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GREENING EUROPE'S POST-COVID-19 RECOVERY

Edited by Simone Tagliapietra, Guntram B. Wolff and Georg Zachmann

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Foreword

Under the European Union's post-COVID-19 recovery plan – Next Generation EU – 37 percent of the money should be spent on climate-relevant projects, amounting to about €225 billion of public green investment across Europe between 2021 and 2026. This effort is necessary and welcome in the context of the EU's goal of reducing greenhouse gas emissions by at least 55 percent by 2030 compared to 1990. However, Next Generation EU spending pales in comparison to the estimated €5 trillion in additional private and public investment needed by 2030 to realise the aspirations of the European Green Deal and set the EU on course for net-zero by 2050.

Comparing these two figures helps appreciate that while green spending financed by Next Generation EU represents an important short- to medium-term policy, a broader and sustained green investment push is needed to make the European economy climate-neutral, in terms of both more private sector investment driven by appropriate regulation and carbon pricing, and public investments where the private sector does not deliver.

For this to happen, the EU's priority should be delivery of the 'Fit for 55' package. This would both deepen and broaden the decarbonisation of Europe's economy. It is a huge package containing hundreds of pages of legislative proposals, including the creation of a new EU emissions trading system for buildings and road transport, a profound restructuring of energy taxation in Europe, increased renewable energy and energy efficiency targets, the introduction of a carbon border adjustment mechanism and revised emissions standards for new cars. Prompt and undiluted approval of the package by the

European Parliament and the European Council would be a strong signal of the EU's commitment to deep decarbonisation, and would help foster private investment in the green transition.

Meanwhile, revision of the EU's fiscal rules will be essential. It is estimated that the public sector will have to spend €1 for every €4 in private capital invested to deliver the goals of the European Green Deal. Given that some of the investment will be in public goods, government spending in the EU must be increased by about €100 billion per year. But how can governments simultaneously reduce deficits and increase green investment? One option would be to put in place a 'green fiscal pact' in the EU based on a green golden rule that would exclude from deficit and debt calculations net public contributions to climate protection. An alternative would be a new European joint borrowing programme to finance transnational green investment. Deciding on this will be a crucial conversation for the future of EU economic governance and of the European Green Deal. Without the possibility of deficit financing, EU democracies will not prioritise carbon neutrality when faced with difficult choices between green investment and preserving current expenditures. This discussion comes against the backdrop of high debt levels in some countries and potentially rising interest rates, raising questions of debt sustainability.

To help decision-making on all these complex issues, we initiated in 2020 the Bruegel Green Recovery Group as a platform for dialogue between European policymakers and academics. This Blueprint includes some of the Group's most prominent voices on the different aspects of the multidimensional issue of green recovery.

I hope this Blueprint will trigger a fresh discussion on the principles and policy tools that should underpin a green recovery in Europe and beyond. I would like to thank all the contributors for their work, and the European Climate Foundation for its financial support.

Guntram Wolff, Director of Bruegel
Brussels, February 2022

1 Introduction and overview: greening Europe's post-COVID-19 recovery

Simone Tagliapietra, Guntram B. Wolff and Georg Zachmann

European governments responded to the COVID-19 outbreak that started in 2020 with unprecedented measures to support the economy. Initially, the main focus of these economic recovery packages was boosting and sustaining aggregate demand, while providing direct support to companies whose operations were affected by public health measures (Anderson *et al*, 2020). But as economies have moved out of the immediate danger zone, governments have started to re-engineer their stimulus policies in order to re-direct their economies towards a more sustainable model.

In other words, in the same way that the Great Depression accelerated a major structural shift in the United States automobile manufacturing sector, economic recovery policies can provide an opportunity for structural supply-side shifts. After all, as businesses rethink value chains, and as governments inject huge resources into economies, the government's role is larger than during normal times and there is a political imperative to think about how government intervention affects the shape of our economies.

In Europe, policymakers quickly signalled their commitment to use the unprecedented economic and social disruption of the pandemic to reinforce the reorientation of the European economic model towards sustainability, and specifically to accelerate implementation of the European Green Deal.

It is not the first time Europe has sought to use economic recovery policies to foster green transformation. In the wake of the great financial crisis of 2007-2008, the European Commission published a European Economic Recovery Plan with the intention of speeding up the shift towards a low-carbon economy, with a focus on clean infrastructure, energy efficiency in buildings and green cars (European Commission, 2008).

However, the results of that initiative have been unconvincing, with limited progress on both housing renovation and clean cars. A European Central Bank (ECB, 2010) decomposition of budgetary stimulus measures adopted by the euro area in 2009-2010 sheds light on the reasons for the failure of that green recovery attempt. Half of the total stimulus went to household measures, such as cuts to direct and indirect taxation, social security contributions and direct income support. A further 17 percent of the stimulus came in the form of business support, typically accelerated payment of value-added tax refunds, subsidies and export promotion. As a result, only a little more than a quarter of stimulus was public investment, which provides the most substantial opportunities for explicit greening. Darvas and Wolff (2014) documented how fiscal consolidations happened at the expense of public investments.

Also in 2009-2010, European policymakers did not match their stimulus plans with significant action on the carbon-pricing front. This would have represented an important policy tool to manage expectations and steer the private sector's longer-term investment and divestment decisions. As the IEA (2020) noted, this was one of the key lessons from the attempts to green the European recovery in 2009-2010: economic recovery funding is most effective when aligned with long-term price signals.

During 2020, how to best operationalise the political goal of promoting a green recovery, without replicating the mistakes of 2009-2010, was discussed widely. These conversations ranged from identifying the green investments to prioritise achieving the so-called triple

dividend (economic growth, job creation and emissions reduction; see, for instance: Hepburn *et al*, 2020), to how to use carbon pricing to guide longer-term investment decisions (McWilliams *et al*, 2020).

At institutional level, the main result of this conversation was the decision to devote at least 30 percent of the European Union 2021-2027 budget and at least 37 percent of EU recovery spending (Next Generation EU) to climate-relevant projects. Moreover, EU emissions trading is considered an important source of revenues to help pay back Next Generation EU borrowings of €150 billion per year between mid-2021 and 2026 (Fuest and Pisani-Ferry, 2020). A fresh conversation has also been sparked on the future of EU fiscal rules, and in particular on the possibility of introducing a 'green golden rule' to ensure that governments can continue financing the green transition even when fiscal consolidation starts (Darvas and Wolff, 2021).

To help political decision-making on these difficult issues, Bruegel in 2020 launched, with the support of the European Climate Foundation, the Bruegel Green Recovery Group, to provide a platform for dialogue between European high-level policymakers and top academics. This dialogue clearly pointed to the fact that while the European Green Deal represents the most comprehensive and ambitious climate policy package in the world, major open questions remain on how to incentivise private investment, how financial markets can be leveraged for that purpose, how to find the budget headroom for public investments and how to ensure global collaboration.

The Group's discussions have shown that while there is broad agreement on the decarbonisation goal, substantial differences remain on how to get there. In our view, not enough attention is given to ensuring an optimal pathway to decarbonisation that minimises costs. A critical requirement for rapid decarbonisation is higher and broader-scope pricing of emissions. Such a market incentive will ensure private sector action and minimise costs. But a price signal alone will not be sufficient. Additional policies, including public funding, are needed. It is this intersection of the debate that we discuss in this volume.

Chapter 2, *After the recovery, a new European voice* by Laurence Tubiana, argues that in 2022, EU countries will set about "*bringing the Green Deal home*", in a delicate process of translating broad targets into the myriad of domestic contexts. This phase marks the most concrete effort of any region in the world to align itself with the goals of the Paris Agreement. It occurs at a crucial moment for Europe, faced with the dual – and potentially conflicting – challenges of recapturing jobs lost to the pandemic, while initiating the transformative and comprehensive decarbonisation of its economy. This phase will also significantly redraw the post-fossil fuels geopolitical map, just as the transition to renewables interacts with domestic anxieties about social impacts and heightening geopolitical tensions. The Green Deal has international reverberations, raising questions about the international outlook of the EU institutions and whether cohesive and concerted Green Deal diplomacy is possible. Somewhere within this tension, the contours of a new European project that is crafted together with citizens and strengthens a global European voice is possible, but far from given.

Chapter 3, *The COVID-19 recovery, growth and climate change mitigation*, by Laurence Boone, Antoine Dechezleprêtre and Tomasz Koźluk, notes that the recovery from the pandemic has been presented as a unique opportunity for governments to 'build back better' and to steer the economy onto a greener growth trajectory. Over 120 countries have committed themselves to achieving carbon neutrality around the middle of the twenty-first century. But policy measures to achieve this and to trigger the needed investment in zero-carbon energy sources and production processes often lag behind. Given the significant reallocations implied by the low-carbon transition (between activities, sectors, firms, workers and technologies), policymakers should focus on the transition costs and risks and on how to mitigate and address them. Climate policies need to be designed carefully with political economy and distributional considerations at their root, but structural policies will also be required to facilitate reallocation, boost competition and innovation, strengthen skills and support people through the transition.

Chapter 4, *The missing macroeconomics of climate action*, by Jean Pisani-Ferry notes that while climate change mitigation was for a long time regarded as a gradual process, the impact of which would be felt in the long term only, this is no longer a tenable assumption and a macroeconomic assessment of the consequences of climate action is needed urgently. The chapter argues that it is imperative to develop a research programme on the global macroeconomic implications of net zero, and suggests that, relying on a variety of instruments and methodologies, researchers should assess the potential costs and benefits and help define a strategy for minimising the economic and social costs of the transformation.

Chapter 5, *How green are EU countries' recovery and resilience plans?* by Klaas Lenaerts and Simone Tagliapietra seeks to understand EU countries' green priorities and to what extent their green spending corresponds with the European Green Deal's estimated investment requirements. In EU aggregate terms, spending to increase the energy efficiency of buildings takes the largest share, with €45 billion of recovery and resilience plan spending, followed by public transport (€34 billion), high-speed trains (€26 billion), renewable energy (€23 billion) and hydrogen (€11 billion). Overall, about €220 billion of EU Recovery and Resilience Facility funds is set to be spent on green elements. This is certainly welcome and necessary, but pales in comparison to the €350 billion per year that will be needed by 2030 to realise the aspirations of the European Green Deal.

Chapter 6, *To what extent can and should the fiscal framework be reformed?* by Thomas Wieser, argues that given the many challenges fiscal policy is expected to address in the aftermath of the pandemic, an update to the EU's fiscal framework is necessary. Warning that an update will rather take the form of an evolution than a radical overhaul, the chapter suggests a number of possibilities on which compromise could be feasible. For instance, a common understanding on issues such as the debt reduction path, or an agreement that protects green investments, could be reflected in interpretative changes to the

rules-based framework. Legislative changes may take longer, but are arguably preferable from the perspective of transparency and democratic accountability. Importantly, the chapter clarifies that success is on the ground, and for that to work one would need in each and every Member State, especially the high debt Member States, a National Pact on policies and timelines in order to convince partners and markets – just as was successfully done between 1995 and 2000 in several countries that were motivated by the desire to be part of the launch of the euro.

According to chapter 7, *Driving the transition to net zero: creating a suitable business environment for innovation* by Sabine Mauderer, achieving the goals of the European Green Deal, will require the European real economy to undergo a fundamental, large-scale transformation. This crucially depends on carbon reduction and sequestration and clean-energy technologies. To foster an innovation-friendly business environment, broad cooperation is essential between politics, the real economy, the financial sector, civil society and science. For Europe's economies to become more innovation-friendly, barriers stemming from fragmented European tax regimes, regulation of state aid, public procurement and patent frameworks must be addressed. The chapter reminds us that strengthening the business environment for breakthrough climate technologies will also have positive effects for the competitiveness of the EU as a global financial centre. Developing and deploying novel technologies will also create new jobs, making it important to be mindful of the social implications of the transformation.

Chapter 8, *Four ways to make the European Commission's carbon pricing proposal fitter for 55* by Ottmar Edenhofer, Mirjam Kosch, Michael Pahle and Georg Zachmann, argues that putting carbon pricing at the centre of the EU climate policy architecture would guarantee cost-effective emission cuts and provide a clear path to net-zero allowing for international cooperation and a global carbon pricing regime. Though its extension is politically and institutionally challenging, the

role of carbon pricing can be strengthened gradually within a three-part framework. First, a separate emissions trading scheme should be introduced for the transport and heating sectors to prepare them for integration into the EU emissions trading system, and to manage distributional implications. Second, a carbon price stabiliser (a price floor and price ceiling) should be implemented for both systems to manage price expectations and ensure price convergence between the two systems in the long run. Third, complementary policies should be strengthened or put in place to trigger investment and innovation, helping policymakers to commit credibly to enforcing the emissions cap while addressing other market failures.

Chapter 9, *The case for an international carbon price floor* by Ian Parry, suggests that while making sufficient progress on climate stabilisation requires ratcheting up near-term mitigation action, doing so simultaneously among the 195 parties to the Paris Agreement is proving challenging. An international carbon price floor (ICPF) would jumpstart emissions reductions, while circumventing emerging pressure for border carbon adjustments. The ICPF would have two elements: participation of a small number of the main large-emitting countries, and a minimum carbon price each would commit to implement. The arrangement could be designed pragmatically to accommodate equity considerations and emissions-equivalent alternatives to carbon pricing.

Chapter 10, *What will happen with US climate policy under the Biden Administration?* by Robert Stavins, suggests that even if little can be accomplished at federal level during Biden's first term as president, his administration is unlikely to be hostile to US states and municipalities taking more aggressive action. Climate policies at state level (California and Washington State) and regional level (the Regional Greenhouse Gas Initiative in the Northeast) have become increasingly important, particularly during the four years of the Trump administration. Bottom-up evolution of national climate policy may thus continue to develop in the Democrat-leaning states of the Northeast, Middle

Atlantic, Upper Midwest, Southwest and West Coast, which together represent more than half of the US population and an even larger share of economic activity and greenhouse gas emissions.

The broad variety of issues here presented are illustrative of the multidimensional nature of the concept of 'green recovery'. Our hope is that this book could provide useful insights – and potentially some valuable directions – for the reader to navigate these, partially uncharted, waters.

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2 After the recovery, a new European voice

Laurence Tubiana

Decision-makers in the European Union and United States have, more-or-less concurrently, grappled with the volatile politics of their COVID-19 recoveries and, for the longer term, advanced versions of a 'Green Deal'. They thus face the monumental – and potentially conflicting – challenges of recreating jobs lost to the pandemic, while initiating the transformative and comprehensive decarbonisation of their economies, which must stay in line with the Paris Agreement, keeps the goal of a maximum 1.5 degrees celsius temperature rise within reach and redraws the post-fossil fuel geopolitical map.

The twin challenges of recovery and decarbonisation raise enormous questions for society, foremost among them the governance of borrowing and debt. As advanced economies engage in braver levels of spending and stretch the conventions of the debt-to-GDP ratio, the fundamentals of economic dogma must increasingly confront an existential struggle for human security and biodiversity protection. The linkages between these two fiduciary duties to future generations – balanced books and a safe planet – are no longer abstract debates.

On both counts – the economic recovery and the net-zero imperative – European leaders have so far demonstrated the greater foresight, and have integrated the sombre reality of climate change into the design of their reform packages.

In 2020, when President Emmanuel Macron and then-Chancellor Angela Merkel made a pact that paved the way for the Next Generation EU fund, a new foundation was laid for Europe's future. The pact's core

tenet of a common borrowing and transfer union beyond the existing EU budget marked a fundamental departure from previous EU policy, particularly from the more conservative German perspective. After one of the longest European Council summits in history, in summer 2020, EU leaders adopted what amounted to a €1.8 trillion recovery package, as well as core provisions on climate policy.

In doing so, the EU enshrined its vision for the green recovery and put EU policy more firmly within the orbit of the European Green Deal, with one-third of the recovery plan and the EU's seven-year budget financing it.

In summer 2021, we saw the quiet continuity of that recovery pact. The European Commission proposed its 'Fit for 55' package, setting the course for the European Green Deal vision of a carbon-neutral Europe by 2050 via a 55 percent reduction in emissions by 2030 compared to 1990. This is, to date, the most concrete expression of the Paris Agreement, offering a set of very precise, sector-specific reforms. In 2022 and certainly beyond, EU member states will set about the delicate process of translating the Commission's targets into myriad domestic political contexts.

There is an obvious tension in the EU's position as it embarks on a bruising and protracted chapter to realise its climate ambitions at home, while striving to hold the line on the global stage. In managing this tension, European institutions must be visionary – but in doing so, they will rely largely upon a toolbox of technocratic strengths, which risks leading to a stultifying form of policy path-dependency. Somewhere within this tension, the contours of a new European project that is crafted together with citizens and strengthens a global European voice is possible, but far from certain.

Climate: a 'macro-critical' concern

Climate change is now a "*macro-critical*" concern, in the words of European Central Bank President Christine Lagarde. Macroeconomists and central bankers increasingly share this view – as do I.

The problem is not sectoral, far from it: the transition requires major transfers of cross-sectoral, large-scale resources, involving nothing less than the transformation of the European economy.

In that sense, the European Green Deal cannot be isolated from the broader debate on public finances in Brussels and among European capitals – and indeed beyond, as shown by US Treasury Secretary's Janet Yellen's continued appeals for an increase in the US debt ceiling.

The question of managing a potential common debt as well as individual debts within the euro area is one of the most difficult and strategic political issues on the European agenda. But the fact that the recovery is being underpinned by the Commission's novel (and time-bound) ability to borrow on the markets on behalf of the EU has enabled a new impetus among European countries – one of reinforced solidarity, which constitutes the most significant evolution in Europe's political integration in recent years.

Of course, this has only happened because of exceptional circumstances, alongside the suspension of rules governing public debts in the EU and the activation of the general escape clause. The solidarity was borne out of urgent necessity: should the pandemic-related economic crisis have led to a euro-area state facing the risk of debt distress, affecting its ability – and that of others in the euro area – to obtain financing, the thinking went that new tools for borrowing were necessary. It was solidarity as a narrow exercise in damage limitation.

In relation to the financial governance of a post-pandemic Europe, the question of a return to previous fiscal discipline rules is predictably arising, with some recalling the real risk and mechanics of sovereign insolvency[1]. The political scene is divided[2]. While countries including

1 See Marek Dabrowski, 'Fiscal arithmetic and risk of sovereign insolvency,' *Bruegel Blog*, 18 November 2021, https://www.bruegel.org/2021/11/fiscal-arithmetic-and-risk-of-sovereign-insolvency/.

2 See Bjarke Smith-Mayer, 'Hopes of EU fiscal reform on the rocks after pushback from eight capitals,' *Politico*, 9 September 2021, https://www.politico.eu/article/eight-countries-led-by-austria-slam-calls-to-loosen-eu-fiscal-rules/.

France, Italy and Spain are in favour of revising the rules, the so-called frugal countries, led by Austria and supported by Czechia and Sweden, are strongly opposed. Germany's new coalition – while it contains fundamentally diverging views on the matter – has indicated a willingness to consider some reforms to EU fiscal rules as well as widening the fiscal space through other means, such as development banks and public firms[3]. Nonetheless, this is a debate with very uncertain future contours.

At any rate, it is a debate that must be reframed. We are surely beyond the artificial dialectic between 'spenders' and 'frugals', which hung over the 2010s and the apex of the European debt crisis (although, already now, and to give just one example, the likes of France's proposed finance law for 2022 has identified and earmarked €165 billion euros of 'COVID debt' in exceptional expenditures that have been promptly placed on the books for repayment[4]).

In parallel, we face a time of unprecedented required expenditure in order to enact the necessary transition. The global needs in terms of clean energy projects and infrastructure alone amount to $4 trillion by 2030 (IEA, 2021). Europe has yet to reconcile its own investment programmes to implement the Green Deal with a viable plan for deficit consolidation. Moreover, the macroeconomic implications of the transition to a climate-neutral economy have not been sufficiently taken into account: "*there is no guarantee that the transition to carbon neutrality will be good for growth*" (Pisani-Ferry, 2021).

One might be tempted to add, 'growth – as we know it'. Put another way, continued economic growth in Europe would need to look quite different from today's models. During the transition, a net-zero model raises the following questions, among others, for growth: will private

3 See Michael Nienaber, 'German coalition eyes return to debt limits from 2023, open to EU reforms', *Reuters*, 24 November 2021, https://www.reuters.com/markets/europe/german-coalition-eyes-return-debt-limits-2023-open-eu-reforms-2021-11-24/.

4 See 'Loi du 30 décembre 2021 de finances pour 2022', available at https://www.vie-publique.fr/loi/281557-loi-de-finances-pour-2022-budget-2022.

consumption go down? Will investment, especially public investment, play a greater role? If so, where will those resources come from?

Options available to European policymakers include a general relaxation of rules, the creation of a centralised European investment capacity to finance the transition through markets, and finally, the removal of green investments from the accounting of sovereign debt (Darvas and Wolff, 2021). This solution would protect these vital expenditures from the debt-to-GDP ratio.

Another proposal is that the €4 trillion of EU countries' public debt currently held by the ECB (which amounts to more than 25 percent of all EU public debt) be 'simply' cancelled, in a manoeuvre involving a requirement from those indebted countries to commit the equivalent sums into green investments (Dufrêne *et al*, 2021).

Debt cancellation by the ECB is certainly not an option today, and has been decisively swatted away by Christine Lagarde[5]. Nonetheless, such proposals are indicative of the mood surrounding the debt debate, while appeals for debt cancellation are also growing increasingly strident in the context of low- and middle-income countries threatened by pandemic-induced debt distress – some of which, according to estimates from campaigners[6], spend currently five times more on debt servicing than on climate finance.

It is clear that the whole debate on debt and borrowing must be rethought, and a guiding question must be whether public investment – of any kind, let alone that required on the scale compelled by the ecological transition – should be included in any deficit target. By design, such targets induce a short-term view that is fundamentally

5 See *Euractiv*, 'ECB's Lagarde says cancelling COVID debts "unthinkable"', 8 February 2021, https://www.euractiv.com/section/economy-jobs/news/ecbs-lagarde-says-cancelling-covid-debts-unthinkable/.

6 See Philip Inman, 'Poorer countries spend five times more on debt than climate crisis – report', *The Guardian*, 27 October 2021, https://www.theguardian.com/environment/2021/oct/27/poorer-countries-spend-five-times-more-on-debt-than-climate-crisis-report.

incompatible with the levels of investment needed, and with the time horizon required to deliver upon net-zero commitments. In that regard, it could make sense to exclude green investments from the accounting of sovereign debt, as Darvas and Wolff (2021) proposed. Likewise, it would make very little sense to pass over urgent 'no regret' investments – such as in renewables and energy savings – because they do not fit a given fiscal straitjacket. As Pisani-Ferry (2021) put it succinctly, "*climate investment is a powerful argument for letting governments go into debt, because the usual intergenerational objection does not apply*". Indeed, "*governments may choose to go into financial debt to be able to pay down climate debt*".

From public spending to public opinion, the European Green Deal hinges on a new social contract

This 'macro-critical' case for greater levels of borrowing and investment also shares a natural affinity with a view of transition costs from the perspective of those in Europe most vulnerable to them.

From public spending to public opinion, in other words, the European Green Deal hinges on a new vision in which the need for ambitious investment programmes is placed into a conversation between institutions and citizens, whose desire for climate ambition grows stronger daily.

Inversely, to isolate the Green Deal's reform package from a genuine and attentive conversation with citizens will bring predictable patterns of rejection. As the *gilets jaunes* protests in France illustrated, the cost of energy and utilities is a potent vehicle for latent and unaddressed resentment to become mobilised into large-scale opposition – and in turn, for this resistance to be weaponised by organised interests who wish to delay and derail climate action.

Yet confidence in state institutions is the basis of consent to taxation – or in other words, the basis for our modern social contract. Regardless of how the euro-area debt debate progresses, budgetary consolidation will in many cases be achieved with tax increases. At the

same time, extending carbon pricing to sectors that directly affect citizens, such as transport and heating, risks creating the impression that all the costs of the transition are being passed on to the people, with disproportionate impacts on the most economically disadvantaged strata of society.

To try to impose the European Green Deal in this way, with restrictive – and possibly regressive – solutions to policy problems, would be a guarantee of failure and social disarray.

The Green Deal should instead be envisioned as a deal first and foremost with citizens themselves. The adoption of Green Deal legislation should be a moment to debate issues of social justice and equity – not unlike what was attempted by the French government's Citizens' Convention on Climate in the aftermath of the *gilets jaunes* protests. While the French government's commitment to those proposals has been uneven since, polls show that flagship proposals were popular across the country[7]. In this bittersweet outcome lay both the untapped potential and the obvious institutional obstacles that must be revisited.

What the mounting furore surrounding rising energy prices in many parts of Europe in late 2021 also showed is the risk of such supply shocks being attributed to climate policies, even when their role may be non-existent or marginal. This will likewise be true of lacking opportunities in the labour market, while the question of reskilling sectors of the workforce will continue to crystallise and grow.

For all these reasons, European leaders will not be able to claim they were caught unawares. If these valid societal anxieties are not addressed head on and become obstacles to climate action, it will in fact be the lack of investment, planning and coordination between member states and Brussels that will be to blame.

