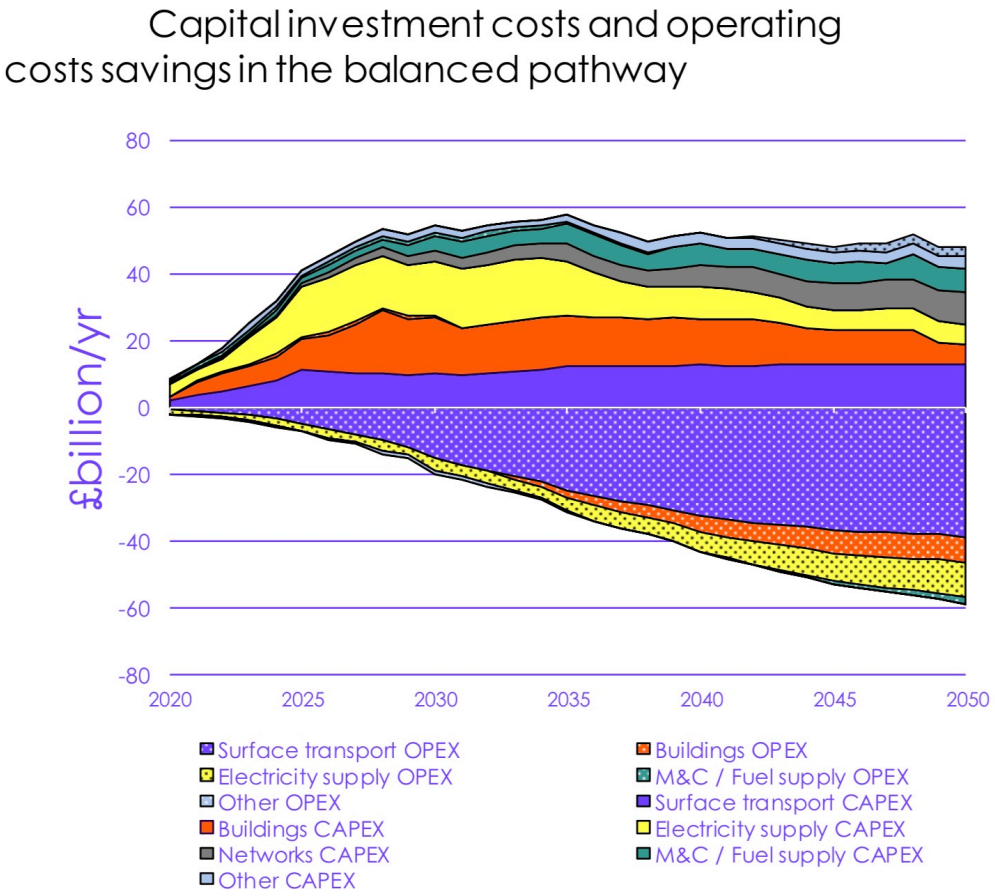
There has been ongoing debate about whether carbon pricing should be introduced via some form of direct taxation or through an ETS scheme; each has its merits. This paper first outlines the need for a phased form of carbon pricing in general and some of the issues it needs to address, before considering tax and ETS options. Given the UK Government is developing the ETS scheme, this approach can highlight possible shortcomings of ETS which a tax approach may have overcome, and therefore what issues policy will have to address as it develops the UK ETS scheme. References to a carbon tax or price in the early parts of this paper are therefore generic and could refer to a tax or ETS approach.

In practice, the UK ETS may have to be supplemented with some direct carbon taxation, regulation, border tariffs and direct Government support for early infrastructure adopters. These themes are explored in the paper.

This paper considers the arguments for phasing in a carbon price to provide the right market signals and help the transition to Net Zero. It then describes how this needs to be introduced alongside a coordinated programme to support the infrastructure investment that will reduce the cost of transition, provide carbon-free alternatives and lead to a reduction in what carbon tax is necessary; a virtuous double-act!

THE GREEN INVESTMENT CHALLENGE

The infrastructure investment challenge to deliver Net Zero is perhaps best summarised in the CCC's recent 6th Carbon Budget:



Source: CCC Analysis

This table shows a need for around £50bn of capital investment per annum from 2025 onwards, although importantly in the CCC's latest analysis, they believe the overall savings to the economy in operating expenditure will exceed that amount by 2045; in the long term the transition to Net Zero could actually save us money in aggregate.

Similarly, in its recent Net Zero Interim Report, HM Treasury has concluded *"the net impact of the transition on growth to 2050 is likely to be small compared to total growth over that period, and it could be slightly positive or slightly negative. The scale, distribution and balance of new growth opportunities and challenges will depend on how the economy and policy respond to the changes required[1]".*

What this CCC graph only hints at is that the savings will be in different parts of the economy than the costs; there will be winners and losers corporately and individually unless there is clear, integrated policy. As the HM Treasury Report says, *"though the macroeconomic impact might be small, there could be significant distributional implications."*

The CCC draws three conclusions in its Budget, which are themes through this paper:

- People – *"over half the emissions reductions identified actively involve people, whether choosing to purchase low-carbon technologies, or by making different choices".* This begs the question, what will incentivise those changes in behaviour?
- Transition – in the short term, when green products and services are at a competitive disadvantage to carbon-intensive products, *"taxpayer funding should be used to support deep decarbonisation in manufacturing sectors at risk of carbon leakage".*
- The need for carbon pricing – *"to incentivise the transition to Net Zero, relative prices will need to reflect carbon content sufficiently to favour low-carbon options over high-carbon options. That can be achieved through explicit carbon pricing or other levers". "Most pressing is the development of improved metrics for carbon-intensity on which border tariffs or standards can be based, along with international negotiation and consensus building on these measures".*

[1] HM Treasury Net Zero Interim Review December 2020

THE CONTEXT FOR CARBON PRICING – WE ARE NOT PRICING THE PROBLEM

Normally one would expect in efficient markets that two very basic principle of economics are true. First, that prices should reflect the underlying costs of a product. Second, that relative prices change behaviours.

However, when we turn to the question of climate change and in particular the 'cost' of emitting carbon dioxide (CO2), then these two principles evidently do not hold true. To take just two individual consumer and one corporate example:

- A flight to Mallorca this coming January could cost £21.99 and emit roughly 5X the CO_2 compared to taking a train to Edinburgh that costs £105 (£191 if you don't want to change!).[2]
- Blueberries sold online by Tesco cost the same, irrespective of origin (UK, Spain, Chile or Peru!)
- Fertiliser prices are set globally, so the current international cost of UK produced Ammonium Nitrate, with a carbon footprint of around 1 ton of CO_2 (pre the introduction of CCS) is the same as a ton sourced from Russia or China, with a carbon footprint of 2.6 or 3.8 tons of CO_2 respectively

All of us could cite innumerable similar examples, on a personal and corporate basis, that would illustrate the problem. Put simply, the cost of the relative environmental impact of products is simply absent from their price to both individual consumers and companies. The two economic principles are not being applied; the true full cost of products does not include their carbon emissions and, as a result, economic signals do not exist to change behaviours.

Reports by the CCC describe the radical changes in behaviours needed by households and companies to reach Net Zero by 2050. Yet we lack the strong market signals needed to change those behaviours.

For example, the management of a particular business may be convinced of the environmental benefits of switching their heating source from the current gas supply to hydrogen; a switch that is being championed in the Ten Point Plan. But what economic incentive have they, when the current price of gas is so much cheaper? Similarly, why would an individual or company buy 'green' products when alternatives from, say, the Far East (whose production was fuelled by coal) are cheaper? Those

[2] It is 1,100 miles to Mallorca versus 410 miles to Edinburgh and trains very roughly emit 50% CO_2 versus flights, although this ratio would be lower for electric trains using green energy.

alternatives include cars, TVs and even wind-turbines (which rather undermines their green credentials).

To make matters worse, our successful reduction in emissions through investment in solar, wind and now nuclear has been funded through increases to the electricity price. We have increased the price of the commodity the CCC wants us to migrate to relative to gas that it wants us to abandon. In contrast, home heating from gas and aviation have no such carbon price attached.

There currently simply aren't the signals and incentives to lead both individuals and companies to change behaviours in the way the CCC believes is critical to delivering Net Zero by 2050. At present 85% of global emissions are not priced, and about three quarters of emissions that are covered by a carbon price are priced below US$10/tCO2; a level not likely to make behaviours change materially.

This paper therefore considers the arguments for embedding the cost of carbon through a form of carbon tax in our goods and services, but also considers whether this can be achieved without harming businesses and in particular our international competitiveness, and the critical role the infrastructure has to play in achieving this.

