SECURING DECARBONISATION AND GROWTH

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Executive Summary

The need to decarbonise the economy in order to slow the pace of climate change is now recognised as one of the most pressing international policy challenges. While the UK cannot by itself materially affect global climate change, it has an opportunity to play an influential role, both by persuading others of the need for action but also by reshaping its domestic economy to benefit from a low-carbon transition.

Far from hampering competitiveness, adoption of a coordinated policy approach to climate change today would generate positive benefits for the UK economy, especially if it addresses the multiple market failures that promote pollution and places decarbonisation at the heart of structural economic policy.

Desirable strategies would include public support for research, development, and deployment of new technologies, and measures to foster an environment where innovation can rapidly shift the economy from dirty to clean production systems. Focusing UK industrial strategy on securing strong domestic supply chains for green products and services, for example, could help create an early mover advantage in rapidly growing global market sectors. Interventions could include the establishment of a National Infrastructure Bank to support decarbonisation in crucial sectors such as energy and transport, and would also need to encompass measures to assist structural adjustment in affected industries and their workforces.

The world is warming and the economy is changing

Global warming is serious. Human activities are causing the planet to warm at an unprecedented rate, with potentially catastrophic consequences for the environment, humans, and economies. At the same time, mankind's response to the problem, though slow, uneven, and insufficient to address key risks, is already radically transforming the global economic landscape, with far-reaching effects, not least on the UK economy.

The estimates of the likely probabilities and potential damages from climate change are so large they are hard to comprehend. The Intergovernmental Panel on Climate Change (IPCC), in its 'likely' climate sensitivity analysis, estimates the median temperature increase at different levels of atmospheric concentration of carbon dioxide equivalents (CO2e). It concludes that, even if governments keep their current promises, atmospheric greenhouse gas concentration will reach 700 ppm, resulting in a 10 per cent chance of the increase in global temperature exceeding 6oC. This has been described as "an indisputable global catastrophe" (Wagner and Weitzman, 2015).

Had global policymakers kept to their commitment to secure a 50:50 chance of temperature increase below 2 degrees – which is now almost impossible – this would have required stabilisation not far from current concentration of 450 ppm; and would have given a 0.3 per cent chance of exceeding a 6oC temperature increase (Wagner and Weitzman, *op.cit.*).

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To put such probabilities into perspective, there are currently around 37 million aircraft flights per year,[2] with one fatal accident every three million flights.[3] This gives a probability of a fatal accident of 0.0000324 per cent per flight. Putting it another way, a 0.3 per cent probability of a fatal accident would mean over 300 fatal accidents per day. Few would fly given such odds: yet such is the estimated order of magnitude of the risk that human societies are currently taking in respect of catastrophic climate change (Ekins and Zenghelis, *forthcoming*).

Even without the low, but growing, risk of catastrophe, climate change stands to be extremely disruptive on a number of levels, undermining livelihoods, forcing migration of people, and destroying assets, all of which will undermine the growth and development capacity of the global economy (Dietz and Stern, 2015).

The low-carbon transition is inevitable

Yet decarbonisation of the global economy is inevitable. The extent of global warming depends on the *stock* of greenhouse gases in the atmosphere – not the *rate* of emissions. Greenhouse gases (GHGs) stay in the atmosphere for years, decades, or centuries (depending on the gas), so the stock will keep growing for as long as the flow of GHG emissions exceeds the earth's capacity to absorb them. This means that to halt continual temperature increase requires transitioning to a net zero emissions world.

Mankind will either manage the transition to net zero carbon emissions proactively by transitioning the economy, or nature will do it for us, by depopulating and deindustrialising the planet. Put another way, the fastest and the slowest global economic growth paths will both be low-carbon. The growing realisation that the low-carbon transition is inevitable, and that it will be most effective if managed early rather than postponed, is changing the lens through which global climate policy is viewed.

The UK must manage its low-carbon transition

The UK cannot by itself materially affect global climate change: it is directly responsible for only 1 per cent of global emissions of greenhouse gases, and only 2 per cent even when indirect effects (arising from net imports of greenhouse-gas-intensive goods) are taken into account. However, there are likely returns to leadership and early action in effecting structural transition.