7 See *Réseau Action Climat*, 'Sondage : des Gaulois pas si réfractaires à l'action climatique', 26 June 2020, https://reseauactionclimat.org/sondage-des-gaulois-pas-si-refractaires-a-laction-climatique/.

All member states must shape their own Green Deals – or citizens will step in

Like the Paris Agreement, the European Green Deal largely rests on the recognition that governments and national institutions will need to find their own paths, and some critical policy areas lay beyond its scope. For example, governments will be solely responsible for delivering greenhouse gas emission reductions in sectors that are not covered by a carbon price. The new rules of the Common Agriculture Policy (CAP) likewise leave much of the detail of implementation to governments.

A survey of opinion leaders by the Institute for European Environmental Policy (Charveriat and Holme, 2021) showed that the three main obstacles which, respondents felt, could impede the implementation of the European Green Deal all related to member states failing to take responsibility for its implementation at home, including a lack of government commitments, the absence of adequate governance mechanisms to measure progress, and uneven progress in climate action across the continent.

As the critical era of implementation gets underway, the question is therefore whether member states will push one another in the right direction, or drag each other down through watered-down compromises and foot-dragging.

And yet, well-organised citizen initiatives appear to be a crucial guardrail against lagging and backsliding. The state is legally liable for the integrity of its climate ambition, and therein lies a paradox: while leaders are wary of social backlash against the climate transition, the judiciary is now more often siding with people-led litigation and advancing climate ambition further than governments have dared. In Germany, the Constitutional Court in Karlsruhe ruled against the government for its insufficient action in relation to its

international engagements, as has France's Council of State[8].

Even though citizen mobilisations for the environment are generally local, focused on concrete projects and aimed at local political decision-makers, they are also anchored in global challenges and often chime with the language of international treaties, covering areas from greenhouse gas emissions to biodiversity loss.

These dynamics of litigation underpinned by mobilisation are a powerful phenomenon. This must be analysed together with the above-mentioned potential offered by citizens' assemblies and other forms of participative democracy, as well as the generalised desire for climate action across the EU: 93 percent of Europeans consider climate change a serious problem; and 90 percent support Europe's 2050 target of climate neutrality[9].

Energy geopolitics and the emerging faultlines

There is therefore a popular mandate, a roadmap and an array of technocratic competence across the European institutions to steer the continent towards its goals. But there are also a number of dangerous rifts, foremost among them the emerging uncertainties of energy geopolitics during the transition.

The late 2021 'gas crunch' and associated energy crisis that ensnared Europe should be considered a clarifying moment for climate action across the continent.

In addition to driving up euro-area inflation to record levels[10], these high commodity prices near-instantly interacted with a stark range of

8 See Corine Lepage, 'La portée universelle de la décision de la Cour constitutionnelle de Karlsruhe du 29 avril 2021', *Actu Environnement*, 4 May 2021, available at https://www.actu-environnement.com/blogs/corinne-lepage/77/portee-universelle-decision-cour-constitutionnelle-karlsruhe-29-avril-2021-456.html.

9 See European Commission press release of 5 July 2021, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3156.

10 See Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Inflation_in_the_euro_area.

geopolitical interferences: Russian President Vladimir Putin blaming Europe's green transition leading to "*hysteria and some confusion*" on the energy markets[11]; accusations that Russia deliberately withheld part of its gas supplies to the continent to foment Europeans' climate anxieties[12]; or the unsteady progress of certification of the Nord Stream 2 pipeline in Germany, previously entangled in tensions related to the US sanctions regime.

This scenario has been further aggravated by EU-Belarus tensions, with Belarus President Alexander Lukashenko threatening to cut off the Russian gas pipeline to Europe as part of a broader stand-off with the continent, amid added fears of a humanitarian refugee crisis on its border with Poland, and after months of escalating tension connected to allegations about its egregious human rights violations against the country's pro-democracy movement.

This, of course, is a highly synthetic account of months-long crises – and energy geopolitics are nothing new. Nonetheless it offers a glimpse into the potential risks of volatility in an age of transition, one that does not always augur a seamless switch to renewables.

And yet, such tensions also make the case for accelerating that very switch compelling. The EU may have avoided a gas bill of €33 billion from July to September 2021 by compensating for gas shortages with zero-carbon output[13], illustrating acutely the need to rethink energy pricing in Europe. With high commodity prices causing Europe's power prices to balloon, it also indicates that the best

11 See *Euractiv*, 'Putin blames green transition for Europe energy market "hysteria"', 6 October 2021, https://www.euractiv.com/section/energy/news/putin-blames-green-transition-for-europe-energy-market-hysteria/.

12 See *BBC News*, 'Gas price rises: Russia not withholding supplies, says ambassador to UK', 17 October 2021, https://www.bbc.com/news/business-58945024.

13 See Isabella Suarez, 'Europe's zero-carbon generation broke records in the third quarter, cutting fuel bills during the gas crisis', Centre for Research on Energy and Clean Air, 8 October 2021, https://energyandcleanair.org/europe-gas-crisis-vs-clean-energy.

way to hedge against price volatility is to ramp up wind and solar.

To put this case study into the context of the European Green Deal's transformative provisions, it should be remembered that nearly three-quarters (72.2 percent) of the EU's total energy needs are currently provided for by fossil fuels and three-fifths (61 percent) of the EU's energy is imported (Eurostat, 2019).

To achieve a 55 percent emissions reduction by 2030 – let alone net zero by 2050 – the EU will need to embark on a radical redrawing of its map of energy dependencies, with profound implications for its partners. This is true of the neighbourhood across the Mediterranean, in the Balkans and Central Asia, and for energy exporters further afield.

The EU's oil imports account for 20 percent of the global market share. Therefore, a drop in those imports is also a fundamental shift in the economics of oil, regardless of specific trade relationships with Europe. For major exporters as varied as Norway, Saudi Arabia and Venezuela, the price of the oil barrel has been a basic function of geopolitical leverage for decades.

Already by 2030, a number of *de-facto* shifts can be expected (Leonard *et al*, 2021). Compared with 2015 data, by 2030 oil imports to the EU could fall by up to 25 percent, natural gas by 20 percent and coal by 80 percent. Countries including Algeria, Libya and Norway look to the EU for most of their fossil fuel exports and are variably positioned to transition out of this strategy. The EU represents nearly half (45 percent) of Russia's fossil-fuel export market; Russia is also Europe's main source of imported gas. States including Nigeria and Peru also sell heavily into the EU, which in both cases accounting for up to a third of their fossil fuels export market.

'Fit for 55' sets a target of 40 percent renewable energy by 2030, up from 14 percent today. This will have a profound impact on the EU's electricity system and will maintain and deepen the existing focus on power sector decarbonisation. At any rate, a major share of Europe's energy will likely come from imports and will require new partnerships with the neighbourhood and beyond. This shift, combined with the

anticipated application of the carbon border adjustment mechanism (CBAM) to electricity imports, will also likely have regional spillover effects into grid policies with neighbours and third countries.

It is important to highlight here the uncertainties associated with a new pattern of dependencies implied by the new energy geopolitics – in other words a shift from a system based on fuel-based energies to one more reliant on metal commodities, namely the minerals and critical raw materials used in batteries, photovoltaic technology and other technologies. For example, China currently accounts for 98-99 percent of Europe's imports of heavy rare earth elements and light rare earth elements, used for wind energy and electric vehicles (Dröge, 2021).

In this transition, where will the EU find, retain and enhance its leverage?

The Green Deal as diplomatic toolbox

Without question, the European Green Deal will be a powerful driver of this century's geopolitical reality. The reforms will reverberate beyond Europe. Some global issues are already starting to crystallise, from setting standards for emerging technologies such as electronic vehicles, to the taxonomy on sustainable finance's ability to influence other jurisdictions and capital markets, to the anticipated impacts of a CBAM being applied on some sectors of international trade, or measures to stop goods linked to deforestation.

The EU's financial firepower will further make it so, from the €750 billion in the Next Generation EU recovery instrument to the European Investment Bank's €1 trillion envelope of green investments through to 2030.

The question is whether a passive form of path dependency, including the existing bilateral and trade ties of its member states, will primarily shape Europe's role, or whether a concerted and integrated European push can emerge to match the bloc's climate ambitions at home.

COP26 showed both examples of EU leadership and its limits within formal multilateral fora and beyond.

On the energy transition, and even if the COP26 final text ultimately stopped short of pledging a global phase-out of coal, there is no doubt that Europe's efforts have done much to set the end of the coal era in motion, and have helped create a crucial space for China to announce its ending of international coal financing at the UN General Assembly prior to COP26, with the G20 following suit weeks later. This itself set the stage for strong signals on retiring coal from hundreds of countries and organisations in Glasgow, the COP26 venue. The era of international coal financing is effectively over. This may have been the biggest advance for climate ambition in 2021, and EU leadership can take some credit.

We also saw increased financing and political mobilisation for coal phase-outs and the emergence of funded coal retirement mechanisms – such as South Africa's $8.5 billion just-transition plan for its coal fleet, which the EU will support, alongside the US and the United Kingdom. This plan shows what the EU can do best: accompanying a partner's pathway with concrete and detailed action that goes beyond headline finance numbers.

On the whole, however, COP26 showed that the European voice could be still stronger, bolder, more cohesive within the treaty process and beyond, especially by distancing itself from US reticence and its hard-line view on finance. In those fora, the EU should align more closely with low- and middle-income countries, which, in parallel, it is pledging to partner with in their net-zero transitions. This voice requires connectedness across member states' relations with the world – and also consistency.

In addition, the EU can use the socio-economic model of the Green Deal, its policies, participatory approaches and strong emphasis on just transition in its bilateral relationships with other countries. This means consistency across all aspects of 'Green Deal diplomacy', spanning foreign policy, climate policy and areas such as agriculture and trade.

Trade is an obvious blemish today. In principle, any EU trade negotiation must be compliant with the Paris Agreement. However, the way

in which this is interpreted remains too vague and ad hoc as the clauses related to sustainable development in trade agreeements are not always binding. The stalled deal with the Mercosur, which faces vocal objections from member states over its inadequate environmental provisions, is the clearest example. By contrast, environmental clauses are an integral part of the trade agreement with New Zealand that is at time of writing being finalised. It shows it is possible, when the political will is there.

It should be clear by now that environmental integrity – in addition to being a necessary condition for any government wanting to uphold the Paris Agreement – is also a political necessity for any trade agreement to gather support within the European Parliament and beyond. With member states such as Spain expressing anxiety that the absence of a deal with the Mercosur will allow China to step into the vacuum with more advantageous terms[14], there is a clear opportunity for the EU to try to differentiate itself by seeking the highest standards of climate integrity.

Alongside trade, the ecological transition is also a major source of opportunity for a concerted global investment strategy underpinned by European diplomacy, particularly in the broad areas of renewable energy, infrastructure and adaptation. These, in essence, were Commission President Ursula von der Leyen's words at the September 2021 launch of the European Commission's Global Gateway initiative, or Europe's response to China's Belt and Road Initiative. "*We are good at financing roads*," she said. "*But it does not make sense for Europe to build a perfect road between a Chinese-owned copper mine and a Chinese-owned harbour. We have to get smarter when it comes to these kinds of investments*"[15].

14 See *Euractiv*, 'Spain urges European Commission to unblock Mercosur agreement', 4 May 2021, https://www.euractiv.com/section/economy-jobs/news/spain-urges-european-commission-to-unblock-mercosur-agreement/.

15 See https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_21_4701.

At a time when states are eyeing ways to jump-start their economic recovery from the COVID-19 pandemic, the opportunities for Paris-aligned investments are immense. The current pipeline of renewable energy projects capable of supporting green recoveries across 47 economies and could provide an injection of more than $1.9 trillion (EY Parthenon, 2021). These projects would then yield a permanent recurring GDP contribution of £60 billion, or $83 billion.

With India, for example, announcing a massive 500 gigawatt ramp-up of its solar capacity by 2030 (an initiative supported by President Joe Biden's climate envoy, John Kerry, who pledged US support[16]), and Vietnam increasing its solar capacity 25-fold in 2020 alone[17], outpacing even optimistic forecasts, the scope for opportunity beyond the 'shovel-ready' pipeline is likely to be vast. Notably, both India and Vietnam came to COP26 with ambitious plans for their transitions to renewables, which should bolster investor confidence in these countries' infrastructure needs.

Nearer Europe, 238 shovel-ready projects in Turkey alone, representing $19.4 billion in investment opportunities, could help to align Turkey with the European Green Deal (EY Parthenon, 2021).

An enhanced commitment to mobilising and leveraging such finance – coupled with European technical expertise – offers clear opportunities to support the transition elsewhere in the neighbourhood. North Africa and Middle Eastern states are prime candidates for large-scale solar projects, while the coastal regions from Morocco through to Egypt could likewise host wind-farm infrastructure.

"*Links, not dependencies*" was another phrase used by President

16 See Shreya Jai, 'India is a "red-hot investment destination for solar": John Kerry', *Business Standard*, 21 October 2021, https://www.business-standard.com/article/economy-policy/india-is-a-red-hot-investment-destination-for-solar-john-kerry-121102001146_1.html.

17 Douglas Broom, 'Viet Nam has installed 6 coal plants' worth of solar in a year', *World Economic Forum*, 8 February 2021, https://www.weforum.org/agenda/2021/02/viet-nam-solar-power-surge/.

von der Leyen during the Global Gateway unveiling – implying, in other words, an enabling environment with positive-sum outcomes for everyone.

Of course, this assumes that such investments and transitions are desirable to all of Europe's partners. As identified earlier, among them feature many extractive-wealthy nations, which may not be in need of, or interested in, European partnerships to finance their own transitions when they can become Europe's energy competitors in other markets.

Conclusion

Europe is embarking on an extraordinary new chapter. There are important opportunities ahead to clarify the EU's position and leverage. Germany has taken the G7 Presidency just as the new German governing coalition has announced its plan to promote an 'international Climate Club' to help avoid trade friction over issues of carbon pricing and carbon border adjustment[18]. These two central features of the European Green Deal will indeed require interoperability with other economic blocs. Like the emerging question of harmonising taxonomies (Kammourieh and Vallée, 2021), inter-regional efforts like these can work if they bolster the multilateral process overall – in other words, if this 'club' does not become exclusive.

The response to the pandemic has shown the resilience of the European institutions and exposed their limits; it is a cautionary tale. Two years of crisis have severely stressed Europe's ability to coordinate within itself and with the world, on vaccines and other issues, while the world faces a climate crisis that will engulf it by orders of magnitude. The economic fallout from climate impacts in G20 countries could rip through Europe – across urban centres, agriculture and

18 Kerstin Appunn, 'Next German government's key climate and energy plans in 2021 coalition agreement', *Clean Energy Wire*, 25 November 2021, https://www.cleanenergywire.org/factsheets/future-german-governments-key-climate-and-energy-plans-2021-coalition-treaty.

tourism, bringing heat waves that could last at least ten times longer by 2050, impeding productivity and entailing towering healthcare costs (Spano *et al*, 2021). These amount to GDP wipe-outs equivalent to multiple COVID-19 pandemics.

Meanwhile, at the time of writing, challenges of a humanitarian or security nature continue to deepen at Europe's borders, in the Mediterranean, the Channel, and on its borders with Belarus and Ukraine.

There will also be the matter of the continued disbursement of Next Generation EU funds, while Poland (supported by Hungary) continues its stand-off with Brussels, whether on rule of law or its required transition out of coal. At COP26, Poland – by far the most coal-reliant in the EU – ultimately maintained its low-ambition coal phase-out deadline of 2049[19].

This is a landscape dotted with question marks – but out of this uncertainty, there are at least areas of certainty created by the European Green Deal roadmap. It is the best plan out there – Europe should make the most of it.

Finding this cohesive and ambitious European voice thus starts at home, in the pursuit of a new social contract which combines the impressive framework of the Green Deal and Fit for 55 with the need to reconcile citizens with their institutions, and imagine a just transition that is well funded, feasible and fair.

19 Kira Taylor, 'Poland clarifies position on coal phase-out, it is still 2049', *Euractiv*, 5 November 2021, https://www.euractiv.com/section/energy/news/poland-clarifies-position-on-coal-phase-out-it-is-still-2049/.

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3 The COVID-19 recovery, growth and climate change mitigation

Laurence Boone, Antoine Dechezleprêtre
and Tomasz Koźluk[20]

Climate neutrality is a massive task

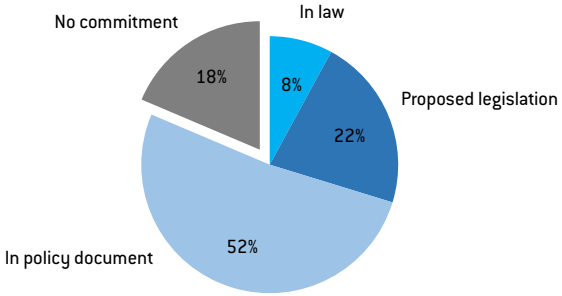
Mitigating the disastrous effects of climate change is one of the most significant challenges faced by our generation, and those that will follow. In line with the international commitments of the 2015 Paris Agreement, limiting average temperature increases to well below 2 degrees Celsius above pre-industrial levels requires global emissions to be cut to net zero by around mid-century.

In terms of long-term commitments, policymakers appear to be taking this scientific imperative very seriously. Over 100 countries, representing more than 80 percent of the world economy, have now announced targets of carbon neutrality by mid-century (Figure 1). Medium-term targets have also been increased, for example with the June 2021 European Union Climate Law, which has increased the EU's target for reduction of greenhouse gas emissions by 2030 from 40 percent to at least 55 percent, compared to 1990 levels. The United States has pledged a 50 percent reduction in 2030 with respect to 2005

20 The opinions expressed and arguments employed in this chapter are the responsibility of the authors and should not be seen as representing the official views of the OECD or its member countries. The authors are grateful to Assia Elgouacem, Filippo Maria D'Arcangelo and Tobias Kruse for their helpful comments and discussions, and to Penny Elghadhab for editorial support.

emissions. Moreover, during COP26, parties agreed to revisit and strengthen 2030 targets already in 2022[21].

Figure 1: Share of global economy that announced net-zero CO_2 or greenhouse gas emissions by mid-century



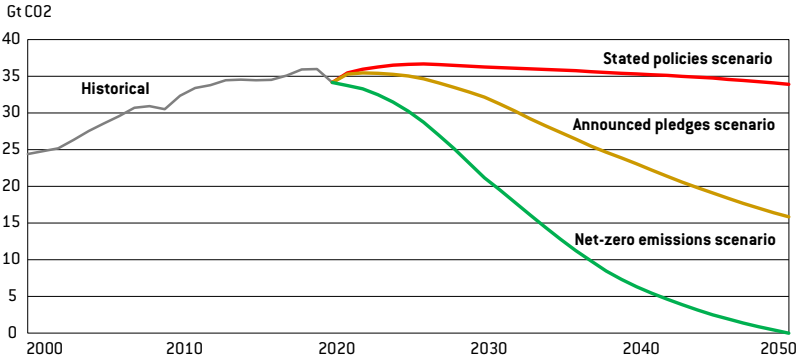
Source: Own calculations based on the share of global GDP represented by the countries that commit according to the Net Zero Tracker (https://eciu.net/netzerotracker). Share of global GDP is calculated based on GDP in 2017 taken from World Bank national accounts data and OECD National Accounts data (2021). Note: In law: Sweden, United Kingdom, France, Denmark, New Zealand and Hungary. Proposed legislation: European Union, Canada, South Korea, Chile and Fiji. In policy document: US, China (by 2060), South Africa, Japan, Germany, Switzerland, Norway, Costa Rica, Iceland and Marshall Islands.

The scale of the challenge is massive. For example, when in 2020 the world locked down against COVID-19, with travel restrictions, curfews and grounded flights bringing GDP down by 3.4 percent, global CO_2 emissions declined by roughly two gigatonnes (5.8 percent) – the largest ever decline, almost five times greater than the 2009 decline following the global financial crisis (IEA, 2021). Emissions have since recovered to pre-pandemic levels, and are not expected to decline under currently implemented and announced policies (Figure 2). Yet, to achieve global net zero in 2050, net emission reductions of a comparable order of magnitude would be necessary *every year* from now to

21 See https://ukcop26.org/cop26-keeps-1-5c-alive-and-finalises-paris-agreement/.

2050 – all without the growth-hampering lockdowns or disruptions of 2020.

Figure 2: The world's CO2 emissions are not in line with net-zero by 2050



Source: OECD based on IEA (2021). Note: The net-zero emissions scenario shows the global energy-related emission pathway developed by the International Energy Agency. The announced pledges scenario includes COP 26 pledges as of 3 November 2021.

Achieving net zero would require a massive transformation of production and consumption patterns. For example, even the relatively optimistic International Energy Agency report on achieving net zero stipulates that, as of mid-2021, no investment in new fossil-fuel supply projects or new unabated coal plants should occur (IEA, 2021). The IEA further assumes that by 2035, there are no sales of new internal combustion engine passenger cars, and that global electricity production is fully (net) decarbonised by 2040. This is highly ambitious and would require extremely rapid deployment of available technologies, as well as major development and scale up of new breakthrough technologies. Indeed, "*in 2050, half the reductions come from technologies that are currently at the demonstration or prototype phase.*" (IEA, 2021). This proportion is even greater in 'hard-to-abate' sectors, including steel, aluminium and cement manufacturing. Fossil fuels are still required for high-temperature processes, for which potential

substitutes such as green hydrogen are still far from commercial maturity. As if this was not challenging enough, additional efforts will be required for the abatement of other greenhouse gasses, for example from agriculture.

What is missing?

Countries' current commitments collectively fall short of what is needed to shift towards a pathway consistent with carbon neutrality, and are often not binding. For example, the Climate Action Tracker, an independent NGO that monitors countries' climate policies, estimates that the projected global temperature increase from current policies is around 2.7˚C by the end of the century. UN Environment arrives at a similar conclusion (UNEP, 2021).

Possibly even more importantly, while climate mitigation ambitions are being ramped up, bold policy measures to achieve them are lagging. Policymakers have not announced what policy tools they will implement or how will they deal with trade-offs, cost and risks. One potential explanation is they are slowly realising how huge the effort will be.

Why is it so complicated?

It is well known that two features of the climate – its global public good nature and its relatively long time horizon – complicate the case for climate mitigation. The benefits of mitigating climate change are global, spanning far beyond national borders, and curbing domestic emissions only has a tenuous link with the domestic damage from climate change. Similarly, most mitigation efforts made today will only yield benefits in decades to come. In addition, climate stability is obviously not the only objective of policymakers, and in a world of constrained resources, the costs and benefits of action must be weighted against other policy objectives, including growth, inclusiveness, healthcare and governments' prospects of re-election. As a result, any short-term, domestic costs of climate action may be difficult to accept politically, limiting support for climate mitigation.

Recent surveys show citizens becoming increasingly concerned about climate change, notably in many advanced economies (Bell *et al*, 2021). However, in practice, climate tends to lose out to other priorities, with the risk of job losses concentrated in certain regions, social groups or professions tending to hinder bold government action in advanced democracies. Clearly, part of this sentiment is linked to the potential freeriding and fear of loss of competitiveness and leakage to other countries. Yet, The general notion of incurring any costs is not an easy sell politically. For example, while most survey respondents say they are willing to change their lifestyles at least somewhat, energy price hikes – which would most likely accompany a climate transition – seem politically hard to accept. This has been made clear by the energy price hikes in late 2021 and early 2022, amid a COVID-19 recovery: governments, especially in Europe, have stepped in with measures, often untargeted, to insulate households and firms (Boone and Elgouacem, 2021).

The macroeconomics of climate mitigation

The low-carbon transition: long-term benefits, short-run costs

The low-carbon transition undoubtedly offers economic benefits and opportunities. First and foremost, if the effort is global and successful, there is the key benefit of minimising the risks from climate damage. Most mainstream models struggle to quantify such benefits in economic terms, and often come up with relatively small climate damages, as such longer-term avoided damages are inherently difficult to estimate and model. This includes difficulties in modelling tipping points in the climate system (eg melting of the West Antarctic Ice Sheet, dieback of the Amazon forest, melting of permafrost etc). Once triggered, climate and geophysical shocks can become irreversible and may induce further warming via positive feedback loops. Such non-linear effects in the climate system can be particularly difficult to model with existing tools, although progress is being made (Dietz *et al*, 2021).

Another part of the discourse to advocate policy action has focussed on the new job opportunities created ('green jobs'), revenues from carbon pricing and macroeconomic gains from increased public and private investment and innovation (Stern and Valero, 2021; Stern *et al*, 2020). For example, some analysis suggests that clean-energy infrastructure creates superior employment opportunities relative to fossil-fuel investments (Pollin *et al*, 2008).

However, while a large part of the debate focusses on the benefits, we argue the focus should be on the transition costs and risks, and on how to mitigate and address them[22]. Models focussing on the medium to long-term, often used in looking at the climate transition, tend to find that the overall growth costs of climate mitigation are likely insignificant, or even positive (OECD, 2014; OECD, 2017; NGFS, 2021a; IEA, 2021). However, such models are not suited to capture the short-term transition, in part because of the lack or poor modelling of cost-inducing frictions. In these models, reallocation is smooth: workers are reallocated to jobs, often regardless of their skills, age or location; firms adopt new technologies and capital flows smoothly towards low-emission firms and activities. In a similar manner, consumers understand and make the right choices, electricity grids balance demand and supply without disruption, energy security is not a problem, and no-one goes out on the street to protest. Moreover, the aggregate macro approach tends to lose localised costs in aggregation, and thus winners and losers cancel out.