"Explicit carbon prices remain a necessary condition of ambitious climate policies" – UN Intergovernmental Panel on Climate Change.[3]

Summary: The cost of the environmental impact of products from their carbon content is absent from their price to consumers and companies, so there are no price signals to incentivise a change in behaviours

'NET ZERO' MEANS 'NET ZERO' – WE HAVE TO STOP EMITTING CO2 OR PAY THE FULL COST OF OFFSETTING RESIDUAL EMISSIONS FROM OUR COMSUMPTION BY 2050

The fact that it is 'Net Zero' means we need a combination of initiatives to succeed:

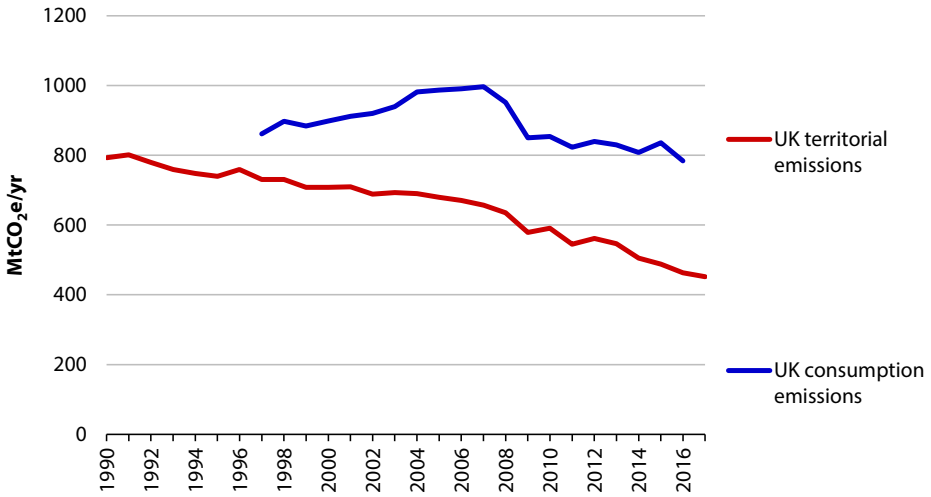
- Changing behaviours to move away from high emitting activities
- Building the infrastructure to allow the transition, giving us carbon free alternatives
- Developing the infrastructure that can offset residual, unavoidable emissions

Why have I underlined the word 'consumption'? Quite simply; Net Zero should be primarily about consumption not just our emissions (consumption includes emissions

[3] Intergovernmental Panel on Climate Change Report - Global Warming of 1.5 Degrees C

embedded in what we consume that is not manufactured in the UK and hence no UK CO_2 is emitted).

This distinction is key. The UK has reduced our territorial emissions from 800 $MtCO_2e$/year in 1990 to around 450 $MtCO_2e$/year in 2017. But the same data from the CCC show our consumption at about 850 $MtCO_2e$/year in 1996, actually rising to 1,000 $MtCO_2e$/year by 2007 and returning to around 800 $MtCO_2e$/year in 2017. We haven't really improved our consumption position in the last 20 years despite all of our investment into renewables.



Source: CCC Analysis; Defra (2019) UK's carbon footprint; BEIS (2019) Final UK greenhouse gas emissions national statistics: 1990-2017

As we have been increasing our energy prices over this period, we have reduced our domestic manufacturing, ironically offshoring to countries with far higher CO_2 content in their energy mix and products.

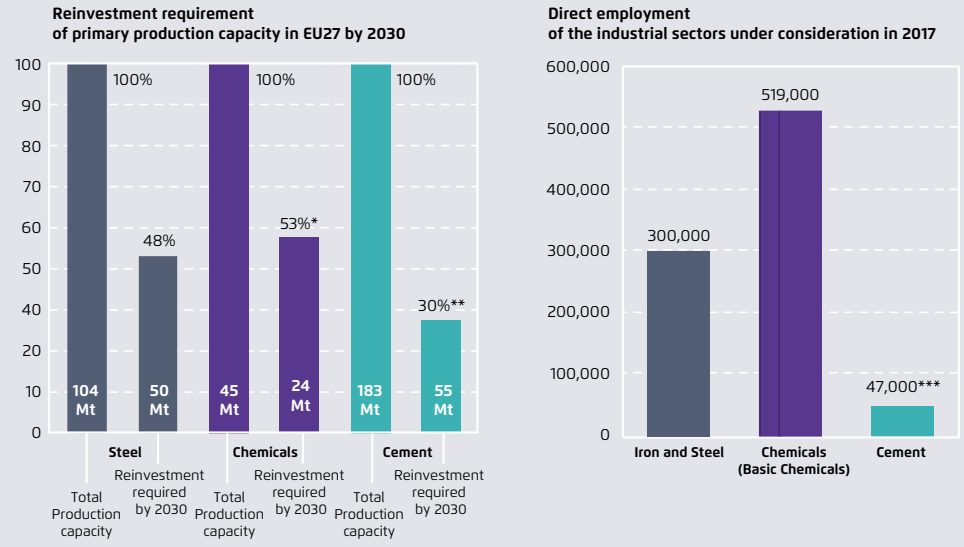
We are not helping climate change in the slightest if our policies just lead to the closure of manufacturing and the importation of all our goods!

To return to the real-world fertiliser example from earlier. Not only is UK fertiliser competing internationally with products containing 2.5 to almost 5 times the carbon content, but it also has to contend with far higher costs of energy, which are a significant component of overall costs. From a consumer's perspective, where fertiliser is a relatively undifferentiated product, price is paramount, so they are likely to favour foreign fertilisers because of their cost advantage. Because there is no price for their consumption of CO_2, this behaviour is unlikely to change.

Our current policy approach therefore discriminates against domestic production and is likely to disincentivise any investment in UK plant because it is hard to maintain competitiveness from the UK, despite the CO_2 efficiency of UK plant.

This perverse effect is common across much of Europe, with similar policies on energy transition, where production in our high emitting industries is having to compete with international products. The significance of the adverse impact of this policy becomes more worrying when one considers that a large proportion of our production capacity needs reinvestment in the next decade, as shown in the table below:

Re-investment needs by 2030 and direct employment in cement, steel and basic chemicals in the EU Figure 2



Source: Agora Energiewende/Wuppertal Institut, 2020

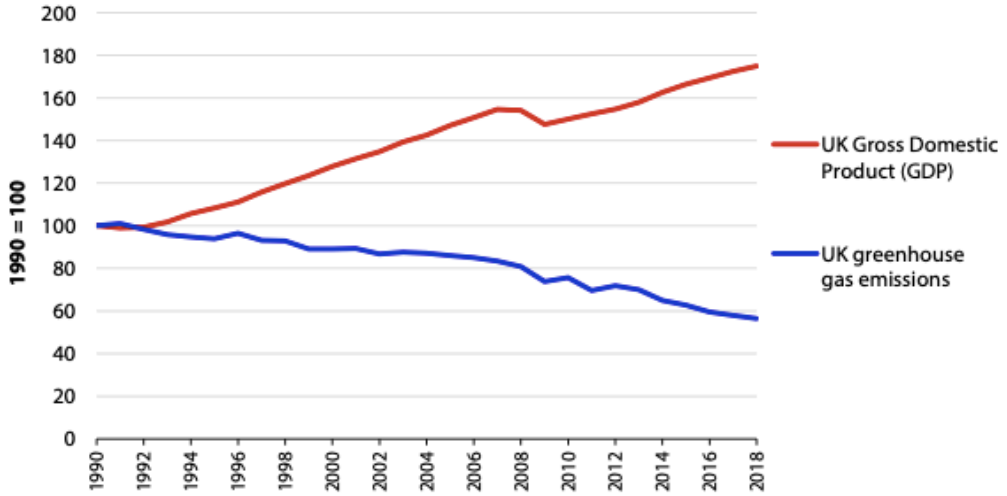
The current policy mix therefore risks new investment migrating away from the UK (and Europe) and as a consequence our consumption of CO_2 will actually increase, because of the higher CO_2 embedded in the imported products we will then consume.

This problem would of course diminish if all other countries were decarbonising at an equal rate. Recent and expected Net Zero emissions commitments from the EU, Japan, South Korea, the US and China mean that around 48% of imported emissions would be covered by Net Zero. But if countries only follow their National Determined Contributions to CO_2 reduction, UK consumption would still exceed 100 Mtpa in 2050.

If we ignore the trend of offshoring and just focus on remaining industries for a moment, we can look at the issue in another way, comparing the UK's impressive

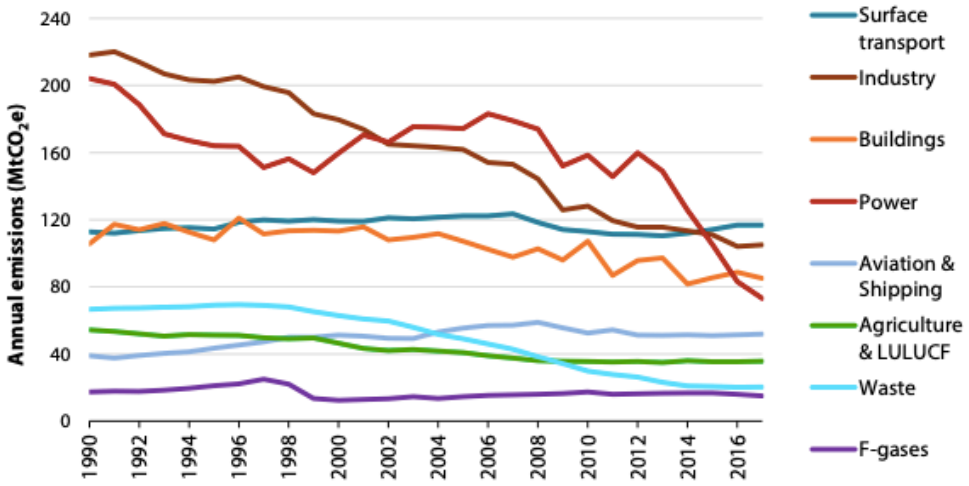
reduction in emissions since 1990 to the analysis of the industries in which this has occurred, shown in the charts below from the CCC's Net Zero report of 2019. The industry detail shows the reduction has come from the power sector, from investment in renewables (from a policy focus on emissions), with good contribution from parts of industry. But in sectors where the consumption of free carbon is of particular importance - surface transport, aviation and shipping, agriculture, buildings – there has been little progress. A policy focusing on emissions rather than consumption has produced this imbalance.

Figure 1.3. The UK as a positive exemplar – falling emissions in a growing economy (1990-2018)



Source: BEIS (2019) Final UK greenhouse gas emissions national statistics 1990-2017; BEIS (2019) 2018 UK greenhouse gas emissions: provisional figures; ONS (February 2019) Gross Domestic Product: chained volume measures: Seasonally adjusted £m; CCC Analysis

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



Source: BEIS (2019) Final UK greenhouse gas emissions national statistics 1990-2017; CCC Analysis. LULUCF = land use, land use change and forestry.