- First, the UK can help to change global attitudes: this has been demonstrated already by the diplomatic awareness-raising activities of the UK government from the analytical lead of Lord Stern to the diplomatic leadership of Margaret Beckett, John Ashton, and others at the Foreign and Commonwealth Office. The UK's influence will be lessened, to the extent that it is no longer speaking as a member of the EU, but nevertheless will continue to have influence.

Policy proposal

- *Renew the UK's diplomatic push. In sectors where the UK is not well placed to lead, there must be an understanding of the pace of change in the rest of the world and its likely domestic impact.*

- Second, given that the world is going to have to adapt and innovate, the UK can direct its industrial and other policy so that, in preparing itself, it promotes activities and develops industries that will be in demand not only domestically, but worldwide.

The UK is well placed not only to adjust to, but also to benefit from, a low-carbon transition. To realise the benefits, however, it will be essential that policy clearly and consistently supports appropriate innovation and investment. The evidence for this is set out in the Report of the Advisory Group on Costs and Benefits of Net Zero for the Committee on Climate Change (CCC).[4]

The report concluded that the costs of transitioning the UK economy to low-carbon forms of production are a function of the decisions taken by policymakers and investors today. The more coordinated the UK's response to managing a low-carbon transition, the more cost-effective it will be.[5]

Decarbonisation can yield immediate benefits

A number of authoritative studies have shown that, contrary to what is often asserted by some politicians, many or at least most of the policies required to decarbonise the global economy stand to boost economic growth, not reduce it.

Much of this boost stands to come from addressing multiple market failures – situations where a pure market outcome misallocates resources, for example because polluters escape paying for the damage they cause.

- Thus a recent World Bank study (Hallegatte *et al.*, 2012) found that, compared with business-as-usual,

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green growth would produce immediate positive effects on the economy, when taking proper account of co-benefits (e.g. reduced local pollution); growth in new 'green' sectors; and reduced energy price volatility via reduced dependence on fossil fuel imports.

- The Global Commission on the Economy and Climate (2014) found that more than half, and perhaps as much as 90 per cent, of the global emissions reductions required to meet an ambitious climate target could generate net benefits to the economy. These include health benefits from reductions in urban pollution; falls in traffic congestion; increases in efficiency; improvements in energy security and supply.

- The OECD (2017) argues similarly:
"… bringing together the growth and climate agendas, rather than treating climate as a separate issue, could add 1 per cent to average economic output in G20 countries by 2021 and lift 2050 output by up to 2.8 per cent. If the economic benefits of avoiding climate change impacts such as coastal flooding or storm damage are factored in, the net increase to 2050 GDP would be nearly 5 per cent."

- In the UK, congested, polluted cities, with leaky buildings, using outmoded energy technologies, and ill-served by public transport, are inefficient and wasteful.

- Urban air pollution is a major cause of respiratory illness, cardiovascular disease, and early mortality. The Committee on the Medical Effects of Air Pollutants (COMEAP) estimates that, in the UK, premature deaths resulting from a single particulate pollutant, PM2.5, currently total around 29,000 per year.[6]

Decarbonisation can address dynamic market failures

Public support for research, development, and deployment of new technologies has already driven remarkable, and often unexpectedly large, cost reductions in renewable and other energy technologies.

Over the past decade, the cost of both solar photovoltaic generation, and battery storage necessary to address intermittency of supply, has fallen tenfold (Bloomberg, 2019). In many parts of the world, renewable energy is now cheaper than fossil fuel-based energy (Holder, 2019). Within the coming decade it will be cheaper almost everywhere. Regardless of whether policymakers care about carbon or not, the world will now have cheaper energy; and this is the result largely of policy initiatives to steer investment in renewables. The markets alone would not have delivered this.

Overcoming such dynamic market failures in this sort of way has the potential to change the world. This understanding, first outlined by the Nobel prize winning economist Romer and others when they postulated the theory of endogenous technological change (Romer, 1990), is central to the task of efficiently managing a low-carbon transition.

As costs have become increasingly competitive, investment in renewable generation, excluding nuclear and hydroelectricity, is already outstripping investment in coal, gas, and oil power the world over, with renewables now on track to power the bulk of global electricity in the second half of the century (Bloomberg, 2019). Transformative cost reductions are also occurring in other key technologies, such as fuel cells, electric vehicles, and even electric aviation.