This is not to say the macro-modelling is not useful, but in a situation in which the short-term costs are blocking action, shying away from such costs and risks can backfire and undermine the transition or make it more expensive. The French *gilets jaunes* experience (Douenne and Fabre, 2020), which was triggered partially by the increase in the carbon tax rate, is a reminder that in the short-term costs will be a much more significant concern for policymakers.

22 General equilibrium models can however be usefully complemented with specific engineering and sectoral models and empirical estimations which can address many of these issues, but often in a piecemeal approach.

Ultimately, climate mitigation can be characterised as a "*large negative supply shock*" (Pisani-Ferry, 2021), though not unexpected and spread over time. The net-zero transition implies effectively giving up on using a 'free' production input (the carbon sink function of the atmosphere). At the macro level, this will drive an accelerated scrapping of emissions-intensive capital, stranding of certain fossil fuel-related assets (both tangible and intangible, including skills and knowledge) and investment in otherwise "*unproductive*" assets (Pisani-Ferry, 2021; IEA 2021)[23]. It will mean jobs (and some types of human capital) will be lost. The negative effects will be magnified if action is uncoordinated internationally, due to cross-border leakage of economic activity reducing the global effectiveness of mitigation efforts (OECD, 2013; NGFS, 2021b). Frictions in the reallocation of capital and labour will increase the costs of such a shock, eg due to hysteresis in the labour markets. Moreover, increased investment in low-emission capital and innovation will also shift the composition of growth, from consumption to investment.

Net budgetary gains from carbon taxes are less than certain. First, (temporary) gains from carbon pricing are likely needed to finance compensatory measures to improve their public acceptability, or offset leakage. For example, one of the world's most successful carbon pricing schemes, British Columbia's carbon tax, was from the onset designed as revenue neutral – a key factor behind its success (Harrison, 2013)[24]. Second, these new revenues will likely be needed to finance the necessary public investment and innovation, as well as worker reskilling. For example, in 2021, the Dutch government introduced a new carbon levy in industry that sets out an ambitious price trajectory until 2030, but in order to attenuate the potential impacts on competitiveness and to improve the political acceptability of the new

23 A prime example of such 'unproductive' investment is carbon capture and storage.

24 In the initial years, it turned out revenue negative, ie compensation cost more than the revenues received.

instrument, proceeds from the levy and from the sustainable energy surcharge (ODE) are used to finance a new instrument (the SDE++) to support the deployment of low-carbon technologies (Anderson *et al*, 2021). Importantly, the analysis of the fiscal implications of climate mitigation is surprisingly thin, though several countries have made such attempts (see for example, OBR, 2021).

Winners and losers, reallocation

The transition to a low-carbon economy will lead to reallocations both between and within economic sectors and firms. The ability to minimise the costs (and maximise the benefits) of such reallocation will be crucial for the overall macro outcomes and for the public acceptability of climate mitigation. Modelling results tend to point to very limited overall reallocation of jobs (sum of created and destroyed jobs): around 0.3 percent for OECD countries and 0.8 percent for non-OECD countries in the case of a 450 parts per million CO_2 concentration target in 2035 (Chateau *et al*, 2018). One of the main explanations for the limited consequences in terms of job reallocations is that the heavily impacted sectors (mostly energy sectors) represent only a small share of total employment (82 percent of the largest CO_2 emitting non-agricultural sectors comprise only 8 percent of the total jobs in 27 OECD countries). However, a key factor limiting the transition 'costs' is that the simulation concerns a global, uniform carbon tax, which would exclude leakage across borders. And, again, such models abstract from any short-term adjustment costs, focussing on longer-term reallocation.

Job losses specifically from the low-carbon transition are expected to be concentrated in 'brown' sectors, broadly defined as carbon-intensive industries and sectors related to extraction and processing of fossil fuels. For example, employment in 'Mining and fossil fuel supply' and 'Fossil-fuel electricity generation' is predicted to decrease by around 8 percent in OECD countries compared to baseline estimations (Chateau *et al*, 2018).

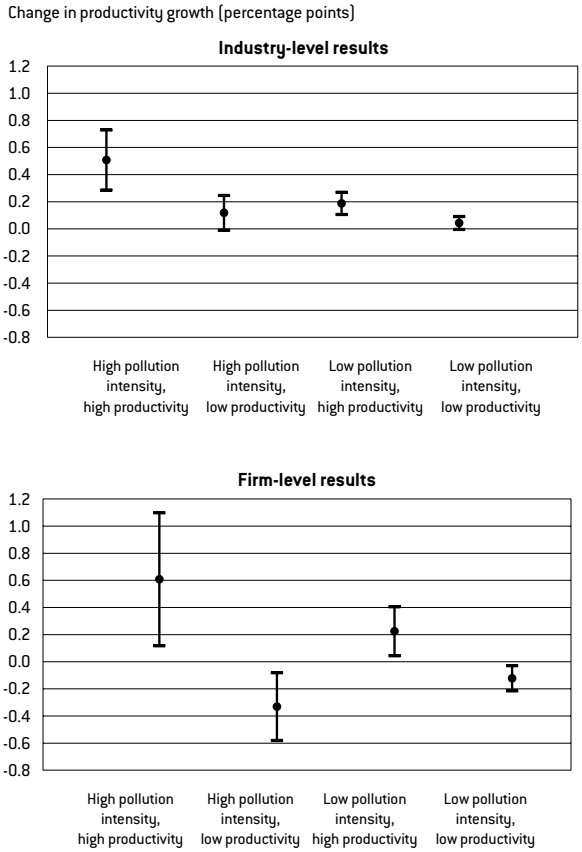
The expected job reallocation rates – taken at face value – do not seem something a well-functioning job market cannot handle. They are relatively small compared with reallocation movements observed during the past decades: job reallocation rates averaged at 20 percent over 1995-2005 in OECD countries (OECD, 2009). These reallocations also appear small when compared to other major macroeconomic trends such as globalisation and the diffusion of new information and communication technologies – though admittedly would add to these ongoing trends. Ever-increasing computing power, big data, the penetration of the internet, artificial intelligence, the internet of things and online platforms are among the developments radically changing prospects for the types of job that will be needed in the future, and how, where and by whom they will be done. In a study using workers' reports of the tasks involved in their job, from the OECD's *Survey of Adult Skills*, Arntz *et al* (2016) estimated that 9 percent of jobs are at a high risk of being automated. In addition, 25 percent of jobs will be changed fundamentally. In comparison, therefore, the green transition appears manageable.

However, even within narrowly defined sectors, ie beyond the scope of cross-sectoral modelling exercises, there will be reallocations between firms (or even within them), as energy and emissions efficiency becomes a competitive asset. For evidence on such effects, one has to turn to firm-level evidence. In a global firm-level study, Albrizio *et al* (2017) showed that within-sector effects appear much more significant than effects across sectors (Figure 3). At the firm-level, a tightening of environmental policies leads to an increase in the productivity growth of firms close to the technology frontier, but to a decrease in productivity growth for those further away from the frontier. Only one-fifth of the firms are estimated to benefit from environmental policies, while the bottom 30 percent of firms suffer losses in terms of productivity growth. Since smaller firms tend to be further away from the productivity frontier, they are more exposed to the negative effects, possibly because they have limited resources to adapt to the policy changes.

Comparing firm- and industry-level results on the productivity effects of environmental policies suggests that part of the adjustment, particularly for less technologically-advanced firms, may take the form of firm exit. The exit of the least-efficient firms would raise overall industry productivity, cancelling out the negative productivity effects observed in surviving, less-efficient firms. Indeed, one may consider the negative effect on the least-productive firms as one way to reallocate resources previously locked in firms that were at the margin of exit (Andrews *et al*, 2017).

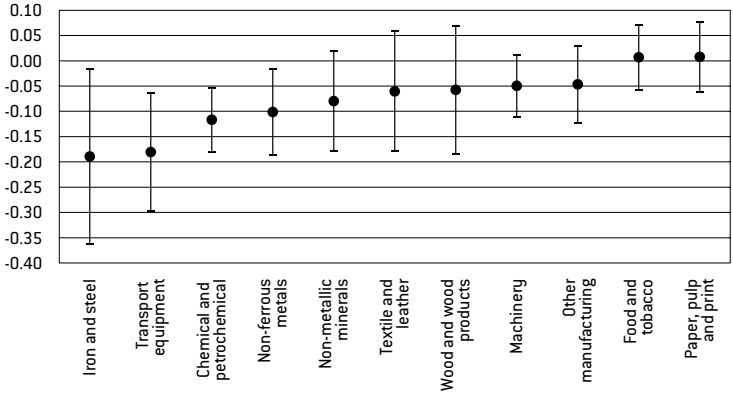
Similar differences between small macroeconomic effects and large microeconomic impacts have been found for the effect of environmental policies on employment. Dechezleprêtre et al (2020) showed that, at the sector level, increases in energy prices and in the stringency of environmental policies have a negative and statistically significant impact on total employment in the manufacturing sector. The overall magnitude is small: a 10 percent increase in energy prices leads to a reduction of manufacturing employment by 0.7 percent. However, the effects vary across sectors: energy-intensive sectors (eg non-metallic minerals, iron and steel) are most affected, while the impact is not statistically significant for less energy-intensive sectors (Figure 4). Within sectors, higher energy prices also increase the probability of firm exit. Accelerated firm exit then allows surviving firms to expand, boosting employment in these firms. Some firms lose, others win, explaining why the effects appear small at the macro level.

Figure 3: More stringent climate policy is related to diverse effects on productivity growth across firms and sectors



Source: Albrizio *et al* (2017). Note: (1) One-year effect of a mean in-sample increase in environmental policy stringency (EPS), ie 0.12 change in the value of the EPS index in one single year. Effects on productivity growth are estimated to last for three years after the policy change and then fade away: (2) High (low) pollution intensity is defined as an industry with the highest (lowest) pollution intensity on seven selected key pollutants with respect to value added. (3) High productivity is defined as the country-industry pair (or firm) on or close to the estimated global industry (or firm) productivity frontier. Low productivity is defined as country-industry pair (or firm) at the 70th percentile of distance to the global industry (or firm) productivity frontier. (4) 90 percent confidence intervals are reported.

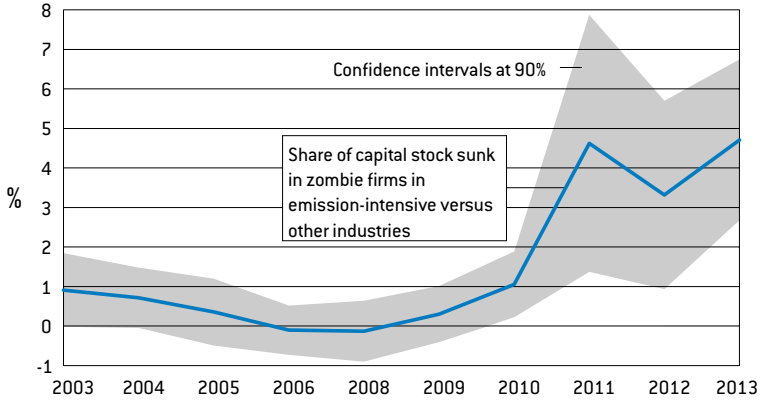
Figure 4: Short-term employment effect of a 10% increase in energy prices across sectors



Source: Dechezleprêtre *et al* (2020). Note: The figure shows the effect of a 10 percent increase in energy prices and 95 percent confidence intervals of the energy price variable on the log of employment. These underlying models are estimated with a one-year time lag. For the iron and steel sector, a 10 percent increase in energy prices leads to a nearly 2 percent decline in employment.

The reallocation story has multiple dimensions: reallocation between sectors, between firms within sectors and within firms, across technologies, products and activities. Firms will exit and enter at the margin, but the population of firms will need to reallocate resources to reduce the carbon footprint of their activities. An increase in the prevalence of zombie firms (weakly productive firms that in a fully competitive market would exit or restructure) in the OECD is often put forward as one of the drivers of the overall productivity slowdown (OECD, 2017). In this respect, zombie congestion can pose another risk to the transition. Zombies do not exit, hampering reallocation by blocking resources from flowing to more-productive and less emissions-intensive firms. But zombies themselves also struggle to find resources with which to invest, innovate and adopt new cleaner production technologies. Following the global financial crisis, zombie shares increased particularly in emission-intensive industries – precisely those that need to invest and innovate their way through a low-carbon transition (Figure 5).

Figure 5: After the global financial crisis, zombie congestion rose more in emissions-intensive sectors.



Source: OECD (2021).

The COVID-19 recovery: A favourable macroeconomic context?

The COVID-19 recovery is an opportunity to set growth on a sustainable and resilient path (OECD, 2021). Following a pre-crisis period of slow growth and low investment, the recovery brings major investment opportunities and accommodative monetary policy, coupled with ample pent-up savings to finance investment. Public investment – in infrastructure, innovation and skills – is of crucial importance for reigniting productivity and inclusiveness in general, and to achieve the transition to net zero. For example, the world's largest greenhouse gas emitters, China, the United States and the European Union, are all currently rolling out or announcing massive infrastructure investment programmes. Hence, overall, the macroeconomic conditions for reshaping the economy – steering reallocation through investment for the recovery – seem particularly favourable.

However, short-term trade-offs between growth and sustainability priorities will need to be managed. The recovery will need to prioritise jobs and incomes – bottlenecks in energy, commodities and some

manufacturing sectors are already eroding purchasing power. A vulnerable recovery is unlikely to be the perfect time to ramp up carbon prices, in particular as energy taxes are often regressive (Flues and Thomas, 2015). Similarly, disruption to electricity markets and high prices – even if only indirectly linked to the climate transition – could easily undermine public support. Public investment choices will need to be made carefully. For example, despite some claims (IMF, 2021), there is little evidence of the superiority of 'low-carbon' fiscal multipliers, in particular in the context of a widespread low-carbon transition. Evidence from the global financial crisis suggests rather that green stimulus packages can help redirect the economy onto a greener path, but are less effective at generating jobs in the short run (Popp *et al*, 2020).

What can policies do?

Due to its all-encompassing nature, a low-carbon transition will require a comprehensive approach. More ambitious climate policies will be needed to drive the transition, facilitated by a broad policy package. Structural policies will be required to facilitate reallocation, boost competition and innovation, strengthen skills, reduce frictions and support people through transitions (OECD, 2021). Tailoring such broad policy packages to country-specific circumstances requires a much deeper understanding of the short to medium term costs and trade-offs involved, as well as of their public acceptability.

More stringent climate policies to provide incentives for the transition

To ensure that the private sector picks up on the low-carbon transition, government policies need to make a business case for low carbon. In a similar manner, incentives provided to households need to change behaviours and consumption patterns. This requires policies that incorporate the emissions (and their associated social costs) into decision-making through pricing, subsidies, nudging and information

provision or regulations. Current policies are far from what would be required to achieve the net-zero targets. For example, four-fifths of energy-related CO_2 emissions in key emitting countries are priced below levels consistent with Paris targets and about half are not priced at all (Figure 6). In addition, while carbon prices have generally become broader in scope and have risen, public spending on technology and innovation support policies (eg public expenditures on R&D and demonstration) has actually decreased in ambition over the last 10 years (Figure 7).

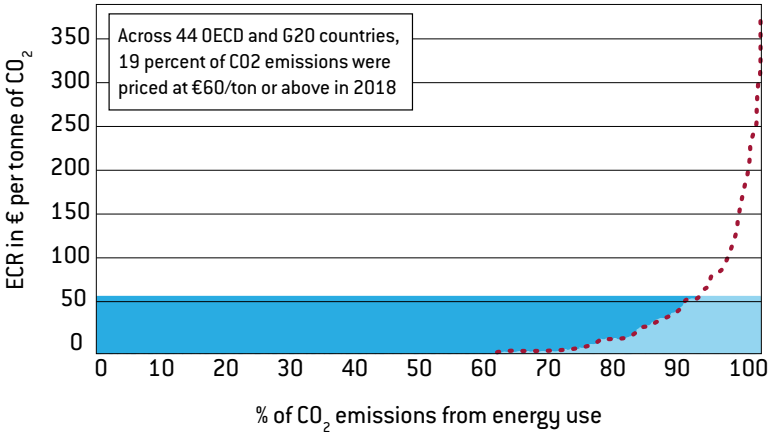
Many countries still subsidise the production and use of fossil fuels – skewing the incentives against low carbon energy. The latest combined OECD and IEA estimates indicate that governments provided $351 billion in fossil-fuel support in 2020, more than double the support given to renewable energy (OECD, 2020a; IEA, 2019). A key obstacle to the removal of fossil fuel subsidies is their stated aim to provide accessible and affordable energy. While support for fossil fuels has proved inefficient in delivering on this goal, due to poor targeting (OECD/IEA, 2021), the political economy is complicated, as exemplified in the rush to provide various types of energy subsidy to households and firms in the wake of the energy price hikes in late 2021 (Boone and Elgouacem, 2021).

Economists tend to recommend carbon pricing policies with broad coverage and clear price trajectories to incentivise changes in planning of investment, innovation and consumption for businesses and households. Carbon pricing can be both effective and efficient (OECD/IMF 2021). However, the political economy and public acceptability constrain the use of carbon pricing in practice (Carattini *et al*, 2018). Carbon taxes, the phasing-out of fossil fuel subsidies and the non-pricing of climate mitigation policies carry the risk of disproportionally affecting lower-income households and small businesses, which would magnify the negative impact of the crisis on vulnerable populations. Compensation measures and other complementary policies can be used to offset some of these hindrances and boost acceptability

(Douenne and Fabre, 2020). Lessons learnt from the successful introduction of the British Columbia carbon tax, where the higher carbon tax is combined with labour and business income tax reductions, could be applied in other countries (Harrison, 2013). Providing lump-sum payments to households and the most affected firms, and boosting investments in green infrastructure, can increase public acceptance of such policies (Yamazaki, 2017; Murray and Rivers, 2015; Douenne and Fabre, 2020). More generally, choices and communication regarding revenue use and accounting for local circumstances determine the public acceptability of carbon pricing. Finally, it is important to consider that carbon taxes can often be less regressive than other commonly used climate-related policies, such as fuel-efficiency standards.

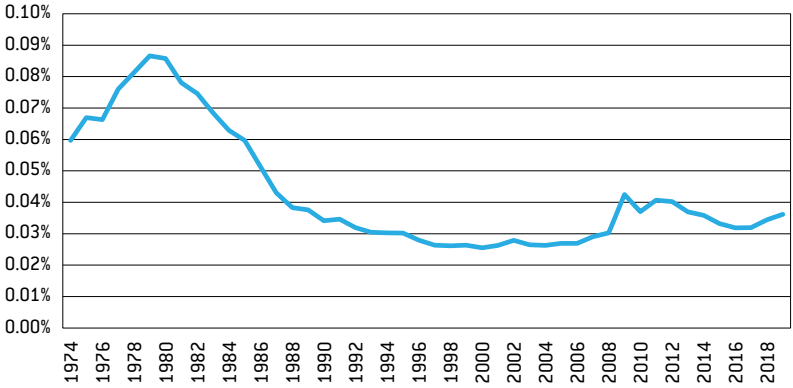
In practice, a whole range of climate policies will be needed for a low-carbon transition. These span public investment and policies directly supporting investment in R&D, innovation, demonstration and technology adoption of low-carbon and enabling technologies (notably digital); product standardisation (eg charging points for EVs, hydrogen); regulations (eg emissions standards, recycled content, bio-based products); public infrastructure (eg EV charging stations), public procurement, competition policies to support the emergence of new innovators, start-ups and entrepreneurs; and labour market policies, focusing on training and skill provision.

Figure 6: The carbon pricing gap



Source: Effective Carbon Rates 2021. Note: The area shaded in light blue shows the carbon pricing score (CPS) at €60 per tonne CO2. It shows the extent to which the group of 44 OECD and G20 countries together reached the benchmark to price all emissions from energy use at least at €60 per tonne CO2 in 2018. The area shaded in dark blue shows the carbon pricing gap, ie the shortfall from pricing all emissions at least at €60 per tonne. ECR = effective carbon rate.

Figure 7: Low-carbon public RD&D expenditures in GDP, 1974-2019



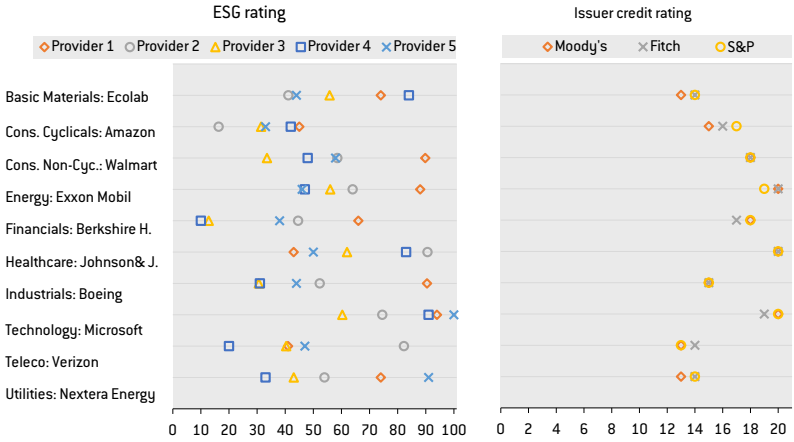
Source: IEA energy RD&D expenditures database.

Fixing the information asymmetry

Significant market failures, such as information asymmetry between investors and innovators, can make it difficult for investors to identify firms that are low-emission or reducing emissions, and to channel funds to them, muting the response to climate policies. Taxonomies, identifying clearly what is 'low emission' and what is not, could help fix this failure and direct funds to green innovation and firms that genuinely invest in reducing emissions. This is what the environmental pillar of environmental and social governance (ESG) aims to do.

However, in practice, ESG initiatives face significant challenges, including proliferation of different approaches and data inconsistency, lack of comparability of ESG criteria and rating methodologies, and insufficient clarity over how ESG integration affects asset allocation (OECD, 2020b). The result is confusion and performance assessments that are more linked to the evaluation methodology rather than actual performance (Figure 8). Furthermore, ESG investors often make binary distinctions between 'green' and 'polluting' firms. This can induce capital reallocation to low emission-intensity firms – for example in the services sector – while a key aspect of the low-carbon transformation is to induce polluting firms producing steel or other energy-intensive goods to switch to clean production processes. Current ESG scores may be ill-designed to help reallocate capital in 'hard-to-abate-sectors'. Hence, coordinated action would be welcome – at least among key financial markets – to foster a more transparent and acceptable taxonomy and strengthen the tools that underpin disclosure, valuations and scenario analysis in financial markets. This would be particularly effective given the proliferation of net-zero or similar pledges in the private sector, where actual bold moves, good intentions and simple greenwashing may otherwise be difficult for investors to identify and scrutinise.

Figure 8: ESG ratings are not providing clear signals to investors; selected ESG ratings and issuer credit ratings by sector in the US, 2019



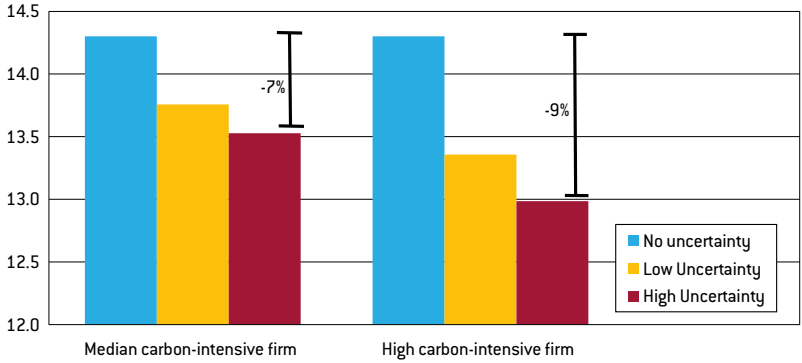
Source: Boffo and Patalano (2020). Note: Sample of public companies selected by largest market capitalisation to represent different industries in the United States. The issuer credit ratings are transformed using a projection to the scale from 0 to 20, where 0 represents the lowest rating (C/D) and 20 the highest rating (Aaa/AAA). Data from Bloomberg, MSCI, Refinitiv, with OECD Staff calculations. For full methodology, refer to source.

Policy uncertainty

Since private-sector investment in low-carbon technologies is fundamentally dependent on expectations of future climate policy stringency, policy uncertainty is a major barrier to private-sector investment in 'green' technologies. Investments in energy infrastructure tend to be capital-intensive, are often irreversible and characterised by a long time horizons, thus requiring a high level of certainty for planning purposes. Yet, policy uncertainty causes delays in firms' investment decisions, in particular for capital-intensive and irreversible investments (Bernanke, 1983; Dixit and Pindyck, 1994). Uncertainty in climate policies, which make future market conditions less predictable, has been empirically associated with large reductions

in firms' investments in low-carbon technologies and infrastructure, as shown in Figure 9. Therefore, stable, long-term policies are a necessary condition to achieve sufficient private investment into climate-change mitigation technologies.