Fortunately, this emission-consumption distinction is fully recognised by the CCC in its latest report:

"The Committee will continue to scrutinise progress on consumption emissions alongside territorial emissions. Reducing emissions must not be at the expense of exporting jobs and emissions overseas.

Summary: To reach Net Zero, we need to change behaviours and deliver carbon-free alternatives or offsets to residual emissions. We need to focus on our CO_2 consumption, not just emissions, to avoid offshoring our carbon footprint and to encourage decarbonisation across the economy

'FREE CARBON IS EMBEDDED IN EVERYTHING WE DO; OUR CONSUMPTION IS AS A RESULT OF OUR INDIVIDUAL AND CORPORATE CHOICES.

The graphs above should make it clear that this debate is not just about where we derive our energy. 'Free' carbon is embedded in everything to a lesser or greater extent; those aforementioned Peruvian blueberries, holiday flights, TVs and wind turbines, but also meat, steel, cement, fertilisers, travel, plastics, and clothes.

While many of us try to be virtuous, both our lifestyle choices and corporate decisions can be, and largely are, made oblivious to the carbon footprint that they create.

Unless companies and individuals, as ultimate polluters, are aware of and pay for that footprint, it is pretty unlikely they will change behaviours. We need incentives, signals and alternatives if we are to change.

While policy focus remains on reducing UK emissions, carbon consumption risks not being picked up and the problem around offshoring will worsen.

But if our focus were on carbon consumption, it becomes clearer that we are the polluters and all our goods and services need to reflect the cost of that pollution and incentivise individuals and companies to move to greener alternatives.

Summary: Carbon is embedded in almost everything we do; as the ultimate consumer and polluter, we - individuals and companies - should bear the cost of that pollution or be incentivised to transition to greener alternatives

INTRODUCING A CARBON TAX ON PRODUCTS HAS TWO BENEFITS

If you agree that we are all at fault and the principle that the cost of that pollution should be included in goods and services - the polluter pays - then the need for a carbon tax becomes clear.

A carbon tax has two particular benefits:

- By showing the true cost of goods, including their environmental impact, this incentivises a transition to a less (and ultimately zero) carbon world
- Carbon tax proceeds can be used to fund new infrastructure to reduce emissions, provide alternatives or offset residual emissions

We shouldn't hide the fact; to achieve Net Zero will need huge investment across the economy. Carbon tax proceeds can help fund investment in enhanced fibre, new production of hydrogen, Carbon Capture and Storage, grid-scale electricity storage, bio-energy with negative emissions, public transport and electric charging infrastructure, soil capture, and more nuclear and renewables. Carbon tax will also offset HM Treasury's declining tax revenues from fuel and vehicle duties; currently around £37bn per year.

It can be a virtuous spiral. That investment will drive competition, reduce costs and provide consumers with carbon-free alternatives, so that less carbon tax will be necessary.

"A well-designed carbon price is an indispensable part of a strategy for reducing emission in an efficient way…to incentivise the changes needed in investment, production and consumption patterns." N. Stern and J. Stiglitz – Report of the High-Level Commission on Carbon Prices for the UN 2017

Summary: The key argument for introducing carbon pricing is it gives a framework under which large numbers of individual choices and investments are made that reflect their true environmental cost, while raising funding to make that transition as economic as possible.

WHY SHOULD A CARBON TAX BE PHASED, GROWING OVER TIME?

If the goal of a carbon tax is to change behaviours, one might well ask why not introduce a full carbon price tomorrow; a massive hit that fully reflects the cost of our pollution and can fund offsets?

But while the principle of carbon tax may be sound, there are in practice a variety of reasons to introduce it in phases:

- **Political acceptability** - We need to transition according to a long-term plan. It would be a brave politician that introduces a policy where overnight voters' holidays, heating and meat become unaffordable. We also need to avoid shocks to the economy; this will be a new tax in a Covid battle-weary world
- **Building infrastructure alternatives takes time** - a carbon tax incentivises a change in behaviour, but you can't change unless there are real alternatives – public transport, fibre, an electric car network, reliable sources of hydrogen, affordable offsetting negative emissions through CCS, Direct Air Capture CCS, and soil capture at scale
- **Industry needs to plan** - A clear commitment to phased price increases will allow businesses to factor this into future investment decisions – at the point of renewing their fleet, replacing boilers, sourcing their products, or re-investing in steel, chemical and cement plants – rather than taxing them now on existing infrastructure that it takes time to change. We need an approach that protects industry, helping with the cost of transition, not penalising them immediately, which would lead to ever-increasing offshoring[4]
- **Costs will fall** - To fully offset carbon consumption today would be prohibitively expensive; too much is being produced with too few offsets available. The carbon tax needs to go up slowly while we deliver the investment in infrastructure needed to reduce the cost of offset – Greenhouse Gas Removal and Bioenergy with carbon capture and storage - or deliver carbon-free alternatives
- **Carbon taxation is complex and an art not a science** – Advocates of a carbon tax don't under-estimate the difficulties of introducing it. (How will it be applied, to what goods, how do we know the cost of offset and how do we change it as costs change?) But rather than looking to introduce the perfect tax, priced correctly across all products (an impossible task), we could start with lower amounts in high emitting products and sectors – flights, cement,

[4] This approach would be in strong contrast to the current ETS system, which only covers around 40% of European emissions, has required large numbers of exemptions and has not produced a carbon price that has incentivised investment. When exemptions fall away in 2030, industry will be faced with an uncertain and volatile carbon price; not a basis for good decision making. How the emerging UK ETS system will address these historic issues is considered later in this paper.

petrochemicals, white goods, electricals for instance – or on consumer products to initiate behavioural changes, and track its success and the behaviour change it leads to

But while there are good reasons for introducing a carbon tax in stages, that is not an argument to delay forever, precisely because we need significant time for infrastructure and behaviours to adapt.

In Nov 2018, Greg Clark's response to the Helm Review[5] agreed that introducing a carbon tax would be useful alongside other measures, although it would have to be a 'gradual transition'.

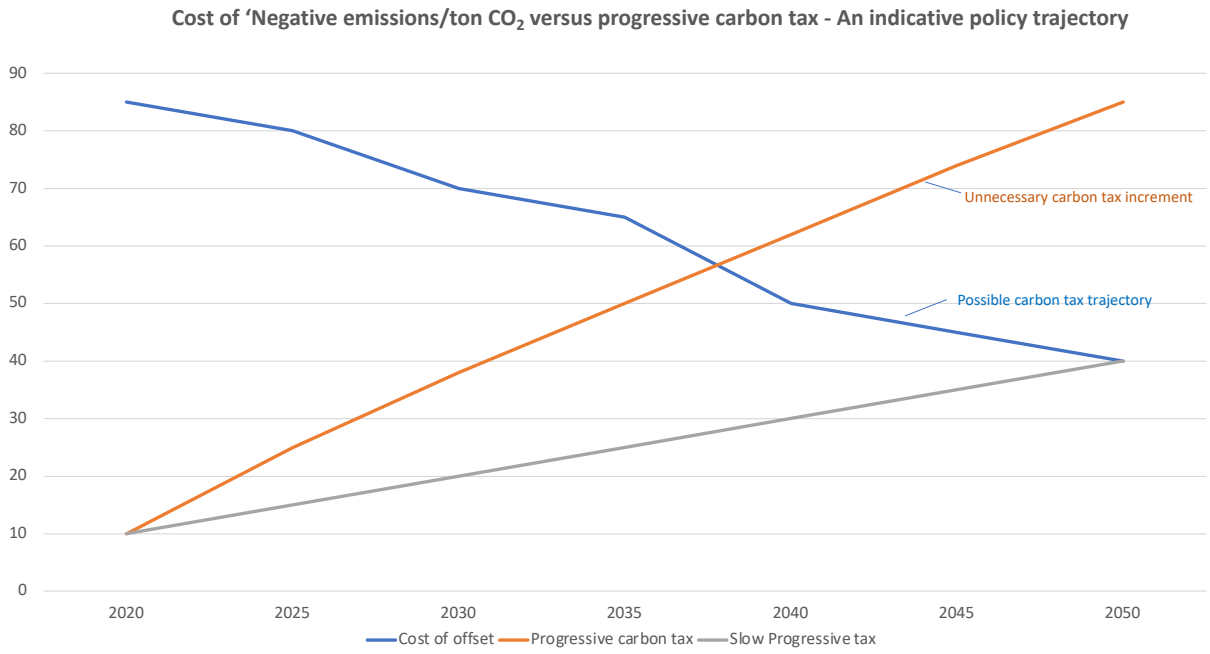
A Government commitment to a phased carbon price would be a strong signal that the demand for carbon-free alternatives will grow. **It is a policy the infrastructure sector should support, not only because it would help underpin their investment, but also because it would provide incentives for significant derivative expenditure** (growing bio fuels, converting to hydrogen HGVs, switching to electric vehicles) **that create the demand for that infrastructure investment**. The recent White Paper's commitment to developing a UK ETS will be an important contribution to this, although, as we shall see later, only a part of what is required.

The following indicative diagram is an illustrative example of the virtuous relationship between phased taxation and infrastructure investment:

- 'Negative emissions' are delivered through technologies that actually put CO_2 back in the ground. At the moment this is most effective through Bioenergy CCS (burning wood pellets and storing the CO_2) and enhanced soil capture
- The cost of 'negative emissions' today (or more precisely when the first CCS plants come on stream) is roughly £85/ton (based on a simplistic blend of the forecast range for the first BECCS plants of £75-100 plus some contribution from soil capture at £25-35/ton)
- This price is expected to fall as BECCS is introduced at scale and through competitive rounds run by Government with increasing competitive feedstock. The relative contribution of soil capture may also increase as more land is made available.
- Let us say, for illustrative purposes, a carbon tax was to be introduced on outward flights. If introduced today, equal to the full cost of offset - the negative emission cost - £85 would have to be added to each ton of CO_2 emitted; roughly £136 on a one-way flight to New York from London.