Decarbonisation can spur innovation and accelerate network shifts

Innovation is thus essential in determining economies' ability to decouple growth and consumption from environmental degradation and resources use. Yet innovation does not just 'happen'. It relies on path dependencies of three kinds (Aghion *et al*., 2014):

- First, discovery and invention, with scientists working in areas that are well funded, where other good scientists work, leading to geographical clustering of research and knowledge production.

- Second, deployment, whereby innovations leverage existing infrastructure and ideas rather than risk investment in potential new sectors.[7]

- Third, incentives for technology adoption, whereby the net benefits of unilaterally switching to an alternative network rise with the number of others using it.

Without direct policy intervention, strong inertia and high switching costs often make it difficult at first to shift the innovation system from dirty to clean technologies.[8] But once they reach a tipping point, where expectations change rapidly, and technologies switch from one network to another, these effects frequently go the other way (Krugman, 1991). Positive and reinforcing feedbacks derived from reduced technology cost accelerate further deployment and investment in supporting networks,

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infrastructure, and institutions. Investments in enabling infrastructure spur technology tipping points through generating network externalities.[9]

It is easier for countries to become competitive in new green products that require similar production capabilities and know-how to existing sectors(Hidalgo *et al*., 2007; Mealey *et al*., 2017). As a result, green transitions are highly path-dependent: countries that successfully invest early in green capabilities have greater success in diversifying into future green product markets. A firm's choice whether to innovate 'clean' or 'dirty' is influenced by the practice of the countries where its researchers/inventors are located. Moreover, firms tend to direct innovation towards what they are already good at (Aghion *et al*., 2012).

This all suggests that, to the extent that the UK can shift its energy and production systems from one network to another, this will likely generate large spillovers across the economy.

Policy proposal

- *Extend and integrate the focus of the UK Industrial Strategy on securing strong domestic supply chains[10] so as to support the full spectrum of decarbonisation activities.*

There is mounting evidence that productivity-boosting knowledge spillovers from low-carbon innovation are substantially greater than those emanating from conventional technologies (Dechezlepetre *et al*., 2014). These findings suggest that low-carbon investment can 'crowd in' rather than 'crowd out' productive investment and generate growth.

A study of OECD patent data shows that both wind and solar technologies create knowledge spillovers at the national level. On the evidence of data on 1 million patents and 3 million citations, another study (Dechezlepetre *et al*., 2014) suggests that spillovers from low-carbon innovation are over 40 per cent greater than from conventional technologies (in the energy production and transportation sectors).

Even looking backwards, over the period when renewable and energy efficiency technologies were more expensive, there has been no appreciable difference in economic growth rates between those countries that adopted emissions-reducing technologies early and those that did not. Yet the early-adopter countries are in a stronger position to benefit in years to come from global transition to a net-zero-carbon economy.

Behaviours, norms and institutions are also changing

Additional feedbacks, beyond the technology sphere, are likely to accelerate the pace of transition. As better ways of consuming, producing, and living are found, complementary changes in behaviour, institutions, and social norms will evolve (Boyd *et al*., 2015). The presence of low-cost alternatives to emitting greenhouse gases has enabled anti-fossil-fuel campaigns to point to superior energy alternatives (Bradshaw, 2015; Collier and Venables, 2014).

Anti-fossil-fuel norms are already concentrating moral pressure on the largest culprits of climate change (Green, 2015). A spate of lawsuits have been filed against fossil fuel companies and governments for deceiving shareholders and citizens by knowingly undertaking or supporting unsustainable and damaging activities.[11]

These factors are driving global climate policies at an accelerating pace: more than 1,500 climate laws and policies worldwide; and 106 since the Paris Agreement was reached. At the same time, new business lobbies in fast-growing sectors are starting to challenge the influence of incumbents on policymakers (Lockwood, 2013).

Markets increasingly recognise the strong economic and commercial case for early mitigation action by divesting from risky, high-carbon sectors (Ralph, 2018). The growing risk that failing to keep up with changing technologies and policies will render assets ill-suited to the economy of the 21st century, thereby leading to a fall in their value and perhaps even their becoming stranded, is reflected in share prices for renewable goods and services outperforming those of carbon-intensive sectors (Lewis, 2019).