Figure 9: Impact of environmental policy uncertainty on firm investment



Source: Berestycki *et al* (forthcoming).

A policy package to reduce the costs (and boost benefits) of reallocation

In a policy-driven transformation, failing to properly account for the costs and those who lose out, risks the transition being abandoned. Those who fear losing out – whether their fears are real or perceived – can demand backtracking on policies or oppose their ramping up at election time, leading to a lowering of policy ambition.

For this reason, structural policy reform will be an essential part of a climate transition package. Structural reforms will need to increase flexibility, reducing short-term costs and frictions that are likely to determine the success of the transition. Product and service market reforms are needed to facilitate reallocation by reducing barriers to entry, exit and competition – encouraging entrepreneurship and innovation and an orderly restructuring of unviable firms. Markets that are more flexible will ensure the responsiveness to climate policy signals

and to incentives for innovation. But, in particular in the recovery, governments will need to ensure support for people during the transition. Workers, who risk losing their jobs, will need reskilling, activation policies and efficient income-support policies. Governments will need to decide which households, firms and regions to support and how, in order not to create dependency but spur development and growth.

In the short run, job-search and training schemes can help workers with jobs at risk during the transition – particularly the low-skilled – to find new opportunities with equivalent skills, but unemployment support and welfare benefits are an important complement to active labour market policies to support displaced workers' income during the transition. However, in the medium- to long-run, the education system needs to adapt structurally to the increased demand for skills demanded throughout the transition. Vocational education and training programmes (including continuing training) will need to cover the relevant skills.

In areas heavy reliant on fossil fuels, the green transition will require transformation of the industrial specialisations of entire regions, and potentially the geographical relocation of large numbers of workers. Past policies, such as early retirement schemes, have proved ineffective at creating new jobs. A more promising approach combines place-based policies (early-stage re-skilling and up-skilling and improvement of public services provision) with policies aimed at removing obstacles to geographical mobility.

Finally, international collaboration can do wonders. While the lack of it should not prevent unilateral actions, cooperation and coordination on policies reduces the costs of abatement – both in the short-term and over time, through innovation. It is also likely to reduce tensions inherently related to leakage and free riding.

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4 The missing macroeconomics of climate action

Jean Pisani-Ferry[25]

Climate change mitigation was for a long time regarded as a gradual process. Of the many issues raised by the changeover to a decarbonised economy, few were macroeconomic in nature. For finance ministers and institutions interested in growth, jobs, inflation and public debt, climate was perhaps an important issue, but it was an issue for the day after tomorrow.

This is no longer a tenable assumption – if it ever was. The carbon-neutrality commitments entered into by a majority of countries and, even more, the ambitious intermediate targets set by the European Union or the United Kingdom for 2030, call for a change of perspective[26]. Too late, certainly, and also too slow in many respects,

25 The author is grateful to participants in seminars at Bruegel, the EUI and PIIE, as well as at the Banque de France, CEPII, CEPR, the EBRD, the European Commission, ICRIER, IWEP/CASS, the OECD, OFCE and the RBWC. Thanks also to Jean Boissinot and Jean-Michel Glachant for fruitful discussions, and to Laurence Boone, Maria Demertzis, Tomasz Kozluk, Benoît Leguet, Marie Le Mouel, Selma Mahfouz, Mauro Pisu, André Sapir, Simone Tagliapietra, Guntram Wolff and Georg Zachmann for comments on an earlier draft. Special thanks to Jean-Charles Hourcade and Thomas Veyrenc for detailed feedback, and special gratitude to Thomas Belaich for excellent research assistance.

26 Commitments to net zero now cover 88 percent of global emissions and 90 percent of global GDP (but they are of unequal strength). But only 45 percent of the corresponding emissions are covered by a pledge to reach net zero by 2050 or earlier. Source https://zerotracker.net/.

what has started is a major transformation, the impact of which is being felt already and will only grow in importance in the years to come. Issues that used to be on (if not beyond) the horizon have suddenly become matters for immediate concern.

Leaders tend to present this transformation in a positive light. European Commission President Ursula von der Leyen, for example, has called the European Green Deal Europe's new growth strategy, whereas US president Joe Biden has said that when he talks to Americans about climate, he is really talking to them about jobs[27].

This reassuring 'green growth' perspective is puzzling, to say the least. Of course, investments required by the transition will stimulate demand and employment. But the changeover will also affect supply because one way or another, decarbonisation amounts to putting a price on a resource – a stable climate – that was previously available for free. Whether this pricing is explicit (in the case of carbon pricing) or implicit (if policy proceeds through regulation instead), it impacts adversely the potential for production from a given capital stock.

How this supply channel will play out and how it will interact with the demand-side channel are matters for discussion, but it cannot be ignored. Nor can the possibility be ignored that the required investment effort will for a time require more resources to be devoted to investment and, by implication, less to consumption. In which case, consumer welfare may well suffer in the short term, although it will benefit from a better climate in the long run.

Eliminating net greenhouse gas emissions will also involve significant reallocation of capital, labour and technology across and within sectors. Trade and technology shocks provide ample evidence of the significance of the associated frictions. The closure or conversion of

27 See Ursula von der Leyen, 'The European Green Deal – our new growth strategy,' 11 December 2019, https://ec.europa.eu/commission/presscorner/detail/en/ac_19_6745, and 'Remarks by President Biden at the COP26 Leaders Statement,' 1 November 2021, https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/11/01/remarks-by-president-biden-at-the-cop26-leaders-statement/.

coal-powered plants, combustion engine factories or livestock farms will inevitably entail a loss of physical, human and financial capital. Spatial relocation will be hard to grapple with. If experience with trade adjustment has taught us anything, it is that reallocation costs should not be underestimated.

Finally, it would be wrong to assume that policy will be flawless throughout. Climate policies involve major difficulties because of the technological uncertainty they involve, their intertemporal dimension, their global public good character and their distributional implications. Moreover, decarbonisation must be regarded as a transformation that will inevitably entail first-order changes in behaviours and lifestyles. To put it bluntly, climate action often involves making life today for the lower middle-class or the citizens of developing countries more expensive, in the hope of improving the living conditions of yet-unborn future humans, most of whom will be foreigners. For these reasons the political-economy obstacles to effective and efficient action are daunting. Governments face strong incentives to postpone, posture and cheat.

How can the macroeconomic impact of net zero be assessed? A back-of the envelope way to gauge it is to use the price of carbon as a shortcut and to compare the size of the shock triggered by repricing it in line with the Paris Agreement objectives to the experience with past shocks. The advantages of such an approach are, first, to encompass many transmission channels at once and, second, to provide a yardstick against which the magnitude of the shock can be assessed.

In Pisani-Ferry (2021), I did the corresponding arithmetic and concluded that the pricing of carbon at $75/ton globally (instead of $3/ton currently, according to the International Monetary Fund, or about $10/ton, if energy taxes are taken into account) would result in a supply shock of a similar magnitude to the first oil shock. This is a rather sobering assessment, especially as most estimates put the price of carbon at a much higher level if it is to be consistent with meeting the net-zero objective, and it should be taken as indicative of the fact that climate

change mitigation will entail significant supply-side effects[28]. But this reduced-form methodology ignores significant differences between a carbon price shock and an oil shock, especially in relation to their distributional and demand-side effects[29].

In this chapter, I explore the same issue but rely on a more structural approach. I start by discussing the nature of the economic transformation involved in the decarbonisation process. I then analyse the economics of an optimal transition scenario. Finally, I examine the potential risks of departure from that scenario, before concluding.

A primer on the economics of net zero

Let us take as a given that net zero must be achieved by 2050. From an economic viewpoint, the reduction in greenhouse gases will involve four main processes, of which the first two are expected to deliver by far the largest part of the cut in net emissions:

1. The decarbonisation of the energy system through substituting carbon-free primary energy sources (renewables and nuclear) for fossil fuels;
2. A reduction in the energy intensity of GDP and total energy consumption through an across-the-board improvement in energy efficiency and behavioural changes;
3. The introduction of emissions-reducing technologies such as carbon capture;
4. Other evolutions that do not mainly involve a transformation of the energy system, primarily in agriculture and land use, and for some industrial processes.

28 The $75/ton level is consistent with the 2030 estimates put forward by High-Level Commission on Carbon Prices (2017). Other estimates by NGFS (2021), France Stratégie (2019), BEIS (2021) and Bank of England (2021) put the price tag at multiples of that. Note, however, that some of these prices are marginal prices, not average prices.

29 See Pisani-Ferry (2021) for a discussion of these differences.

Table 1 provides a snapshot of the changes in final energy consumption and electricity consumption in the prevailing 2050 net-zero scenarios of the main European countries[30]. It is apparent that all of them combine a significant reduction in energy consumption (and therefore a much sharper reduction in the energy intensity of GDP) with the substitution of carbon-free electricity for fossil fuels. All also envision the substitution of hydrogen or biofuels for fossil fuels[31].

Table 1: Change in final energy consumption and electricity consumption in major 2050 scenarios

Scenario	Change in electricity consumption	Change in final energy consumption
EU (European Commission)	+160% to +174%	-23% to -28%
Germany (Dena)	+52% to +111%	-37% to -41%
France (Government and RTE)	+15% to +57%	-40%
Italy (Government)	+92% to +123%	-40%
Spain (Government)	+89%	-33%
UK (CCC)	+100% to +195%	-26% to -46%

Source: RTE (2021), Chapter 3 for France and Chapter 6, Table 6.1 for the other countries.

The expected reduction in energy consumption may come partly from changes in consumer behaviour (away from carbon-intensive travel, for example), but it mainly results from energy efficiency gains. These, in turn, stem from investment in infrastructure, buildings, equipment, industrial processes and new consumer durables, and from the mere process of adopting more suitable sources of energy,

30 The scenario for Germany does not take into account the more ambitious objectives set by the new coalition government (see BMWK, 2022).

31 Global scenarios also combine massive electrification and accelerated increases in energy efficiency, but as they make room for development, they do not envision a significant fall in total final energy consumption. See for example IEA (2021a) and IRENA (2021a).

such as when substituting electricity-based heat pumps for oil-fired boilers. The increase in electricity production from carbon-free sources is similarly expected to result from the building of new capacities and the substitution of green capacities for existing fossil fuels-based capacities.

Economically, these transformations can be represented in a nested production function:

$$E = E\,(K_E, F)$$
$$Y = Y\,(K_Y, L_Y, E, F)$$

Where Y is GDP net of the value added of the energy sector, K and L are capital and labour, E is non-primary energy (essentially electricity) F is fossil fuels (including refined products), K_E is capital in use in the non-primary energy sector, and K_Y and LY are capital and labour in use in the rest of the economy[32]. It is assumed for simplicity that non-primary energy is produced exclusively with capital and fossil fuels (freely available renewable resources and uranium are omitted). Decarbonisation essentially consists in eliminating F, first by substituting K_E for F (totally) in the first equation and second by substituting E for F (totally) and K_Y and L_Y for E (partially) in the second equation. This can in particular be achieved by taxing F, which has two effects: first, to substitute capital for fossil fuels in the production of non-primary energy; second, to substitute capital and labour for energy in the production of other goods and services.

As indicated in Table 1, for all countries both processes are involved in the transition. They are not identical: the elimination of fossil fuels requires first and foremost additional capital, whereas the lowering of the energy intensity of GDP may also trigger an increase in demand for labour, at least in the short term (eg for insulating buildings), as well as for capital (eg for improving heating systems).

32 Other representations are possible, for example through distinguishing brown capital powered by fossil fuel and green capital powered by renewables.

From an economic standpoint, three important questions are:

- How much capital must be invested to substitute *F* entirely by 2050 (and what mix of carbon pricing, regulatory measures and subsidies will trigger this investment)?
- What will be the eventual impact of decarbonisation on the price of *E*?
- What will be the impact of fossil fuels divestment on the productivity of capital and labour (in the production of *Y*) and therefore on potential output?[33].

There is no consensus on the answer to the first question, in part because available scenarios refer to different scopes and different concepts. There are currently few fossil-fuel producers among advanced countries (with the US a big exception), so for them additional decarbonisation investment is not offset by a cut in investment in fossil-fuel extraction. At world level, however, this substitution is significant.

Even within a single country, some consider only part of the required investment, typically investment within the energy system or in infrastructure. Most ignore downstream investment (in energy-consuming sectors). But some also consider the renovation of buildings. Some take into account the replacement of private cars (which is not part of capital investment in the national accounts). Moreover, some report gross investment (instead of netting out fossil-fuel investment) and some also include adaptation investment. Finally, they use different baselines for determining the amount of additional investment (either a no-action baseline or a moderate-action baseline).

At the bottom end of the range of estimates, Jaumotte *et al* (2021) regard decarbonisation as capital-saving. In their scenario, global private investment is lower than in the baseline scenario, as de-investment from fossil fuels exceeds investment in low-carbon sectors and

33 I consider in the next section whether the transition involves an accelerated depreciation of the existing capital stock.

technologies. Their simulations, however, rely exclusively on a macroeconomic model characterised by very high elasticities of substitution.

Recent structural estimates produced by international or national institutions result in significantly higher numbers. Unlike the pure macro scenarios that are based on highly stylised representations of the energy system, structural estimates rely on disaggregated techno-economic analyses of investment needs in economic sub-sectors. Table 2 reports results from the studies, suggesting a headline figure of 2 percent of GDP for the net annual additional 2030 investment (in comparison to a business-as-usual scenario)[34]. Longer term, the investment effort would be less significant, though still in excess of 1 percent of GDP annually.

34 Because they lack numerical detail, Table 2 does not report the net-zero scenario of IRENA (2021a), which envisions an increase of annual investment from $2.1 trillion in 2019 to $4.4 trillion over 2021-2050.

Table 2: Net additional mitigation investment implied by the transition to net zero (in comparison to business-as-usual baseline)

	IEA (2021)	European Commission (2020)	UK CCC (2020)	France RTE (2021)
Scope	World	EU	UK	France
Sectors	Energy	Net	All sectors	Energy, infrastructure, buildings
Concept	Net of fossil-fuel disinvestment	NZ by 2050	Gross	Net
Target	NZ by 2050	-55% by 2030a	NZ by 2050 -78% by 2035 [a]	NZ by 2050 -55% by 2030[a]
Additional investment in 2030 (% of GDP)	2%	1.9%-2.2%	2.0%	1.8%
Additional investment in 2050 (% of GDP)	Gradual return to baseline	About 1%	1.3%	n.a.

Source: IEA (2021a), European Commission (2020), CCC (2020), RTE (2021), own calculations. Amounts indicated represent additional investment in comparison to a no-action business-as-usual baseline. [a] with respect to 1990. NZ = net zero.

Based on a survey of available scenarios, the 1.5° report of the IPCC (2018) puts the mean annual additional investment in the energy sector required to keep the rise in global temperature "*well below*" 2°C at a much lower level: 0.36 percent of global GDP from 2016-2035[35]. This figure is scaled up to 0.6 percent of global GDP if investment in transportation and infrastructure is also taken into account, and would

35 See Box 4.8 in Chapter 4 of IPCC (2018).

be close to 1 percent of GDP if the scenario is corrected for not resulting in reaching net zero by 2050. The remaining discrepancy with the figures for advanced countries is largely explained by different period averages and by a larger netting out of disinvestment in fossil-fuel extraction when reasoning at world level[36].

Evidence on the answer to the second question regarding the impact of the transition on the price of non-primary energy (E) is hardly consistent, in part because of a high degree of uncertainty about future developments, in part because different sources rely on different underlying concepts, and in part because the price of electricity is determined by the cost of the marginal source of energy rather than by the average cost. The good news from recent years is that endogenous technical progress anticipated by Porter and van der Linde (1995) and formalised by Acemoglu *et al* (2012) has materialised to an unforeseen extent. It has resulted in the collapse of the cost of renewable-generated electricity, the levelised cost of which is now inferior or equal to that of electricity generated from fossil fuels (IRENA, 2021b)[37]. However, this is a partial approach, which ignores on the one hand the cost of adapting electricity transport networks, and of backing up electricity from intermittent renewable resources with alternative sources or storage capacities, and on the other hand the cost of the changeover of final energy consumption (from fossil fuels to electricity, especially for heating and transport).

Although estimates of these costs tend to be scenario-, system- and country-specific, the prevailing consensus for advanced countries is that, at least based on current technology expectations, decarbonisation is bound to significantly increase the total cost of final energy. Scenarios by RTE, the French electricity transport utility, resulted in a

36 I am grateful to Jean-Charles Hourcade for discussions on this topic.

37 Comparisons are based on the levelised cost of electricity (LCOE) defined as the present value of the cost of producing it over the lifetime of a new equipment, divided by the present value of the electricity stream. LCOE is the standard metric for comparing the cost of different primaries energies.

15 percent median increase in the real cost of electricity by 2050 (RTE, 2021). This is however for a country where electricity production costs are comparatively low, because of its massive reliance on nuclear power.

Finally, the third question regarding the impact of the transition on productivity (and consequently growth) has not been explored extensively. Standard three- or four-factor production function approaches lead to the expectation of a negative impact. Endogenous technical progress approaches result in more subtle results, as productivity takes a hit in the short term (because of the switch from dirty to yet-underdeveloped green technologies), but may improve in the longer term (Aghion *et al*, 2016). Empirically, the evidence reviewed by Dechezleprêtre *et al* (2019) seems to suggest that environmental regulations do not affect economic performance.

The economic cost of an optimal transition

Having surveyed the investment and cost implications of decarbonisation, the next step is to assess its potential implications more precisely in what can be called an optimal transition scenario. Under the constraint that net zero must be achieved by 2050, a natural definition of the optimal transition is that it minimises the present value of the associated annual welfare losses in comparison to a hypothetical no-action scenario[38].

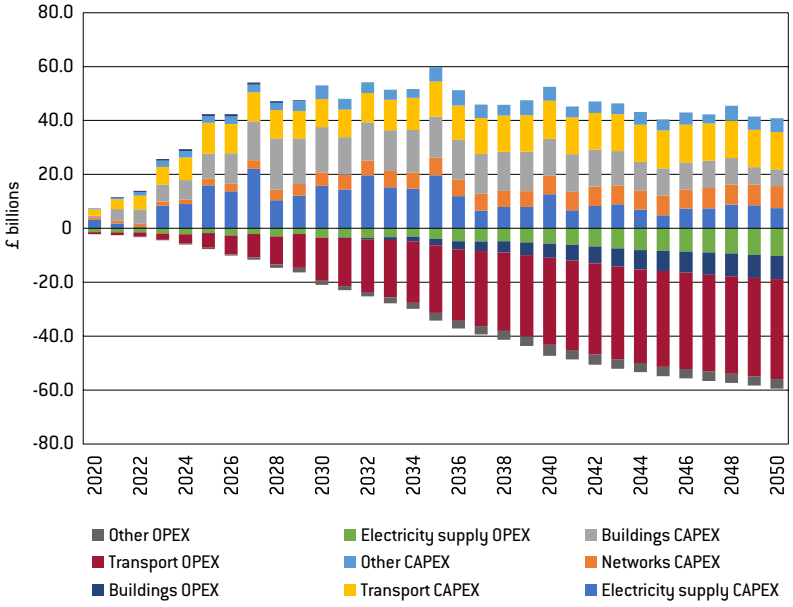
The 'balanced pathway' to net zero prepared by the British Climate Change Committee (CCC, 2020) is an interesting attempt to build an optimal system transition scenario, which also has the advantage of being explicit about the underlying hypotheses. The scenario, which encompasses changes in the energy mix as well as end-use

38 Obviously, a global no-action scenario would result in massive climate-induced welfare losses. Because of the collective action dimension of climate action, however, at individual level the welfare cost of decarbonisation tends to be assessed in comparison to a business-as-usual case where income and consumption remain on trend.

transformations, is based on a no-sunk-cost assumption: existing capital is replaced by new, carbon-efficient capital when it reaches the end of its economic life. GDP can in a first step be assumed unchanged, whereas its composition is affected (more resources must be devoted to investment, at the expense of private and public consumption).

Figure 1 depicts the nature of the changeover: upfront investment, especially from 2020 to 2030 (above the horizontal axis), gradually delivers operating-cost savings (below the axis) so that by 2030, cumulative additional investment exceeds cumulative operating-cost savings by 15 percent of GDP. Eventually, as the bulk of new equipment has been phased in, operating-cost savings exceed annual investment.

Figure 1: Capital investment costs and operating costs savings in the CCC's balanced pathway scenario, 2020-2050



Source: CCC (2020), Figure 5.3. Constant 2019 £.

Cumulative additional investment from 2020 to 2050 amounts to 40 to 50 percent of GDP, a figure that can be regarded as the gross cost of the transition. The net cost however is lower, as investment results in later operating-cost savings resulting from the substitution of renewables for fossil fuels and from other transformations of a similar nature. In the CCC calculations, the present value of additional investment, net of resulting operating-cost savings, still amounts to 0.6 to 1 percent of GDP annually, or 13 percent of GDP over the 2020-2050 period[39]. This figure can be regarded as the net cost of the transition.

These numbers can be thought of as the cost of tackling climate change through retooling the energy system and energy-intensive sectors, while leaving GDP roughly constant[40]. How large are they? Two percent of GDP in annual additional investment by 2030, amounting over 2020-2050 to a gross total of some 50 percent of GDP is certainly a meaningful number[41]. In gross terms, it exceeds the cost for the US of the post 9/11 wars in Afghanistan and Iraq (Crawford, 2021). For slow-growing advanced economies, the implied dent in the annual increase in real consumption expenditures could reach one-fifth to one-fourth during the next decade, certainly a high enough burden to arouse discontent[42]. But when assessed against the economic cost of sudden shocks such as the global financial crisis, or against that of gradual transitions such as ageing, this cost looks fairly manageable. It is not a toll that should discourage us from undertaking the effort.

39 This evaluation is consistent with an overall increase in the levelised cost of energy.

40 Estimates reported in Table 2 generally envisage a minor GDP impact from the transition to net zero. Growth implications are further discussed in the next section.

41 These are possibly underestimates as investment in non-energy intensive sectors is typically ignored in bottom-up analyses.

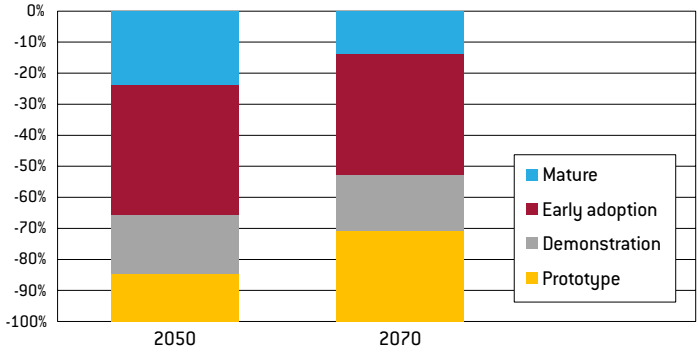
42 Assuming a 2/3 share of private consumption in final domestic demand, an increase of the share of investment by 2 percentage points translates into a 3 percent drop in consumption. If phased in over ten years, this implies a decrease in real consumption growth of 0.3 percent per year.

Transition obstacles and risks

The conclusion from the analysis just presented is that it is possible to avoid catastrophic climate change while keeping economic costs at a manageable level. It suggests that growth can be 'decoupled' from emissions (Lenaerts *et al*, 2021). A challenging question remains, though: is the optimal transition scenario a realistic perspective? The answer is that it faces a number of obstacles and that the assumptions it is based on are likely to prove too benign.

The first obstacle is *technology uncertainty*. Future technologies, especially the negative emission ones, are still in their infancy. Others, such as hydrogen, are available but their cost-effectiveness and social acceptability remain to be proven. Optimal transition scenarios in which the changeover to new technologies takes place gradually assume away uncertainty by hypothesising that at a 30-year horizon, as-yet-untested technologies will become available at affordable cost. But the reality is that uncertainty remains very large and that long-term emissions reductions are largely predicated on yet-to-come technology developments with hughely uncertain economic parameters (Figure 2). This for example applies to bioenergy with carbon capture and storage, or to direct capture.

Figure 2: Contributions of technologies to emission reductions in 2050 and 2070, by stage of technology development



Source: IEA (2020). Note: The graph compares a 'sustainable development scenario' in which the rise in global temperature would have a 66 percent probability of remaining below 1.8°C to a 'stated policies scenario' that assumes a continuation of policies in place or planned.

There is actually more involved in technological innovation. Wherever efficient green technologies are yet to be developed, the best strategy may well be to invest in green research and development rather than to rely on existing technologies. This would have two consequences: first, it slows the pace of technical progress based on existing technologies; second, it lays the ground for disruption and the accelerated discarding of the existing capital stock when alternative technologies become available. Aghion *et al* (2016) found evidence of the impact of the transition on the distribution between brown and green patents. Their simulations showed that a shift to green R&D investment will reduce output in the short run (because of the disinvestment in brown R&D) until the efficiency of green technologies catches up. At that point, however, the changeover is bound to be abrupt, as part of the existing capital stock will be struck by obsolescence. In other words, technology may yield more long-term benefits than assumed in optimal transition scenarios, but also more supply-side disruption at a medium-term horizon.