[5] "Cost of Energy Review" – Dieter Helm, October 2017. Cost of Energy Review Dieter is the strongest and most articulate advocate for carbon tax and associated reforms; much of the reasoning of this paper in relation to carbon tax aligns with his publications. In addition to the Helm Review, do try his recent book "Net Zero – How we stop causing climate change" for a more detailed analysis of the arguments.

- But if introduced in stages, say starting at £10 and slowly increasing, behaviours can start to change and adapt to increasing prices, while the price of offsets will fall as the industry grows.[6]



- In this indicative example, the curves intersect at £55/ton and thereafter the carbon tax could fall in line with the declining curve (i.e. any carbon tax increment is unnecessary and could thereafter mirror the cost of offset trajectory)
- Of course, the slope of the carbon tax curve could be changed, for instance only reaching the full cost of offset by 2050 (shown by the 'Slow Progressive Tax' line). At that point, the offset might be only £64 for the same New York flight (and of course other new offset technologies might have reduced that cost further)[7]

Summary: A carbon tax should be introduced in phases to avoid shocks and allow the costs of transition and alternatives to come down. It does not need to be complex and could be focused on key sectors and products with particularly high carbon content.

[6] Applying a tax to outward flights only is something the UK could do unilaterally without the need for difficult international negotiations. The indicative approach here tallies with a CCC example where it envisages paying for CO2 removal could add over £100 to a £500 return flight to New York in 2035 (at a point when aviation emissions are not fully offset – something that might not happen until 2050).

[7] The Stern Stiglitz UN Commission in 2017 concluded that the explicit carbon-price level consistent with achieving the Paris temperature target is at least US$40-80/$tCO_2$ by 2020 and US$50-100/$tCO_2$ by 2030, provided a supportive policy environment is in place.

COULD WE DELIVER NET ZERO THROUGH JUST INVESTMENT AND REGULATION?

A counter-argument to a carbon tax might run something like, "our investment into wind and solar has been highly successful. Surely, we should just do some more of the same across industries, then add some regulations on products that aren't captured within this?" As the CCC state in their Budget, "regulation can be used to give a strong and investable signal to businesses and consumers that the highest carbon technologies and behaviours will be phased out."

Perhaps in theory we could go down that route if we want to reach Net Zero emissions, with rounds of Contracts for Differences for more renewables, hydrogen and CCS, and regulations to reduce the carbon content of products.

But such an approach has obvious drawbacks:

- More offshoring – placing the cost on the industry not the consumer will lead to more offshoring[8]
- Competitive disadvantage – regulating industry may put their international sales at a competitive disadvantage
- There will be no income to fund the investment we need in new infrastructure
- No behavioural signals – you can't really regulate the carbon content of meat! You need a mechanism that progressively changes relative prices and hence behaviours.

The ambition shown in the Ten Point Plan is admirable, but it will be more difficult to achieve and arguably costlier if it is carried out without introducing carbon pricing at the same time.

Summary: The current approach, that focuses on infrastructure investment and regulations alone, risks more offshoring and putting businesses at an international disadvantage. A carbon tax can address these issues, raise funding and access sectors previously untouched.

[8] Could you prevent offshoring through regulation of imports? Well what would you regulate – the carbon content? Carbon tax is a more direct approach.

WOULD A GOVERNMENT COMMITMENT TO AN INCREASING CARBON TAX LEAD TO THE REQUIRED INFRASTRUCTURE INVESTMENT?

Put simply; no!!

To be clear, such a commitment will be hugely beneficial to the momentum and propensity of industry to invest. But it is a necessary but not sufficient condition, because of the following issues:

- **Too long-term.** Precisely because a carbon tax should be introduced in stages, it will be a long time before the economics of the vast majority of the new projects needed would be positive. The Net Present Value would be too low or negative today. The industry would simply wait until it was positive, so costs won't come down and alternatives won't be built. The virtuous relationship between carbon taxes and infrastructure investment described above would not start

- **Uncertain value.** Government should be able to change the tax's level and reach over time to ensure it is having the desired effects. If the level of tax is inherently uncertain, this will not help the investment decision process (unless it could only ever be increased). As this paper reviews later, this volatility could be worse if an ETS price approach relies solely on auctions, i.e. market forces, without some government-determined escalating minimum price.

  "It will be important to monitor and regularly review the evolution of emissions, technological costs, and the pace of technological change and diffusion so that carbon prices can be adjusted, particularly upward, if actual prices fail to trigger the required change." Stern and Stiglitz UN 2017

- **Policies change.** Government's track record isn't exemplary on this: it reduced wind farm and solar tariffs for new procurement, it cancelled the first two CCS projects mid procurement, it withdrew over £250m of funding for the Green Deal energy efficiency initiative. Could a future economic downturn or a more populist government reverse a commitment to a phased tax?

  To stimulate investment, a Government commitment to a carbon tax would have to be pretty inviolate – enshrined in regulatory processes and divorced from day-to-day politics; a level of commitment it is probably hard to implement and demonstrate. One possibility to address this might be to give

it to an independent body to determine and update; for instance, to the CCC, who could update the price regularly as part of its ongoing reviews.

- **A carbon tax accrues to Government.** Whether through a direct tax or through the proceeds of UK ETS allowance auctions, a commitment to a tax alone is insufficient, simply because it does not necessarily mean tax proceeds will be used for infrastructure. We also need the business models that funnel those tax proceeds into funding investment by the private sector (although no direct hypothecation is being suggested in this paper)

"Efficient carbon-price trajectories begin with a strong price signal in the present and a credible commitment to maintain prices high enough in the future to deliver the required changes……It is of vital importance to the effectiveness of climate policy, particularly carbon pricing, that future paths and policies be clear and credible.

Carbon pricing by itself may not be sufficient to induce change at the pace and on the scale required for the Paris target to be met, and may need to be complemented by other well-designed policies tackling various market and government failures." N. Stern and J. Stiglitz – Report of the High-Level Commission on Carbon Prices for the UN 2017.

A carbon tax needs to be supplemented by clear Government policy and business models, which is why the Ten Point Plan and within it the commitment, for instance, to complete the detailed business models for hydrogen and CCS, is so welcome.

Summary: A Government commitment to a phased carbon tax is a necessary but not sufficient condition to underpin investment. Business models and contracts are needed to further underpin investment now.

WE NEED BUSINESS MODELS TO INCENTIVISE THE INFRASTRUCTURE INVESTMENT THAT WILL REDUCE THE COST OF TRANISTION

Today non-fossil fuel products are at a competitive disadvantage; to the extent that they are non-investable.

For instance, as long as hydrogen (made from steam reforming methane or energy-intensive electrolysis) has to compete with methane (with no carbon tax) as a company's source of heating, it will lose. So will CCS power pitted against conventional power. Or grid-scale Compressed Air Energy Storage, whose costs to provide power when intermittent renewables aren't producing have to compete against cheap gas-fired power stations.

For the period of transition, we will need business models across sectors to overcome this competitive disadvantage and give sponsors and investors the certainty they need:

- In some cases, the business models just need to give protection against unpredictable markets[9]

- In most cases, the business models are there to give industry protection whilst the competitive disadvantage to fossil fuel alternatives endures

(**It is important that this 'protection' is not thought of as subsidy.** The actual subsidy is being given to those industries and consumption that use high levels of fossil fuels, as they are not being charged for the CO_2 they are emitting, despite its known effect on our environment.)

Business models are also needed to underpin investment in excess capacity in advance of associated demand; investing in a CCS Transmission and Storage network that can accommodate a growing (but uncertain) level of demand, investing in Bio Energy CCS plant to encourage the growth of a feedstock market, investing in inter-connectors on the strength of long-term forecasts, developing a CO_2 shipping fleet to allow for the growth of a European import market, or building an electric car charging network in anticipation of demand.

The private sector is not good at investing in such excess capacity speculatively. Business models are needed from Government that support the provision of this excess capacity and stimulate new markets.

The benefits of clear, repeatable business models are clear, as evident in the rounds of windfarm CfD competitions and their benign impact on capital expenditure and finance costs, where a recent report indicated that the average Weighted Average Cost of Capital of UK offshore wind farms has decreased from over 10% in 2010 to below 7% in 2020, contributing nearly 20% of the cost reductions over the same period.

This implies Government will need to take a much more active controlling role, integrated across broad sectors, developing and implementing long-term contracts to give investment certainty and address current market failures and the hidden subsidy to carbon-intensive industries.

[9] For instance, grid-scale storage is profitable at today's forecast prices for electricity and ancillary services (providing capacity, fast response, inertia etc). But no investor will take this revenue risk in an uncertain market, whose volatility and demand are directly impacted by Government policy that the investor can't control.

It is in this context that the Government's 10 Point Plan for Green Investment just announced is so welcome as it covers investment in a number of sectors that need exactly that level of support. This includes support for large and modular nuclear plant, Carbon Capture and Storage (including a commitment to complete the underlying business models and revenue mechanisms to underpin investment[10]), a hydrogen economy, electric car investment (both the battery technology and support for the charging infrastructure) quadrupling offshore wind production, an extended energy efficiency programme for housing, and a commitment to issuing Green sovereign bonds to finance the transition.

In appendix 1 to this paper is a synopsis of the main elements of the Plan for ease of reference.