Changing expectations (Zenghelis, 2019a) accelerate the deployment of new technologies, which in turn accelerates cost reductions (Aghion *et al*., 2014) and policy support. Strategic complementarities occur as the payoff to investing in low-carbon technologies rises (and the costs fall) when others are expected to invest in low-carbon technologies. This contributes further to tipping points across key technologies, institutions and behaviours as agents shift rapidly to new networks.[12,13]

Recognising the opportunities from such innovation helps to overcome the classic 'free rider' problem.[14] One big innovation of the 2015 Paris Agreement was that it focused on opportunities rather than costs. This overturned the dominant climate mitigation narrative of

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'burden-sharing', scarcity, and shared sacrifice, which bred distrust and ill will, replacing legally-binding commitments with voluntary nationally-determined contributions. This reflects the recognition that self-interest breeds cooperation (Averchenkova *et al.*, 2014).

UK policy must set, and keep up with, the pace of change

These endogenous technological dynamics suggest that decarbonisation can be rapid. But policy can influence both the direction and pace of change, and steer a comparative advantage in what is now one of the world's fastest-growing global markets (Fischer and Newell, 2008; Farmer and Lafond, 2016). The costs of delay mean there is no place for fatalism or complacency (Romer, 2018), for example by waiting for new technologies to emerge.

Central to keeping costs low is guiding expectations through credible policy, while securing institutional flexibility to respond to rapid technological change. This is the most effective way to generate investor confidence to accelerate the green innovation machine (Aghion *et al.*, 2009). By contrast, mixed and muddled signals delay action, and raise the policy risk premium attached to decarbonisation investments.

One influential study (Acemoglu *et al.*, 2012) makes a powerful case that policy to support clean innovation needs often be only temporary. Once the 'clean innovation machine' has been 'switched on and is running', it can be more innovative and productive than the conventional alternative, with a positive impact on GDP levels and growth. Once low carbon is the norm, policy pressure can be eased.

These studies have at times been criticised by some as optimistic, yet the pace of cost reductions in low-carbon technologies has surprised all commentators.

A medium-sized open economy such as the UK is likely to require a joint strategy of helping to drive a global transition where it can, while accepting that it will need to react to developments across the world.

Policymakers need to do their utmost to develop and deploy certain technologies, especially where public support is required to develop network infrastructure. For example, the UK has already had considerable success in directing policy support at two appropriate technologies, coal-to-gas transformation, and wind power. (Clean tech solutions that are likely to be crucial for the development of sustainable cities, transport and energy systems in the UK are also those most complementary with AI and digitisation.)

Policy proposals

- *Integrate the UK's industrial strategy with its clean growth strategy*[15]
- *Develop research priorities based on a range of metrics, including positive technology spillovers based on a forward-looking strategy to retain comparative advantage in future markets.*[16]

Investing in new networks and technologies is not risk-free. But there is a greater risk, when the rest of the world is decarbonising, in being a last rather than a first mover.

This requires government to work in partnership with business to develop growth strategies that harness the potential for discovery, innovation, and directed technical change (Acemoglu *et al.*, 2012). This will inevitably need to include a strong and comprehensive carbon price signal to guide consumer and producer behaviour in a transparent, non-discriminatory manner. However, prices alone will not achieve an efficient transition. Some non-price-sensitive sectors will require standards, regulations, and planning,[17] while others will require R&D and deployment support, as well as targeted sectoral innovation support.

The fact that much of the transition will occur in policy-driven, highly-regulated sectors such as transport and energy argues for institutions designed to relieve private investors of policy risk through risk guarantees or direct financing and investment support.

Policy proposal

- *Establish a National Infrastructure Bank, with an explicit sustainability mandate, to help leverage private finance at scale.*

(The proposal for a National Infrastructure bank is developed in the paper *Improving infrastructure*.)

Managing the process of change

Rapid transformative change, whether from decarbonisation or artificial intelligence, automation, and digitisation, needs to be managed carefully. The gains must be, and be seen to be, equitably distributed if the political economy is not to inhibit and retard progress. This requires:

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- 'Enabling institutions' (Haldane, 2018) to reskill, retool, and compensate affected workers. (This matter is considered further in the paper *Supporting dynamic economic adjustment*).

- Policies designed to compensate those who lose out;[18] and

- Targeted 'place-based' employment transition policies in areas at high risk of disruption (Austin *et al.*, 2018).

Adjustment costs are real, but manageable, and with the right policies can be minimised. Risks are often overstated, and realised costs are often much lower than predicted. Economic history shows that economies that embrace change, and do not inhibit the flow of resources from declining, low-productivity sectors to new, more productive sectors, are better able to manage structural adjustment (Zenghelis *et al.*, 2018; Combes and Zenghelis, 2014).