The second obstacle to factor in is the magnitude of *distributional challenges*. These first arise from reallocation effects. Following Mark Carney's stern warning[43], there has been much discussion of the financial stability risk resulting from the loss of value of stranded assets in financial portfolios. Comprehensive assessments of the magnitude of the problem are lacking, however, with estimates varying between $1 trillion and several trillions.

A perhaps more concerning aspect is labour reallocation across firms, sectors and regions. Reallocation costs are typically assumed away in smooth transition scenarios, but they are likely to be significant. A few sectors, including energy, manufacturing and agriculture, are responsible for a large share of the emissions and there is large heterogeneity within them (see for example Alogoskoufis *et al*, 2021). Even though the transition is job-creating, reallocating labour away from those sectors and towards labour-intensive tasks such as buildings renovation is bound to be costly.

Further challenges arise from the distribution of costs among households and from their unequal ability to change behaviour. Early experience with carbon pricing provides a strong warning that failure to tackle the consequences of the transition for income and living conditions inequality could derail the whole process. Because low-income consumption and low-income jobs are more carbon-intensive than high-income, high-skill ones, and because the poor cannot afford the capital cost of the necessary retooling, distributional conflict represents a major roadblock.

The third obstacle is *policy incoherence*. For economic and political economy reasons, policies in place in most countries are not coherent with the governments' intended emission targets, as recorded in their

43 'Breaking the tragedy of the horizon - climate change and financial stability', speech given at Lloyd's of London, 29 September 2015, available at https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.

Nationally Determined Contributions (NDCs), which are themselves not coherent with delivering on the collective commitment to limit the rise in temperature to well below 2°C (IEA 2021b, Climate Action Tracker, 2021)[44]. The gap is huge, with the IEA evaluating that "*stated policies*" would merely stabilise global emissions.

The implications are twofold. To begin with, achieving net zero in due time is bound for most counties to imply an abrupt policy adjustment and a switch to a more ambitious path than currently. Whenever this adjustment takes place, it is bound to imply that, unlike in the optimal scenario, part of the capital stock in place will end up being stranded before it has reached the end of its operational life, implying a loss of economic potential and an increase in the net burden of the transition. What the NGFS (2020) calls a "*disorderly transition scenario*" will entail significant macroeconomic costs in the medium term.

The second implication regards credibility. The 2015 Paris Agreement was predicated on the (correct) hypothesis that, at the time, governments were far from ready to commit to binding targets or precise action plans. They could only agree on a global aim and on setting nationally determined intended goals. Contrary to pessimistic expectations (especially among economists), the Paris Agreement has been able to create a momentum: while commitments still fall short of what is required, a process has started, the effects of which were still noticeable at the Glasgow COP in 2021. COP21 in Paris and what followed provided a signal that helped change expectations, especially those of businesses and financial players.

But the flipside of this approach is that climate policies face a massive credibility problem. Private agents are being told simultaneously that they should prepare for net zero and plan investments accordingly, and that governments are unwilling to set for today and the future carbon prices that correspond to their stated objectives. The result of this

44 Climate Action Tracker (2021) estimated the implementation of the Glasgow pledges would lead to a 2.4°C rise in global temperature.

credibility gap is an incentive to keep the options open and wait until policy actually delivers on commitments. In a standard decision model, the option value of waiting leads to firms postponing investment decisions. The consequence is that they neither invest in brown nor in green technologies. Such behaviour increases the economic cost of decarbonisation (Fried *et al*, 2021).

The fourth obstacle is *policy inefficiency*. Optimal transition scenarios naturally assume that policy will rely on effective and efficient instruments. These involve carbon pricing, but also regulatory decisions, incentives and public investment, among others. Whereas simple models assumed that carbon pricing was always superior to other instruments, economists have come to a more realistic assessment of what is an appropriate mix (Blanchard and Tirole, 2021).

The political economy of the transition is however likely to drive policy away from the efficiency frontier. IMF research indicates for example that fossil energy subsidies remain pervasive (see Parry *et al*, 2021 and the OECD-IISD Fossil Fuel Subsidy Tracker[45]). Moreover, the US case provides a perfect illustration of how political constraints can prevent policy from relying on appropriate instruments. Not only is carbon pricing ruled out at federal level, but legislation is blocked by the lack of a majority in congress. The result is that climate action will rely on second-rank instruments such as subsidies, and will depend on uncoordinated initiatives taken by subnational governments.

The fifth obstacle – and certainly not the least – is the *lack of international coordination*. Much of the discussion on the cross-country dimension focuses on the trade implications of multi-speed decarbonisation and the pros and cons of carbon-border adjustment mechanisms. The issue is broader, however. The transition away from fossil fuels will have a massive impact on fossil-fuel producing countries, several of which will be deprived of their main sources of income and export revenues (Leonard *et al*, 2021). Their adaptation to a new environment is unlikely

45 See https://fossilfuelsubsidytracker.org/.

to be smooth, and it will involve financial stability risks and geopolitical risks. Trade and balance of payments patterns will be affected accordingly.

Moreover, non-fossil fuel producing countries in the emerging world will be affected heavily because of the higher carbon intensity of their economies and the relative youth of their capital stock. Whereas advanced countries have cut the energy intensity of their GDP by half since the first oil shock, energy intensity in several emerging countries is much higher. Furthermore, fossil-fuel intensive equipment such as coal power plants is much younger than in advanced countries, implying a greater loss of economic value.

Each of these five obstacles – technology uncertainty, distributional challenges, policy incoherence, policy inefficiency and the lack of international coordination – represents a potential roadblock to a smooth transition. If mismanaged, they could magnify transition costs and easily turn a manageable transformation into a major economic disruption. Comparison with the oil shocks is actually relevant here: there is evidence that those of the early 2000s had a much milder economic impact than the first oil shock, in part because there had been policy learning and they were much better managed (Blanchard and Galí, 2007). Conversely, policy mistakes can compound the inherent cost of structural transformations.

Having reviewed the nature of the transformation our economies are facing and the main obstacles along the road, it is time to return to the question posed at the beginning of this chapter: how can the macroeconomic consequences of net zero be assessed?

What is clear is that the evaluation that essentially focuses on demand-side effects misses a large part of what is at stake. For example, the CCC's analysis was complemented by an economic impact assessment prepared by Cambridge Econometrics (2020). As with many exercises of this sort, this assessment is unconvincing, however, because it essentially uses the additional investment resulting from techno-economic analysis as an input and does not consider the potentially adverse

supply-side consequences of the transition. What amounts to a negative supply-side shock is therefore simply treated as a positive demand shock. Under the assumption that the economy starts from an excess supply situation (a disputable assumption for a 30-year outlook), the investment boom simply results in additional output and employment.

Another route is to rely on dynamic computable general equilibrium (CGE) models that provide a detailed representation of the supply-side. Such models have the advantage of representing the formation of the capital stock accurately, including through distinguishing between ex-ante and *ex-post* factor substitution. They are helpful in assessing the implications of alternative scenarios that differ by the speed of the transition and the corresponding capital obsolescence costs, and can also be adapted to take reallocation frictions and policy inefficiencies into account. But they are unsuited to consider Keynesian demand-side effects and cannot be used to evaluate the consequences of policy incoherence and weak credibility.

Finally, open-economy models cannot adequately capture the global interactions involved. Because it will affect fossil-fuel consumers and producers or advanced and developing countries asymmetrically, the transition to net zero must be looked at in a general equilibrium framework. *Ad-hoc* assumptions about what is happening in the rest of the world are likely to result in artificially biased estimates.

The upshot is that evaluating the implications of net zero requires relying on eclectic methodologies. Instruments – techno-economic models, CGE models or neo-Keynesian models – are available or can be adapted. What is missing is an encompassing methodology for combining them and learning from the necessarily partial results each provides.

Conclusions

Climate action has become a major macroeconomic issue, but the macroeconomics of climate action are far from the level of rigour and precision that is now necessary to provide a sound basis for public discussions and to guide policymakers adequately. For understandable

reasons, advocacy has too often taken precedence over analysis. But at this stage of the discussion, complacent scenarios have become counterproductive. The policy conversation now needs methodical, peer-examined assessments of the potential costs and benefits of alternative plans for action.

The aim of this chapter has been to provide a critical reading of the available evidence on the macroeconomics of the transition to net carbon neutrality by 2050, in accordance with the Paris target of keeping the rise in global temperature well below 2°C. It leads to the following conclusions:

1. Macroeconomic assessments should start from a compact economic representation of the transformation implied by the elimination of greenhouse gases emissions. This representation should be as parsimonious as possible, as excessive detail blurs the underlying logic of decarbonisation.
2. The greening of the economy simultaneously involves substituting capital for fossil fuels in the production of final energy, and substituting carbon-free, capital-rich energy for fossil fuels in final energy consumption. As it entails an increase in the cost of energy, decarbonisation also involves a reduction in the energy intensity of GDP.
3. In an optimal scenario, reaching net zero by 2050 will require significant additional investment over the next three decades. Annual additional investment can be assessed to reach 2 percent of GDP by 2030. Overall, the cumulated additional investment from 2020 to 2050 (the gross cost of the transition) can be anticipated to amount to about 50 percent of GDP. The net cost of the transition will be much lower (some 15 percent of GDP), once discounted operating-cost savings are taken into account, but costs will have to be paid upfront while benefits will show up gradually.
4. An optimal transition scenario therefore appears manageable macroeconomically. Five obstacles may complicate the changeover from a carbon-intensive to a carbon-free economy, however. These are

technology uncertainty, distributional challenges, policy incoherence, policy inefficiency and the lack of international coordination. If not properly addressed, they would significantly increase the economic cost of the transition and could turn a manageable challenge into a first-order disruption. More perhaps than the challenge represented by the transition itself, policy failure can cause major economic and social costs.

5. There is wide dispersion in the quantitative estimates of the macroeconomic implications of this transformation. There is a worrying lack of agreement on the appropriate methodology for assessing them as well as on the very basic mechanisms, the orders of magnitude involved and even the sign of expected impact on GDP and other key variables.

Many more macroeconomic issues than those addressed in this chapter deserve to be discussed thoroughly. To mention just a few, will the surge in capital investment implied by decarbonisation impact the equilibrium interest rate? Will labour reallocation impact the equilibrium unemployment rate? Will the changeover on the energy market affect economic stability? Will the rise in the price of carbon give rise to inflationary pressures, as argued in January 2022 by ECB Executive Board member Isabel Schnabel ? Will public finances be adversely affected? And should the transition to net zero be financed by taxes or by increases in public debt?

These are difficult issues that must be explored. As the EU, the UK and many other economies around the world step up efforts to accelerate decarbonisation, it is urgent to develop a research programme on its macroeconomic implications and to design a strategy for minimising the economic and social costs of the indispensable transformation we face.

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5 How green are EU countries' recovery and resilience plans?

Klaas Lenaerts, Simone Tagliapietra and Guntram B. Wolff

Policymakers have made a clear commitment to use the European Union's post-pandemic recovery plan, Next Generation EU, to accelerate the bloc's green transition. The underlying idea is simple: seize a moment of unprecedented economic and social disruption to reinforce the reorientation of Europe's economic model towards sustainability, and in particular to accelerate the implementation of the European Green Deal.

This idea also reflects a hope that green investments will have high fiscal multiplier effects and that they can achieve in one swoop a so-called 'triple dividend': promoting economic growth, fostering job creation and reducing greenhouse gas emissions (Hepburn *et al*, 2020). While this might be overly optimistic, it has shaped policymakers' preference and means that significant parts of the EU's recovery fund will be spent on green investments.

In practice, this has meant setting a 37 percent minimum target for spending on climate objectives under the Recovery and Resilience Facility (RRF), the largest component of Next Generation EU.

For this it is, of course, necessary to define 'green', 'climate' and 'environmental' spending. The regulation establishing the RRF (Art. 18) includes three different requirements that must be met by EU countries' recovery and resilience plans, which are the framework for RRF spending:

1. All proposed measures must respect the 'do no significant harm' principle in relation to environmental objectives, and adherence to this must be demonstrated;
2. Countries must explain how their plans contribute to 'the green transition.' This term refers to both environmental and climate-change objectives and is not subject to a target;
3. At least 37 percent of a plan's spending must go to measures which are specifically meant to support climate-change objectives, a narrower aim than the 'green transition.' The regulation provides coefficients to be used for the calculation of each measure's contribution to the target. Note that there are also coefficients for 'environmental objectives,' but no minimum share of spending was established for these.

Bruegel's dataset of EU countries' recovery and resilience plans, and the European Commission's assessments (2021), show that all countries have met this 37 percent minimum requirement. However, in some cases the Commission's assessment of the plans reported a different 'climate share' than originally stated by the member states concerned (eg higher for Austria while lower for France and Italy). The Commission judged that all plans respected the 'do no significant harm' principle to a great extent.

In this chapter, we look at both the climate and environmental components of the national plans in the RRF framework to understand countries' spending priorities in these fields. Including both these areas in our analysis is important, as doing so better reflects the encompassing nature of the European Green Deal.

Overall priorities

We first looked at each country's green spending, as categorised under the European Commission's green 'flagship areas': *Power up, Renovate and Recharge and Refuel* (referring, broadly, to cleantech, buildings energy efficiency and sustainable transport). This provides an

understanding of overall spending priorities. Note that the numbers we present here are different from the allocations to climate-change objectives, as reported in the national plans and Commission assessments, since we count the full allocations of measures included in the relevant categories (though some of their components might not contribute to climate objectives) and exclude some measures that contribute to the 37 percent target but have a non-green primary focus.

When classified this way, national allocations differ significantly (Figure 1). For the EU as a whole, *Recharge and Refuel* is the main green spending priority, accounting for more than a third, or €86 billion. For countries including Estonia, Germany, Hungary, Latvia, Luxembourg and Romania, this item even accounts for 50 percent or more of all green spending. Italy and Spain also have notably high sustainable transport allocations.

The *Power up* priority has been allocated around a quarter of green spending at EU level, or €55 billion. Shares are, however, much larger in countries including Cyprus, Czechia and Poland, which allocate close to two-thirds or more to this area. Though not visible in Figure 1, Sweden also spends money on this, but the amount could not be singled out based on the information in the plan, and is therefore captured by 'other green.' Some spending on renewable energy is included under *Renovate* for Luxembourg.

The smallest green flagship in spending terms is *Renovate* (energy efficiency of buildings), which receives €48 billion in the EU. France, Greece, Latvia, Slovakia and Belgium go against the trend by devoting considerably higher shares to improving their building stocks.

Finally, 'other green' in Figure 1 captures spending that either could not be put into one single category, or which is primarily devoted to other items in support of the green transition. This amounts to €34 billion of spending on measures including reforestation and biodiversity protection. For Sweden it includes broad 'climate investments' with many different elements. Luxembourg directs half of its green spending to environmental protection and biodiversity, and Croatia plans relatively

high spending on waste and water management and tourism. Finally, a significant share of Slovenia's 'other green' goes to water management and flood prevention.

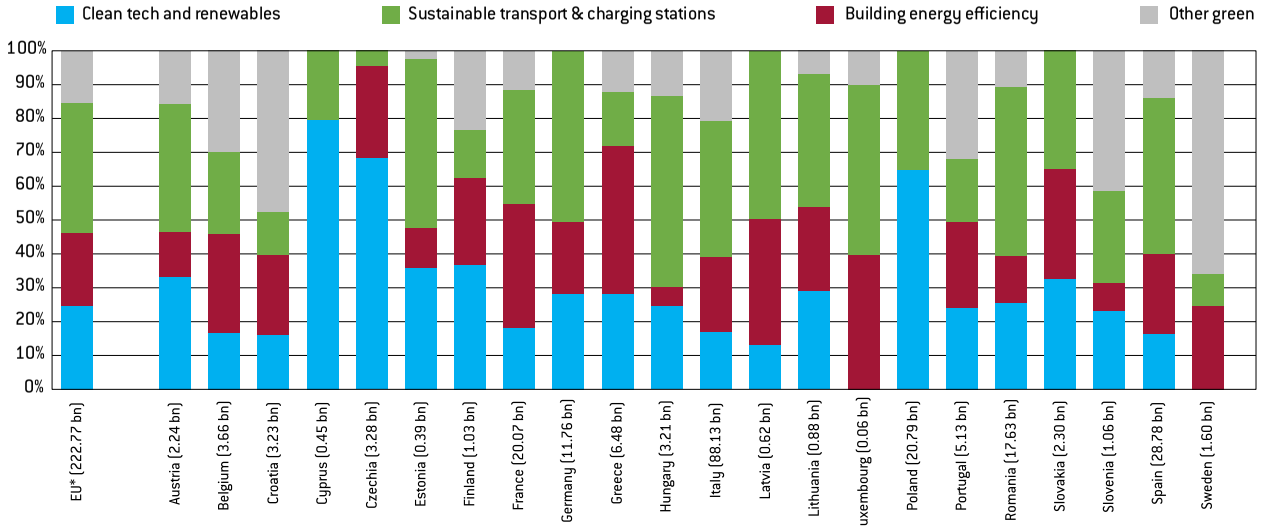
A more detailed examination

While the Commission's flagship-based classification is useful to get an overall idea of green spending priorities, a more granular breakdown is required to understand thoroughly the measures countries intend to put in place (Figure 2). Bruegel introduced its own classification to allow for such a deeper analysis.

Unsurprisingly, this more detailed classification too reveals significantly varying national spending priorities. In EU aggregate terms, spending to increase the energy efficiency of buildings takes the largest share, with €45 billion, almost a fifth of total green spending. This usually concerns both public and private buildings, sometimes explicitly targeting social housing as part of a 'just transition' narrative. Belgium and France have made renovations the largest component of their green spending, devoting around 28 percent to it. Czechia, Greece, Latvia and Slovakia spend even larger shares on this, reflecting what is shown in Figure 1.

The second biggest category at EU level is public transport, with €34 billion, or 15 percent. This is a particularly large part of planned green spending in Romania (47 percent) and also in Austria, Hungary, Latvia and Lithuania, where it accounts for more than a third of green spending.

Figure 1: Green spending in national recovery and resilience plans (% of total green spending)



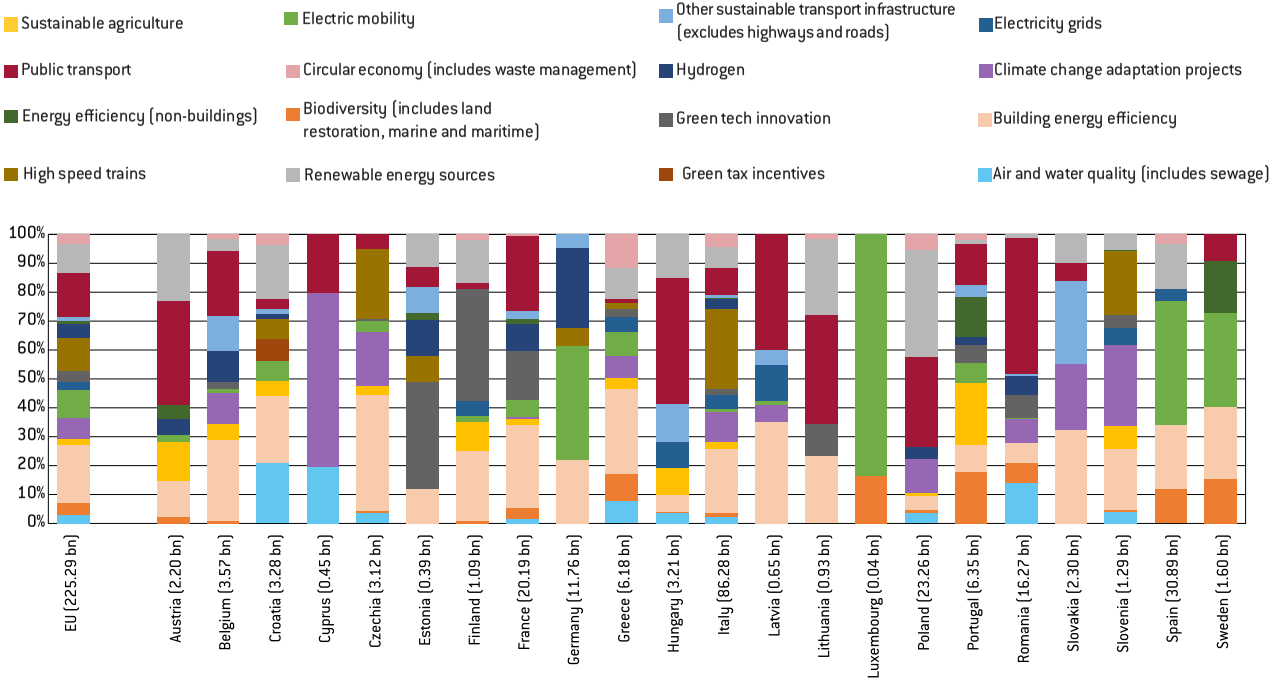
Source: Bruegel based on submitted national recovery plans. Note: country names are followed by total green spending in € in brackets. These amounts are the sums of spending (grants and loans) categorised under the flagships Power up, Renovate, Recharge and Refuel, and a residual category 'other green.' This last category captures measures that could not be assigned to any single flagship but which still primarily contribute to the green transition. Some measures that also contribute to the green transition but are aimed primarily at other fields are not included. Total green spending can therefore differ from the total amounts of spending related to climate change objectives as reported by the plans, which are calculated with weights assigned to individual spending items by member states and which should be at least 37 percent of total RRF spending within a country. * Includes 22 countries in dataset at time of writing.

We created a separate category for high-speed trains, which ranks third in size with €26 billion, or 12 percent. Almost all the planned investments are in Italy (€24 billion), where it is one of the largest spending categories. The rest of the spending on high-speed trains is planned most notably in Czechia and Germany. Taken together, spending on 'regular' public transport and on high-speed trains surpasses spending on renovations in the EU as the biggest green subcomponent.

The fourth biggest category in the EU is renewable energy sources, which receives €23 billion, or around 10 percent of green spending. Most of this spending will be concentrated in three countries: it is the biggest green component for Poland with 37 percent (€9 billion); Spain and Italy will also be big spenders in absolute terms, with €5 billion and €6 billion respectively. Remarkably, renewables don't really feature in the French and German plans, which allocate substantial amounts to hydrogen development instead.

Finally, measures specifically targeting hydrogen come in seventh place at EU level, behind electric mobility (mostly championed by Germany and Spain) and climate adaptation. Countries will spend in total €11 billion (5 percent of green spending) on this alternative fuel, with €3 billion of spending planned in Germany, €3 billion in Italy, €2 billion in France, and around €1 billion each in Poland and Romania.

Figure 2: Green spending by Bruegel's own Level 2 classification (% of total green spending)



Source: Bruegel based on submitted national recovery plans. Note: the classification used is 'Bruegel Level 2, 1st' from the Bruegel dataset. Country names are followed by total green spending (as defined by Bruegel's Level 1 classification) in € in brackets. See also note to Figure 1.

Depending on which classification system is used, at EU level some €225 billion of the RRF funds is set to be spent on green elements. This is certainly a welcome and necessary effort, but it pales in comparison to the annual investment needed by 2030 to realise the aspirations of the European Green Deal, as illustrated hereafter.

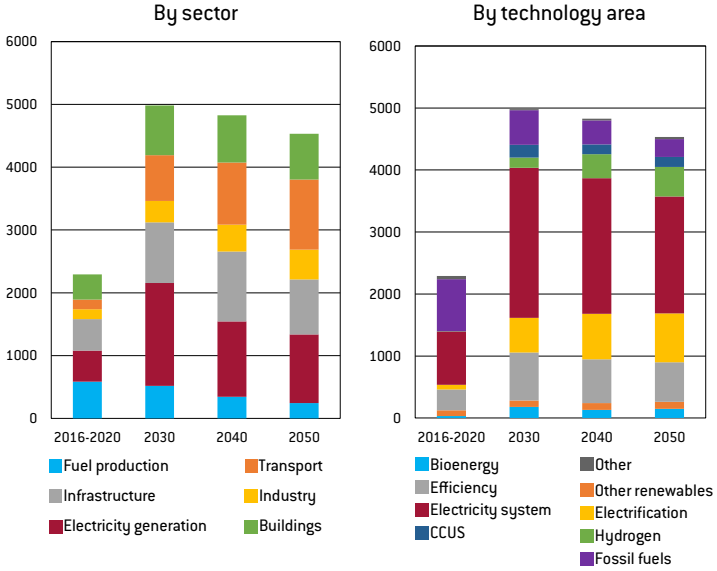
Investment requirements to deliver the European Green Deal and global net-zero pledges

To become climate neutral by mid-century, the European Union and other major economies must substantially reduce their greenhouse gas emissions during this decade. The EU aims to reduce its emissions by 55 percent by 2030 compared to 1990 levels with a wide range of policies proposed in the European Commission's 'Fit for 55' package. Meanwhile, the United States aims to reduce its emissions by 50-52 percent by 2030 compared to 2005 levels[46], and China wants its CO_2 emissions to peak before 2030. To achieve this, major investment will be needed.