With such a comprehensive plan, it would be wrong to be critical, but over time we will also need further explicit support in other industries. Amongst a range of possible further support, we may need:

- Long term contracts that value the **grid resilience** that storage provides
- Contracts for **Equivalent Firm Power** – the Helm report makes the coherent argument that the cost of intermittency of renewables isn't properly reflected in their strike price. Contracting for capacity as 'EFP' would incentivise intermittent generators to contract with demand side response, industry with flexible usage, and grid-scale storage, removing the need for the first two contracts above to be let separately. (Minister Greg Clark agreed the need for EFP contracts in 2018)
- Structures to **incentivise energy efficiency** – the Green Homes Grant and Social Housing Decarbonisation Fund extension are welcome new injections of cash into the housing energy efficiency industry, but those initiatives will peter out with the grant. Previously, Government's Green Deal initiative was a good business model, but their insistence on it being at market rates killed demand. We need a business model to support the industry and create sustained demand
- A model that encourages improved **carbon sequestration in land**. At around £25-35 per tonne of CO_2, soil capture's potential is perhaps undervalued, and can have wider environmental benefits. There is currently no business model that might channel funds to farmers
- A framework to **reward negative emissions**. This could be achieved, for instance, by including negative emissions in the UK ETS scheme (it is not currently in EU ETS) so that companies could buy offsets at the prevailing carbon price. As the CCC say in their 6th Carbon Budget, the "CCC

[10] A more detailed review of the need for and opportunities presented by CCS can be found in the TIF paper – "Carbon Capture and Storage, "a necessity not an option"" TIF July 2020.CCS: A necessity not an option

recommends that CO_2 removal is allowed to contribute to Net Zero. A UK removals credit (carbon unit under the Climate Change Act) could be defined. This would enable the 23MT of CO_2 removals in our 2035 scenario to be funded through UK carbon credits paid for by sectors like aviation that are still expected to have positive emissions."

This is an incomplete list of what will be needed alongside the huge amount of work necessary to flesh out the business models and policies needed to underpin the 10 Point Plan. All of this investment obviously comes with a cost. That cost is the funding embedded within those contracts, to compensate for the invisible subsidy currently given to fossil fuel alternatives.

But the scale of what is required is also an exciting opportunity for the infrastructure sector and its financiers. So many projects to deliver, innovations to introduce and competitions to be won!

But at the same time, there is a fundamental challenge for the infrastructure industry; if carbon pricing is introduced in stages, it will also impact the economics and benefit:cost ratios of future projects, which should take account of the carbon intensity of projects. The industry will have to be far more focused both on the carbon intensity of projects and deliver more investment in greenhouse gas removal to compensate.

Summary: Business models are needed in this transition to underpin infrastructure investment and incentivise investment in excess capacity in a rapidly growing market. These are not subsidies; the actual subsidy is already being given to industries and consumption based on intensive fossil fuels as they are not being charged for the CO_2 they are emitting. The support to investment described in the 10 Point Plan is extremely welcome; we now need to develop the underlying business models and funding rounds to realise that ambition.

BUSINESS MODEL SUPPORT SHOULD BE TRANSITIONAL

Clearly Government has to have an active, controlling role during this transition, through the contracts it puts in place and the breadth and speed at which it introduces a carbon tax.

As long as carbon tax is less than the true cost to offset or replace the related emissions, business model support will be needed. The inherent 'support' in these

contracts should equal the amount by which the carbon tax is not yet equal to the full cost of offset.[11]

But as the carbon price increases and regulations kick in, then the level of support should reduce:

- The level of support embedded in new contracts will reduce, as competitive disadvantages to fossil fuels will be falling

- If correctly structured, the level of support within future contracts in place should also fall over time. For instance, to remain competitive, hydrogen may have to be sold at the methane price and its CfD contract will include support for the cost of conversion. But over time, as methane users pay increasing levels of carbon tax and hydrogen producers don't (because they use electrolysis, or CCS captures the CO_2), then the competitive disadvantage and hence the level of support offered by the CfD contract should fall

We shouldn't regret the long-term costs of putting these business models and contracts in place; they reflect the hidden subsidy to fossil fuels. But correctly structured, the level of Government support embedded in those contracts will fall as carbon taxes increase. The faster the increase, the quicker the fall.

Again, it is a virtuous relationship. The greater the carbon tax, the more funds available to fund the transition, and the lower the support needed by infrastructure in existing and future contracts.

In Appendix 2, there is a brief consideration of the development route for the hydrogen industry; one of the key priorities of the 10 Point Plan. This describes the business model's necessary to underpin hydrogen investment, but also how this might interface with a phased carbon tax and therefore Government support will be transitional. The appendix is therefore a high-level summary of the virtuous link between infrastructure investment and carbon tax.

WOULD A CARBON TAX BE FOREVER?

Well yes and no!

- Yes, because some sectors, flying for instance, will still emit CO_2 in 2050 (although the R&D within the 10 Point Plan to reduce flight emissions could have important benefits). By then polluters should be paying a 'full' carbon

[11] For instance, if the carbon tax on methane equalled the full cost of its offset or alternative (i.e. hydrogen) then methane and hydrogen would be the same price to a consumer. If the carbon tax is less, hydrogen will need support to be competitive.

price, that reflects the total cost of offsetting those emissions; the Net of 'Net Zero'

- No, because the carbon tax is there to incentivise the transition away from carbon intensive consumption. It therefore should be a victim of its own success; there's no point having a carbon tax if we don't emit any CO_2!

Summary: Business models should be designed to last only for the transition and will reduce in cost as the carbon tax increases. The amount of carbon tax should fall longer term; the victim of its own success.

WON'T A CARBON TAX MAKE US UNCOMPETITIVE?

As described above, actually current policy has already had that effect, as increasing energy prices have led to offshoring, and ETS volatility and uncertainty disincentivises industrial investment.

Think of what would happen if we took that inadvertent approach to the extreme: if we massively increase our energy price unilaterally, our emissions could go to zero overnight: because we would import everything from other countries! But our CO_2 consumption would of course increase.

That's why we need a carbon tax approach focused on consumption. Critically, this tax must also apply to competing imported goods and not be applied by the UK to our exports, so as not to put them at a competitive disadvantage overseas.

This approach delivers fair trade here and allows British industry to remain competitive overseas.

This approach is not discriminating against foreign products (an approach which could be subject to challenge), but treats all products on a common basis.

If other countries choose to reciprocate, that's fine - they need to fund their transition too - as long as it is applied fairly and consistently to domestic and imported goods, so that they can compete on a level playing field.

Of course, what would be ideal would be to build an international consensus around the trajectory and level of appropriate carbon taxes. But unlike the current multilateral approach to agreeing reducing emission targets, we do not have to wait for that consensus; we can take unilateral action that incentivises others to follow suit while protecting our export businesses.

"International cooperation to promote consistency of action across countries can help lower costs, prevent distortions in trade and capital flows, and facilitate the efficient reduction of emissions." N. Stern and J. Stiglitz – Report of the High-Level Commission on Carbon Prices for the UN 2017.

So, it is possible to introduce carbon tax and yet protect the competitiveness of businesses. But at the same time, we can also invest in infrastructure that will help our businesses to decarbonise. In a recent TIF paper[12], I argued that by introducing CCS at our industrial clusters, we can offer the opportunity for industry to decarbonise cheaply. This would also mean those clusters become a safe haven for inward investment in new plant in a world likely to impose increasing levels of CO_2 tax or regulations.

If we introduce that virtuous combination of a non-discriminatory carbon tax and investment in decarbonising infrastructure such as CCS, then we can protect our businesses, keep them competitive, and lead a transition to a green economy, rather than adopt an approach that penalises them and pushes production offshore.

Earlier in this paper we discussed how energy policy has effectively led to the offshoring of manufacturing and over the next decade risks far more offshoring in major emitting sectors considering whether to re-invest in UK infrastructure. We have the opportunity to reverse this trend. A carbon price with border controls can make those businesses competitive domestically and internationally. Providing them with CCS infrastructure can go one step further, allowing them to produce green products at marginal extra cost, while the rest of the world catches up.

Summary: A carbon tax should be applied to imports so all products are treated fairly and our exports remain competitive, while investment in infrastructure should make it cheap for businesses to transition to green products. We can actually make our industries more competitive as we decarbonise and the UK a more attractive place to invest.

A CARBON TAX OR ETS SYSTEM?

Having reviewed the rationale and benefits of some form of carbon pricing, we can address the debate of whether this is better achieved by a tax or ETS.

While Government has announced its intention to develop a UK ETS, this debate is not superfluous. Either the UK ETS scheme needs to ensure it can capture the full benefits of carbon pricing, or it needs to be supplemented with additional measures.

[12] CCS: Time for an ambitious leap forward- TIF July 2020

A comparison of the two can help show the policy implications[13]:

- A **carbon tax** is relatively straight forward; it is a government/regulator determined carbon price attached to goods for their carbon content. It could be applied upstream or downstream; upstream as a tax on fuels, downstream as a tax on goods and services at the point of consumption. It can be narrowly applied on particular industries or products, or more comprehensibly introduced. Like any well-constructed tax, it can be designed to be fair, simple and predictable.

- Under an **Emissions Trading System (ETS),** a cap is set on the greenhouse gases that businesses can emit via the total number of allowances in circulation, which will decrease over time. Businesses then buy and sell emissions allowances through government auctions or secondary markets. It tends to be focused on particular carbon-intensive sectors of the economy, and 'free allowances' are given to those industries most susceptible to international competition, so at the greatest risk of offshoring, although those free allowances are set reduce over time.