The adjustment to a low-carbon economy in the UK and globally will inevitably be uncertain and complex, and there will be winners and losers. A strategic risk management and hedging strategy for policymakers and business is required to ensure that the UK is well positioned in this changing world.

There is no reason in principle why a decarbonised UK economy would not be cleaner, quieter, more efficient, innovative, and productive, in the face of changing global markets, than any alternative. A broad-based, coordinated, credible, and coherent set of policies is the surest way to secure a productive, competitive and inclusive UK economy in the low-carbon decades ahead.

NOTES

1 This would be in line with the IEA's projection for 2100.
2 https://www.quora.com/How-many-airplanes-fly-each-day-in-the-world.
3 https://edition.cnn.com/2019/01/02/health/plane-crash-deaths-intl/index.html.
4 Available at: https://www.theccc.org.uk/wp-content/uploads/2019/05/Advisory-Group-on-Costs-and-Benefits-of-Net-Zero.pdf.
5 For example, policy can generate cost reductions and new economic benefits by avoiding locking into high-carbon infrastructure, behaviours and institutions which will be expensive to subsequently retrofit or scrap, while at the same time, inducing resource-efficient innovation.
6 See: https://www.gov.uk/government/publications/comeap-mortality-effects-of-long-term-exposure-to-particulate-air-pollution-in-the-uk and also http://www.eea.europa.eu/media/newsreleases/many-europeans-still-exposed-to-air-pollution-2015/premature-deaths-attributable-to-air-pollution .
7 For example, conventional cars have historically been easier to sell than electric vehicles because the existing network of petrol stations is far larger than that of charging stations.
8 This is consistent with early slow progress in deployment of decarbonisation technologies.
9 For example, once electric vehicle infrastructure is rolled out, the incentives to conduct research and development on electric cars increase relative to combustion engine, or fuel cell, vehicles. Volvo will stop producing combustion engine cars from 2019 and start focusing its R&D on electric vehicles; others are sure to follow.
10 See https://www.gov.uk/government/topical-events/the-uks-industrial-strategy.
11 Cities and counties in California, New York, Colorado, Washington and Maine have filed civil lawsuits against oil and gas companies. The Grantham Research Institute's 'Global trends in climate change legislation and litigation' survey, (available at http://www.lse.ac.uk/GranthamInstitute/publication/global-trends-in-climate-change-legislation-and-litigation-2018-snapshot/) identifies 25 climate-related lawsuits brought against governments or their representatives.
12 The virtuous cycles described above explain why the likely speed of the transition and the opportunities from climate action have tended to be systematically underestimated (see Zenghelis, 2019b). Most conventional approaches to assessing the efficient decarbonation path at the national and global level presuppose the technologies, tastes, preferences, and behaviours that will dominate in the decades and centuries ahead, in order to give the model structure. But the structural assumptions imposed on these models are precisely the things users want to know in order to predict the costs of transitioning to low carbon networks, processes and behaviours. For more, see Zenghelis (2018). Marginal static analysis techniques, which assume the broader environment is unchanged by the intervention, are inappropriate where there are potential non-marginal effects or structural changes in underlying relationships – such as those inherent in systemic transitions.
13 Grubb points out that if technology substitution in a structural transformation is intrinsically dynamic and irreversible, with technologies '"striving" for dominance', new technological systems can rapidly scale-up and displace older ones in a way that cannot be determined from examining past data in that sector. See https://www.ineteconomics.org/perspectives/blog/growth-with-decarbonization-is-not-an-oxymoron.
14 The effects of mitigation are non-excludable and so individual countries can free-ride on others' actions, while those undertaking mitigation incur the whole cost but only a fraction of the benefits.
15 See https://www.gov.uk/government/publications/clean-growth-strategy
16 See the recommendations of the LSE Growth Commission Report, 2019, 'Sustainable growth in the UK: Seizing opportunities from technological change and the transition to a low-carbon economy', available at: http://www.lse.ac.uk/GranthamInstitute/publication/sustainablegrowth/
17 For example in buildings, land use and infrastructure networks.
18 Examples include proposals for the US Democratic Green New Deal to return carbon tax revenues to households, or former London Mayor Ken Livingstone's popular use of congestion charge revenues to fund extra capacity on London's bus networks.

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