To understand the investment required to deliver on these pledges it is useful to review the multiple estimates in the field. Global energy investment currently stands at around $2 trillion per year or 2.5 percent of global GDP, according to the International Energy Agency (IEA). In an illustrative pathway (IEA, 2021), this will have to rise to $5 trillion or 4.5 percent of GDP by 2030 and stay there until at least 2050 to reach net zero CO_2 emissions by 2050 (Figure 3). Much of this will be spent on electricity generation and infrastructure to electrify new economic sectors and to make the electricity system more suitable for much higher volumes and variability of renewable energy.

46 See White House factsheet, 22 April 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

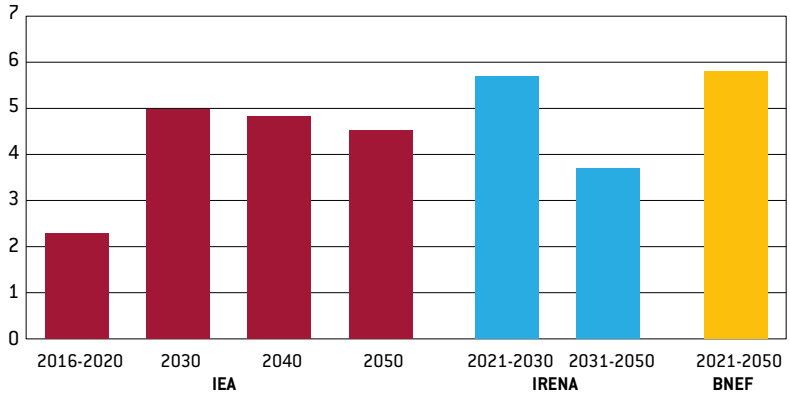
Figure 3: Annual average capital investments worldwide to reach net-zero CO_2 emissions by 2050 ($ billions, 2019 prices)



Source: International Energy Agency (2021). Note: CCUS = carbon capture, utilisation and storage.

Other net-zero pathways point to similar orders of magnitude (Figure 4). The International Renewable Energy Agency (IRENA, 2021) frontloaded the necessary investments into the 2020s, resulting in global investments of $5.7 trillion per year until 2030, though less thereafter. Bloomberg New Energy Finance (BNEF, 2021) estimated average investment requirements to be between $3.1 trillion and $5.8 trillion per year up to 2050.

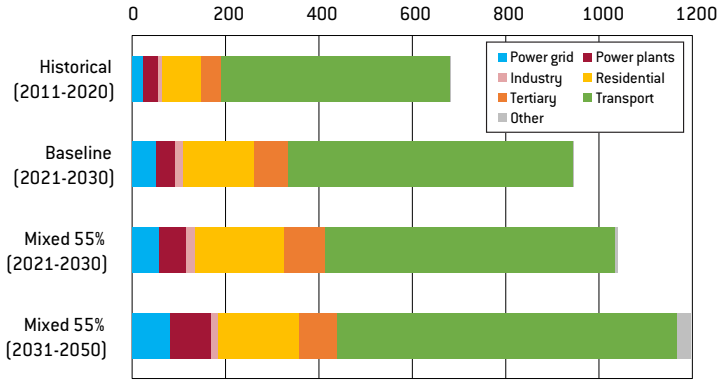
Figure 4: Average yearly global investment needs in order to reach net-zero CO_2 emissions from energy by 2050, different estimates ($ trillions)



Source: Bruegel. Note: BNEF (2021) estimated average yearly investment needs at "*somewhere between $3.1 trillion and $5.8 trillion*". IEA (2021) and IRENA (2021) estimates are in 2019 dollars.

For the EU, the European Commission (2020) estimated that reaching the 2030 climate target will require additional annual investments of €360 billion on average, starting now. This will raise relevant investments from an average of €683 billion per year in the last decade to around €1,040 billion per year. Roughly a third of the additional investment is in transport, by far the largest component because of substantial vehicle replacement needs. Apart from transport, the emphasis seems to lie more on doubling investment in residential heating, but smaller components, such as power grids and plants, still have to increase by a factor of two (Figure 5).

Figure 5: Average annual investment needs to reduce EU emissions by 55% by 2030, compared to baseline trend and historical data (€ billions, 2015 prices)



Source: European Commission (2020). Note: 'Mixed 55%' is a scenario (MIX) that features a combination of expanded carbon pricing and moderately increased ambitions in energy regulations. The baseline is a scenario in which current policies and targets for 2030 continue to apply (-40 percent emissions).

According to all these estimates, reaching climate neutrality by mid-century will thus require investments in energy and transport systems roughly 2 percentage points of GDP higher than current levels. No government can finance this with public money alone, so enabling and incentivising policies such as carbon taxes and green financial regulation will be necessary to mobilise private investments. Governments could also try to focus their spending on areas and initiatives from which viable companies can arise, as part of a green industrial policy (Tagliapietra and Veugelers, 2020). The extent to which governments can rely on private funding for these additional investments will vary widely between countries (see, for example, EIB (2021) for EU countries), but given the large overall expansion, global public energy investments may need to double in absolute terms even with significant private participation (IRENA, 2021). In the EU, a rough estimate suggests additional public investments of €100 billion per year are required (Darvas and Wolff, 2021).

The green spending financed by the Recovery and Resilience Facility may serve primarily as a short- to medium-term stimulus policy. In reality it will have to be the start of a bigger and sustained investment push to make the European economy climate-neutral and able to prosper in a post-fossil fuel world. The national recovery plans suggest that member states have different needs and approaches, and make choices between, for example, renewables versus nuclear energy or electric cars versus public transport and high-speed trains. All countries have in common however that massive mobilisation of private funding will be necessary, given the limited fiscal space of most governments. Spending choices need to create opportunities for private initiatives to take off, and suitable policies and regulation must incentivise and facilitate.

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6 To what extent can and should the fiscal framework be reformed?

Thomas Wieser

National fiscal policy has played a key role in mitigating the socio-economic fallout from the pandemic and the containment measures introduced in reaction to it. With the activation of the Stability and Growth Pact's (SGP) general escape clause in March 2020, the European Union's common fiscal rules were suspended in order to give member states full fiscal flexibility when reacting to the crisis with an unprecedented anticyclical fiscal stimulus, notwithstanding the already high debt levels that constrained some countries.

There was an international consensus on the appropriate course for fiscal policy in 2020 and 2021, but for 2022 and beyond the course of fiscal policy has become less clear as the immediate crisis recedes, but multiple challenges exist.

Acting on the notion of 'building back better' will require public funds well beyond today's levels, not only in the context of financing the ecological transition, but more generally to ensure the future resilience of economies (see, for example G7 Panel on Economic Resilience, 2021). To what extent this will be done within the established frameworks of national policies remains to be seen, but it is clear that a point has been reached when fiscal policies are being called on to play a major role in re-shaping economies. Post-pandemic, a return to business as usual will not be a viable or sensible option for national fiscal policies.

In many countries, including the United States and United Kingdom, discussions on the future role of fiscal policy are in full swing. It may only be in retrospect that the changes in direction that may emerge are understood fully. The EU and in particular the euro area occupy a special place in these deliberations because of their rules-bound framework, which limits national discretion on policies.

Economic risks and needs may differ across EU countries and regions, but need to be managed in a common framework. The European discussions will need to address a number of aspects, most of which need to be seen against very country-specific challenges and fiscal starting points.

On 19 October 2021, the Commission restarted the review of the EU's economic governance framework[47], in which possible reform of the fiscal rules takes centre stage. This has set the scene for contentious political discussions. A common understanding on three separate, but clearly related key issues will need to be reached. First, what is the appropriate fiscal adjustment path post-pandemic? Second, should the fiscal trajectory be guided by reformed rules, against which future national budgets and debt will be assessed? Third, and importantly, how should public investment for the green and digital transitions be promoted, within the existing or new fiscal rules?

Fiscal strategy

Within the flexibility provided by the general escape clause, member states have sought during the pandemic to coordinate the fiscal strategy for the euro area. This has seemed relatively straightforward. In March 2021, the Eurogroup confirmed that fiscal policy should remain supportive in 2021 and 2022, although fiscal support should shift increasingly from broad-based to targeted measures.

It is important that fiscal policy remains closely coordinated in

47 See European Commission press release of 19 October 2021, available at https://ec.europa.eu/commission/presscorner/detail/en/ip_21_5321. The review had been paused because of the COVID-19 pandemic.

the recovery regardless of whether this is done within the current or updated common fiscal rules. However, coordination might prove increasingly challenging. It requires the Eurogroup to agree on a medium-term orientation for fiscal policies, which should answer questions including:

- Should a supportive fiscal policy stance be confirmed (only) for 2022,
- Or possibly even beyond?
- If so, what would the target variable be?
- Would it be country-specific or for the euro area as a whole?

Context

The discussions on the fiscal strategy take place against the background of a significantly changed economic situation.

The economic recovery is underway, even though supply chain disruptions continue to cloud the picture. There are (what are still assumed to be, at time of writing) temporary mismatches between demand and supply, which have driven up inflation from low levels in 2020 and risk eroding some of the momentum of the recovery. Sovereign bond yields have also been edging up. Meanwhile, governments are taking fiscal measures to protect vulnerable groups from rising energy prices, which also underline the importance of future-oriented investment.

Different EU governments and policymakers draw different conclusions from the same set of data. Southern governments see a need to safeguard investment, especially green investment, whilst northern governments focus more strongly on the need to bring high debt levels back to more sustainable levels. Reconciling the needs for fiscal sustainability and for an investment-led recovery within the same set of rules will be difficult.

There are certainly good reasons for a reality check.

Reality check #1: record levels of government debt

Government debt-to-GDP ratios have increased significantly during the pandemic, in particular in countries that entered the COVID-19 crisis with already elevated ratios and relatively low growth dynamics, and whose economies have been hit disproportionately by the pandemic. The rebound of the GDP denominator will at least in the short run improve the picture only slightly. Contingent liabilities for the government sector have also increased markedly. Adding to the macroeconomic woes, private debt levels globally are high, which may require the government sector to step in at some point.

The current rules (SGP and the Fiscal Compact) prescribe a $1/20^{th}$ debt-reduction rule, which for many countries is neither politically feasible nor economically sensible. For Italy, for instance, it would imply bringing debt levels down by some 4 percentage points of GDP or more per year.

Some have argued that the long-lasting low interest rate environment calls for a new approach to debt sustainability (see for example Blanchard, 2021). In light of interest rates presumably staying low for an extended period of time, it has been suggested to change the 60 percent reference value for debt (Francová *et al*, 2021), which may be easier than changing the Fiscal Compact. Francová *et al* (2021) proposed a value of 100 percent of GDP, making convergence on this value politically and economically easier, and reinforcing the legitimacy of the EU rules-based system.

On the other hand, sovereign bond yields have edged up on the back of increasing inflation, and it seems clear that monetary policy will at some point become less accommodative than now. There is no single metric, let alone numerical value, that defines when debt becomes unsustainable, but the likelihood of debt-sustainability crises increases non-linearly with the debt-to-GDP ratio. This suggests that prudence is warranted and that the debt-to-GDP ratios should be put on a credible downward path rather than allowed to increase further.

The different fiscal starting points of EU countries when they

entered the crisis in early 2020 appear to strengthen this view: low-debt countries such as Germany were able to roll out huge support programmes, while high-debt countries such as Italy were constrained by already high debt levels. Regaining fiscal buffers as a precaution against future crises guides this approach.

Discussion point number 1 should therefore be: is there a problem in present debt levels or not? If so, how large can the risks to debt sustainability become? Can euro-area governments agree politically on future fiscal needs and risks and how to manage them? Should the debt-sustainability debate take precedence over all other questions, such as financing the ecological transformation?

Reality check #2: promoting and enabling investment

EU countries have significant investment needs, not least to succeed in the green and digital transitions. Public investment levels have been on a long-term downward trend in member states and were further cut in response to the previous crisis. There appears to be a broad consensus that this was a policy mistake, which was detrimental to potential growth.

Looking ahead, fiscal sustainability will thus have to be balanced with the need to protect future-oriented investment. Both are necessary for a resilient economy. The question is how to reconcile them. Increasing revenues will remain by and large a weapon of choice only at the margin, given already high tax levels in most EU countries. Even making headway on desirable new taxes, from digital taxes to carbon border adjustment levies, will not change the picture quantitatively in a significant manner. Changes to the tax structure of member states will anyway be a necessary course of action if environmental footprints are to be reduced, and potential growth rates should be supported by growth-friendly tax reforms.

Given these constraints, across-the-board expenditure restraint or cuts will be at the forefront of many policymakers' minds. This tends to be an economically questionable choice as this usually impacts

asymmetrically on investment and expenditure categories that support long-term growth – research and education, for example. While of course the Recovery and Resilience Facility (see chapter 5) will help to ease budget constraints for some countries, the volumes involved are insufficient for ensuring the necessary levels of investment for the digital and ecological transformation of economies.

This suggests that the issue of the quality of the composition of national budgets may require particular attention and that investment should be prioritised over (re)current expenditure. Whilst this 'doing more and better with less' approach is highly attractive in abstract policy discussions, it involves politically difficult and very determined action to overcome entrenched interests. Increasing the efficiency of public-sector operations while paying less is vital if one wants to 'build back better' and lift potential output growth. However, it requires politicians to invest a large part of their political capital, and requires stable parliamentary majorities – ideally over a number of electoral cycles – and thus cross-party agreement on such national strategies. Examples on the ground are few and far between, though where they have been undertaken, they appear to have generated win/win situations for growth and fiscal sustainability.

Reality check #3: complex rules and unpredictable decision-making

In an attempt to make the fiscal rules more economically sophisticated, they have been made increasingly complex and reliant on unobservable variables (the output gap), which hampers national ownership and predictability, and thus implementation. There are also different views on how much room there should be for political discretion and appreciation in the application of the fiscal rules.

Over the last decade or so, it has become obvious that shifting the burden of imposing strict discipline more to the European Commission has not achieved the results the more frugally-minded member states hoped for. The Commission, in charge of relations with

member states across dozens of important policy fields, feels constrained in taking disciplinary action and imposing sanctions based on a rather literal interpretation of the fiscal rules. The preference over the last years has been to rejig the rules to make them conform to policies of (some) member states.

Which fiscal rules?

In view of the imbalances still prevailing in many EU economies it seems likely that a certain measure of budgetary flexibility will be required beyond 2022.

Assuming the concept of the so-called medium term objective (MTO) for national budgets remains intact, two questions must be considered:

- With which trajectory should budgets converge towards the MTOs over time?
- Should there be exemptions for certain expenditure categories, such as green investment?

These considerations beg the question of whether the current fiscal rules are fit for purpose and, if not, if they can be improved, taking into account institutional and political realities. Almost no one considers the present set of rules clear, operational, politically sensible and economically meaningful. Yet, these rules have been fairly stable through many cycles of criticism from within and without.

Libraries have been filled with clever suggestions for reform, but even after the upheavals of the pandemic a complete overhaul of the rules is unlikely. Fears of further loosening and fears of further tightening when reforming the rules have led to a stable but bad equilibrium.

Several options have been proposed over the years, and in previous cycles of attempted reform.

The alternatives are relatively clear, but minds need to be made up. Is a significant revamp of the SGP, or even changes to the 60 percent

reference value, desirable and feasible? As much as this would bring much-needed clarity to the implementation of the EU rules, it is not very likely.

Four alternatives can be identified. The first would be to strengthen the EU Treaty's no-bail out clause – though after the policy reforms of the last decade, this looks unlikely to succeed in practice.

Secondly, more realistic alternatives would be to focus on expenditure-based rules, and/or rules that concentrate on adjustment paths for different debt levels. Still, this is not a high-probability outcome.

The European Fiscal Board (2019) has made a number of eminently sensible contributions to this debate, balancing good economics, practical applicability and possible political acceptance.

The question then is whether there should be a common pace of debt reduction or whether it should rather be differentiated, taking into account country-specific circumstances. The latter makes sense from an economic perspective, but may not be easy to agree and leaves questions of incentives for sound fiscal policies and equal treatment. In this respect, a stronger role for debt-sustainability analyses (DSAs) has been discussed. DSAs rely on forecasts of long-term growth and interest rates, inevitably surrounded by considerable uncertainty, but sensitivity analysis can provide useful insights to guide the design of credible and sound debt reduction paths. As long as growth rates are significantly higher than interest rates the problem is solved. Given the (more-than-ever highly uncertain) rates of potential output growth in Europe, this is politically attractive also for those who wish to do less later.

Third, there will of course be some who favour simply returning to the old set of rules, even if it is not quite clear what that would mean given the numerous escape clauses, exceptional circumstances and other wrinkles that have made the SGP the bureaucratic exercise it has become.

Fourth and finally, some EU countries and institutions may choose to stick by and large with the current set of rules, but agree to apply

them somewhat differently. One obvious candidate for change would be the rule that requires member states with debt levels beyond 60 percent of GDP to bring them down by 1/20th of that excess value per year. It is hard to see advocates for enforcing it over the coming years.

This last alternative seems to be the most plausible at time of writing, not least given the outcome of the 2021 German elections. That said, a number of factors would increase the practical applicability and acceptance of the fiscal rules:

- There should be agreement with member states on a medium-term adjustment path for debt levels (if necessary, as is the case for most). These adjustment paths should be country-specific and should refrain from prescriptive year-to-year numeric target values, but need to be binding on current fiscal policies and governments.
- These adjustment paths should build on expenditure rules that target a certain difference between expected nominal growth rates and expenditures.
- A general exemption for public investment is unwarranted, and given the present-day composition of public expenditures would be counter-productive. It seems sensible that a certain level of ecologically oriented expenditure is taken into account. This can be done by exempting such expenditures from downward adjustments if the expenditure rule were to kick in. Other levers for adjustment are the pace of convergence towards the MTO, or the target debt level that should be reached within a plausible time frame – these levers might not, however, adequately protect green investments. Off-budget financing of such investments in order to protect investment and respect present fiscal rules was at times discussed by German coalition partners. However, this runs the risk that these investments are nevertheless classified as government spending under international national-account rules. Flexibility of rules may thus be less than hoped for.

Renationalisation of the responsibility for sound public finances, with a prominent role for national fiscal boards or councils, has also been called for. This presupposes a high degree of trust among EU countries, including in the quality of their respective national institutions. This, however, does not do away with the question of which rules prescribe which adjustment path, and what non-compliance entails.

Another option that has been put forward would be to establish a permanent or quasi-permanent, centralised EU instrument, building on the Recovery and Resilience Facility (RRF). This should help finance 'good' investment at national levels that contributes to the achievement of EU strategic objectives. This would ease member-state budget constraints in the event of a severe economic downturn or its immediate aftermath, and in the process make it more easy to pursue an appropriate fiscal stance for the euro area as a whole, while ensuring better compliance with the agreed fiscal rules.

The RRF was established as a temporary instrument in response to an exceptionally severe crisis. The instrument's temporary and exceptional nature was a key consideration in its legal and political underpinning. It is also, at time of writing, in the early stages of its roll-out and, regardless of legal arguments, at least some member states will want to assess how successful its implementation is before considering to agree to a permanent instrument (either fully financed, or at least potentially there for a downswing). Moreover, as significant and historic the agreement on Next Generation EU and the RRF was, its redistributive properties are moderate compared to the government debt of some of the net-recipients. The RRF's macroeconomic stabilisation properties may also be limited given the lead times involved in identifying and implementing investment projects.

Next, there is also the question of whether EU borrowing to pre-finance NGEU funding to member states is common debt or, in the end, national debt, given that the EU has no direct taxation power. Against this background, it seems doubtful that a permanent

EU central fiscal capacity is feasible in the short run. This does not exclude the RRF becoming a blueprint for future crises.

Call for action

Given the many challenges that fiscal policy is expected to address in the years to come, it seems clear that an update to the EU's fiscal framework is necessary. Political realities, however, tell us that an update will take the form of an evolution rather than a radical overhaul. Nevertheless, there are a number of realistic options worth pursuing to improve the rules-based framework. None are perfect in their own right, but the fact that these are not mutually exclusive may make it easier to reach a compromise. There is little doubt, however, that an agreement will require difficult debates in Brussels and other EU capitals.

Whether an update of the rules requires legislative changes or only interpretative changes is perhaps a secondary question. A common understanding on issues including the debt reduction path, an agreement that protects ecologically-oriented expenditure, and a more prominent role for DSAs or for national fiscal councils, could be reflected in interpretative changes. Legislative changes may take longer, but are arguably preferable from the perspective of transparency and democratic accountability.

Even if things work out well in discussions in Brussels, it is not enough: success is on the ground, and for that each and every member state, especially the high-debt member states, needs a national pact on policies and timelines in order to convince partners and markets. It worked between 1995 and 2000 in many countries, although their efforts were underpinned by the desire to be part of the launch of the euro. Today there is no similar strong incentive available. Possibly, a common approach to national public debt reduction, underpinned by strong national ownership, could be facilitated by the prospect of more permanent fiscal risk sharing.

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7 Driving the transition to net zero: creating a suitable business environment for innovation

Sabine Mauderer

The goal is set: Europe aims to be the world's first climate-neutral continent by 2050. Achieving this goal will require enormous joint efforts: politics, the real economy, the financial sector, civil society and science will all have to pull their weight to reach net-zero emissions.

The real economy will have to undergo a fundamental, large-scale transformation. This depends crucially on technologies for carbon reduction and sequestration, as well as clean-energy technologies. Developing and deploying novel technologies will also create new job opportunities. It is important to be mindful of the social implications of the transformation to ensure the support of citizens. Innovation can be the driver of a sustainable and just transition towards a climate-neutral economy. A suitable business environment is a necessary condition to unleash this potential.

Breakthrough climate technologies: how to support a suitable business environment?

To create fertile ground for innovation, policymakers should use their integrating powers to build bridges between companies, academia and the financial sector. The EU is already undertaking a range of actions to this effect. For example, the European Innovation Council (EIC) seeks

to turn research into new businesses and to scale up 'game-changing' innovators. Programmes such as the EU Innovation Fund, with the support of the European Investment Bank (EIB), also aim to create the right financial incentives to boost investment in the innovative technologies needed for the EU's low-carbon transition. Innovations need long-term stable funding to flourish.

Equity financing is a central variable in this equation as it offers great potential to connect innovative investment expectations and innovative business ideas. Statistical evidence suggests that the carbon footprint shrinks faster in economies that receive more equity financing relative to bank funding (Popov, 2020). Venture capital financing for climate tech start-ups seems to sit particularly well with the concept of a green recovery, simultaneously supporting economic growth, labour markets and sustainability goals.

Venture capital funds, which provide finance to small but promising companies in their early stages, typically also offer valuable expertise and knowledge, as well as business networks and strategic advice.

Naturally, funding start-ups is high-risk. Only one in 12 start-ups succeeds in building a viable business (Startup Genome, 2019). An adequate financial ecosystem that offers long-term support throughout the different climate tech start-up stages is essential. The financial capacities in the EU bode well for this ambition.

In the public sector, Next Generation EU, worth €750 billion (in 2018 prices), and the EU's 2021-2027 long-term budget, worth €1.8 trillion (in 2018 prices), provide an unprecedented stimulus package for the European Green Deal and Europe's digital decade. In the private sector, gross savings surged to more than 25 percent of GDP in 2020 and are projected to remain at similar levels in 2021 and 2022 (European Commission, 2021). In addition, low or even negative bond market yields and high valuations in public equity markets create incentives to seek out alternative investments.

Venture capital markets: a stocktake

Venture capital is essential for the growth of innovative firms. On account of the private nature of venture capital transactions and the resulting lack of reliable data, it is difficult to determine the true size of regional venture capital markets. However, several studies confirm the general trend.

The German promotional bank KfW concluded that venture capital markets in Germany and in the European Union still lag behind other regions despite the recent upswing in transactions (KfW Bankengruppe, 2020). However, developments in China and the United States, where the venture capital markets are already much larger, have been more dynamic. In the EU, the venture capital to GDP ratio sits at 0.130 percent. In the US, this ratio is 3.5 times higher (0.463 percent). China even exceeds the EU by a factor of 4.5 (0.587 percent).

Globally, investment in climate tech is still at a comparatively low level. Between 2013 and 2019, venture capital invested in climate tech worldwide amounted to $60 billion. However, the trend points upwards. In 2020, a record $17 billion was invested in climate tech[48]. At the same time, China and the United States have an edge over Europe in this market segment as well. At $7 billion invested, the European market is approximately one-third the size of China's (PwC, 2021). Most 'unicorns' – climate tech start-ups valued at $1 billion or more – are located in the United States or China. Fewer than one in ten of the venture-backed climate tech start-ups are located in continental Europe.

Against this backdrop, the pressing question is how to improve the financial ecosystem for climate tech start-up companies in Europe. This applies, in particular, to continental European countries with traditionally more bank-based financial systems.

The European Commission has made it a priority to facilitate access

48 See *BloombergNEF*, 'Climate-Tech VC Investing Tops $17bn in 2020', 15 March 2021, https://about.bnef.com/blog/climate-tech-vc-investing-tops-17bn-in-2020/.

to financing in capital markets for small and medium-sized enterprises (SMEs) by working towards completion of the capital markets union (CMU). The High-Level Forum on CMU (2020) has made recommendations to address some of the issues related to venture capital. These include the creation of a pan-EU public-private IPO fund backed by the EU[49], tax incentives for European long-term investment funds (ELTIFs) and more differentiated regulatory risk weights for speculative unlisted equity exposures.