The fundamental difference between the two in their purest form is that a carbon tax gives certainty over the carbon price, but not whether that will result in zero emissions, whereas an ETS gives certainty over emissions (ultimately reducing to zero in the sectors in which it is applied) but not the market price for allowances on the way.

Given the immediate focus on developing a UK ETS system, policy development will need to recognise the different impacts and nature of ETS to a tax approach and consider whether a wider set of levers are needed to address those potential impacts. Some of these are highlighted below:

BREADTH OF APPLICATION

Emission trading does not currently cover transport, building, agriculture, land, waste, F-gases and less energy-intensive industries. Policy will need to consider how carbon pricing is widened to these sectors, wider businesses and households.

In the Energy White Paper, Government state, *"We have committed to exploring expanding the UK ETS to the two thirds of uncovered emissions. This will include how the UK ETS could incentivise the deployment of greenhouse gas removal technologies."*

[13] Appendix 3 – Hm Treasury Net Zero Interim Review – Pricing Carbon Emissions is an extract from the HM Treasury Net Zero Review that gives a useful summary of the policy levers of carbon tax, ETS, subsidies and regulations that together can be used to deliver the transition

That is one approach. The CCC in contrast has recommended *"that carbon prices and taxes on manufacturers should be strengthened, while we recognise that this may not be the only policy mechanism to support decarbonisation:*

- *For the traded sector, this can be achieved by using the CCC pathway to set the cap for UK ETS*
- *For the non-traded sector, a tax, or equivalent, should be set well above existing levels. This will require the non-traded sector to be covered by some form of carbon pricing"*

ETS therefore is useful focused on particular industrial sectors, but a wider carbon tax may be needed to incentivise the behavioural and non-corporate changes necessary.

GIVING PRICE CERTAINTY

The Energy White Paper correctly asserts *"the operation of the cap will provide certainty about the decarbonisation trajectory over the long term. It will deliver a robust carbon price signal."*

However, the statement, *"knowing that the ceiling on emissions will lower transparently over time enables business to plan and invest to decarbonise, while at the same time protecting the competitiveness of businesses and minimising the risk of carbon leakage"* seems less accurate as ETS does not give price certainty; ETS's failure to deliver a material carbon price to date has not provided the necessary economic signals; and international competitiveness will be impacted unless ETS is accompanied by standards and border tariffs to protect domestic businesses.

However, to address this, Government could publish a minimum carbon price trajectory for future auctions, giving minimum price certainty to underpin proper economic planning by businesses.

SPEED OF TRANSITION

If Government is to adopt the ETS reductions recommended by the CCC, the speed of transition could be pretty severe. The CCC have recommended the cap on the level of traded sector emissions falling from 106 MtCO2e in 2023 to 57 Mt by 2030, as shown in the table below.

Traded sector emissions in 2023-30, based on current scope plus potential inclusion of engineered removals								
$MtCO_2e$	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity supply	39	39	36	26	21	18	16	14
Industry (manufacturing, construction & fuel supply)	57	55	52	48	45	42	38	34
Domestic and intra-EU aviation	10	10	10	10	10	10	9	9
Proposed ETS cap (for currently traded sectors)	**106**	**104**	**98**	**84**	**76**	**70**	**64**	**57**
Engineered removals	0	0	0	0	-1	-1	-4	-5

Source: CCC Analysis
Notes: Engineered removals not included in overall cap level in table

While the rapid reduction in ETS is commendable, it reinforces the need for a suite of policy support to protect businesses through the transition and maintain their competitiveness, for instance providing the funding for businesses to link to the developing carbon capture and storage network so that they could remove all of their emissions, or funding companies' conversions to hydrogen-powered heating and processes.

"Sectors at risk of carbon leakage must be supported through the transition, initially through taxpayer-funded subsidies." - CCC 6th Budget Report.

INCENTIVES AROUND FREE ALLOWANCES

The allocation of free allowances to industries most at risk from international competition has been a tactical solution to the problem, but not a strategic one. By definition, free allowances cannot endure if we are to achieve Net Zero. The prospect of their phasing out creates uncertainty for businesses unless they can see how a replacement suite of policies – carbon taxes, border adjustments, rebates for exports – will replace them.

"Free allowance allocation may not be the most efficient way to achieve the combined goals of deep decarbonisation and avoiding carbon leakage [offshoring]." - CCC 6th Budget Report.

THE NEED FOR A SUITE OF POLICY MEASURES

It should be clear that introducing a UK ETS alone will be insufficient to deliver a just transition and that a suite of integrated policies, as identified by HM Treasury and summarised in Appendix 3, will be required to help businesses through the transition.

It is likely that the introduction of a carbon tax, in addition to ETS, will form an important part of these measures, to widen the reach of carbon pricing and not least because HM Treasury will need to replace the £37bn of fuel and vehicle excise duties it currently enjoys if it is to contemplate providing the underlying funding for the investment needed in new green infrastructure and supporting businesses.

"ETS alone is unlikely to provide a sufficient incentive to enable deep decarbonisation of industry as a) costs for early industrial deep decarbonisation deployment will likely come at a premium above expected carbon price b) the uncertainty of the carbon price level adds a further risk premium to costs c) upfront capital support is likely to be required by manufacturers that seek very short payback periods." - CCC 6th Carbon Budget

GOVERNMENT POLICY NEEDS TO CONSIDER THE WHOLE SYSTEM AND WILL INVOLVE A NUMBER OF TRADE-OFFS

A transition to Net Zero by 2050 is a huge challenge and comes at a cost; effectively we are having to start paying for the 'free' carbon we have enjoyed until now. That path to Net Zero will require carbon tax and ETS policies that find the correct balance between several competing demands:

- At what speed and at what level do we introduce carbon pricing? Slowly gives us time to adjust, but does it give enough incentive to transition, will it change behaviours in time, and will it raise funding to invest in infrastructure and mitigation? Fast will be unpopular, the alternatives won't be in place, and as a 'tax' it will dampen demand in the economy as we look to emerge from Covid

- What should we do with the proceeds of carbon pricing (tax or ETS auction proceeds)? Use it to pay down our deficit, give tax breaks to offset the impact on consumption, aimed at those most effected, or invest the proceeds in infrastructure to provide alternatives and offset remaining emissions?

- Do we introduce carbon pricing across the board with all of its complexity or focus on some particular sectors where we are trying to incentivise change?

- How much transitional infrastructure should Government look to support and when; has it the resources to deliver a lot quickly, or if it defers, then will markets invest and grow at rate that makes Net Zero achievable?

"In every country, the design of carbon pricing policy implies a balance between incentivizing low-carbon behaviour and mitigating the adverse distributional consequences of higher energy prices." - Intergovernmental Panel on Climate Change

"Government needs to use a mix of policy levers to address multiple market failures and support decarbonisation. The most important market failure to address is the negative externality associated with the emission of greenhouse gases. Carbon pricing is an important lever in addressing the negative externality problem but should be supplemented by other policies in order to achieve an equitable balance of contributions from households, businesses and taxpayers." - HM Treasury, Net Zero Interim Review.

Government will need a focused delivery capability to integrate carbon tax and ETS policy and delivery, infrastructure investment policy and procurement, introduce import taxes (and encourage others to follow suit), standards and regulations, and consider the distributional impacts of policy.

Summary: To deliver Net Zero, Government will need a focused delivery capability: a 'controlling mind' approach to carbon tax and infrastructure investment that understands the trade-offs between competing decarbonisation and policy objectives

PARTICULAR FOCUS IS REQUIRED ON LOW-INCOME HOUSEHOLDS AND THE FUEL POOR

The principle of polluter pays is sound, as it directly links costs and incentives to users of products and services. But a key question throughout the Net Zero transition should be whether measures might add an intolerable burden on low income households and the fuel poor. Policy development must consider this risk from the outset, so that the transition is fair and perceived to be fair; an important consideration in ensuring public sector buy-in to the transition.

To put this into perspective, around 10% of English households are considered to be in fuel poverty, representing over 2 million households. In Scotland, Wales and Northern Ireland the figures are higher at 25%, 12% and 42% respectively.

However, this concern does not mean that a carbon tax should not be implemented; consumers need to see the cost of their actions and change behaviours accordingly.

But the burden of a carbon tax applied universally will be disproportionately felt by those on low income. Carbon tax policy needs to link to wider Government policy in areas such as welfare support and minimum wage levels, to ensure this disproportionate impact is mitigated. An element of carbon tax proceeds could be reserved for this purpose.

"All proceeds of the carbon tax must be put towards financing the ecological transition, particularly by compensating the hardest-hit low-income families." T Piketty - Capital and Ideology 2020.

Summary: a carbon tax will disproportionately impact lower income households. Wider welfare and minimum wage policy will need to ensure this potential impact does not occur.

CREATING A GOVERNANCE TO REFLECT THE PUBLIC PRIVATE PARTNERSHIP THAT THE NET ZERO TRANSITION REQUIRES

This paper argues that Government needs to take a central, coordinating role in the transition to Net Zero and will have to let a large number of contracts across multiple sectors to deliver it. The infrastructure industry will benefit massively from those contracts and funding, so its governance and ethos should reflect the public sector provenance of those investments.

In developing these markets, particularly new ones like CCS, we need to have business models and a relationship between public and private sectors that are both sustainable and provide an attractive blueprint for other countries to follow.

This has not been the case in some historic sectors such as PFI in the UK and the relatively adversarial relationships we are currently seeing between utilities and regulators in many regulated sectors.

What does good governance mean and what are the alternatives?[14] Well this will have to be determined by individual companies in each sector, but might include target equity return levels, using refinancing proceeds (the ability to raise significantly more debt once assets are operational) within the company to improve flexibility and resilience or reduce costs to consumers rather than to pay super dividends, consumer

[14] A more detailed review of the need for new governance is explored in my earlier TIF paper – "Private Finance: Press reset – Rebuilding Trust and Strengthening Partnerships" and more recently in Mike Gerard's TIF paper Effective Infrastructure Governance July 2020.

or public sector representation on boards, or enshrining social objectives into a company's governance.