Developing venture capital markets: further points for consideration

For a more general approach to the question of how to develop European venture capital markets, three considerations can be derived from the characteristics of venture capital:

- First, huge amounts of money must be raised;
- Second, money must be available for a long time;
- Third, at the end, there must be the prospect of a rich reward.

For a competitive venture capital market, the ability to raise huge amounts of money from institutional investors, particularly insurers and pension funds, is indispensable. However, current product requirements, regulations and investment rules for insurers and pension funds require them to largely shun venture capital. Venture capital needs to become more 'investable' for large institutional investors, enabling them to reap the benefits of venture capital at lower risk levels, similar to their traditional investments. There are several options to help create this balance.

For example, securitisation techniques could be applied. The

49 Bruegel has also been calling for an IPO fund. See Alexander Lehmann, 'EU support for SME IPOs should be part of a broader package that unlocks equity finance', *Bruegel Blog*, 16 September 2019, https://www.bruegel.org/2019/09/eu-support-for-sme-ipos-should-be-part-of-a-broader-package-that-unlocks-equity-finance.

underlying idea behind these is to bundle together a pool of assets, repackage them as tradable securities and place them in the capital market. Also fund-of-funds constructions like the Pan-European venture capital fund-of-funds VentureEU could help to meet due-diligence requirements.

To attract additional private funding, it is also important to increase venture capital fund sizes. Overall, funds tend to be smaller in the EU compared to the United States and China. The European venture capital market is also fragmented and concentrated in only a few EU countries. The size of venture capital funds seems to be particularly important during the expansion stage and later stages of start-ups, when technological challenges have been overcome and capital intensity surges in order to scale up business. These stages often determine where start-ups will eventually be based. Public-private partnerships, with the objective of mobilising more private capital, can be an option to provide start-ups with sufficient funding during these critical stages. The political benefit from larger venture capital funds would be to keep know-how, jobs and tax revenues within EU borders.

The second aspect to develop European venture capital markets is 'patient money'. Start-ups need long-term funding provided by strategic investors, often companies with a long investment horizon. This long-term horizon seems to be particularly important for developing climate technologies. It may take a long time, often more than ten years, before investors in tech start-ups, including climate tech start-ups, might recoup their contributions and make a profit. BioNTech, the biotech start-up involved in developing a COVID-19 vaccine, is a prominent case. Often, the rationale behind patient money is gaining access to exclusive expertise, rather than a search for quick returns. Therefore, public-private partnerships could be a suitable tool from this point of view as well.

A third aspect to consider is the prospect of a high reward in the long run. Investors need more attractive exit options for start-ups, as they provide start-ups with funding in exchange for equity or another

ownership stake for a limited time, hoping that venture will eventually make a profit. Typical exit options range from trade and secondary sales to buy-backs, and one of the most rewarding exit options is an initial public offering (IPO).

All in all, there is room for improvement in the European IPO ecosystem for start-ups. A pan-EU public-private IPO fund is an important step to make progress on strengthening this ecosystem. In addition, stimulating EU SME growth markets could be another promising approach. However, several other issues prevent Europe from reaching its full potential. Obstacles that need to be addressed range from regulatory and tax conditions for employee stock options (in some countries) to a lack of specialised analysts and investors.

Enhancing the competitiveness of the EU as a global financial centre

The various projects and measures of the European Green Deal will promote much-needed climate tech innovation. To reinforce these efforts and to foster an innovation-friendly business environment, broad cooperation is essential: politics, the real economy, the financial sector, civil society and science have to work together and pool their resources and expertise.

Innovation can only flourish if capital abounds for a long period. Investors must be in it for the long haul: innovation takes time and needs to attract patient money. Improving the conditions for long-term investors such as insurers and pension funds to invest in venture capital could be an important measure in this context.

In order to mobilise the required private investment in climate technologies, a certain amount of public risk coverage may be appropriate, for example in the form of public-private partnerships.

Furthermore, Europe's economies must become more conducive to innovation. One vital step in this direction would be addressing potential barriers stemming from the fragmentation of European tax regimes, regulation of state aid, public procurement or patent frameworks.

Ultimately, strengthening the business environment for breakthrough climate technologies also has positive effects on the competitiveness of the EU as a global financial centre.

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8 Four ways to make the European Commission's carbon pricing proposal fitter for 55

Ottmar Edenhofer, Mirjam Kosch, Michael Pahle and Georg Zachmann

In July 2021, the European Commission published the 'Fit for 55' package – its proposal to reform EU climate policy to achieve the bloc's new climate target of reducing greenhouse gas emissions by at least 55 percent below 1990 levels by 2030. The package comprises 14 proposals for ratcheting up existing policies and measures, as well as introducing new ones. Notably, it proposes the implementation, from 2026, of a second emissions trading system (ETS) for road transport and buildings (which we will call ETS2) alongside the existing ETS, which regulates fossil-fuel combustion and energy-intensive industry (which we will call ETS1). The linear reduction factors (LRFs) of both systems – the fixed volume of allowances by which the cap is tightened each year (expressed as a percentage of emissions in a reference year) – are to be set at a level that ensures substantial emissions reductions in the regulated sectors by 2030, relative to 2005: -61 percent in the ETS1 and -43 percent in the ETS2. The thus-reformed ETS is the centrepiece of the package.

Nevertheless, European Commission executive vice-president Frans Timmermans, speaking on the publication of the Fit for 55 package, acknowledged that achieving the bloc's new climate targets "*is going to be bloody hard*". To put this into perspective, the LRF for ETS1 would rise

to 4.2 percent from 2.2 percent currently. Accordingly, the rate at which regulated sectors would need to decarbonise would roughly double. Meanwhile, free allocations of allowances to industry would need to be phased out earlier, implying a stronger push for firms to decarbonise to prevent the risk of carbon leakage. In the case of ETS2, an initial LRF of 5.15 percent is proposed. Given that emissions reductions in road transport and buildings practically stagnated between 2015 and 2019, this will require a substantial shift from the current trend.

The main indicator for how hard it will be to achieve these targets will be the level of carbon price that emerges in both systems. According to the impact assessment accompanying the ETS proposal, the price in 2030 will be relatively modest: €52 per ton of CO_2 in ETS1 and €80/t CO_2 in ETS2[50]. But this will depend chiefly on the effectiveness of complementary EU and member-state policies in driving down emissions, and thus the demand for allowances as well as their price. The less effective they are in doing so, the higher carbon prices will be. Given the risk of very high carbon prices and the potential political ramifications, and considering the central role the ETS is envisaged to play, making it truly 'fit for 55' is thus of the utmost importance.

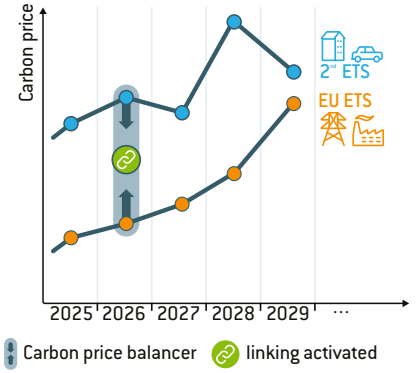
Four suggestions for improving the Commission's carbon pricing proposal

Against this background, we offer four suggestions to make the Commission's ETS reform proposal even 'fitter for 55'. The first three suggestions (summarised in Figure 1 and detailed in the following sections) are based on recommendations for making carbon pricing the centrepiece of EU climate policy in Edenhofer *et al* (2021). Section 4 details our final suggestion for addressing the potential detrimental interactions between ETS2 and the current Effort Sharing Regulation (Regulation (EU) 2018/842), which covers non-ETS parts of the economy.

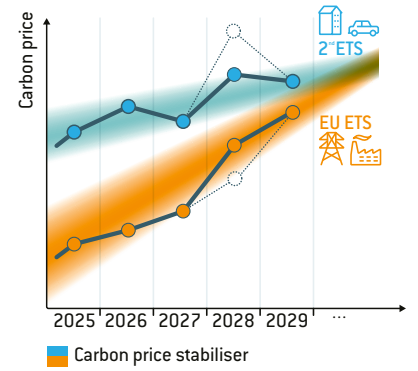
50 Price levels refer to the MIX-CP scenario; see Table 36 in European Commission (2021).

Figure 1: Three design elements for making carbon pricing the centrepiece of EU climate policy

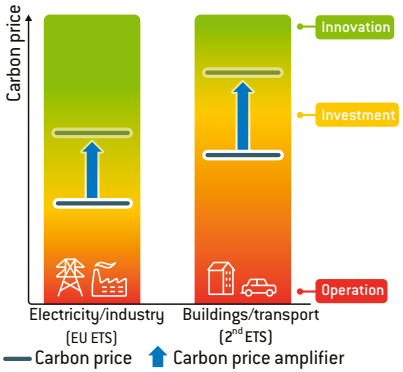
Enable linking of ETS1 and ETS2 to manage price differences between the two systems in the short run.



Implement price corridors to address the commitment problem, strengthen the role of carbon pricing and ensure price convergence between the two systems in the long term.



Implement well-designed additional policy instruments to trigger investment and innovation.



Sources: Bruegel.

Enable linking of ETS1 and ETS2

The Commission proposed not to link the two systems initially. Instead, any "*possible merger of the two systems should be assessed only after a few years of functioning of the new emissions trading, based on experience*". However, this strict separation could lead to high efficiency losses, especially if the targets for the two systems are not chosen appropriately. Modelling simulations (Abrell and Rausch, 2021) suggest that the cap in ETS1 should be substantially tighter than in ETS2.

Accordingly, a mechanism is needed to link the two systems in order to contain price differences and thereby manage the political and economic trade-offs. Linking needs to be introduced gradually so convergence takes place over time. There are two important design considerations here: (1) how and when is the linking triggered, and (2) how are initial restrictions on linking implemented and determined? On the first, a maximum price differential should be established as a threshold for triggering linking. There are several options for managing the second consideration (Quemin and de Perthius, 2019), but a quantitative restriction of the volume of tradable allowances (quota) seems to be the most feasible. The level of the quota is crucial, however, since the effect on prices of any given quota in either system is uncertain. The quota should therefore be based on market prices in both systems, eg through a (differential) price-responsive supply schedule (Burtraw *et al*, 2020). This guarantees an automatic adjustment process – the higher the price difference, the higher the quota.

Implement price corridors

Price stability in the allowance market is crucial for the functioning of both ETS1 and ETS2. The Commission proposed to continue relying on the mechanism already in place, the so-called Market Stability Reserve (MSR), which involves the removal (or introduction) of allowances based on the size of the market surplus (or shortfall). But this poses a number of risks (Perino *et al*, 2021): it could actually destabilise the market, subjecting the ETS to micromanagement and patchwork rules,

and hamper linking with ETS2. Current proposals for adjusting the MSR would fix some of these problems – notably the risk of a squeeze on the market (see Pahle and Quemin, 2020). But this falls short of addressing the core problem of the ETS: managing the expectations of market participants about the long-term price trend in light of the commitment problem (Edenhofer *et al*, 2019).

This core problem could be alleviated by a dedicated price corridor: a price floor and ceiling at which automatic market intervention would be triggered. This would make the system more stable politically and economically, and make allowance prices more predictable (Flachsland *et al*, 2020). More specifically, the stabiliser would (1) reduce price uncertainty for firms; (2) act as a safeguard against discretionary regulatory interventions in reaction to prices that are politically deemed too high or too low (Friedrich *et al*, 2020); and (3) set the timeline for convergence between the two systems. A carbon price stabiliser can also act as a hedge if the individual caps for both systems are set inefficiently, considering the relative marginal abatement costs in both systems (Abrell and Rausch, 2017).

Moreover, a price floor would have significant implications for the design and implementation of complementary policies. Since a price floor stops the price falling below a certain level, it is not necessary to manage the interaction of overlapping policies at EU or member-state level (see Burtraw *et al*, 2020). As such policies reduce emissions and the demand for allowances under the ETS, a price floor would prevent allowance prices from falling too far, or from reducing or even neutralising the effectiveness of additional policies. Moreover, if the floor is sufficiently high and rises gradually over time, it sends a strong and credible signal in favour of investing in low-carbon technologies. It can thus, at least partially, alleviate the commitment problem.

In contrast, the price ceiling has two objectives. First, it establishes a politically acceptable maximum price level, obviating the need for discretionary interventions and related speculation that could distort allowance prices. Where mitigation costs exceed the price ceiling,

additional allowances must be injected into the market, implying that the ETS can no longer ensure the targets will be met. To compensate for this, auction revenues or more stringent emissions standards could be used to incentivise investment in green technologies. In any case, this should be only temporary. If the price stays at the ceiling for a long period, the ceiling should be raised – preferably using a rule-based procedure.

The second objective of the price ceiling would be to preserve the allowance price differential between the two emissions trading systems in light of market participants' anticipation of their future integration. That is, if allowance prices in either system are considerably lower than the anticipated future single allowance price in an integrated system, market participants might buy and bank lower-priced allowances for future use, driving up short-term prices. The greater the difference between the prices, the more buying and banking can be expected in the system with the lower price. This opportunity for arbitrage could reduce and potentially even equalise the price gap right away, rendering futile an approach involving two systems with temporarily different prices. Unless banking of allowances is restricted or a price ceiling is implemented, allowance prices could rise beyond the politically acceptable level in each system as a consequence of this effect.

Finally, it might be politically difficult to establish exact minimum and maximum price levels (a 'hard collar') for each year. A 'softer' price-management mechanism (eg establishing a supply function for lower/higher allowance allocation at very low/high prices)[51] could provide almost the same benefits as a strict version at potentially lower political cost.

51 An example of this approach can be seen in the Regional Greenhouse Gas Initiative, one of the state-level emissions trading systems in the United States.

Implement well-designed additional policy instruments

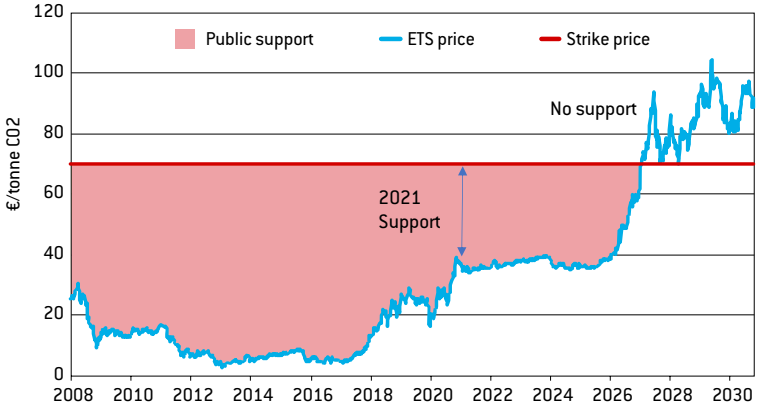
The ETS reform is a necessary, but not sufficient condition for efficient decarbonisation over the next three decades. Robust additional policies will be needed for two main reasons. First, lawmakers today are unable to commit themselves (and future lawmakers) to accepting mechanically increasing carbon-price pathways. Without such a commitment though, there is a constant risk that governments will deviate from efficient carbon pricing for the sake of short-term competitiveness or social concerns. Policymakers have several tools at their disposal to cause this deviation, for example, depressing carbon prices by changing the schedule for issuance of new allowances or enabling the import of foreign allowances. Therefore, investors are likely to believe that there is some 'political carbon price ceiling' – a price above which policymakers will intervene in markets. As a result, investor expectations about future carbon prices are volatile, and often below efficient levels.

Second, efficient decarbonisation is hampered by a number of market imperfections beyond under-priced pollution externalities. Examples include innovation externalities, system lock-ins, market power and information and incentive asymmetries. Many of these externalities cannot be addressed with perfectly targeted policies. Accepting that decarbonisation is a societal priority, governments should ensure that the tools for overcoming market imperfections are sufficiently intrusive, rather than too timid. In the absence of complementary policies therefore, capital turnover through carbon pricing alone will be too slow for the EU to hit its climate targets, whereas poorly designed complementary policies carry a risk that mitigation will be far too expensive.

Against this background, we argue that a cost-effective approach should be based on providing long-term certainty around a sufficiently high carbon price on a project-by-project basis for low-carbon investments. This should be done through transparent competition at the European level which would both allow for lower-cost

decarbonisation and prevent nationally focused plans from disrupting the single market. 'Commercialisation contracts' (McWilliams and Zachmann, 2021) would be one approach. These involve a private buyer and a public seller agreeing on a fixed carbon price over a set period for abated emissions associated with a low-carbon project. If the actual price is below the agreed price, the public seller makes up the difference to the private buyer. If the actual price is at or above the agreed price, there is no payment (Figure 2). Potential projects would participate in auctions to determine a fair price, which should just tip low-carbon investments into profitability.

Figure 2: Illustration of compensation levels for a commercialisation contract



Source: Bruegel.

Commercialisation contracts would be well-suited to large projects taken on by private firms, particularly within heavy industry (eg a new clean-steel plant). In principle, however, commercialisation contracts could be adapted to a wide range of sectors. For example, households investing in clean-fuel technology (such as a heat pump or electric vehicle) could receive a price guarantee to ensure that the clean fuel (eg electricity or hydrogen) is always cheaper than the displaced fossil fuel. This guarantee would take the form of a payment,

the size of which would depend on the carbon price.

Commercialisation contracts have a number of advantages. First, they benefit from a direct link to the carbon price; as the carbon price increases, the subsidy decreases and is eventually phased out. This avoids the problem of significant 'legacy' (locked-in) costs. Consequently, the policy would frontload investment, which is useful given the need for stimulus spending in response to the COVID-19 economic crisis, in the context of low interest rates. This process also implies increased transparency regarding abatement costs. Project-by-project fixed prices could set an example to countries outside the EU as they look to follow with a decarbonisation pathway.

Second, the instrument would facilitate competitive market outcomes because contracts can be auctioned. An auctioning scheme could be designed at EU level to address the problem of overwhelmingly national industrial climate policy fragmenting the EU single market. Over time, subsidies for different technologies requiring different carbon prices – and the explicit link between the subsidy and the carbon price – naturally push toward the first-best solution: A single carbon price for all sectors (Edenhofer *et al*, 2021). Along the way, proper auctioning design ensures that the cheapest abatement options are chosen.

Third, the policy is politically attractive because the volume of funding translates visibly into reduced carbon emissions. This addresses the climate externality directly and again enhances the transparency of abatement costs.

Fourth, by eliminating carbon price risk, projects' overall financing conditions are improved. The increased certainty of pay-offs would allow projects to increase the share of debt in overall project financing relative to equity. As debt is cheaper, this reduces the cost of capital and hence reduces the breakeven carbon price in a virtuous cycle (Richstein, 2017).

Finally, the policy can be viewed as an important commitment device. Lower carbon prices would become a liability on public

balance sheets, and there would therefore be a clear public desire for higher carbon prices. This would send strong market signals.

Overall, the power of the contracts lies in their ability to push transparent and least-cost decarbonisation pathways for a range of different sectors. At the same time, auctioning would encourage convergence of abatement costs across sectors, meaning that the later stages of decarbonisation could more efficiently be driven by uniform carbon pricing.

Disentangling ETS2 and the Effort Sharing Regulation (ESR)

In the Commission's proposal, emissions from road transport and buildings will be covered under ETS2 and the ESR at the same time – ie there is a significant, though not total, overlap of the sectoral scope of the two mechanisms. The introduction of ETS2 implies an EU-wide reduction target for the two sectors and relies on carbon pricing as the single instrument. The ESR, in contrast, sets national reduction targets for all non-ETS1 emissions, including agriculture, waste and other emissions. It does not define a single instrument, but calls for a set of national measures. In the public debate, the main argument for ETS2 is the cost-effectiveness of carbon pricing, whereas ESR is lauded for its burden-sharing and the impact on individual member states.

From a political point of view, having compliance mechanisms for both EU countries (ESR) and firms (ETS2) seems appealing because it offers a double safety net. Moreover, ETS2 will only start to operate from 2026, so achieving short-term climate targets will rely entirely on the ESR. However, policy interactions between different instruments have to be addressed in advance and their monitoring and management must be ensured. In other words, there should be "*a 'coherence process' that readjusts as needed*" (Ariadne Project, 2020). Unfortunately, the Commission's July 2021 proposal pays too little attention to the interaction between the ESR and ETS2. Thus, their co-existence may lead to non-transparent and hard-to-predict interactions, resulting in an unstable and socially unfair outcome, and potentially endangering the achievement of climate reduction goals.

The problem can be illustrated by considering two extreme scenarios. In the first, EU countries are proactive. They implement national measures to reduce emissions and individually reach their ESR targets; no trade is needed in annual emission allocation (AEA) certificates to guarantee compliance under the ESR. This implies that national measures induce sufficient abatement and thus the carbon price in ETS2 will likely be very low or even zero. In other words: ETS2 becomes pointless. At the same time, the implicit abatement costs for EU countries with stringent targets are very high.

In the second scenario, member states wait and see. They fail to implement national abatement measures, leading to (very) high carbon prices in ETS2 to ensure sufficient abatement. In this scenario, it is likely that member states with stringent ESR targets will not reach them, while those with less-stringent targets will over-perform. As a consequence, countries will have to trade AEAs in order to comply with the ESR targets. In summary, the ESR becomes pointless as a compliance mechanism, acting only as a transfer mechanism (although this will only function if EU countries can establish trading).

The reality will almost certainly lie somewhere in between the two scenarios, but it is unclear where exactly. It follows that the major risk of the overlap is the high level of uncertainty it creates regarding prices and social transfers:

First, uncertainty around the ETS2 price is very high. Depending on how EU countries act, the ETS2 price may be very low or very high. Given the lack of a price corridor (see above), the system will be unstable with very high market risks for public and private participants.

Second, there is a high risk that EU countries will not be able to trade AEA certificates. Under the ESR, they have this option, but the AEA market is not yet established. Without this marketplace, and because of the low number of market participants, it is very likely that EU countries will fail to establish a transparent and functional market for AEA trading. Most importantly, the price formation mechanism is not clear, ie prices that are too low or too high might materialise, which

leads to unfair outcomes. Thus, the proposed policy mix puts the burden-sharing agreement at risk.

Third, ETS2 does not include sufficient transfer mechanisms. The July 2021 proposal includes a social climate fund financed by revenues from ETS2. However, only a fixed sum of €72 billion over eight years is earmarked for this fund. The Commission expects this to be around 25 percent of total revenues. The rest is expected to be used for the EU's own resources and allocated to member states according to their historic emissions. In summary, ETS2's social transfer mechanism is much weaker than the ESR's effort sharing. Thus, if the ESR fails to act as a just transfer mechanism, the socially fair decarbonisation of the buildings and transport sectors cannot be guaranteed.

The above implies different winners and losers under different scenarios. The high uncertainty for member states, firms and households leads to a highly unstable and non-transparent system, unable to induce the high public and private investments required for the energy transition. Two changes to the July 2021 proposal would help make the abatement costs more transparent and ensure a socially fair transition:

- After 2030, ETS2 needs to become the only binding compliance mechanism for road transport and buildings emissions[52]. National ESR targets can continue to co-exist but these would only be indicative and no longer legally binding. Since the non-transparent trading of AEA certificates would then no longer be needed, this change would ensure that the road transport and buildings sectors are only subject to one transparent carbon price.

52 Our analysis focuses on road transport and buildings emissions. However, the ESR currently also covers non-energy emissions (eg from agriculture and waste). The current proposal, with partially overlapping ETS2 and ESR, therefore potentially induces inefficiently high abatement in ETS2 and too-low abatement in the remaining ESR sectors. Thus, a disentangling of ETS2 and the ESR is also necessary to ensure the decarbonisation of the agriculture and waste sectors. In any case, it is necessary to have legally binding reduction targets that induce sufficient emissions abatement measures in the respective non-energy sectors.

- ETS2 needs an improved social transfer mechanism. The July 2021 proposal to allocate a high share of revenues according to historic emissions does not correspond to the idea of burden-sharing and will likely be to the disadvantage of poorer countries. To resolve this issue, ETS2 revenues must be fully recycled to member states with an allocation key that includes elements of the burden-sharing agreement (eg GDP) and the proposed allocation of the social climate fund (eg risk of energy poverty).

These two adjustments would enhance the transparency and social justice of the whole proposal – two crucial elements for a coherent policy mix that is 'fit for 55'.

Acknowledgements

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9 The case for an international carbon price floor

Ian Parry

The last window of opportunity to keep alive the possibility of containing global warming to 1.5 to 2 degrees Celsius is about to close, unless global carbon dioxide and other greenhouse gas emissions are cut by 25-50 percent below 2019 levels by 2030.

This will require phasing in new measures equivalent to a global carbon price of around $75 per ton. The current global average carbon price is only around $3 per ton (Parry, 2021), however, the world is really at base camp in terms of what is needed from a global perspective. And if 2030 emissions requirements are not achieved, the likelihood of stabilising the climate at manageable levels will decline rapidly, especially if there is lock-in of long-lived fossil-fuel capital, such as coal plants.

The 2015 Paris Agreement aimed to catalyse global mitigation ambition. Economies that have committed to net-zero emissions by around the middle of the century include Canada, China, the European Union, Japan, Korea, the United Kingdom and the United States . Compared to initial promises, some have strengthened their pledges for 2030. The Paris Agreement, however, needs reinforcing to achieve the required near-term emissions reductions. In fact, even if fully achieved, current pledges would only cut global emissions by about two-thirds of the needed reduction in 2030, even for the upper bound (2^{o}C) of the temperature target. Moreover, there is currently no mechanism to ensure that even these emission pledges will be achieved.

Under the Paris Agreement approach, there are two key obstacles to scaling up global mitigation. First, it is difficult to negotiate greater

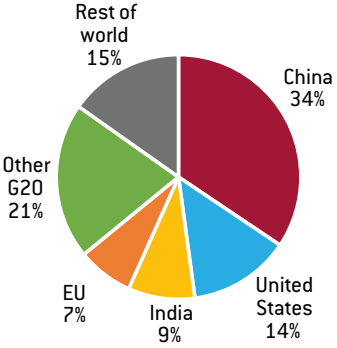
mitigation ambition as there are too many parties (nearly 200) to the Agreement, and too many parameters (one per party). In addition, when countries act unilaterally, it is very difficult to aggressively scale-up mitigation policy because of national concerns about impacts on their industrial competitiveness and uncertainty over policy actions of other countries. An additional international mechanism is therefore needed to complement and reinforce the Paris Agreement. This mechanism should facilitative negotiation; that is, it should be focused on a small number of countries and a small number of transparent parameters. And the mechanism must be effective: it must contain a concrete plan which, if enacted, would deliver the emissions reductions needed by 2030.

An international carbon price floor

Parry *et al* (2021) therefore proposed an international carbon price floor (ICPF), with two main elements.

The first would be a focus on a small number of large-emitting economies, accounting for a dominant share of global emissions. For example, China, the EU, India, and the United States account for 64 percent of projected global CO_2 emissions in 2030, while the Group of Twenty (G20) large economies (including the EU) account for 85 percent (Figure 1).

Figure 1: Shares in baseline CO_2 emissions, 2030



Source: Parry *et al* (2021).

The second main element would be a focus on a minimum carbon price that each participant must implement. A carbon price implemented through a carbon tax or an emissions trading system is an efficient and easily understood parameter. Joint action by large-emitting countries to scale up carbon pricing would the most effective mechanism to address concerns about competitiveness and policy uncertainty in other countries. Participants would be required to meet whichever is most stringent of the price floor or their 2030 mitigation pledge. In the latter case they would have flexibility to set prices higher than the floor price.

Most likely however, the ICPF would need to be designed pragmatically in two key regards. First, to address international equity issues – the 'differentiated responsibilities' for developing countries – price floors may need to be higher for advanced countries and lower for developing countries. This differentiated floor price may need to be complemented by a transparent mechanism to provide financial or technological assistance to developing countries. Second, the ICPF needs to accommodate countries for which carbon pricing is especially difficult for domestic political economy reasons, so long as they achieve through other measures the same emissions outcome as they would have achieved had they implemented the price floor. This will require acceptable conventions for modelling the emissions impacts of carbon pricing and alternative (eg regulatory) approaches.

Other design issues would need to be resolved, such as which sources of emissions should be included under the arrangement (eg whether to include the forestry and agricultural sectors), and how to monitor carbon pricing, for example when pre-existing fuel taxes are being adjusted. These issues should be manageable however (Parry *et al*, 2021).

Countries should have a strong incentive to join an ICPF. Without this or some similar mechanism, the planet may soon become locked into future temperature rises exceeding 2ºC with rapidly escalating risks of tipping points in the global climate system – and that is in no

country's interest. Other countries would likely follow the lead of the large emitters in an ICPF. And participants would also enjoy domestic environmental and health benefits, particularly reductions in premature deaths from local air pollution, from curbing their use of coal and other fossil fuels.

The effectiveness of an ICPF

It is striking just how effective an ICPF could be. For illustration (Table 1), if advanced economies, high-income emerging market economies (EMEs), and low-income EMEs were subject to price floors of $75, $50 and $25 per ton respectively in 2030, G20 emissions would be in line with keeping warming below 2°C, even with only six ICPF participants: Canada, China, India, the EU, the UK and the US (and assuming other G20 countries meet their 2030 mitigation pledges).

Table 1: G20 CO_2 outcomes under alternative ICPFs

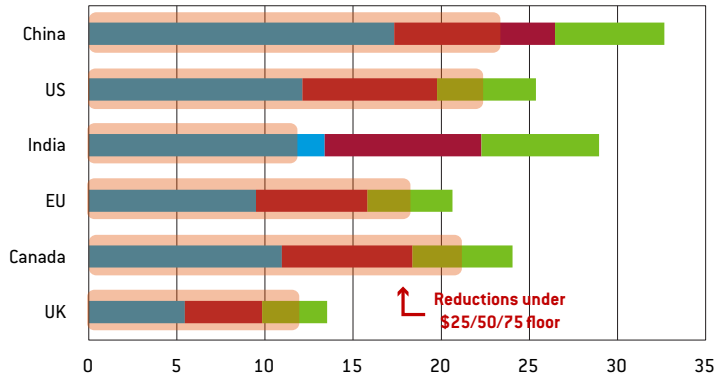
Required for 2 degrees (1.5) target[a]		
2°C	20.8	
1.8°C	32.8	
1.5°C	46.6	
	China, US, India, EU, Canada, UK	All G20 countries
NDCs only	10.9	14.1
NDCs + $50 floor	23.4	25.3
NDCs + differentiated floor $75/50/25[b]	22.6	24.6

Source: Parry *et al* (2021). Note: G20 = Group of twenty; NDC = nationally determined contributions (as of 2 June 2021). [a]Assumes energy-related national CO_2 emissions need to reduce in proportion to total greenhouse gas emissions. [b]Higher/middle/lower price for advanced/high income emerging market/low income emerging market economies.

And the emissions reductions might be viewed as equitable from a low-income EME perspective. For example, India's absolute emissions

in 2030 would still be higher than at present, and the proportionate emission reduction below baseline levels in India would be much lower than in four other ICPF participants (Figure 3).

Figure 3: Emission reductions under alternative carbon prices, 2030



Source: Parry *et al* (2021).

Price floors versus other international regimes

The pragmatically designed ICPF seems more promising than other possible international regimes to complement the Paris Agreement. One alternative would be a pure pricing regime in which all participants are required to impose the same carbon price. This approach however would offer less scope to address international equity issues (as requirements are not differentiated by development level) and would preclude participation by countries where pricing is difficult (as it does not accommodate other policy approaches).

Another possibility would be annual country-level emissions targets, with the sum of targets across participants constrained by global emissions requirements. This approach, however, involves a large number of parameters (60 for six participants over a 10 year period), and negotiation over these targets is a zero-sum game in the sense that if one member pushes for a weaker target for itself, other

participants must adopt more stringent targets. This approach also leaves critical uncertainties over the policies that will be enacted in other countries.

Finally, in the absence of an international pricing agreement, a unilaterally imposed system of border carbon adjustments is likely to emerge as some jurisdictions move ahead with more aggressive carbon pricing than others. This approach however is far less effective than an ICPF at scaling up global mitigation because it only prices emissions that are embodied in traded products, which are a very small fraction of countries' total emissions.

There is no time to waste in putting in place an ICPF or similar arrangement. A good prototype is Canada where the federal government sets the minimum carbon price (rising progressively from CAN$10 per ton of CO_2 in 2018 to $50 in 2022 and $170 in 2030), and provinces and territories have the flexibility to meet it through taxes or trading systems. And there are precedents for international agreements on minimum tax rates, for example, floors for indirect taxes in the EU and, in late 2021, on minimum corporate tax rates at global level.

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10 What will happen with US climate policy under the Biden Administration?

Robert Stavins

On 20 January 2021, Joseph Robinette Biden Jr. was inaugurated as the 46th president of the United States. On that day, he faced an unprecedented set of challenges, including global climate change – one of four stated policy priorities of his administration (along with the coronavirus pandemic, economic recovery and racial equity[53]) – in addition to the immediate issue of the then looming Senate trial of President Trump and ongoing threats of violence from Trump supporters in the wake of the 6 January insurrection at the US Capitol.

Because climate change is a global commons problem (Stavins, 2011) and international cooperation is necessary to limit free-rider incentives, Biden had promised during the presidential campaign (Democratic National Committee, 2020) to initiate on the day he would take office the process of re-joining the Paris Agreement (from which President Trump withdrew the United States on 4 November 2020 – the earliest date permitted by the agreement).

Thirty days after Biden filed the necessary paperwork with the United Nations on Inauguration Day, the United States again became a party to the Paris Agreement, on 29 February 2021. That was the easy part. The hard part was producing a new, credible Nationally Determined Contribution (NDC) – a quantitative statement of how and by how much

53 See https://www.whitehouse.gov/priorities/.

US emissions of greenhouse gases would be reduced by 2030.

The historical context

To appreciate fully the challenge the new administration faced, it is helpful to reflect on the history of international negotiations that brought the US to that point. At the Earth Summit in Rio de Janeiro in 1992, the UN Framework Convention on Climate Change (UNFCCC) was first negotiated, committing parties to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would "*prevent dangerous anthropogenic interference with the climate system*" (United Nations, 1992).

Three years later in Berlin at the first annual Conference of the Parties, it was agreed that the wealthier countries (listed in UNFCCC Annex I) would commit to targets and timetables for emission reductions, but not the other 129 (largely developing) countries. This was an attempt to provide for distributional equity among nations and recognised that the industrialised countries were responsible for the lion's share of accumulated greenhouse gases in the atmosphere, and that by virtue of their wealth they were more capable of taking action. Two years after that, in 1997, the Kyoto Protocol was enacted, codifying these objectives with quantitative targets for Annex I countries alone[54].

The Clinton Administration negotiated the Kyoto Protocol with considerable enthusiasm under the leadership of Vice President Al Gore, but it did not submit the Protocol to the Senate for possible ratification, knowing that the Protocol's lack of any emissions-reduction responsibilities for the large emerging economies (China, India, Brazil, Korea, South Africa, Mexico and Indonesia) meant it would fail in the Senate. This was a reasonable assumption, given that the Byrd-Hagel Resolution, which said as much, had passed the Senate by a vote of 95-0 just four months before the Kyoto conference[55].

54 See https://unfccc.int/kyoto_protocol.

55 See https://www.congress.gov/bill/105th-congress/senate-resolution/98/text.

The Kyoto Protocol was highly flawed. First, the Annex I countries alone could not reduce global emissions, despite a particularly severe target for the US (relative to business-as-usual emissions in the first compliance period, 2008-2012), as the significant growth in emissions came from the emerging economies. Second, because the Protocol excluded most countries (in particular, developing countries with relatively low costs of emissions mitigation), the costs were vastly higher than necessary – four times the cost-effective level by conservative estimates. Third, it was questionable whether distributional equity was even achieved, given that 50 non-Annex I countries had greater *per-capita* incomes than the poorest of Annex I nations (Stavins, 2011).

So, the United States never ratified Kyoto, and eventually Australia, Canada, Japan and Russia dropped out, leaving the European Union and New Zealand as the only Annex I parties participating (accounting for 14 percent of global emissions).

Almost two decades after Kyoto, a fundamentally different approach to international climate cooperation was taken in the Paris Agreement of 2015, which was developed under the joint leadership of the US and China during the Obama Administration.

The key attribute of the Paris Agreement is its hybrid structure, combining top-down (legally binding) and bottom-up elements. The former are largely procedural (but binding under international law), including a requirement in Article 4 that countries submit Nationally Determined Contributions (NDCs, statements of their emissions reductions from 2020 to 2025/2030), and update them by the end of 2020 and every five years thereafter (UNFCCC, 2015). The key bottom-up element consists of the set of submitted NDCs, which are not part of the agreement but, rather, are assembled in a separate public registry.

The notion is that the NDCs – unlike the negotiated Kyoto targets – arise from or are at least consistent with domestic policies, goals and politics in the respective countries. The 'bindingness' of the targets, therefore, comes not from the Paris Agreement itself, but from any domestic laws and regulations put in place to achieve the NDCs. It was because

of this structure, which avoided binding quantitative targets in the Agreement itself, that the Obama Administration felt it was able to ratify it as an executive agreement, without Senate approval (Bradley *et al*, 2020). Indeed, this structure led to the participation of countries responsible for some 97 percent of global emissions.

One year after its approval in Paris, the Agreement came into force in November 2016, when the threshold of 55 countries representing at least 55 percent of global emissions had ratified it (UNFCCC, 2015). Remarkably, it had required seven years for the Kyoto Protocol to achieve the same threshold for coming into force. What caused the exceptionally rapid accumulation of Paris ratifications?

The explanation lies in the fact that the Agreement also provides that once it comes into force, there is a four-year delay before any ratifying country may withdraw (UNFCCC, 2015). So, from 2015 to 2016, international concern that Donald Trump might be elected president of the United States and live up to his promise to pull the US out of the Agreement led countries to move as fast as they could, and the Paris Agreement came into force on 4 November 2016[56]. So, global fear of Trump gets credit (and explains why Trump's eventual withdrawal date of 4 November 2020, was the earliest allowed under the Agreement).

The US withdrawal from the Paris Agreement had no direct impact on domestic greenhouse gas emissions. Rather, those emissions were affected by the Trump Administration's rollbacks of Obama-era domestic climate policies[57]. The greatest concern was that such action by the US would lead China, India, Brazil and other emerging economies to rethink their Paris pledges. But this did not happen, as far

56 See Ban Ki-moon and Robert N. Stavins, 'Why the US should stay in the Paris agreement', *Boston Globe*, 20 April 2017, available at https://www.bostonglobe.com/opinion/2017/04/20/why-should-stay-paris-climate-agreement/w2akTLmxR891Y-hz1ziSduO/story.html.

57 See Nadja Popovich, Livia Albeck-Ripka and Kendra Pierre-Louis, 'The Trump Administration Rolled Back More Than 100 Environmental Rules. Here's the Full List', *New York Times*, updated 20 January 2021, https://www.nytimes.com/interactive/2020/climate/trump-environment-rollbacks-list.html.

as we know. Of course, the comparison ought to be with what those countries would have done had the US not withdrawn, but such a comparison would be with an unobservable hypothetical.

It is too soon to assess what has been achieved with the initial set of NDCs, since those describe reductions over the period 2020 to 2025/30, but by early January 2021, only 23 countries had submitted their updated NDCs, due at the end of 2020[58] (Climate Action Tracker, 2021).

The challenge faced by the new administration

The easy part for the Biden Administration was submitting the necessary paperwork on 20 January 2021 to re-join the Paris Agreement, but the hard part was coming up with the new US NDC. This was challenging because the new NDC needed to satisfy two necessary conditions. First, it needed to be sufficiently ambitious to please (at least to some degree) both domestic green groups and some of the key countries of the international community, particularly those of the European Union (despite the likelihood that Biden and his special envoy for climate change, John Kerry, would initially find a warm reception and abundant goodwill from most world leaders).

That essentially meant that the NDC needed to be at least as ambitious as (and probably more ambitious than) the Obama Administration target of a 26-28 percent reduction in greenhouse gas emissions by 2025, compared with 2005 (which would have been difficult to achieve even if Hillary Clinton had become president). And it needed to compare favourably with the targets being announced by other major emitters, such as the European Union pledge to cut its emissions 55 percent below its 1990 level by 2030.

It is fair to say that the new US NDC target announced by President Biden at his virtual Leaders Summit on Climate on 22 April 2021 – a

58 See Climate Action Tracker, https://climateactiontracker.org/climate-target-update-tracker/.

50-52 percent reduction below the 2005 level of emissions by 2030 – was sufficiently ambitious to satisfy that first necessary condition. But if significant ambition was one necessary condition for the new Biden NDC, the other necessary condition was and is that it be credible, that is, truly achievable given existing and reasonably anticipated policy actions. The only way that both of these necessary conditions can be achieved is with aggressive new domestic climate legislation.

Possibilities for meaningful legislation

Even with the Democratic-controlled US Senate – with a one-vote margin – meaningful and ambitious climate legislation will be difficult, if not impossible. The budget reconciliation process, whereby only a simple majority is needed to pass legislation, rather than the 60 votes required to cut off Senate debate, can be used to reverse some of Trump's last-minute policies connected to the tax code or mandatory spending if every Democrat or enough Republicans to make up for any defections support the given move. And the one-vote margin can be effective for confirming Biden's appointees, and it can help for increasing the budgets of federal agencies. But for ambitious climate (or other) legislation, the 60-vote threshold is likely to be the binding constraint.

Under these circumstances, it will be challenging, to say the least, for Democrats to enact Biden's climate plan (from the campaign, see Democratic National Committee, 2020), including its $2 trillion in spending over four years with the goal of making all US electricity carbon free in 15 years and achieving net-zero emissions economy-wide by 2050. An analysis by the Rhodium Group (Larsen *et al*, 2020) suggests that to be on a steady path to achieve Biden's 2050 goal, a cut of 43 percent below 2005 levels by 2030 would be necessary – very much in line with the new US NDC under the Paris Agreement. The problem is that passing comprehensive climate legislation that can put the US on such a path of emission reductions will be very difficult, at best.

It is helpful to keep in mind that the Obama Administration's major climate legislation – the American Clean Energy and Security Act of 2009 (the so-called Waxman-Markey bill) – failed to receive a vote in the Senate, even though Democrats (and independents who caucused with Democrats) then held a total of 59 seats. Although climate change is now taken more seriously by the public and receives considerably greater attention in political circles, the prospects over the next two to four years for comprehensive climate legislation – such as a truly meaningful carbon-pricing system – are not good.

But other legislation that would help reduce greenhouse gas emissions in the long term appears more feasible. That includes a post-coronavirus economic stimulus bill, which might have a green tinge, if not a fully green hue. The Obama Administration's 2009 stimulus package enacted in response to the Great Recession included some $90 billion in clean energy investments and tax incentives.

Another candidate will be a future infrastructure bill, something both parties seem to recognise is important for upgrading aging US infrastructure. This could include funding for: improvements in the national electricity grid (which will be necessary for greater reliance on renewable sources of energy and greater penetration of electric vehicles, EVs), EV charging stations, and public transport.

There are also possibilities for less ambitious but bipartisan climate legislation, with stringency and scope much less than what Biden's climate plan calls for. The key approaches here might involve tax incentives, that is, nearly every politician's favourite instrument – subsidies. This may fit well with Biden's moderate approach to governing and his stated desire to work with both parties in Congress. Specific bipartisan options could include (explicit or implicit) subsidies targeting wind and solar power, carbon capture and storage/utilisation, nuclear power, technology initiatives and electric vehicles via a rebate programme.

Separate legislation via budget reconciliation procedures (to allow for a simple majority vote in the Senate) will be needed for a key element

of Biden's domestic climate strategy – a Clean Energy Standard in the electricity sector. The problem here is that explicit climate policy instruments, particularly those that require new taxes to pay for them, are unlikely to gain bipartisan support. At the same time, modest, bipartisan initiatives are unlikely to satisfy the demands of domestic climate policy advocates, international calls for action, or achieve the targets in the new US NDC. Because of this, the Biden Administration – like the Obama Administration – will have to look beyond possibilities for legislation, but opt instead for regulatory approaches.

What can be expected from regulatory approaches?

President Biden, under existing authority, can take actions – and in some cases already has taken actions – through executive orders in a number of areas to reverse many of Trump's regulatory rollbacks. Will Democrats use the Congressional Review Act, which allows Congress to nullify a rule within 60 legislative days of its adoption? Republicans used this at the end of the Obama Administration, but the law prohibits Congress from later adopting a regulation that is of "*substantially the same form*" as the disapproved rule unless it is specifically authorised by a subsequent law.

More generally, the administration has moved to (again) prohibit new oil and gas leasing on federal lands, and the White House has blocked the Keystone XL pipeline from being completed. Much more importantly, the Biden Administration is moving to reinstate and possibly surpass the Obama Administration's ambitious Corporate Average Fuel Economy (CAFE) standards for motor-vehicle fuel efficiency. Also of great importance was reinstating Obama's rule regulating methane leaking from natural gas wells and pipelines, because of the exceptionally high radiative forcing potential of short-lived methane concentrations[59] (Natter, 2021).

59 See Ari Natter, 'Congress Reinstates Obama Methane Rule for Oil, Gas Wells,' *Transport Topics*, 25 June 2021, https://www.ttnews.com/articles/congress-reinstates-obama-methane-rule-oil-gas-wells.

What is – for now – missing from the triumvirate of key regulatory actions – CAFE standards, control of leaking methane and electricity-sector emission reductions – is the last of these. Hence, legislation that would implement a Clean Energy Standard is of great importance, as noted above (Gonzales *et al*, 2020).

Biden has directed that the 'social cost of carbon' (SCC; see Rennert and Kingdon, 2021) be revised, presumably returning it to the Obama Administration's appropriate use of global (not just domestic) damages and a 3 percent (rather than 7 percent) discount rate in the calculations, thereby increasing the SCC from about $1 under Trump to $50 per ton of CO2 emissions, and directing federal agencies to use the revised SCC in their own decision-making. In fact, a taskforce the Administration has established may favour a 2 percent discount rate, yielding an SCC estimate of the order of $100 per ton.

Also, there is the possibility of using the authority of the Securities and Exchange Commission to use financial regulation of publicly traded companies to raise the cost of capital for fossil energy development, or to set standards for disclosure of climate-related corporate information. Likewise, the Commodity Futures Trading Commission has itself begun to explore options via its Market Risk Advisory Committee (CFTC, 2020).

Thus, regulatory approaches under existing statutory authority through rule-making often appear to be an attractive option, but using new regulations under existing legislation rather than enacting new laws raises another problem – the courts. Rule-making entails lengthy notice and comment periods and requires extensive records and interagency consultation. Furthermore, rules are frequently subject to litigation. The Obama Administration promulgated its Clean Power Plan after the Senate failed to deliver on the administration's comprehensive climate legislation. And the Clean Power Plan was subject to a stay from the US Supreme Court even before Trump entered office. Then Trump arrived and killed the regulation outright.

But the real challenge to the regulatory approach is that new

regulations are much more likely to be challenged successfully in federal courts in 2021-2024 than they were during the Obama years. This is partly because there are 245 Trump-appointed federal judges. But more importantly, the Supreme Court's 6-3 conservative majority is likely to favour a relatively literal reading of statutes, giving executive departments and agencies much less flexibility to go beyond the letter of the law or to interpret statutes in 'innovative ways.'

The Supreme Court may move to modify or even overrule the critical Chevron Doctrine, under which federal courts defer to administrative agencies when Congress was less than explicit on some issue in a statute (such as whether carbon dioxide can be regulated under sections of the Clean Air Act of 1970 intended for localised pollutants).

Finally, during the presidential transition and since then, there has been considerable talk about a 'whole of government' approach to climate change, in which the White House pushes virtually all departments and agencies to put in place changes that are supportive of decarbonising the economy[60]. This would be beyond or instead of the focused statutory and regulatory policies considered in this essay. Of course, the critical question is what such an approach can produce in terms of short-term emissions reductions and/or long-term decarbonisation of the economy. This is, at best, an open question.

Sources of optimism for US policy action

Even if little can be accomplished at federal level over the next two to four years, surely the new administration will not be hostile to states and municipalities taking more aggressive action. Indeed, climate policies at the state level (California[61] and Washington state) and regional level (the Regional Greenhouse Gas Initiative in the Northeast) have

60 See Juliet Eilperin and Annie Linskey, 'How Biden aims to amp up the government's fight against climate change', *Washington Post*, 11 November 2020, https://www.washingtonpost.com/climate-environment/2020/11/11/biden-climate-change/.

61 See https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006.

become increasingly important, particularly during the four years of the Trump administration.

Bottom-up evolution of national climate policy may continue to evolve from the Democratic-leaning states in the Northeast, Middle Atlantic, Upper Midwest, Southwest and West Coast (and Georgia!), which together represent more than half of the US population and an even larger share of economic activity and greenhouse gas emissions.

The Biden Administration may or may not find creative ways to break the logjam that has prevented ambitious national climate change policies from being enacted (or, if enacted, to be sustainable). My greatest source of optimism is that the Biden-Harris team, in sharp contrast to the Trump-Pence administration, gives every indication that it will embrace scientific and other expertise across the board – whether that means the best epidemiologists and infectious disease experts designing an effective strategy for the COVID-19 pandemic, or the best scientists, lawyers and economists designing sound climate policies that are also politically feasible.

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GREENING EUROPE'S POST-COVID-19 RECOVERY

Even in the early days of COVID-19, the European Union signalled its commitment to make its post-pandemic recovery green. The disruption caused by the pandemic would require significant rebuilding of the economy, offering an opportunity to accelerate green investment in the context of the European Green Deal. But pursuing a green recovery is not as straightforward as it might seem. Complex trade-offs must be negotiated between the need for short-term stimulus and the need to address the long-term challenge posed by global warming.

To support policymakers in this difficult endeavour, Bruegel launched in 2020 the Bruegel Green Recovery Group, an initiative supported by the European Climate Foundation. Its aim was to be a platform for dialogue between high-level EU policymakers and academics on green recovery, in Europe and beyond. This Blueprint compiles some of the work of prominent voices of the Group, on issues that will touch the lives of all Europeans.

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