The infrastructure investment to deliver the transition will come about as a result of sustained public-sector support for infrastructure and the contracts they put in place. The key question each private sector infrastructure company should therefore be asking is "why am I the best custodian of public assets". If this public-sector ethos runs through the business models that the public and private sector develop, they will be global exemplars of good practice.

Summary: With high levels of Government support to the infrastructure industry to achieve Net Zero, private sector governance needs a public sector, consumer-facing ethos. If we get this right in the UK, our business models and industry can be seen as global leaders.

CONCLUSION

The transition to Net Zero will require massive investment by the private sector and strong leadership by the public.

It will not be free!

The Government's Ten Point Plan, White Paper, the CCC's 6th Budget and HM Treasury's Net Zero Review are a welcome, integrated approach to stimulate investment across sectors and put the necessary supporting business models in place.

Implementing a phased carbon tax and ETS, perhaps focused on particularly high emitting sectors at the outset but widening their reach over time, can provide both the incentives to consumers and funding to infrastructure to deliver that transition. It can be a key support and facilitator for Government's Plan.

That funding can support a competitive infrastructure industry across sectors, which can both build the infrastructure to give decarbonised alternatives to consumers and the means to offset their remaining carbon emissions.

There is therefore a virtuous relationship between a carbon tax and Green infrastructure investment, the former funding the latter to get down the cost of the former!

Quite a double-act!

PANEL REVIEW BY MEMBERS OF THE INFRASTRUCTURE FORUM

An early draft of this paper was reviewed and debated by an expert panel with the following members:

Sacira Coric, Director, Turner & Townsend
Samuel Ebohon, Transaction Associate Director, Arup
Regina Finn, Director, Lucerna Partners
Mike Gerrard, Chair, INPP Limited
Angela Hepworth, Commercial Director, Innovation, Drax
Matthew Knight, Head of Business Development, Siemens Energy
Michael Powell, Tax Director, EDF Energy
Paul Spence, Director of Strategy & Corporate Affairs, EDF
Scott Tindall, Partner, Hogan Lovells

I am grateful for their comments and thoughts (and certainly wouldn't represent they agree with the paper in whole or part!) and have tried to reflect them in the final paper.

About the author:

For the past 4 years, Paul has been an independent infrastructure adviser, after over a decade in project finance banking and then 20 years as an infrastructure partner at PricewaterhouseCoopers.

He established and chaired the CCS Advisory Group and is now adviser to BEIS on the implementation of CCUS in the UK and a member of the Committee on Climate Change's industry decarbonisation policy steering group.

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APPENDIX 1 – TEN POINT PLAN FOR A GREEN INDUSTRIAL REVOLUTION – GOVERNMENT ANNOUNCEMENT ON 18 NOVEMBER 2020.

The Government has just announced a 10-point plan for investment to accelerate the UK's path to Net Zero. The plan is, in my view, ambitious, clear and integrated. It focuses on key initiatives in the main infrastructure sectors, understands the catalysts needed and market failures to address and recommends both R&D to complement the strategy and international action, with its imminent joint chair of both the Climate Ambition Summit this year and its COP26 Presidency in 2021.

The plan does not address the question of carbon pricing, nor should it; it is a plan focused on investment and jobs. I suspect longer term carbon pricing will be introduced into the mix for all the reasons described in this paper, as well as the Government's commitment to a UK ETS in certain sectors. But starting with the investment that will deliver the underlying infrastructure and skills and reduce the costs of transition is the right order of events.

The following are extracts from the high-level plan.

"The Prime Minister today sets out his ambitious ten-point plan for a green industrial revolution which will create and support up to 250,000 British jobs.

The Prime Minister's ten points, which are built around the UK's strengths, are:

Offshore wind: Producing enough offshore wind to power every home, quadrupling how much we produce to 40GW by 2030, including 1GW of innovative floating offshore wind, which will extend the reach of wind power, supporting up to 60,000 jobs in aggregate. Government will invest £160 million in ports and manufacturing infrastructure to enable 60% of offshore wind content to come from the UK.

Hydrogen: Working with industry aiming to generate 5GW of low carbon hydrogen production capacity by 2030 for industry, transport, power and homes, and aiming to develop the first town heated entirely by hydrogen by the end of the decade. Government are committing to complete testing to allow 20% blending of hydrogen into the gas distribution grid.

This includes up to £500 million of funding, including for trialling homes using hydrogen for heating and cooking, starting with a Hydrogen Neighbourhood in 2023, moving to a Hydrogen Village by 2025, with an aim for a Hydrogen Town – equivalent

to tens of thousands of homes – before the end of the decade. Of this funding, £240 million will go into new hydrogen production facilities.

Nuclear: Advancing nuclear as a clean energy source, across large scale nuclear and developing the next generation of small and advanced reactors, which could support 10,000 jobs. £525 million of funding is allocated to help develop large and smaller-scale nuclear plants, and research and develop new advanced modular reactors.

Electric vehicles: Accelerating the transition to electric vehicles and transforming national infrastructure to better support electric vehicles, including funding of:

- £1.3 billion to accelerate the rollout of charge points for electric vehicles in homes, streets and on motorways across England, so people can more easily and conveniently charge their cars
- £582 million in grants for those buying zero or ultra-low emission vehicles to make them cheaper to buy and incentivise more people to make the transition
- Nearly £500 million to be spent in the next four years for the development and mass-scale production of electric vehicle batteries

Public transport, cycling and walking: Making cycling and walking more attractive ways to travel and investing in zero-emission public transport of the future, and £120 million to begin the introduction of fleets of zero emission buses.

Jet Zero and greener maritime: Supporting difficult-to-decarbonise industries to become greener through research projects for zero-emission planes and ships, including £20 million for a competition to develop clean maritime technology, such as feasibility studies on key sites, including Orkney and Teesside.

Homes and public buildings: Making homes, schools and hospitals greener, warmer and more energy efficient, whilst creating 50,000 jobs by 2030, and a target to install 600,000 heat pumps every year by 2028, while leaving open the option as to whether hydrogen or electrified heating or both will be used for household heating.

Funding includes £1 billion next year into making new and existing homes and public buildings more efficient, extending the Green Homes Grant voucher scheme by a year and making public sector buildings greener and cutting bills for hospitals and schools, as part of the Public Sector Decarbonisation Scheme.

Carbon capture: Becoming a world-leader in technology to capture and store harmful emissions away from the atmosphere, with a target to remove 10MT of carbon dioxide by 2030, equivalent to all emissions of the industrial Humber today, and an

introduction of the supporting business models and revenue support mechanisms next year, including for hydrogen.

An extra £200 million of new funding (on top of the existing £800 million CCS Fund) to create two carbon capture clusters by the mid-2020s, with another two set to be created by 2030. This increases the total invested to £1 billion, helping to support 50,000 jobs, potentially in areas such as the Humber, Teesside, Merseyside, Grangemouth and Port Talbot.

Nature: Protecting and restoring our natural environment, planting 30,000 hectares of trees every year, whilst creating and retaining thousands of jobs.

Innovation and finance: Developing the cutting-edge technologies needed to reach these new energy ambitions and make the City of London the global centre of green finance, including a £1bn Net Zero Innovation Portfolio focusing R&D on areas to correspond with the ten-point pan such as floating offshore wind, nuclear reactors, energy storage, bioenergy, CCUS and artificial intelligence for energy, as well as support for demonstration nuclear fusion plant. The UK will launch the first Sovereign Green Bond and introduce mandatory climate-related financial reporting.

This follows ambitious plans to make the UK the world leader in clean wind energy, and plans for greater protections for England's iconic landscapes and the creation of new national parks, as set out by the Prime Minister over the last few weeks.

Other key parts of the plan will be driven forward by significant investment set out over the last year, including the £1 billion energy innovation fund to stay ahead of the latest technologies needed to reach new energy targets, £5 billion for alternative greener ways of travel including cycling, walking, and buses, and £5.2 billion to create for new flood and coastal defences in England by 2027."

This marks the beginning of the UK's path to net zero, with further plans to reduce emissions whilst creating jobs to follow over the next year in the run up to the international COP26 climate summit in Glasgow next year.

Link to full report:

The Ten Point Plan for a Green Industrial Revolution

APPENDIX 2 – DEVELOPMENT OF THE HYDROGEN MARKET

The Ten Point Plan has made the development of the hydrogen market as one of its key pillars.

As an example of the virtuous relationship between infrastructure business models and carbon tax, this appendix considers the business models necessary to underpin hydrogen investment, how this might interface with a phased carbon tax and as a result how Government support will be transitional.

Development of the hydrogen market

The transition to hydrogen is a key building block in the path to Net Zero as it both needs to replace the use of gas for heating and can be used to power vehicles, in particular heavier vehicles such as trains, HGVs and ships.

There are two main sources of hydrogen. 'Blue' hydrogen is made by reforming methane through heat into hydrogen and CO_2 with the latter then put back into the ground using Carbon Capture and Storage. 'Green' hydrogen is made through the electrolysis of water breaking H_2O into the H and the O.

The advantage of blue hydrogen is its scalability and it is currently a lot cheaper than green. Its disadvantage is it is not entirely green, both because it does rely on the use of CCS, but more importantly the reforming of methane does have some residual emissions.

The advantages of green are that it is 100% green (hence the name!) can be produced at a local level and can be produced in small units; i.e. it does not require large capital expenditure necessarily.

The need for supporting business models

As both of these hydrogen technologies have different advantages, they both need encouragement to develop and reduce their costs and improve efficiencies. They will need different business models given their different capital and operating costs and risks.

In both cases, **hydrogen is competing with users who at the moment buy gas (or fuel) which does not carry a carbon tax**. Existing users are therefore 'subsidised' as they are not having to pay for the carbon emissions their use creates.

Until this subsidy has been eroded through a carbon tax or ETS imposed carbon price, hydrogen users will remain at a competitive disadvantage. The **business models** that underpin the development of hydrogen **will have to support that investment to offset the subsidy given to existing users**. The level and nature of support will need to be different for blue and green hydrogen because of their differences. (The market is actually more complex as there are different qualities etc of hydrogen, which at the margin will need to be recognised in support levels and structure)

In the short term, while the inherent cost of hydrogen is much higher than methane gas, **users should be able to buy hydrogen at the cost of methane**. This solves the incentive problem; businesses no longer have to increase costs to become green. (they do however have to worry that there is a reliable supply of hydrogen, so the greater the scale of investment into hydrogen production, the faster businesses will not see this as a risk)

If businesses can convert to hydrogen at no incremental cost, this makes it easier and less punitive for Government to introduce regulations to 'encourage' the transition to hydrogen.

This will help concerns to producers and government that there will not be a market for hydrogen; if it is effectively costless for businesses to convert, then it is more likely this will happen sooner.

The cost of methane however should increase over time as it should include a phased carbon tax (direct or ETS imposed). For as long as methane plus carbon tax is less than the full cost of producing hydrogen, then hydrogen users should be paying this full price, including carbon tax, because whilst they have gone green, they are still getting 'subsidised' hydrogen.

Procuring blue hydrogen

Blue hydrogen should be procured through a series of competitive CfDs, where the CfD supports the difference between the hydrogen producer's cost (methane plus cost of conversion) and its revenues (methane price plus carbon price). Note that the hydrogen producer should be exempt from the carbon tax from the methane it uses as it is capturing the CO_2.

This means that as the carbon taxes increases, the hydrogen producer's revenues from customers will increase and so the level of support actually payable under the CfD will fall over time.

Competition and innovation will be reducing the cost of blue hydrogen over time. There will come a time **in the medium term** where **the cost of methane plus carbon tax exceeds the cost of blue hydrogen.** At that point:

- **Users of hydrogen should pay the cost of hydrogen only**; so at the point of crossover they should only pay the cost of hydrogen, which going forward will be lower than methane plus tax. They will gain competitive advantage over those companies that have not converted away from gas
- **There will be a market price for hydrogen**, so the need for future CfDs should fall away, the industry can return to a world where government intervention is not required
- As user purchase contracts come to an end and hydrogen producers come to the end of their CfDs, there will be **an increasing amount of hydrogen produced not covered by contract and a true hydrogen market price will evolve**, freely available to the market
- In addition, it is unlikely that hydrogen producers under CfDs will have 100% of their output contracted (or those contracts may expire), so **the CfD should incentivise a degree of price discovery**; effectively an incentive to begin a nascent market

The combination of a carbon tax and supportive business models actually allows for the smooth transition to a hydrogen market with no requirement for long term support.

Note that the CfD protects the producer until its marginal cost is competitive.

Procuring green hydrogen

We need to **ensure the development of the hydrogen market allows for both green and blue hydrogen**, to nurture both and allow for innovation and cost reduction.

At the moment, green hydrogen is more expensive than blue, but with completely different cost structures. Green hydrogen's capital expenditure is proportionately higher and its operating costs are linked to the cost of electricity. Of course, this means its opex could be close to zero if it is using electricity only in periods of low demand.

A business model could use a CfD (this time linked to the electricity price) whose strike price covers the cost of electricity and amortisation of the finance needed to pay for the electrolysers. Similar to blue hydrogen, users will pay the methane plus carbon tax price for the hydrogen, until the cost of hydrogen is lower than that price.

The interface of the hydrogen markets

Careful consideration needs to be given to the interface between these two business models.

Currently, the all-in cost of blue hydrogen is lower, but that is not necessarily the case. In addition, when green producers have amortised their capital, their marginal cost of production will be lower and will depress the market price for hydrogen (this impact may be marginal given the relative scale of production of blue and green, but will become more material over time and influence the developing market price)

Assuming this cost differential endures for some time, a user that contracts for green hydrogen will not want to pay methane plus carbon tax for longer than a blue hydrogen user (where the crossover point is forecast to occur earlier). Contracts will need to reference an emerging generic hydrogen price to not incentivise users to favour one technology over the other while both markets are in their development phase.

Actually, this is equally true for different producers within each market. An early producer of blue hydrogen may be more expensive than subsequent rounds. Either its offtakers need to absorb this risk, or like green hydrogen, the CfD might contain some protections for lower prevailing hydrogen prices; i.e. it would get more support within the CfD to reflect its higher historic cost base, rather than be penalised for being a first mover.

What if a carbon tax is not introduced?

Without a carbon tax, methane and fuel will continue to have a competitive advantage over hydrogen. Therefore, businesses and households will not convert to hydrogen, unless standards are introduced that force the conversion.

While there are no immediate proposals, it does not seem conceivable that we get to 2050 without some increasing level of tax on methane to incentivise a move away from gas.

In theory, Government could adopt a 'standards approach' or simply legislate for the replacement of boilers, but without a carbon tax a number of issues arise with this approach:

- The approach is binary not gradual - they comply by a certain date – rather than incentivising a phased transition as businesses refresh their power sources and replace equipment

- Unless hydrogen is subsidised, businesses that transition will face higher ongoing costs, and so are incentivised to delay to the regulatory backstop date; so, we need a business model that means they pay no more than those that haven't converted – i.e. methane plus carbon tax
- We lose the mechanics to both incentivise gradual behavioural change towards hydrogen and for a hydrogen price to emerge from the original contracts
- The longer that gas and fuel is 'subsidised' the less change is likely to occur and the more inherent support is needed in business models for blue and green hydrogen
- Household conversions will have to be implemented by area; overnight all boilers and cookers will need to be converted to 100% hydrogen. But you could not expect the 'lucky' recipients of new boilers to have to suddenly pay the hydrogen price, increasing their bills. Instead, everyone should pay the methane price plus phased tax, which will fund the transition and share the cost equally.

These issues are not insurmountable, but in general a carbon tax approach seems easier to introduce, can incentivise businesses to switch while protecting them on the way, gives competitive advantage to those that have switched and delivers an unsupported hydrogen market once the carbon price exceeds the price of the conversion of methane to hydrogen and/or electrolysis of hydrogen. For households, it gives a fairer, shared cost for the conversion to hydrogen.

APPENDIX 3 – HM TREASURY NET ZERO INTERIM REVIEW – PRICING CARBON EMISSIONS.

The following extract form HM Treasury's Net Zero Interim Review is an excellent summary of the four key policy levers of carbon tax, UK ETS, subsidies and regulation.

Pricing carbon emissions

Taxes, ETS, subsidies and regulations are all important policy tools to support decarbonisation. However, they have different functions and distributional implications.

Emissions taxes can increase the cost of greenhouse gas emissions directly or implicitly through relative rates of indirect taxes on carbon-intensive and low- carbon products or services. Taxes can apply to emissions, particular inputs or outputs and can be sector-specific or more broadly applied. As well as creating an incentive to reduce emissions, emissions taxes can spur innovation and greener investments to reduce future tax liabilities. For example, if the tax system allows carbon offsetting, it could help drive innovation in negative emissions technologies.

In an emissions trading scheme (ETS) an emitter must buy a quantity of permits equivalent to the amount of greenhouse gases they emit. The number of permits is fixed, and the price is determined by the market for permits.

ETS and taxes are conceptually similar levers. Both provide price signals to drive behaviour change, granting the private sector substantial flexibility on how best to decarbonise, while raising revenue, directly or from the sale of the permits. However, their deployment and technical specification is different. While a tax fixes a price for emissions, an ETS fixes the quantity through a system-wide cap. This cap on emissions can then be reduced over time to provide confidence that the UK will mitigate its emissions to meet its net zero target and to provide an effective, responsive price signal to drive decarbonisation.

An alternative to increasing the price of emitting greenhouse gases is to decrease the price of carbon abatement through a subsidy or tax relief. Subsidies may be effective at supporting new markets to develop, helping to manage high initial costs for producers or stimulating demand to encourage supply chains to develop. They tend to be linked to specific actions rather than general abatement. This may limit the incentive for firms to innovate in non- subsidised technologies that could prove more effective. Unlike regulation or tax, it is not possible to compel action through subsidies, as they rely on economically rational responses and awareness of the government offer. Additional market failures, such as inertia, may therefore affect uptake.

A subsidy is more likely to be inefficient when there is uncertainty about the technological pathway, while a tax can encourage decarbonisation in a technology neutral way. Subsidies may be more effective, however, where households or firms do not have access to the money required to adopt lower-carbon technologies or there is a risk of carbon leakage.

Regulations can ban use of certain technologies, require adoption of others or impose standards for efficiency, packaging or the allowable level of emissions. The feasibility depends on the complexity of the regulation, the characteristics of the regulatory base, the frequency of reform and the efficiency of the enforcement authority. The implied carbon price of a regulation is the cost of adhering to it.

Regulations can allow government to directly drive the pace of decarbonisation in certain sectors and set direction for innovation and technological development by providing certainty and creating a level playing field. This can drive large scale adoption and allow firms to generate economies of scale. Regulations can also help ensure decarbonisation where firms and households are not responding in the expected way to price signals. As with subsidies, there is a risk that the government does not choose the optimal technology and limits the scope for the private sector to innovate, although this is less of a risk with technology neutral standards.

Source: HM Treasury Net Zero Interim Review